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ICED13

The 19th International Conference on Engineering Design

August 19 (Mon) - 22 (Thu), 2013

Sungkyunkwan University, Seoul, Korea

www.iced13.org

'Design for Harmonies'

- Harmony of Products and Services
- Harmony of Old and New
- Harmony of Culture and Technology
- Harmony of East and West

PROGRAMME & ABSTRACT BOOK

the Design Society
a worldwide community

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SUNGKYUNKWAN UNIVERSITY

Creative Design Institute

	19 August 2013 MONDAY	20 August 2013 TUESDAY	21 August 2013 WEDNESDAY	22 August 2013 THURSDAY
07:30 – 09:00	Registration	Registration	Registration	Registration
08:45 – 10:15	Opening Ceremony 09:00 – 10:15	Podium Sessions / Discussion Sessions / Workshops	Podium Sessions / Discussion Sessions / Workshops	Podium Sessions / Discussion Sessions
10:15 – 10:45	Keynote	Break	Break	Break
10:45 – 12:15	Break 10:45 - 11:15; Podium Sessions / Discussion Sessions / Workshops	Podium Sessions / Discussion Sessions / Workshops	Podium Sessions / Discussion Sessions / Workshops	Podium Sessions / Discussion Sessions
12:20– 13:20	Lunch 12:50 – 13:50	Lunch	Lunch	Lunch
13:30 – 14:00		Keynote 13:30 - 14:00 (14:00 - 14:15)	Keynote 13:30 - 14:00 (14:00 - 14:15)	
14:00 – 15:30	Podium Sessions / Discussion Sessions / Workshops	Podium Sessions / Discussion Sessions / Workshops	Podium Sessions / Discussion Sessions / Workshops	Podium Sessions / Discussion Sessions; Break 14:45 - 15:15
15:30 – 16:00	Break	Break	Break 15:45 - 16:15	Keynote 15:15 - 15:45
16:00 – 17:30	Podium Sessions / Discussion Sessions / Workshops	Design Society General Meeting 16:00 – 17:30	Podium Sessions / Discussion Sessions / Workshops	Closing Ceremony 15:50 - 16:30; Closing Reception 16:30 - 17:30
17:30 –	Welcome Reception 17:30 - 19:30	Young Members Event 18:00 – 20:00	Short Palace Tour 17:30 – 18:30; Conference Banquet 18:30 – 22: 00	

ICED13

The 19th International Conference on
Engineering Design

19th-22nd August 2013
Sungkyunkwan University
Seoul, Korea

Organised by
the Creative Design Institute
and the Design Society

PROGRAMME & ABSTRACT BOOK

Edited by
Udo Lindemann
Srinivasan Venkataraman
Yong Se Kim
Sang Won Lee

the Design Society
a worldwide community

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Korea Institute of Design Promotion (KIDP), which is one of the biggest institution of its kind in the world, was established by the Korean government in 1970. As a non-profit organization affiliated to and funded by the Ministry of Trade, Industry & Energy, it promotes Korea's mid- to long-term design policies and engages in various exchange programs with countries around the globe. In order to meet the demands of the digital design era of the 21st century, KIDP particularly focuses on leading Korea's economic development and enhancing the quality of life for all Korean citizens by promoting cutting-edge design industry.

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Product-Service Systems (PSS) can offer diverse values for stakeholders in a service-dominant manner to suit for various needs and wants of stakeholders. A systematic design framework for PSS composed of design methods and tools has been developed by the Product-Service Systems Design (PSSD) consortium (http://pssd.or.kr) led by the Creative Design Institute of Sungkyunkwan University, sponsored by the Korean Ministry of Industry, Trade and Energy. A suite of software tools for PSSD composed of Context-based Activity Modeling, Service Blueprint, PSS Function-Based Design, Touch Point Design with an Affordance Feature Repository, Business Model Analysis and Customer Experience Sampling and Analysis tools will be demonstrated at PSSD booth of ICED13. The PSSD framework will enable business innovation of manufacturing industry by designing PSS with customer supporting services tightly associated with specific product elements and enhance experience values of stakeholders including service receivers and providers.

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Preface by the Conference Chair

Welcome to the 19th International Conference on Engineering Design 2013 (ICED13), and its conference proceedings. The theme of ICED13, Design for Harmonies, is well reflected in the programme and papers of the conference. As design practice and research make progress, integration and incorporation of diverse viewpoints take more essential roles. ICED13 will make its mark in the history of ICED and the Design Society as an important cornerstone for harmonies in design.

Increasing numbers of presentations in topics like human behavior in design and product, service and systems design indicate that issues of harmonies of products and services and those of human-centered views and technology support are at the core of design research. With continued excellence in the topics of design methods and tools, design information and knowledge and design processes, strong research foundations of design have been confirmed in the programme. Presentations in design organisation and management, design for X, design to X, and design theory and research methodology also demonstrate the leadership of the Design Society community in these important issues. Design education is yet another important area where new needs and requirements appear as the roles of design become broader. As Seoul is the very first Asian city hosting ICED, more papers from Asian countries appear in ICED13. This reflects harmonies of East and West being strengthened in design research. ICED13 will make a good transition for drawing more such harmonies.

In addition to a technical programme of keynote, podium and discussion sessions, ICED13 has organized a few special events such as the Young Members Event. Ten selected presentations by young designers and design researchers will address the Future of Design. This event is open to the (young) public so that diverse harmonies can be achieved by the attendees. With opening and closing ceremonies and receptions as well as a conference banquet, diverse opportunities for cultural harmonies are prepared. For example, Korean traditional culture experiences are available for conference attendees and accompanying guests together with old Korean traditional buildings in order to draw harmonies from the Old and the New. The optional Gangnam-Style tour will introduce modern Korean culture as featured in the world hit music video.

We hope you enjoy ICED 13 and have the fun and excitement of Design for Harmonies.

Yong Se Kim
Conference Chair

Sang Won Lee
Assistant Conference Chair

Welcome to the ICED13 Proceedings!

We welcome you to the proceedings of arguably the biggest conference on engineering design: 19th International Conference on Engineering Design (ICED13) held in Sungkyunkwan University, Seoul, Korea!

This proceedings is a compilation of the 342 peer-reviewed and accepted papers submitted to ICED13. The proceedings is published in different forms: a book of abstracts, a soft-copy of proceedings on a USB-based memory device and a hard-copy of proceedings, which is available via a print-on-demand supplier. All these different forms of proceedings are numbered against both Design Society and ISSN referencing to allow wider access, better referencing and improved citation in the near and distant future. All the accepted papers are divided among the following 9 themes: Design Processes; Design Theory and Research Methodology; Design Organisation and Management; Products, Services and Systems Design; Design for X, Design to X; Design Information and Knowledge; Human Behaviour in Design; Design Education; and Design Methods and Tools. The hard-copy of the proceedings is in turn divided into 9 volumes where each volume comprises papers from a theme. All the accepted papers are presented in podium or discussion sessions in the conference. It is important to make it explicit that all the accepted papers have successfully cleared the criteria for acceptance in ICED13. The division into podium and discussion sessions is solely based on grouping similar papers so as to allow relevant, connected, lively and stimulating presentations and discussions. For this year's conference we have introduced a number of novel schemes to reduce the bureaucratic load for authors and organisers and, it is hoped, to increase the quality of the conference. To name a few: (i) automatic production of the cover page of papers based on title of paper, details of authors, abstract and list of keywords in the Conference Management System, (ii) electronic acceptance of terms and conditions in copyrights, (iii) feedback of acceptance and quality of reviews to reviewers from authors, etc.

This proceedings is a consequence of dedicated efforts of many people, namely, the authors, the reviewers, the chairs and associate chairs of the various themes, and the members of the Programme Committee. The Programme Chair on behalf of Programme Committee would like to acknowledge the contributions of: (a) Authors for submitting papers, (b) Reviewers for providing timely comments and feedbacks to improve the quality of papers, (c) Chairs and Associate Chairs of themes for assisting in selection of reviewers, providing directions for improvements to papers with the status of major revisions, and helping in the final decisions of papers.

We hope that you enjoy the programme of ICED13 as much as we have enjoyed creating and organising it.

Udo Lindemann
Programme Chair

Srinivasan V
Assistant Programme Chair

Preface by the Design Society President

The2013 International Conference on Engineering Design (ICED) will be the nineteenth held since the conference series was inaugurated in 1981. It will also be the sixth held under the auspices of the Design Society, an international society founded in 2001 to develop an understanding of all aspects of design. The previous five conferences have been in Stockholm, Melbourne, Paris, Stanford (California) and Copenhagen, and by holding the conference in Asia for the first time it is surely established as a truly world-wide event. The 2013 conference continues the tradition of holding the conference in an exciting location with a vibrant design research community and for which design is important to local industry and commerce. Seoul is exceptional in this regard, the dynamic heart of the world's second largest metropolis whose success is built on great design and engineering.

ICED13 also continues the format, established in 2009 and continued in 2011, of a conference programme made up of plenary sessions, podium presentations, discussion sessions with focused debate and workshops led by the Design Society's Special Interest Groups. We hope that this varied programme, combined with extensive opportunities for networking, will provide an exciting opportunity for researchers and practitioners to learn about the latest developments in design research and practice.

Organising an international conference takes an enormous amount of work, and I would like to express the thanks of the Society to the great team that has worked over many months to make the Conference a success. Especially I would like to thank Yong Se Kim, Sang Won Lee and colleagues at Sungkyunkwan University for their great work in the Organising Committee, and Udo Lindemann, Srinivasan Venkataraman and the Programme Committee for bringing together such an excellent programme. Of course, their work would be in vain without the fantastic contributions of the authors, reviewers, theme chairs and session chairs, and the thanks of the Society are due to all of them.

Chris A McMahon
Design Society President

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Torry-Smith, Jonas Mørkeberg - Technical University of Denmark, Denmark
Troussier, Nadege - University of Technology of Troyes, France
Udiljak, Toma - University of Zagreb, Croatia
Vajna, Sandor J. - Otto-von-Guericke University Magdeburg, Germany
Valderrama Pineda, Andres Felipe - Aalborg University, Denmark
Vance, Judy M. - Iowa State University, USA
Vaneker, Tom Henricus Jozef - University of Twente, Netherlands
Vargas Hernandez, Noe - University of Texas at El Paso, USA
V, Srinivasan - Technical University of Munich, Germany
Vermaas, Pieter - Delft University of Technology, Netherlands
Vietor, Thomas - Braunschweig University of Technology, Germany
Vukic, Fedja - University of Zagreb, Croatia
Wang, Charlie C.L. - Chinese University of Hong Kong, Hong Kong
Wang, Yue - Hong Kong University of Science and Technology, Hong Kong
Wartzack, Sandro - Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany
Weber, Christian - TU Ilmenau, Germany
Weil, Benoit - Mines ParisTech, France
Weiss, Menachem P. - Technion - Israel Institute of Technology, Israel
Whitfield, Ian - University of Strathclyde, UK
Whitney, Daniel E - Massachusetts Institute of Technology, USA
Wood, Kristin - Singapore University of Design and Technology, Singapore
Wörösch, Michael - Technical University of Denmark, Denmark
Wynn, David - Cambridge University, UK
Yan, Liang - National University of Singapore, Singapore
Yan, Xiu-Tian - University of Strathclyde, UK
Yanagisawa, Hideyoshi - University of Tokyo, Japan
Yang, Maria - Massachusetts Institute of Technology, USA
Yannou, Bernard - Ecole Centrale Paris, France
Yilmaz, Seda - Iowa State University, USA
Yuen, Matthew - Hong Kong University of Science and Technology, Hong Kong
Zavbi, Roman - University of Ljubljana, Slovenia
Zeiler, Wim - TU Eindhoven, Netherlands
Zeng, Yong - Concordia University, Canada

On behalf of the entire community we would like to express our gratitude to the work performed by our scientific committee. The reviews of the scientific committee were used by the programme committee to make informed accept/reject decisions for each submission and by the authors to make the appropriate amendments to their papers.

In addition, the reviews also allowed the programme committee to acknowledge the top 10% of papers based on the scores given by the reviewers; look out for the following emblem throughout the abstract book:

Reviewers' **Favourite**

Themes and Theme Chairs

The ICED 13 program committee organises various topics that cover substantial, original and previously unpublished research. The ICED 13 sessions are composed of plenary sessions, podium sessions, discussion sessions and workshop sessions from both academia and industry based on rigorous analysis or argumentation in the following themes.

Design Processes

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Design Theory and Research Methodology

Chair of Design Theory
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Human Behaviour in Design

Chair
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Design Education

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Associate Chair
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Chalmers University of Technology
Sweden

Design Methods and Tools

Chair
Panos Papalambros
University of Michigan
United States of America

Associate Chair
Wei Chen
Northwestern University
United States of America

Meetings

Research in Engineering Design Editorial Meeting

Date: Tuesday 20 Aug 2013
Time: 8:45 - 10:15
Location: IH-9B312

Design Society General Meeting

Date: Tuesday 20 Aug 2013
Time: 16:00 - 17:30
Location: IH-9B217
Chair: Chris McMahon

DS Advisory Board (AB) Members Meeting

Date: Wednesday 21 Aug 2013
Time: 12:20 - 13:20
Location: Conference Room 1 (AH-10305)
Chair: Warren Seering

DS SIG Leaders Meeting

Date: Thursday 22 Aug 2013
Time: 8:45 - 10:15
Location: IH-90109
Chair: Dorian Marjanovic

International Journal of Design Creativity and Innovation Editorial Board Meeting

Date: Thursday 22 Aug 2013
Time: 10:15 - 11:45
Location: IH-9B106
Chair: Yukari Nagai

DS SIG Leaders and AB Members Meeting

Date: Thursday 22 Aug 2013
Time: 13:30 - 14:45
Location: IH-90109
Chair: Dorian Marjanovic

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WEDNESDAY

THURSDAY

07:30 - 09:00	Registration IH-902Lobby										
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10:15 - 10:45	**Keynote: Global Impact of Design Korea - A Modernized Korean Identity?** Speaker: Young S. Kim, Innodesign, Republic of Korea (South Korea) New Millennium Auditorium										
10:45 - 11:15	Break Location: IH-90101										
	P Podium Sessions				**D** Discussion Sessions			**W** Workshop Sessions			
11:15 - 12:45	Idea and Concept Generation Location: IH-90110	Modelling Design Information and Knowledge Location: IH-90104	Engineering Change Management Location: IH-9B218	Innovating Design Education Location: IH-9B217	Modelling, Simulation and Optimisation Location: IH-9B320	System Modularity and Complexity Location: IH-9B321	Design for X (Tolerance, Affordance, Manufacture, Adaptability) Location: IH-9B312	SIG Workshop: Eco-Design Location: IH-9B106			
12:50 -13:50	Lunch Location: Cafeteria (AH-1B102) & International Conference Hall (AH-10501)										
14:00 - 15:30	Design Teams Location: IH-90110	Design Theory Location: IH-90104	Process Modelling Location: IH-9B218	Interdisciplinary Design Education Location: IH-9B217	New Design Methods and Tools Location: IH-9B320	Design for X (Tolerances, Environment, Safety, Ergonomics) Location: IH-9B321	Service Design Location: IH-9B312		SIG Workshop: Creativity in Design Synthesis Location: IH-90109	Tutorial-Style Workshop: Mobile App Design & Development - Design Thinking in Mobile Application Development Location: IH-9B208	
15:30 - 16:00	Break Location: IH-90101										
16:00 - 17:15	Universal and Collaborative Product Development Location: IH-90110	Engineering Design Education Location: IH-90104	Criteria in Product Development Location: IH-9B218	Modelling of Products and Product-Service Systems Location: IH-9B217	Methods and Tools for Evaluation and Selection Location: IH-9B320						
17:30 - 19:30	Welcome Reception Location: International Conference Hall (AH-10501)										

Welcome on Behalf of the Design Society

Christian Weber

Technical University Ilmenau

Bio-Sketch

Christian Weber acquired the Diploma in Mechanical Engineering and his doctorate (Dr.-Ing.) at the Ruhr-University in Bochum, Germany. Afterwards he worked as Senior Engineer at this institution. In 1989 he was appointed full professor of Engineering Design and Computer-Aided Design at Saarland University in Saarbruecken, Germany. Since 2007 he holds the chair of Engineering Design at Ilmenau University of Technology, Germany. He is founding member of the Design Society (2001) and, since 2005, member of the Design Society's Board of Management. Since 2000 Christian Weber is co-organiser of the annual Summer School on Engineering Design Research. He is appointed to several national advisory boards, e.g. in the DFG (German National Science Foundation) and in VDI (German Association of Engineers). His research interests are in Design Theory and Methodology (DTM), Computer-Aided Design (CAD), the links between DTM and CAD, and design and simulation of mechatronic systems.

Global Impact of Design Korea: A Modernized Korean Identity?

Young S. Kim

Innodesign

Abstract

In the mid-1960s, when I was just sixteen years old, I learned about the existence of the occupation of the industrial designer. Industrial Design magazine from the United States opened my eyes, and allowed me to dream "One day, I'll become a designer." And that dream came true—I became the first Korean to study industrial design in the United States and founded and still direct the industrial design company INNO Design. Over the twenty-five years as the head of this company, I have traveled for business from Korea to the US more than two hundred times. Having the experience of working with Korean companies and knowing its society, I have witnessed Korea become increasingly modernized and sophisticated in terms of industrial design.

After the Korean War, Korea started literally from next to nothing. Over the past sixty years, innovative start-up companies were responsible for the historical economic miracle we now see today. Perhaps it was desperation that made it possible. Whatever the cause, by 2011 South Korea became the ninth largest country in terms of international trade, representing a total of one trillion dollars. Over the years South Korea's industrial design has rapidly evolved. Once primarily dedicated—as an original equipment manufacturer (OEM)—to mass production for other countries, "Brand Korea" began to enter the global marketplace with their own brands and original design. Today, Korea is highly competitive in several industries, including electronics and automotive products, situated in the top spots of global markets and on a par with many of the globe's best companies.

Over the past thirty years Korean design has achieved much in a fierce market and has grown increasingly self-aware. But now is the time for us to take the next step, to make a new breakthrough. I believe our greatest hope lies in a "Modernized Korean Identity," one that embraces the thousands of years of Korean history.

I strongly believe that we Koreans must put our energies into developing "Design in Korea," a design consonant with global trends that would thus empower the value of the "Made in Korea" brand. Potentiating the "Made in Korea" or "Design in Korea" brands is the only way for us to survive in the design jungle. We must harness everything that is unique about us, our "Koreanness," our creativity and expertise, and even global "K-pop" culture, in order to build a gateway leading to true Korean art and design.

Bio-Sketch

YoungSe Kim founded INNO Design in Palo Alto, California in 1986, and his company has since received numerous awards from, among others, IDEA, Reddot, and IF. His most well-known products are the iRiver H10 mp3 player (necklace type) and the Lobster portable burner. He is currently teaching his ideas on design-first management based on CIPD (Corporate Identity through Product Designs) to designers and students.

Idea and Concept Generation

Chair: Gul Kremer, Penn State University, United States of America

Empirical evaluation of flexible design concept generation procedures: A study in emergency services

Michel-Alexandre Cardin, Howard Ka-Ho Yue, Yixin Jiang, Yinghan Deng, Deepak Santhanakrishnan

National University of Singapore, Singapore

This paper presents the results of an empirical study of concept generation procedures enabling flexibility in engineering systems design. Evaluation of two educational training procedures (analogies vs. explicit) and two ideation procedures (free undirected brainstorming vs. prompting) was done. The procedures aim to improve quantitative lifecycle performance, while providing users with satisfaction with the process. Controlled experiments involved ninety participants working on a design problem in emergency services. Results suggest that combining explicit training on flexibility and free undirected brainstorming was best to improve lifecycle performance, measured as average response time and net present cost of infrastructure. No statistically significant effect was measured when comparing procedures against one another based on lifecycle performance, suggesting that any procedure could be used. Analogies combined with free undirected brainstorming led to better process satisfaction for users. The results give insights on the true effects of concept generation procedures, considering quantitative performance impacts, as well as qualitative user impressions.

Exploring storyboarding in pre-brief activities

Anders Wikström, Roberto Verganti

Mälardalen University, Sweden

Creating ideas is no longer seen as a challenge within companies, creative sessions and brainstorming is widespread in most companies. However, when creating a design brief there is a lack of tools and methods finding problems and framing situations of interest. This paper examines the characteristics of storyboarding, the making of the storyboard, in pre-brief activities. In an explorative study 54 teams participating in an idea development workshop is analyzed. The workshop was developed using theories from design, visual thinking and narrative, using visual tools in every step with a focus on framing a situation of interest. This study provides an initial understanding of storyboarding in a new area and tentatively suggests that storyboarding stimulate creativity and reflection on emotions in the situation of interest. It also seems like storyboarding stimulates teams in organizing and discussing raw data widely. Storyboarding seems promising as a method but needs to be compared to the traditional way of describing a brief, a written document. An experiment is suggested to evaluate the differences between pre-brief activities made with storyboarding compared to written.

Benchmarking bio-inspired designs with brainstorming in terms of novelty of design outcomes

Reviewers' **Favourite**

Sonal Keshwani[1], Torben Anker Lenau[2], Saeema Ahmed Kristensen[2], Amaresh Chakrabarti[1]

[1]Indian Institute of Science, India; [2]Technical University of Denmark, Denmark

With the increasing demand of innovative products in the market, there is a need for effective creativity approaches that will support development of creative design outcomes. Most researchers agree that novelty of design concepts is a major element of creativity; design outcomes are more creative when they are more novel. Biomimetics has emerged as a creativity approach that can lead to generation of novel design concepts. However, not many researchers explored how the degree of novelty of the concepts generated using biomimetic approaches compare with the degree of novelty of concepts generated using existing traditional creative problem solving approaches.

In this research we have compared the novelty of design concepts produced by using biological analogies with the novelty of design concepts produced by using traditional brainstorming.

Results show that there is an increase in the percentage of highly novel concepts produced in a design task, as well as the novelty of the concept space, when biological analogies are used over traditional brainstorming.

Personality bias in user centred design

John Magnus Roos[1], Thomas Nilsson[2], Ellen Wheatley[2]

[1]University of Gothenburg, Sweden; [2]Veryday, Sweden

Personality theorists divide people along traits as extraversion, agreeableness, conscientiousness, emotional stability and openness. The present study investigates to what degree personality traits of participants in two separate user studies (e.g. craftsmen and high-frequent gamblers) are representative for respective target group of end users. Our findings indicate that some traits are significantly ($p < .05$) overrepresented among participants in user studies, e.g. extraversion, emotional stability and openness, which bias our user insight findings.

Potentially this bias negatively affects the gathered user insights and derived user knowledge. Fewer and biased insights are most certainly a liability to the design and development processes and equally the final success of any innovated product or service. If we commence upon considering personality traits in the recruitment process, we will create the conditions necessary for the identification of novel user insights and maximize the potential of the design outcome.

Modelling Design Information and Knowledge

Chair: Marco Aurisicchio, Imperial College London, United Kingdom

Knowledge base for supporting the handling of product models in engineering design

Andreas Kohn, Udo Lindemann, Maik Maurer

Technische Universität München, Germany

Product models are the medium of capturing and transporting information about the product in engineering design. The correct handling of product models is important for efficient and effective product development processes. Currently, existing best practices or support measures for handling product models are often not available for the product developer. This leads to an inadequate use of product models and consequently to inefficient and ineffective product development processes. In this paper, we propose a knowledge base that supports the application of best practices and existing support measures to support the handling of product models. Requirements for developing the knowledge model are identified in industry study in form of model-related situations and tasks that need to be supported. The knowledge base is described in the paper and initially evaluated by implementing a support tool for the task of developing a product model. The insights from this work can not only be used in supporting the handling of product models in engineering design, but in principle in all fields of applications where models are used in order to enable a more efficient way of handling information.

Establishing key elements for handling in-service information and knowledge

Emily Carey[1], Steve Culley[1], Frithjof Weber[2]

[1]Bath University, United Kingdom; [2]Airbus Operations GmbH, Bremen, Germany

In-Service support is an increasingly important part of product lifecycles in particular for complex high value, low number products such as in the Aerospace sector. Although there is a significant predicted increase for in-service products the overall in-service experience is expected to decrease increasing the pressure upon design repair engineering teams. There is additional requirement to capture and transfer expertise, thus innovative knowledge management is required to continue to support this activity. It is important to understand explicit knowledge for In-Service design repair and two pilot audits are conducted. Approaches for the effective transfer of information and knowledge for reuse are discussed including the use of spatial information visualisation or visual information elements to present In-Service knowledge. The application of human computer interaction principles and organisation of information by temporal product theme is discussed together with its potential in document content understanding. The purpose is to understand aerospace In-Service repair design knowledge elements and to suggest the applying new methods for developing knowledge management support.

A knowledge model for automotive engineering design

Hao Qin, Hongwei Wang, David Wiltshire, Qian Wang

University of Portsmouth, United Kingdom

Within the competitive environment of the automotive industry, increasing the efficiency of the engineering design process and shortening the time to market of a product becomes a key to the success of an automotive firm. Apart from applying design tools and strategies, undertaking knowledge management is also of significant importance as there are always huge amount of data and information generated during a design project. This has driven researchers to study knowledge management and devise a knowledge management system to assist the engineering design process. This paper is based on the study of a Formula Student racing car design project and presents a development of a Project-Process-Product (P3) Model as the core of a knowledge management system. The P3 Model aims to identify the information structure of automotive design knowledge as well as exploring the way to organize the data and information generated during an automotive design project. The preliminary work shows that, the model helps designers, especially novices, gain a clear overview of the project and recognise what data and information may be required for their design as well as how to access the information when necessary.

Mechanical engineering modelling language (MEML): Requirements for conceptual design

Joshua David Summers[1], David Rosen[2]

[1]Clemson University, United States of America; [2]Georgia Tech, United States of America

The objective of this paper is to define the characteristics for a new approach for capturing, representing, and modelling mechanical engineering knowledge in a Mechanical Engineering modelling language (MEml) that was discussed at a recent NSF sponsored workshop. With a focus on conceptual design, the paper provides a vision of design product modelling, relating research on function representations to work on ontologies, reasoning methods, and similar work in other domains. A series of three function-based representations is explored through an application to conceptual design of an additive manufacturing process. A comparison is offered of the types of information represented and reasoning supported by these representations, in light of the application. Finally, gaps are highlighted between the capabilities of these representations and the requirements for MEml to support conceptual design.

Engineering Change Management

Chair: Anja Martina Maier, Technical University of Denmark, Denmark

Including product features in the development of engineering design processes

Jeppe Bjerrum Ulrikkeholm[1,2], Lars Hvam[2]

[1]MAN Diesel & Turbo, Denmark; [2]The Technical University of Denmark, Denmark

Engineering companies offering customised products face growing demands to design products faster and more efficiently. To meet these demands, efficient engineering design processes for specifying customised products need to be in place. A new engineering design methodology currently under development, called Integrated Product and Process Modelling (IPPM), analyses process and product models simultaneously in order to improve engineering design processes. The method provides detailed insight into the activities within an engineering design process by modelling the product features used in the engineering design process and by clarifying in which process step the specific product features are used. The insight gained by the IPPM-method can then be utilized to improve the engineering design process and identify inefficient elements that can be improved within the process flow. The methodology have been tested and further developed in an action research study carried out in collaboration with a major international engineering company.

When to check for deviations in the design process – An approach to determine a systematic checkpoint schedule

Martina Carolina Wickel, Florian Behncke, Lindemann Udo

Technische Universität München, Germany

Changes in engineering design are a necessary and inevitable part of the design process, be it to improve products or to cope with occurring problems. Changes, however, are often connected with high effort which furthermore grows exponentially the later in the design process those changes ocurr. Therefore strategies for identifying the need for changes in the early phases of the product development have been established. These activities themselves imply high effort, though, and are many times not efficient due to unavailable or inaccurate data in the early stages.

This leads to the conclusion that an optimal point of time can be determined within the design process in terms of the ratio of cost for changes vs. effort for change identification. In this paper an approach is presented, that supports the determination of optimal checkpoints to detect deviations from the planned development progress. Relevant aspects that have to be taken into account to determine the optimal time were deduced as a theoretical foundation.

Supporting the modification process of products through a change management tool

Marco Malatesta[1], Roberto Raffaeli[2], Maura Mengoni[1], Michele Germani[1]

[1]Università Politecnica delle Marche, Italy; [2]Università Telematica eCampus, Italy

Updating products requires design activities, virtual and physical prototyping of new solutions, test and validation steps. If problems are detected at any of these stages, they cause iterations, waste of time and resources.

A change propagation method is initially described as a way to facilitate the introduction of product changes. The approach relies on a multilevel product representation, the modelling of the component dependencies, algorithms to compute the propagation of some desired changes. Outputs are represented by the list of the affected components and indices indicating the impact on the product requirements.

The method has been applied in the whole redesign process of a standard product like the fridge. Modifications must be usually released under time constraints. In this context, the outputs of the proposed method are an useful support to reduce iterations and resources waste. The experimentation has been based on case studies assigned to two groups of designers working with and without the tool.

It has resulted that designers become more aware of the implications of the engineering changes, they are allowed of better decisions and the whole process becomes shorter.

Comparison of engineering change cause analysis in literature and industrial practice

Nepomuk Chucholowski, Stefan Langer, Florian Behncke, Udo Lindemann

Technische Universität München, Germany

Engineering changes are a permanent feature of product development. They enable the development of successful and up-to-date products. However, many engineering changes can be avoided or at least anticipated by deriving preventing measures from identified underlying causes. Cause analysis procedures of engineering changes presented in literature aim to identify technical and organizational causes behind a change as soon as the necessity for a change was recognized. The examination of six cause analysis examples from industrial practice shows that cause analysis in industry is additionally used to investigate the reasons for a change. Furthermore, cause analysis in practice is not only conducted ad-hoc when a change is required, but also retrospectively in project reviews. A comparison of procedures and methods described in literature and gained from practice indicates different classifications for cause analyses regarding their initial situation and purposes. It further reveals which procedure steps and methods are useful and where more methodological support is needed. Hence, a foundation for the development of specific cause analysis procedures is given.

A training strategy for managing distributed conceptual design work

Reviewers' **Favourite**

Andrew J. Wodehouse[1], Philip J. Farrugia[2], Hilary J. Grierson[1], Jonathan C. Borg[2]

[1]University of Strathclyde, United Kingdom;[2]University of Malta, Malta

This paper reviews how sketching can support distributed student design teams in the early phases of concept design. When working in the limited communication channels of distributed teams, sketches can form an important way for teams to build a rapport that would otherwise be difficult. This work reviews the performance of ten distributed student design teams made up of participants from Scotland and Malta who were required to undertake a conceptual design task – the design of cardboard packaging for a wine glass. Issues relating to the creation, use and development of sketches were analyzed for a sample of three teams, and correlated to the communication patterns, team satisfaction and quality of output. It was subsequently found that the team who shared the most 'talking sketches', resulted in a higher degree of satisfaction compared to the other teams. Results also suggest that those teams who generated the most 'thinking sketches' developed a more robust design solution. These findings form the basis for a strategy to train students to manage distributed concept design work.

Tutorial sustainable innovations - An innovative role-play concept for education

Karola Rath, Herbert Birkhofer, Hermann Kloberdanz, Dirk Hanusch

TU Darmstadt, Germany

Developing sustainable products is no easy task. For designers, this means that not only technical requirements for functional performance but also ecological, economic and social requirements have to be met. Besides comprehensive knowledge in the field of sustainable product development also persistence is demanded. This is due to the fact that designers often have to defend sustainable solutions more intensively than conventional solutions, so that decision makers in companies do not reject solutions prematurely for instance due to higher manufacturing costs. Therefore, a course at the TU Darmstadt was set up which has the goal to not only impart knowledge to the students in the field of the development of sustainable products but also to deliberately introduce them to coporate daily life. This Tutorial Sustainable Innovations (TutSI) is based on an innovative role-play concept, in which students work in interdisciplinary teams and have to present and defend their solutions in regular quality gates to a management board of a fictive company. Moreover, students learn how to integrate all three dimensions of sustainability into the design process from the beginning.

The development of a lego mindstorms-based curriculum for design and ergonomics students

David W. Garrett, Peter J. Underwood, Gyuchan Thomas Jun

Loughborough University, United Kingdom

Design students' understanding of design processes and their ability to continually improve on them is a fundamental concern in design education. This paper discusses a curriculum development project at Loughborough Design School, investigating the use of LEGO Mindstorms as the basis for a system design learning activity. A range of studies have demonstrated the value of Mindstorms in higher education applications. However, these have typically focused on undergraduate engineering courses and emphasise the development of technical skills. Our aim was to create a learning activity for students from a range of design programmes, focusing on their understanding of design processes. We developed a team design learning activity for undergraduate design and ergonomics students, and conducted a pilot study to assess the feasibility and value of this approach to student learning. This has shown the potential usefulness of Mindstorms problem-based learning activities in improving students' understanding of the design process.

People, place, process: Lessons learnt on the path to a d.school

Véronique B Hillen[1], Pierre Levy[2]

[1]Ponts ParisTech, France; [2]TU Eindhoven, The Netherlands

Since 2006, Design Thinking education programs for master-level students have been developed at Ponts ParisTech, a leading French engineering school. This paper presents a longitudinal study of the creation and dissemination of Design Thinking (DT) as a discipline to educate top-level French students for innovation. From 2006 to 2012, 53 projects were carried out by a total of 224 students. A review is made of the instructional design of those DT projects, from local experiments through the creation of a d.school supported by the French Ministry of Education and Research to the dissemination of DT nationally. From this, key lessons are drawn for faculty members wanting to set up and disseminate DT in their own university. The paper advocates that a DT professor becomes a staging director who should consider three elements - people, place, and process - in order to create "the right conditions for students to innovate" (Leifer, Stanford). A faculty member's task thus defines itself as the art of creating the best conditions for driving students' journeys of exploration within a specific context, and represents a transformative and learning adventure.

Modelling, Simulation and Optimisation

Chair: Kristina Shea, ETH Zurich, Switzerland

A modular design tool for visualizing complex multiscale systems

Paul Egan[1], Jonathan Cagan[1], Christian Schunn[2], Philip LeDuc[1]

[1]Carnegie Mellon University, United States of America; [2]University of Pittsburgh, United States of America

As engineers design ever more complex systems, such as bionanotechnology, it is particularly difficult for engineers to navigate the influences of parameters to design across multiple scales. We introduce a software tool that contains graphical interface modules that display multiple inputs and outputs simultaneously in real-time, across multiple scales of interest. To assess the utility of real-time feedback in the tool, the tool is validated through user studies involving counterbalanced sequences of optimization tasks with varying complexity and either real-time or delayed feedback. Real-time feedback consistently improved a user's ability to find better designs and the benefit increased as task complexity grew. Our scientific contribution is a greater understanding of how users search and understand complex design spaces. Users in the real-time condition were made fewer changes to designs each iteration and identifying such strategies could inform agent-based algorithms. Findings aid complex systems applications including virtual experiments, reverse engineering, and scientific discovery.

Smart tiles systems - Spatial structures based on tile systems without external joints

Polina Karake Tener, Yasha Jacob Grobman

Technion-Israel Institute of Technology, Israel

The paper presents an ongoing research that examines the potential of creating and implementing infinite spatial tiling systems without external joints. It defines types of possible natural nets that have a potential of tiling, and inherent joining variations. In addition, it presents and discusses a case study in which an infinite spatial tile system was developed, and found its implementation as a Green Partition. Finally, it examines the potential and advantages of such systems.

Topographic optimization with variable boundary conditions: Enabling optimal design of interacting components

Martin John Leary, Darpan Shidid, Maciej Mazur, Milan Brandt, Aleksandar Subic

RMIT University, Australia

Topographic optimization provides a valuable opportunity for the design of optimal structures. A significant limitation in the current generation of topographic optimization algorithms is the non-inclusion of boundary conditions as optimization variables. This limitation significantly constrains the domain of design problems compatible with topographic optimization. For example, unique components can be optimized for a given set of boundary conditions only. There is no opportunity to assess whether these boundary conditions are themselves optimal. This work reports on the authors novel contributions to allow boundary conditions to be included as optimization variables, thereby dramatically expanding the domain of design problems that are compatible with topographic optimization. This method is demonstrated by the optimal topographic optimization of interacting components: a previously intractable design problem.

Concept of product development simulator for an excavator using a haptic device

Omer Eldirdiry, Asko Uolevi Ellman

Tampere University of Technology, Finland

The significance of Virtual reality (VR) tools lies on its capability to simulate physical presence. Dealing with 3D model in VR Systems is less expensive, less dangerous and easier to make modifications than dealing with real objects. Haptic devices are used because of their ability to generate and provide force feedback to the user during the real-time simulation. With this extra information, the user has gain more understanding of the model and makes it more real.

In this paper we present a new concept for using VR-environment, real-time simulation model of the excavator and haptic device to sense power consumption. Force signal generated by the haptic device is used on reflecting power consumption of a diesel engine. Such method can be used to evaluate how excavator mechanism and fluid power line works together when excavator accomplishes different work cycles. This approach gives a physical feedback of behavior of the main design property to a human test user. Haptic feedback together with 3D visualization enriches human understanding on nature of the entity and enables human creativity to be involved in design process.

Lack of integration between engineering industrial design processes: An analysis based on the historical evolution of professions and tools

Pierre-Antoine Bernard Arrighi[1], Akin Kazakci[2]

[1]Dassault Systèmes, France; [2]Centre de Gestion Scientifique - Mines ParisTech, France

Numerous researches provide evidence that Industrial design is key to trigger, foster and sustain innovation and can lead to a measurable performance growth of the business. Nevertheless, their integration with the engineering design process has been difficult since the birth of the profession. The lack of dedicated design tools responding to their specific needs is one of the most important reasons for this stagnation. In this paper we propose an historical and technical approach to trace the evolution of digital design tools. It appears they can be classified inside two archetypal categories. The first one has been designed to address the needs of the engineers such as the reusability of design for manufacturing purposes. The second one was made for graphical artist, for artistic composition or with the capacity to animate and render three-dimensional models. The industrial designer profession use tools with qualities from both categories – neither of which have been designed for her specific needs. We detail the technical reasons for this evolution and we argue it might be possible to solve this issue with a holistic consideration of both approaches.

Application of dynamic value-attribute modeling in a product family

Chathura Withanage[1], Seung Ki Moon[1], Taezoon Park[1], Truong Ton Hien Duc[2]

[1]Nanyang Technological University, Singapore; [2]Singapore Institute of Manufacturing Technology, Singapore

Product families are used as a solution to cater the needs of diversified user groups, while minimizing the usage of resources. However, today's design decision makers require additional capabilities to manage the uncertainties brought by highly dynamic nature of the technological markets. Therefore, understanding the time varying behavior of preferences, in addition to the preference differences across market segments, has become an essential tool to survive the intense competition.

This paper provides a new approach to add time varying behavior of preferences to extend the currently two dimensional market segmentation grids. The newly added time dimension provides more information to the design decision makers, while minimizing uncertainties due to the dynamic market behavior. A precursor case study, using the US light truck market data from 2004-2010 was conducted to assess the dynamic nature of the preferences in the market niches. The case study results provide strong evidences of presence of the time variance preference in market niches. A dynamic preference modeling case study, with an extended set of market segment observations, is proposed as the immediate future work.

System Modularity and Complexity

Chair: Warren Seering, Massachusetts Institute of Technology, United States of America

Complexity management in plant engineering

Maik Maurer, Christian Wölfling

Technische Universität München, Germany

Complexity is a major challenge in plant engineering projects. Participants in German plant engineering industry experience delays, cost overruns and stakeholder deception in complex projects. Literature on complexity management only deficiently considers specifics of this industry and lacks empiric insight. This paper analyzes how complexity is perceived in this industry and gives guidance to the improvement of complexity management. Therefore, a literature study and an expert survey have been conducted. Six underlying problem clusters can be distinguished: uncertainty in methods, requirements problem and uncertainty in goals, interfaces, systems thinking, process transparency and communication, and non-holistic complexity management. As a two-step approach, the application of systems engineering with its processes as described in the International Standard ISO 15288 and a complexity management process based on the Deming Cycle are proposed for treating the obtained clusters.

System architecture change decisions in multi-variant product portfolios

Maximilian Kissel, Udo Lindemann

Technische Universität München, Germany

Decisions in complex design environments like in system architecture design can have wide-ranging effects on the operations of a company. The contribution of this paper to the body of research is to clarify the nature of decision-making on engineering changes and to explore success factors towards more rational and sustainable decisions. Our results were obtained through a literature review and evaluated in the context of a research project with six industry partners who formed an industry focus group. We propose a research framework that systemizes the objectives, challenges and possible enablers of complex decision situations. A proceeding model is proposed where possible support in decision-making is highlighted. As implications we claim to support complex decisions by making relevant entities and their dependencies more transparent and accessible. Therefore, a consistent database could serve for consistent model generation, visualization, analysis and evaluation. This will have a positive impact on development costs, resource allocation, product quality, flexibility towards the market and delivery time.

Complexity and preference based methodology for product line planning of customizable products

Sebastian Schubert, Jan Erik Heller, Johannes van der Beek, Jörg Feldhusen

RWTH Aachen University, Germany

Analyses and current market development show that more customizable products are required which are competitive to mass produced products. To be competitive, the products have to be cost optimized. A methodology is presented to support the designer in the product line planning in order to achieve customizable and cost optimized products and is presented with help of a case study. The main steps of the methodology are the determination of the product attributes and characteristics which are required by the market. Subsequently, the preferences of characteristics are determined by application of conjoint analysis including 233 respondents. In a next step, the realization effort for each characteristic is assessed. The customers' preferences are clustered under consideration of the determined efforts. In the case study, three groups are found. For each group a product line is established. Analyzing these product lines, it is shown, that the number of required components can be significantly reduced, while the number of customers' requirements being fulfilled almost remains constant.

An assessment of methodical approaches to support the development of modular product families

Dieter Krause, Sebastian Ripperda

Hamburg University of Technology, Germany

Global competition and the trend to individualized products force companies to lower their internal variety, which can be achieved through modular product structures. The literature comprises a wide range of approaches to support the development of modular product families. A selection of significant methods are investigated and evaluated. The method Integrated PKT-Approach for Developing Modular Product Families developed at the Institute of Product Development and Mechanical Engineering Design (PKT) is also characterized. This approach was developed based on the existing literature and approaches and further experience from industrial practice. It integrates aspects of design for variety with technical-functional and product-strategic modularization methods. The methodical approach, as well as its relevance and development, is explained in addition to the literature review.

Similarity-Based concept development for modular platform systems

Nadia Anggraeni, Sebastian Maltzahn, Reiner Anderl

Technische Universität Darmstadt, Germany

Today's companies are facing the challenge of managing high product variety due to increasing customer demands. This challenge results in a change of product development processes. Platforms and modular strategies are introduced as an approach to deal with increasing product variety. With optimal planning of platform designs and modular systems the effort in dealing with the complexity of multiple product variants can be significantly reduced.

This paper presents a methodological approach aimed at supporting the decision making process in the conceptual phase for the development of new product variants. Based on selected characteristic attributes of product or part variants, a similarity index that allows quantitative comparison of different variants from different modular platforms can be calculated. The main purpose of this method is to derive a clear recommendation regarding the development method of new product variants based on their degree of similarity. The method proposed in this paper can be used for conceptual planning of product, part or assembly variants in all industry areas, such as automotive industry, aircraft industry, or machinery and plant manufacturing industry.

Performance measurement framework for multi-role aircraft under performance based logistics

Chang Ha Lee, Gwang Ki Min, Mayooran Kiritharan, Yoo S. Hong

Seoul National University, Republic of Korea (South Korea)

Under Performance Based Logistics (PBL), the vendor of weapon system is paid for their after-sales service based on the outcome of performance; therefore, it is very important to establish the way to measure outcome of performance accurate. This paper makes an attempt to develop a framework of measuring performance outcome which is specified for multi-role aircraft based on operational availability. The approach for operational availability using the value of stratified uptimes based on modular architecture is suggested to provide realistic measurement of performance when there is a PBL contract for a multi-role aircraft and the vendor is compensated by his outcome of performance.

Design for X (Tolerance, Affordance, Manufacture, Adaptability)

Chair: Kristin Wood, Singapore University of Design and Technology, Singapore

Concept for tolerance design in early design stages based on skeleton models

Philipp Ziegler, Sandro Wartzack

Friedrich Alexander University Erlangen-Nuremberg, Germany

A noticeable trend in mechanical industry is that the product lifecycle and within the product development phase shortens. One consequence is the necessity to perform product-analyses already in early design stages, even if the geometry of the product is only sketchy defined by skeleton models. For product functionality the dimensional and geometric variations of the product components play an important role, which are analyzed and limited by tolerancing. The lack of geometric information in the early design phase is challenging for tolerance analysis, but also offers chances by more flexibility of the product developer in changing the products geometry. Therefore, this paper presents the concept to perform tolerance design based on skeleton models.

A case study for application of design for affordance methodology using affordance feature repositories

Yong Se Kim, Ji Hye Noh, Sun Ran Kim

Sungkyunkwan University, Republic of Korea (South Korea)

The characteristics of products and services that induce natural activities of people, namely affordances, play critical roles in making interactions successful and meaningful. Earlier a methodological framework for design for affordances has been devised where repositories of affordance features are used. Affordance features are retrieved from the repository so that the new affordance feature is to be designed through an analogical reasoning. In two classes of Product-Service Systems Design education, this design for affordance method has been introduced in a tutorial setting for designing a hand carrier cart. This paper describes how the method was introduced and shows new target affordance features in their design proposals with source affordance features retrieved from the repository. Target affordance features have been evaluated based on the distances from the sources. Implications obtained from this tutorial effort are discussed to enrich practical application of the design for affordance method.

Multidisciplinary convergence about "product-use" couple: Intermediary object's structure

Morad Mahdjoub, Ahmad Al Khatib, Jean-Bernard Bluntzer, Jean-Claude Sagot

UTBM, France

Companies call for collaborative work practices and user-centered design approaches to consider use value and user experiences into product design process as a way to propose innovative products to the market. Indeed, collaborative work is especially needed in the convergent phases of design process. However, the actors in the design team have different viewpoints making it difficult to carry out the convergence between them. So, intermediary objects (IOs) are used as supports of the social interactions and communication. However, IOs are loosely defined, loosely structured. They are viewed as just the product model and even sometimes confused with the technologies that support them. Thus, the aim of this paper is to introduce the concept and the roles of IOs and to propose framework to define a structure for these objects. Based on a case study in virtual environment, the framework proposes that IO is the result of seven interdependent models: product model, product use model, interaction model, support tools model, rules and instructions model, evaluation model and convergence situation model. This framework could be used as a base for designing and choosing the IO.

User activity analysis for design for affordance

Yong Se Kim, Yeon Koo Hong, Sun Ran Kim, Ji-Hye Noh

Sungkyunkwan University, Republic of Korea (South Korea)

User interaction with a product is modeled based on user activity composed of perception, judgment and action together with affordances given by the product. Based on user assessment on each step of perception, judgment and action of an activity, inter-relations between specific activity and its affordance feature of the product can be scrutinized. Those affordance features of the current product could be redesigned exploiting hints from other affordance features of the corresponding affordance in the repository. This paper introduces the design for affordance method using activity analysis. An illustrative example is presented where a practicing product designer designed new affordance features for those affordances of activities with poor evaluations hinted from other affordance features in the repository for the corresponding affordances.

A classification system for secondary design features for the use within sheet-bulk metal forming

Thilo Breitsprecher, Sandro Wartzack

University of Erlangen-Nürnberg, Germany

Estimating the potential of new emerging manufacturing technologies for the area of engineering design is crucial for the establishment of these processes in the industry sector. An example for such a new technology is sheet-bulk metal forming (SBMF): New parts can be designed due to the higher design freedom for design engineers and the possibility to integrate more functions by using more functional elements per part. Furthermore it is of high interest if this emerging technology can be used to substitute established manufacturing processes and produce parts with a higher functional density with less process steps and more robust processes. In this paper a new classification system is presented that enables the design engineer to classify parts with primary and especially secondary design features. On the one hand the classification system can be used to identify parts for which the established manufacturing process may be substituted by SBMF. On the other hand potential for new innovative solutions can be revealed.

Managing a methodology-development requirement-process – Best practices and lessons learned

Phillip Schrieverhoff, Udo Lindemann

Technische Universtät München, Germany

The goal of the EU-Project AMISA – Architecting Manufacturing Systems and Industries for Adaptability – is to develop a methodology which allows optimizing system's architecture towards maximum lifecycle value and furthermore implement it as a software tool. This presents a complex undertaking in itself and is enhanced by the complexity originating from the multi-national consortium with broad industry and academic backgrounds.
This paper focuses on the requirement-management-process towards the Design for Adaptability methodology and software tool consisting of the main steps Requirement Acquisition and Categorization, Requirement Consolidation and Grading as well as Status Control and Management of Critical Requirements. The conducted steps are outlined in terms of the procedure, results and lessons learned and best-parcitces described.

Ecodesign Implementation and Management into Manufacturing Companies

Chairs: Tim C. McAloone, Technical University of Denmark, Denmark
Harrison Kim, University of Illinois at Urbana-Champaign, United States of America

Goal of workshop

Ecodesign implementation and management into manufacturing companies – how mature are your processes for developing environmentally sustainable products and services? How can you assess long-term impact of your product development strategy from the product life cycle perspective?

Abstract

Over the last few decades, ecodesign has emerged as a promising approach to integrate environmental concerns into the product development and related processes. Despite the potential benefits of ecodesign and the existence of several tools and techniques for product design, the actual application of ecodesign has not reached companies worldwide, mainly due to difficulties in ecodesign implementation and management. This workshop introduces the Ecodesign Maturity Model (EcoM2), a framework aimed at supporting the ecodesign implementation process, and Life Cycle Assessment (LCA) product design method for strategic product development. Based on a diagnosis of the current maturity profile of a company's product development and related processes regarding ecodesign implementation, the model proposes the most suitable ecodesign practices and improvement projects to be applied, by adopting a continuous improvement approach for process improvement. The model is thus intended to support ecodesign managers in their deployment of strategic and tactical roadmaps for ecodesign implementation. During the workshop, the participants will be invited to apply the EcoM2 into a scenario-based company, so to understand the best practices for ecodesign implementation and management in practice, deploying opportunities for improvement.

Workshop agenda

Presentation, hands-on and use of EcoM2 web portal (participants are required to bring their own notebooks).

- Introduction to ecodesign
  - Concept definition;
  - Drivers and benefits;
  - Barriers and challenges.

- Maturity model as a framework to support ecodesign implementation and management
  - Ecodesign practices
    - Management practices;
    - Operational practices;
    - Methods and tools.
  - Maturity levels on ecodesign implementation
    - Evolution levels;
    - Capability levels.
  - Continuous improvement method
    - Diagnosis of the current maturity profile;
    - Development of a strategic roadmap.

- Scenario-based workshop
  - Hands-on application of the Ecodesign Maturity Model (EcoM2) web portal;
  - Identification of the maturity profile of the scenario company;
  - Development of a strategic roadmap for ecodesign implementation;
  - Discussion of the results.

Design Teams

Chair: Petra Badke-Schaub, TU Delft, The Netherlands

Design teamwork in distributed cross-cultural teams

Jinfan Man, Yuan Lu, Aarnout Brombacher

Eindhoven University of Technology, The Netherlands

In the recent decades, design teamwork in international teams has been taken into account to meet the requirement of product development with different cultural backgrounds in the context of globalization. The aim of this research is to explore the effect of different design teamwork modes (competition, collaboration, cooperation) on design process and support designers to improve design teamwork (design quality and team satisfaction) in the distributed cross-cultural teams. A case study was designed and conducted to investigate the effect of three different teamwork modes in distributed design teams with Dutch and Chinese students. In this research, it is found that different teamwork modes affect design quality and team satisfaction in international teams. In addition, cultural differences also have influence on design teamwork. The result of this study can be used for improvement of design teamwork, it is important for designers to be aware of cultural differences and make use of teamwork modes in design process.

Training for reflective competency in design teams: An empirical study

Ilona Weixelbaum[1], Petra Badke-Schaub[2], Dietrich Dörner[1]

[1]Otto-Friedrich-University, Germany; [2]Delft University of Technology, The Netherlands

The need for flexibility in designers' acting and thinking processes can be seen as a core requirement for successful design practice. For designers collaborating in a team gaining cognitive flexibility is quite challenging, as cognitive processes are not directly observable for other team members and therefore hard to assess and change. The aim of this paper is to clarify how team reflection as the critical analysis and adaption of the team's acting and thinking processes can serve as an instrument to facilitate cognitive flexibility and thereby improve team performance. Based on an empirical requirements analysis a training program for reflective competency in teams has been developed. The training has been evaluated on design teams in industry. Results of the qualitative analysis of four case studies suggest that the training serves as a suitable instrument to teach effective team reflection which leads to more cognitive flexibility. Within this paper, the results of two case studies with quite different training courses are illustrated and discussed in detail. Finally, conclusions both for future research and about the practical relevance of the results are drawn.

Influence of communication elements and cognitive effects on creative solution search in groups

Helena Hashemi Farzaneh, Maria Katharina Kaiser, Udo Lindemann

Technische Universität München, Germany

Creative solution search in groups represents a challenge in technical product development. A number of methods and recommendations exist for creativity sessions in groups. However, the influences of these methods and recommendations on the creative process in groups are controversially discussed. In order to enable a comparison of different groups, methods and recommendations for creative search, a better understanding of the creative process is necessary. Therefore, we develop an approach to analyse the influence of communication elements and cognitive effects on the creative process. The approach facilitates regarding the generation, further development and documentation or abandonment of each solution idea communicated in the creativity session. The entire creative process of a group can be analysed quantitatively and compared to several groups. By this means, influences of communication elements and cognitive effects on different performances in creativity sessions are deduced.

Supporting teamwork in contract furniture design

Maura Mengoni, Margherita Peruzzini, Roberto Raffaeli

Università Politecnica delle Marche, Italy

Contract furniture design is oriented to develop customized products for the creation of a finished commodity for hospitality, offices, retails, restaurants, stores. It is assuming a growing importance all over the Europe and represents a preferred channel for promoting Made in Italy offer. Numerous competences with different skill, abilities and background are necessary to fulfill market requirements. Stakeholders are arranged into complex inter and intra temporary networks where sometimes-conflicting interests and purposes need to converge into a single and integrated design solution. Contract furniture combines product design with interior and architectural design requests to provide coherent furniture by assembling custom high-quality items from different firms. As a consequence, the design process is complex and collaboration is imperative to achieve the expected goals. This paper explores contract furniture design and defines a technological platform to support team working. The proposed methodology is applied to an industrial case study in the hospitality and retail sectors. Method application brings to define the system platform architecture and its main software modules.

Design Theory

Chair: Eswaran Subrahmanian, Carnegie Mellon University, United States of America

Rhetoric and design

Glenn Ballard[1], Lauri Koskela[2]

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The relationship between rhetoric and design has been the subject of numerous scholarly publications in the last fifty years, but has not been addressed by scholars of engineering design. This paper argues that the relationship is important for theory and practice of design in all its varieties, principally by providing evidence from the literature that rhetoric and design share key characteristics. Both

- are broadly applicable across subject matters
- concern the particular and the probable
- require invention and judgment, and
- involve arrangement in space and time

From ancient times through the Renaissance, rhetoric was a key element in education, and its methods were widely adapted to other arts, including design. Rhetoric's loss of status in modern times is explained, and its resurgence in the latter part of the 20th century is described through the works of three scholars that focus on the relationship between rhetoric and design. The conceptualization of these scholars is best represented in the view that rhetoric is design limited to words and design is rhetoric with an unlimited palette.

How design theories enable the design of generic technologies: Notion of generic concept and genericity improvement

Olga Kokshagina[1,2], Pascal Le Masson[1], Benoit Weil[1], Patrick Cogez[2]

[1]Mines ParisTech, France; [2]STMicroelectronics, France

Generic technologies enable to create benefits across wide range of industrial applications. Though providing important insights on generic technologies commercialization, less attention was paid to generic technologies creation. Then, is it possible to design directly generic technologies? Can the intention to build genericity be expressed ex ante? The proposed study indicates that formal design theories provide powerful mechanism of genericity construction when the environments are initially fixed and partially unknown. It is demonstrated that starting point to design generic technology is a generic concept. In addition to a concept definition proposed by C-K theory, the descriptors associated to the domain of existence were added. The generic concept targets the existence domains that are not reduced to one solution but several of them both known or partially unknown. Moreover, it is highlighted that different descriptors of existence domain can lead to various genericity levels. The economic reasoning behind the genericity building provides insights on the dynamics of engineering systems.

The two pillars of design theory: Method of analysis and rhetoric

Lauri Jaakko Koskela[1], Glenn Ballard[2]

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Since the 1960's, there have been many initiatives for promoting theoretical understanding on design. However, in spite of definite progress, there are several puzzles and anomalies in the current theoretical landscape of design. We present an interpretation of the evolution of design theorizing that throws new light on these puzzles and anomalies. We contend that in the modern time, there have been two hidden inspirational sources for design theorizing, namely the method of analysis and rhetoric. As they concern different situations, their prescriptions in many ways differ. However, without explicit recourse to the sources, these mutually incompatible prescriptions, along with associated concepts and terms, have been mixed up in a confusing way. It is proposed that these two influences to design theory and practice have to be disentangled, to be able to act like two pillars supporting the phenomenon of designing. We hypothesize that actual design assignments require the mobilization of ideas and support from both pillars.

Beyond frames: A formal human-compatible representation of ideas in design using non-genetic ad-hoc and volatile class memberships and corresponding architecture for idea operators

Christos Spitas

TU Delft, The Netherlands

This paper proposes a formal human-compatible representation of ideas in design using ad-hoc and volatile class memberships and corresponding architecture for idea operators. The proposed theory departs from genetically inspired object-oriented concepts used in state-of-the-art implementations of Frames, Semantic Networks and the Semantic Web, and Description Logics, which are limited by the endemic complexity of (multiple) inheritance, and whereby reinventing/ reorganising ideas, as is a staple of creativity, is tedious and error prone. Instead, the paper proposes that ideas do not get 'born' out of 'parents'; rather, they exist as either present or not (yet) to consciousness. Thus ideas can be considered as either eternal, or more practically, self-emergent. This is an obvious yet radical and highly promising shift in paradigm, allowing ad-hoc classes, volatile classes, and an unlimited capacity to reinvent/ reorganise classes. Limitations of tree structures and forced directionality present in the genetically-inspired state-of-the-art vanish altogether.

Process Modelling

Chair: Kilian Gericke, University of Luxembourg, Luxembourg

Identifying uncertainties within structural complexity management

Daniel Kasperek, Andreas Kohn, Maik Maurer

Technische Universität München, Germany

Structural complexity management (StCM) is an established methodology to manage complexity within engineering design. Complexity management is necessary if complexity for example due to shorter product life cycles and manifold customer requirements cannot be handled anymore. The application of StCM on complex systems is often challenging. Various uncertainties affect this stage as the final design and properties are not clear yet. A lot of other factors such as the quality of the available information, or the skills of the modelers also have to be considered. Thereby, the shape of occurring uncertainty can be manifold and have several features.
This paper presents an approach on the precautionary identification of uncertainties. Therefore, based on a literature review on different types of uncertainty and an approach on uncertainty management from another modeling discipline, we present the Uncertainty Process step Matrix (UPsM). The UPsM identifies and sensitizes for the incorporation of uncertainty into the model. It encourages modelers to recognize the locations of their specific uncertainty and thus, this approach serves as a step towards precautionary uncertainty management.

Main factor identification for early negotiation in product design

Yun Ye, Marija Jankovic, Jean-Claude Bocquet

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In organizational markets (B2B markets), the buyer and supplier companies often work together as collaborators in the context of an extended enterprise. As such a collaboration involves signing a contract which implies potentially long-term commitment by both sides, it is important to make a global estimation during the phase "early negotiation", where design specifications directly from buyer needs are defined.
Although the early negotiation phase greatly impacts the overall buyer and supplier results, to the best of our knowledge, no framework has been proposed to define what factors should be considered during such an estimation.
In this study, we first propose the definition and process of the phase "early negotiation", where the engineering design steps which help the supplier to estimate buyer requirements satisfaction are identified. Then a framework is proposed to tell both buyer and supplier what factors should be estimated under different contexts.
This framework was developed after an extensive literature review and observations. It aims at providing early decision support for companies and methodology development guidance for researchers.

Process-integrated analysis of the development situation for an efficient simulation planning

Jochen Reitmeier, Kristin Paetzold

Universität der Bundeswehr München, Germany

To save costly and time-consuming physical prototype testing, product functionality is increasingly validated by means of simulations. However, the specificity of product properties is generally strongly influenced by the course of the development process respectively by the boundary conditions of the development situation. Therefore, it is to provide methods and tools to targeted support property validation.
Focus of actual research activities is on a process orientated support of virtual property validation by means of simulation planning. The approach presented in this paper is based on a specific data processing of the design data which differs between characteristics and properties. The development context is described by means of context factors which are linked to this. The demonstrated process integration supports to evaluate the meaningfulness of a simulation and to facilitate operational planning of simulations.

Understanding task structure in DSM: Mining dependency using process event logs

Lijun Lan, Ying Liu, Han Tong Loh

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Dependency Structure Matrix (DSM) has been widely used to analyze and present the inter-structure of design projects which are often characterized by many interrelated tasks. One essential role of DSM is to reveal the dependencies amongst different tasks. To succeed, it heavily relies on how well the initial dependencies are identified. Conventionally, it is accomplished by engineers through interview, survey and discussion that are obviously constrained by resource available in performing such activities. Hence, its liability heavily relies on the understanding of engineers. Moreover, for a complex design project where a higher number of tasks are involved, to gain a comprehensive understanding of their intricate relationships is also a non-trivial task. In order to tackle this, in this paper, we propose a flexible approach to mine dependency from process event logs which dynamically record the detailed information of task execution in a real context. Using process event logs, a number of dependencies can be steadily discovered and derived by focusing on different subsets of data for specific purposes. In the end, a case study is used to illustrate the proposed approach.

Interdisciplinary Design Education

Chair: Mirko Meboldt, ETH Zurich, Switzerland

Walk the talk. or: A design driven approach to design design education

Rianne C. Valkenburg, Janneke Sluijs

The Hague University of Applied Sciences, The Netherlands

The world is, at the moment, rapidly transforming and incites us to rethink and redesign society. Innovation itself is transforming, changing the way organisations and industry innovate and cooperate. Contemporary education in industrial engineering design needs to correspond to the industry and societal needs. This calls for new designers, which we call open innovators.
This rapidly transforming world also involves its habitants. Current 18-year olds have grown up in a digital knowledge focused world. These new students have different needs and values. As teachers we are very aware of this transformation and explicitly looking for new ways to teach, tutor and challenge our students. In this paper we will describe the innovative way in which we designed a new international bachelor program Industrial Design Engineering (IDE) where designers from all over the world are educated to become such open innovators.
We applied a design driven approach, consisting of four pillars (future driven, value driven, participative, and design thinking). We share our insights by explaining what and how we did, and why and how this could be interesting to translate to other programs or contexts.

A comparative study between design students and professionals to understand the effectiveness of ergonomics education in industrial design courses in Turkey

Ilgım Eroğlu, Kerem Özcan, Abdüsselam Selami Çifter

Mimar Sinan Fine Arts University, Turkey

Ergonomics lectures have been a sustained element of industrial design education in Turkey. In this paper, effectiveness of ergonomics education is researched. For this intention a questinnaire survey was conducted with design professionals and students, whom were asked to give their opinion about ergonomics education and application in Turkey through open-ended questions. The results are discussed to see if any improvements can be suggested for certain issues.

Product-Service systems design education and a new interdisciplinary service design graduate program

Yong Se Kim, Sang Won Lee, Seong Il Lee, Kee-Ok Kim, Myoun Kim, Jong Hoon Won

Sungkyunkwan University, Republic of Korea (South Korea)

A Product-Service Systems (PSS) is composed of service and product elements to provide values for relevant stakeholders. PSS designing includes both service and product design aspects, but a service-dominant approach would be desirable. A service designing process can be composed of value modeling, service activity design, service interaction and touchpoint design and experience management, and the corresponding design method and design support tools have been developed at the ABC of DEF University. This paper explains the PSS design education efforts by showcasing a few student design projects and introduces the curriculum of the new Interdisciplinary Service Design graduate program. The case of DEF University in developing an interdisciplinary design program, based on solid research efforts in leading areas give a good insight for design field where combined educational innovation and research development would be necessary in reflecting ever-changing demand of industry competitiveness and human desires.

Interactive fundamentals for graphic design

Viviana Cordova

University of Maryland Baltimore County, United States of America

Graphic Design education is entering a new era where the influence of various fields, including interactivity, cognitive psychology, computer science, and more has broadened the research topics of Graphic Design in academia. Therefore, updating the current Graphic Design curriculum is urgently needed. My research raises current critical questions of the Graphic Design programs in the USA. The work of this paper has been done at the University of Maryland, Baltimore County in the USA. I analyzed and evaluated the teaching effectiveness of one of the basic courses, which students take in the Graphic Design Program at my University. The outcome of this course is the basis of the structure for what is to come in relation to Interactive Graphic Design. According to the results, this class provides positive outcomes for future graphic designers in the professional field. Graphic designers will be able to graduate with a competitive portfolio that involves the knowledge of the latest technology available in the field. I propose that this structure in the classroom would strengthen Graphic Design Programs and prepare their students for successful careers in the new interdisciplinary Graphic Design field.

New Design Methods and Tools

Chair: Panos Y. Papalambros, University of Michigan, United States of America

The DNA of design and design signature: A perspective in motorcycle design

Sushil Chandra

Hero Motocorp Ltd, India

Designers have to frequently face the two terms: the DNA of design and design signature, though no scientific definitions for these two terms are available. This study attempts to formulate a scientific definition for these two terms, differentiate between these terms which are frequently used interchangeably, and explore a mathematical framework. Since the author is a practicing motorcycle designer, this mathematical code has been formulated in context of motorcycle design, but the concepts and methodology can be adopted for design in general. Finally, in context of motorcycles, DNA codes have been calculated for various makers and the results observed, by and large match with the general perceptions. At the same time, limitations faced by practicing designers in devising code have also been discussed.

Theory driven design and real prototyping of biomass pyrolitic stove

Mbeo Calvince Ogeya[1], eric Coatanéa Coatanéa[2], Galina Medyna Medyna[2]

[1]Kenya Industrial Research and Development Institute (KIRDI), Kenya; [2]Aalto University of Science and Technology, Finland

This article introduces a design approach integrating early design phase and model based engineering in order to develop innovative biomass gasifier system for rural communities in Africa. The need for such a systemic perspective is imposed by the imbrication of technical, ecological and cultural issues that cannot be ignored while designing new technology. The article proposes an integrated generic design theory approaches to discover and rank by order of importance system's variables and to single out most desired design parameters. A pre-design user requirement assessment was carried out to identify detailed stove's functions. Causal-ordering diagrams sketched for system's modelling. System functions were described graphically and synthesized through simple linear algebraic matrices. Contradictions in system functions were solved using Theory of Inventive Thinking (TRIZ 40). And system's optimization was done through simple Taguchi experimentation method. A two level L8 degree of freedom Taguchi table was used in the experimentation and optimization of the pyrolitic stove. The design approach was exemplified using the case of the "AKIBA" biomass stove.

Designing on the road; exploring the who, where and why of individual mobility devices

Reviewers' **Favourite**

Mieke van der Bijl-Brouwer[1], Pieta van der Molen[2], Mascha van der Voort[2]

[1]University of Technology Sydney, Australia; [2]University of Twente, The Netherlands

The aim of this study is to support designers in dealing with the variety of situations in which product are used, so-called dynamic and diverse use situations (DDUS). Dealing with varying use situations in the design process is difficult because it is hard to predict the situations in which a product will be used, to anticipate what will happen when the product encounters those situations and to generate solutions for conflicting requirements. A retrospective case study of three design projects in practice furthermore showed that knowledge of DDUS often remains implicit and is not shared between members of a product development team. We therefore developed a set of guidelines to support designers and design teams when dealing with DDUS in the design process. The basic principle of the guidelines is that existing design activities are used to create and apply an explicit 'frame of reference of product use' which makes DDUS and their relation to use issues explicit. In this paper we explain these guidelines and show its application to the design of an individual mobility device.

Knee dynamic analysis in the development of above knee prosthesis for alpine skiing

Ivan Demšar[1], Matej Supej[2], Jože Duhovnik[1]

[1]University of Ljubljana, Slovenia; [2]University of Ljubljana, Slovenia

The development of biomechanical systems requires detailed knowledge of a natural system. The work includes an analysis of the natural process of the kinematics and dynamics in the knee joint in a laboratory simulation of motion through a ski turn. Measurements and analyses of the results are the foundation for the development of the prosthetic knee for ordinary two-track skiing for above the knee amputees. A dedicated testing facility was built, allowing simultaneous capturing of leg structure kinematics and surface loading rates. Changing additional vertical loads in the waist area, different conditions of performing a ski turn were simulated.

Measuring the kinematics and dynamics of a control group of able-bodied skiers show that rotation in the knee joint is below 60°. Longitudinal force in the knee reaches values of up to 1.2 N/kg. Average vertical load in the knee exceeds 10 N/kg. The knee flexing/extension moment reaches values of over 1.5 Nm/kg. The presented laboratory measurements are comparable with those on ski slopes and represent the basis for the development of tailor-made prosthetic knees.

CDS platform: A platform for multi-physics computational design synthesis

Amir Hooshmand[1], Marc Schlaich[1], Liliya Belaus[1], Matthew Campbell[2]

[1]Technische Universität München, Germany; [2]University of Texas at Austin, United States of America

An important obstacle in the development of computational synthesis tools in engineering design is the difficulty in integrating the generation process with efficient simulation packages for evaluating candidates in a search process. The premise of this study is to develop and implement a platform to facilitate generative design systems in achieving more flexible design synthesis automation and optimization. This enables the designers to explore the abilities of generative design systems rather than coping with complexities of automatically integrating these analyses in the design process. The platform has been developed mainly based on open source software (OSS) to be offered to the Computational Design Synthesis (CDS) community for further development, use and investigation. Its modularity and programming based implementation provides a foundation for other researchers to build on and to achieve the next generation of CAD tools substantially faster.

Designing crime prevention - A review of methods

Rodger Neil Watson

University of Technology Sydney, Australia

The Designing Out Crime research centre (DOC) has now operated for almost 5 years. In this time the centre and its staff and students have worked on real life crime problems, using and developing ways of working within a design process.

DOC is a multi-discipline centre and draws on the tools and methods of these disciplines. Recently DOC undertook a stock-take of the methods it uses within a frame creation process. This stock-take was then used to develop DOC method cards, in reference to the IDEO method cards of 2002.

Situated within the frame creation process this paper explores 20 methods that were used in a case study that has gone from complex problem, to piloted solutions in the lifetime of DOC.

Design for X (Tolerances, Environment, Safety, Ergonomics)

Chair: Udo Lindemann, Technical University of Munich, Germany

Process-oriented tolerancing - A discrete geometry framework

Benjamin Schleich, Sandro Wartzack

FAU Erlangen-Nuremberg, Germany

Since the requirements on technical products steadily increase, there exists a growing need for considering all effects which may lead to reduced product quality in engineering design. Geometric variations are a main contributor to malfunction and decreased product quality and have thus to be limited by geometric tolerancing. However, geometric tolerances are a source of disharmonies since manufacturing requires loose tolerances for realizing low manufacturing costs whereas design tends to choose tight tolerances for ensuring the product quality. This paper focuses on an integrated view on process-oriented tolerancing considering information from all stages of the product origination. After highlighting barriers for process-oriented tolerancing, a framework is proposed, which integrates process information in a skin model inspired tolerance analysis approach. This framework takes all sources of geometric deviations into account when evaluating their effects on the product quality. Thereby, manufacturing and assembly aspects can be considered in tolerancing during engineering design, which helps to reduce disharmonies, save manufacturing costs, and increase the product quality.

Agile project management for root cause analysis projects

Sun K. Kim[1], Javier Mont[2]

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Root Cause Analysis (RCA) projects face the issue of frequently changing requirements. When a high degree of uncertainty exists in such a project, traditional project management or the linear DMAIC (Define, Measure, Analyze, Improve, Control) may not provide the agility to respond the constant flux of new information. As a Design for X (DFX) initiative, authors applied Agile Project Management, specifically Scrum Methodology, to two RCA projects. The first RCA project used the formal Scrum methodology and the second project used a hybrid approach of Scrum and Lean Product Development. This paper presents observations and learning from this endeavor. The lesson is that Agile may be a good foundation for RCA projects but project managers need to customize the framework based on the nature of their project and teams.

Design for noise reduction – The architecture of an engineering assistance system for the development of noise-reduced rotating systems

Christof Küstner, Thilo Breitsprecher, Sandro Wartzack

Friedrich-Alexander-University Erlangen-Nuremberg, Germany

Despite detailed planning, conceptual and embodiment design important product properties like the acoustical behavior of complex machinery are only revealed in the later development phases (e. g. prototyping phase). If annoying acoustical behavior of machinery is identified in the later development phases, there will be the need to time- and money-consuming macro-iterations, which sometimes go back to the conceptual phase. This means a high financial risk especially for capital goods like wind turbines, because the operating license of wind turbines can be refused. In this paper, the demands and the basic architecture of a knowledge-based engineering (KBE) assistance system for the development of noise reduced rotating machines will be presented. It will assist the development engineers by context-sensitive allocation of design-relevant knowledge that enables them to identify components of complex machinery which are critical with respect to noise creation, noise transmission or noise radiation. With the aid of this assistance system, which is called ALARM, the risk of a drop back to the conceptual phase regarding undesirable acoustic product properties will be reduced.

A paradigm change in road safety evaluation: From hypothetico-deductive testing to designing safety systems

Akin Osman Kazakci[1], Nicolas Paget[2], Romain Fricheteau[3]

[1]Mines ParisTech, France; [2]Université Paris IX Dauphine, France; [3]CEESAR, France

The automotive industry is going through immense changes. For the rapidly changing technologies and the forthcoming intelligent vehicles, evaluation of road safety is of renewed importance. The traditional evaluation paradigm is centered on a passive safety paradigm and stabilized evaluation routines. However, safety technology is changing with cars becoming capable of communication with other cars and the infrastructure. This implies a move towards a pro-active approach for avoiding accidents. In this work, we argue that, given these changes, road safety evaluators should be involved with the design of those systems. We defend that that the current trends towards an hypothetico-deductive approach extending the traditional paradigm of safety evaluation is insufficient and there is a need for a more holistic approach: road safety system evaluators need to become co-designers of safety systems, providing inputs to the system designers, while, in turn, they build a new generation of evaluation models and practices. The proposed principles are illustrated with examples on lane keeping assistant system and the analysis of a low-friction system design.

A comparison of design for human variability strategies in seating requirements of anthropometrically diverse populations

Charlotte deVries[1], Gregory Roach[2], Matthew Parkinson[1]

[1]Pennsylvania State University, United States of America; [2]Brigham Young University, United States of America

When considering the needs of global populations, variations in overall body size and shape create an interesting situation for designers: should products designed for global markets achieve accommodation through a single variant, or should multiple variants—each targeted at a different market—be considered? The present work demonstrates the range of variability that can be exhibited by three distinct populations (male civilians in India, Japan, and the United States) and the effect of different globalization strategies on design requirements. The work focuses on "fit" or spatial accommodation in seating, excluding comfort and other important aspects of seat design. Qualitative assessments of the strategies and how appropriate they might be for other Design for Human Variability (DfHV) problems are provided.

Service Design

Chair: Ji-Hyun Lee, KAIST, Republic of Korea (South Korea)

Decision support for regional telehealth integration: A system dynamic approach

Camille Jean, Marija Jankovic, Julie Le Cardinal, Jean-Claude Bocquet

Ecole Centrale Paris, France

The purpose of this article is to use System Dynamics approaches for decision support. Telehealth is proposed in many articles as one of the possibilities to answer the challenges of keeping and reinforcing the goodness and fairness of the healthcare systems. But very few studies focus on predicting telehealth integration in the current healthcare system. The model proposed in this paper simulates several scenarios of telehealth integration in order to reduce healthcare cost and save valuable medical time. It also highlights the main factors that have the most influence on the results and provides help for healthcare managers to choose between different strategies and healthcare policies.

Inquiry into Service Processes from the Perspective of 'Steps'

Ryoichi Tamura[1], Akihiro Honda[2]

[1]Kyushu University, Japan; [2]INTAGE Inc., Japan

In this paper, our aim is to initiate research into service design by first understanding the current state of service processes. We study investigates and analyzes a wide range of service cases from the perspective of 'steps', without referring to such things as the properties or evaluations of the users. We then consider the utility of this perspective.

Here, 46 types of existing services are targeted and process steps are extracted according to, for example, changes in the medium by which the service is provided. Successive steps are evaluated according to 5 items and 16 categories for changes in medium, and cluster analysis is performed according to quantification theory type III to classify changes between steps. Relations between this analysis and existing notification methods are also examined.

Because we targeted a wide range of service cases and we were unable to touch upon such things as the properties and evaluations of users, we were only able to consider these issues in broad terms, but we believe that we have been able to hint at the importance of the perspective of 'steps' for future considerations of service processes.

Design of a healthcare service: Teledermatology

Tu Anh Duong[1,2], Julie Le Cardinal[1], Jean-Claude Bocquet[1]

[1]Ecole Centrale Paris, France; [2]Hôpital Henri Mondor, France

Teledermatology (TD) is an application of telemedicine i.e. clinical healthcare using IT-technologies, for skin disorders. This past decade, several publications have studied its feasibility and medical interest. As any innovative system, challenges in telemedicine now stand on large-scale deployment, appropriate user identification, economical and organizational models. Ahead any technological solutions and in the perspective of TD implementation in the French medical healthcare landscape, a key factor may be to design a robust and relevant system fixing the need and the priorities to decision-makers or industry-service. Regarding a design engineering approach, we performed an original study considering TD as any complex system and innovative service to design. This approach of a healthcare system using innovation conception tools and system functional analysis, will identify specific users, use-scenarios and the main functions, which have to be carried out by TD.

Service design for social space in smart city in case of a Taipei MRT station exit

Sheng-Ming Wang, Daniel Aguilera, Frida Cobar, John Aganda

National Taipei University of Technology, Taiwan

The main purpose of this study is to use service design method for provoking better user experiences of social spaces in a smart city. Service design thinking and participant observation methods are used to map the user experiences and to identify user types and needs in a social space. Theoretical improvements are proposed from the perspective of architecture, urban and media design. Finally, this study concludes the most relevant attributes and conflicts in the social space, for proposing strategies to reinforce these attributes and solve the conflicts. Applying service design to public space is different from its application to single products or services. It is because there is an absence of a structured sequence of actions and interactions in the social space. The results of this study show a large scale of intervention followed by the service design results, to perform a valid evaluation is very difficult. However, these proposals are emerged from a deep look into the users' needs and how they interact between each other and with the environment. Thus, this study demonstrated that the service design approach is valid for applying to the social space design in a smart city.

Remodel the public service based on behavioral maps and service design in case of Taipei MRT exit

Sheng-Ming Wang, Rhecel Molina, Meutia Anizar, Wojciech Wilczek

National Taipei University of Technology, Taiwan

The main purpose of this study is to remodel the public service based on behavioral maps and service design in public space. Modeling human spatial behavior in public space is an area of great interest to public service provider and users. Adequate observations will reveal significant information about users' spatial preferences, which are essential considerations in public service designer. This study used behavioral maps and service design in public space with considering the five human factors that include physical, cognitive, social, cultural, and emotional. Researchers recorded the map of users' activity diversity, map of users' experience and emotional, and map of key issues and users' type for analyzed and proposed new service prototype. Experiments are then designed and implemented for evaluating the proposed smart bench and green trellis service prototype in the case study area. The results of this study show that the integration of behavioral maps and service design in public space allow researchers to investigate and deeper understanding the users' emotion, experiences and preferences. So that to increase the design of public service in public space.

A comparison of three types of services with self-service technologies in service encounters

Shu-Shiuan Ho, Yi-Chia Lee, Tung-Jung Sung

National Taiwan University of Science and Technology, Taiwan

Self-service technologies (SSTs) have increasingly been changing the relationship between customers and firms. Therefore, it is a crucial issue for many service providers to understand customer-perceived service encounters. Although there are varied characteristics of SSTs in our daily life, research which has documented the link between customer encounters and SSTs is little. Therefore, the aim of this study attempts to explore service encounters on three types of services (the KTV system, the ticket vending machine, and the city guide kiosk) with SSTs. This study first adopted the critical incident technique (CIT) to collect a total of 722 critical incidents from participants in interviews. This study further categorized these critical incidents into a hierarchy-level service encounters construction. Finally, this study found that "poor design" received the highest percentage at the service failures level of dissatisfactory service encounters. Moreover, there were some deviations among these three types of services with SSTs at the interaction issue level. In addition, this study further proposed some service design suggestions to reduce the negative critical incidents.

SIG Workshop: Design Creativity & Formal Design Synthesis

Creativity in Design Synthesis

Chairs: Kristina Shea, ETH Zurich, Switzerland
Yukari Nagai, JAIST, Japan

Goal of Workshop

To discuss and debate a common topic between the Creativity and CDS SIGs.

Abstract

Key Questions of Workshop Panel:
- Computational Design Synthesis Viewpoint

1. What constitutes success in formal design synthesis research? Is it sufficient to create a system that "only" produces known, new and possibly creative results? Or, does the process by which they are generated also need to be "creative"? Or, both?
2. How does understanding of human creativity influence computational / formal design synthesis methods? Is it possible to use computational synthesis approaches to gain insights on human creativity?
3. What new method directions, e.g. coming from AI or computational creativity, should we be considering to be able to make our computational design synthesis methods more "creative"?
4. How can we better evaluate computational design synthesis systems?
   a. How can we assess the system output and to which reference point, e.g. novice designer, expert designer, "creative" designer or patentable? For creativity, can this only emerge through society and culture and can not be simply assessed by an individual, e.g. as in the arts?
   b. How can we assess system behavior, i.e. is there a "Turing test" for computational design synthesis or a grand challenge, e.g. IBM Watson's Jeopardy test?
   c. How can we assess computational design synthesis methods, not alone, but used in combination with designers?
5. Where are "creative" computational design synthesis systems needed in engineering design applications, e.g. to give one example, is and where is "emergence" really useful in engineering design? -Design Creativity Viewpoint
6. As the complex interaction between individual and social factors is increasingly addressed in creativity research, how can computational systems capture such micro-macro processes, and why/how may we model the systemic/situated character of creativity?
7. Generative models have dominated the research landscape. How can evaluation be addressed from a computational design viewpoint, and what type of studies of design creativity are necessary to understand the gen-eval link?
8. Human vs. algorithmic creativity: pros and cons of modeling the first (validity, analysis) vs. exploring the second (possibility, synthesis)
9. What are the latent assumptions in creativity research and how may we make them explicit in computational systems?
10. What are the practical limitations in creativity research and how may we overcome them in computational systems?

11. What have been the specific impacts of design creativity research and computational design research in everyday creative practice? What are the likely impacts in the next 20 years?

12. What is there in design creativity that is not covered by synthesis (creative non-synthesis)? - more questions (TBA)

Workshop Agenda

1. Panel presentations addressing given questions (~10 min), e.g.,
   necessary characteristics of creativity in synthesis and computational design synthesis. (First 90 min)
   Panelists:
   Kristina Shea (Computational Design Synthesis SIG leader) and 4-6 invited among Jon Cagan, Gaetano Cascini, Andy Dong, Ricardo Sosa, Alex Duffy, Amaresh Chakrabarti, Yukari Nagai (Design Creativity SIG leader) and Tino Stankovic will moderate the panel discussion.
2. Open discussion based on key questions from panel discussion. (Second 90 min)
3. The session concludes with a 30 min wrap-up.

W

Tutorial-Style Workshop : Mobile App Design & Development

MONDAY

IH-9B208

14:00 – 17:15

Design Thinking in Mobile Application Development

Chair: Christopher Han, SAP Labs in Palo Alto, United States of America

Goal of Workshop

Design thinking, innovation, product development, service design, software design and development

Abstract

Mobile applications have exploded in numbers and in popularity in recent years. With the growing ubiquity of smartphones, this trend will likely continue for years to come. How can design thinking help in creating mobile apps? To answer this question, the organizer draws from both academic research and industry practice, and shares practical insights from his current work in designing and developing mobile app. The applicability of design thinking starts with opportunity discovery and extends well into the design process and touches upon team dynamics and interaction quality, in recognition that the human being is the instrument of innovation. Using the design thinking approach, the organizer has been part of creating several consumer mobile applications, including a social, photo.sharing app called, PhotoTribe (currently available on the Apple AppStore). During the workshop, the organizer provides a systematic view of the role of design thinking in creating mobile apps from start to finish.

Workshop Agenda

Presentation, discussions, hands-on exercises, experiential learning

Universal and Collaborative Product Development

Chair: Jean-François Boujut, Grenoble Institute of Technology, France

Universal product development – A want- or wish-based development task

Stig Ottosson

Gjøvik University College, Sweden

To develop universal products that suit everybody is complex for which the guidelines and theories for need-based development are not designed. Instead development principles developed for New Product Development based on a want or a wish can be used when universal products are to be developed. Two successful universal product development projects that started with a wish and a want respectively are in the paper taken as examples on successful development of universal products by using Dynamic Product Development principles.

Design expertise in three different collaborative practices

Maaike Kleinsmann[1], Rianne Valkenburg[2], Janneke Sluijs[2]

[1]TU Delft, The Netherlands; [2]The Hague University of Applied Sciences, The Netherlands

The work field of designers is changing drastically. A designer is not only a creator of products and technical artifacts, moreover he is an entrepreneurial designer who inspires and enables business innovation on a strategic level.

The essence of design is the creation of a vision about tomorrow's world with all its aspects. Important here is that all different aspects need to become connected via collaboration with many different stakeholders. Only if this is done successfully, value for all stakeholders is created and the innovation will become a success. This makes collaboration a crucial aspect of today's innovations.

Since we do not have much knowledge about the nature of this collaboration, we questioned in this paper if we could specify and identify design collaboration. We interviewed 33 practitioners in various fields about the application of their design expertise. We found three different collaborative practices with their own identity because they differ with respect to their knowledge sharing and – integrating processes and because design expertise is used differently.

Context, collaboration and complexity in designing: The pivotal role of cognitive artifacts

Eswaran Subrahmanian[1], Yoram Reich[2], Sruthi Krishnan[3]

[1]Carnegie Mellon University, United States of America; [2]Tel Aviv University, Israel; [3]Fields of View, India

Designing progresses through continuous refinement of models. In today's design practice, these models get created and refined by multi-cultural, multidisciplinary teams that speak different languages, whether these languages are spoken language, disciplinary, or organizational language. When these people come together, they create, negotiate, evolve, and manage a nascent language with which they communicate the meaning of the product they design. The nascent language is a pidgin articulated through cognitive artifacts. Thus their role is essential to designing and their management is critical to successful completion of the process. In contrast, their mismanagement quickly presents itself as design failures, sometimes catastrophic. Given their role, it is critical to understand what cognitive artifacts are, how they are constructed, and how they should be managed. This marks a shift from focusing on the artifact to the process of designing as a social, negotiated process. Such a view results in conceiving designing as a complex and emergent process with implications for design research, practice and pedagogy.

Engineering Design Education

Chair: Haeseong Jee, Hong Ik University, Republic of Korea (South Korea)

Enhancing the concept generation capability of novice engineering designers

Reviewers' **Favourite**

Martin John Leary[1], **Colin Burvill**[2], **Bruce Field**[3]

[1]RMIT university, Australia; [2]Melbourne University, Australia; [3]Monash University, Australia

The professional contribution of an engineer often includes the generation of design concepts in response to an identified need. Concept generation creativity has multiple measures of interest, including: fluency, flexibility, originality and elaboration. Of these metrics, fluency measures the total number of concepts generated, and is of critical importance to an engineer's capability for concept generation. This work reports on a program to enhance the fluency of the concept generation capability of novice engineering designers. The program involves a novel computer based, self-assessed method to capture in real time the fluency of a novice engineer in response to a design task. The outcomes of this work can be applied to assess the effectiveness of teaching on fluency, and can provide tailored feedback to students to identify and overcome scenarios that may have negative influence on concept generation fluency. The outcomes of this initial work suggest that simple methods with minimal teaching overhead can be used to enhance concept generation capabilities. These outcomes are being used to inform a more extensive research program.

Discursive constructions of design and implications for engineering education

Rikke Premer Petersen

Aalborg University, Denmark

Recognition of design discourses at play in professional practice is key when discussing ways to reintroduce designerly ways in engineering education.

This paper outlines three design discourses discussed in literature and mirroring contemporary design practice: Viewing 'design as art' upholds traditional ties to the arts and craft tradition, where individual designers work with tangible form and aesthetics. Perceiving 'design as problem solving' focuses on the process viewed as a collective search for solutions. In 'design as dialogue' this is extended to a reflective practice where the designer is co-developing problem and solution.

From these discourses we learn that different professions practice and interpret design differently. No one discourse can capture all perspectives of the heterogeneous design notion, but instead highlight diverse qualities of good design practice.

Based on the discourses discussed, three key elements of design are highlighted: the materiality, the social, and the reflective sides of designing. All of these elements are represented in the issues of communication, which can be a central focus area when taking a designerly turn in engineering practice.

Innovative teaching approach for the design process of mechanical products

Antoine Varret, Morad Mahdjoub

Université de Technologie de Belfort Montbéliard, France

Nowadays, numerical simulation tools take a central place in the design process of mechanical products, to face the imperatives of reducing costs and development time. However, their use is often done for the validation of a solution in the latest stages of a project, even if they are more efficient earlier in the project for the help to find solutions. Statistical and optimization tools, in an approach based on designs of experiments and response surfaces methodologies, could be an important help, associated with numerical simulations, to find new product architectures. Nevertheless, their use is commonly reserved for complex problems with costly simulations. This article presents a design methodology based on numerical simulation and optimization tools to help to find original optimal architectures. The results of the experimentation of this design process on student projects are presented.

Criteria in Product Development

Chair: Ian Whitfield, University of Strathclyde, United Kingdom

Transforming user requirements into technical requirements for development of a new control access for people with reduced environmental impact

Guilherme Breier, Marcia Elisa Echevest, Carla ten Caten

Universidade Federal do Rio Grande do Sul, Brazil

This paper presents a proposal for evaluation of product development in the electronics industry based on the application of the tool QFD (Quality Function Deployment) oriented environmental parameters. The article presents the development of access control systems guided by the requirements of different segments of users. The survey of demands was performed an exploratory stage through qualitative questionnaire with experts from the company and the users of turnstiles. The use of the tool was adapted from a conceptual model of QFD proposed by Ribeiro et al. (2001), with inclusion of environmental parameters in the matrices. With the result of applying the deployment of QFD matrices were obtained the main criteria for prioritization of needs leading to greater acceptance of the system by users. One feature that has been observed by the users and that can easily be used in developing new turnstiles to access control is the use of recycled materials in building the product. Users also pointed to the construction of the turnstiles with less material and that they were lighter which will reduce the amount of natural resources.

Deploying decision criteria in a cyclical decision process for the product planning phase

Sebastian A. Schenkl, Sebastian Spörl, Florian G. H. Behncke, Robert Orawski, Markus Mörtl

Technische Universität München, Germany

During the planning process of future products or the future product portfolio, ideas for future market opportunities are generated and within a parallel decision process, the best ones are selected. This paper presents a method for the decision process during that product planning process. The focus is on the selection and weighting of the decision criteria. The method is applicable for planning processes with reoccurring decision steps. Therefore a block model is introduced: in every decision step a new block, compromising a set of criteria is added to the existing blocks and thus more and more integrated decisions can be made about the planning alternatives. Based on that the criteria are weighted consecutively in order to assure consistency between the different decision steps. Therefore we show rules for deriving the weighting factors of decision criteria in that additive decision process.

Towards a more event-driven NPD process: First experiences with attempts of implementation in the front-end phase

Geir Ringen[1], Torgeir Welo[2]

[1]Sintef Raufoss Manufacturing, Norway; [2]Norwegian University of Science and Technology, Norway

The search for effective and reliable innovation processes has concerned companies for decades. Stage-Gate (SG) is one of the most common models employed to structure new product development (NPD) efforts. Despite its popularity along with other efforts made to enhance NPD performance, overall innovation failure rates are still reported high. From the perspective of a NPD team SG is not a process at all, it is essentially a series of checkpoints introduced to ensure compliance between resource allocation and perceived business potential. Therefore, NPD teams need a more dynamic environment, focusing on problem-solving and risk mitigation at a more knowledge-based level. The present paper seeks to establish an event-driven NPD process within existing business processes, and determine its applicability in a real-world case study in a company that develops advanced products. An incremental implementation strategy was chosen, introducing the concept in the front-end of a single project, rather than across the entire company. The first experiences show that team performance is improved across three dimensions: outcome (effectiveness); process (efficiency); execution environment.

Modelling of Products and Product-Service Systems

Chair: Yoo Suk Hong, Seoul National University, Republic of Korea (South Korea)

Obstacles and development of support for translation of configuration rules

Anna Tidstam, Johan Malmqvist

Chalmers University of Technology, Sweden

Collaborative product development is a method for reducing costs, but there is a risk of severe obstacles during the product documentation exchange. Product documentation for configurable products describes how parts can be combined with so-called 'configuration rules'. This paper is based on a case study of the configuration rule exchange in a collaboration project between two automotive firms. The research approach was to create information and process models for the configuration rule exchange, and then to discuss obstacles and improvements. The results showed that the main obstacles were the difference in authoring methods, causing difficulties in detecting changes as well as a time-consuming reformulation of configuration rules. An implemented algorithm addressing the change detection serves its purpose to demonstrate the effort required to overcome this obstacle during a configuration rule exchange. The identified obstacles, and the effort to overcome them, are crucial to understand in order to motivate and direct further research of improved configuration rule exchange support.

Redesign of product service system applying failure mode and effects analysis and importance performance analysis

Chih-Chuan Chen, Ming-Chuan Chiu

National Tsing Hua University, Taiwan

In order to advance the competitiveness, more and more enterprises developed an integrated solution called product-service system (PSS) instead of solely new product/service. However, most of new PPS failed due to the lack of systematic methodology. To solve this issue, this study proposed a new methodology based on feedback of losing/unsatisfied customers. Failure Mode and Effects Analysis (FMEA) technique and Importance-Performance Analysis (IPA) are conducted to identify critical customer needs. Several scenarios are developed for different customer requirements. The performance of new PSS is evaluated with Service Quality (SERVQUAL) survey. A clothes service case study is presented to demonstrate the benefit of new PSS and there is 20-50% improvement in customer satisfaction.

Service element level customization for product-service systems using context-eased activity modeling

Yong Se Kim, Sang Won Lee, Jin Hui Kim

Sungkyunkwan University, Republic of Korea (South Korea)

Product-Service Systems (PSS) can offer diverse values for customers in service-dominant manners to suit for various needs and wants of customers. A typical PSS would be composed of many service units, which are then comprised with several service elements in each unit. Each service element takes a service function and multiple activities of relevant stakeholders. Product elements are to be designed for each service element so that activities of relevant stakeholders are properly supported by affordance features of the product elements. Inclusion of a certain service unit in PSS or not would be related with business model level variation of PSS concepts. Once service units of a PSS are fixed, variations of PSS concepts can be made at the level of service elements. We propose a PSS customization method that the context elements of activities facilitate effective customization at service element level. An example of service element level customization is illustrated with the PSS case of Make-up Room Service where some make-up service elements and associated product elements are tailored to a few different contexts reflecting customer needs.

Methods and Tools for Evaluation and Selection

Chair: Maria Yang, Massachusetts Institute of Technology, United States of America

A proposal of the usability checklist corresponding to task flows

Toshihisa Doi, Toshiki Yamaoka

Wakayama University, Japan

Quantifying usability is important in Human-Centered Design. Checklist methods are one of the methods of quantifying usability method by usability inspection. Checklists so often used for quantifying usability in design development at present. However, checklist methods have some problems regarding quantifying usability. First problem, the differences of the results come up by the difference of usability evaluator. Second problem, the right evaluation by checklists is hard if the checklist doesn't coincide with the tasks of evaluated products. Then, we aimed at proposing the usability checklist corresponding to task flows as a way of solution of current problems. The proposed method is versatile and easy quantifying usability method by checklist. This paper shows our proposed method.

Elaboration and assessment of a set of criteria for the evaluation of product ideas

Mathias Messerle, Hansgeorg Binz, Daniel Roth

University of Stuttgart, Germany

It is important for companies to identify the most promising product ideas very early in the product development process in order to use the available resources for the "right" projects. Consequently, the question arises how the most promising product ideas can be identified. A potentially good way to achieve this goal is by applying a systematic process for idea evaluation and selection. Therefore, among other things several evaluation criteria are required.

In literature, a lot of studies dealing with different sets of evaluation criteria can be found. Nevertheless, in business practice often sets of criteria that are not clearly defined are used, with partly vague, incomplete or even changing evaluation criteria. In order to resolve these problems, in this contribution a set of criteria that is as complete as possible and particularly applicable is elaborated by means of a wide literature survey and an assessment in business practice. The results of the assessment show that the set of criteria is suitable for being used in business practice. However, also a potential for improvement has been detected. Based on that, some proposals for improvement are developed.

An integrated screening framework to analyze flexibility in engineering systems design

Reviewers' **Favourite**

Mehdi Ranjbar Bourani[1], Michel-Alexandre Cardin[1], Wen Sin Chong[2], Ravindu Atapattu[2], Kok Seng Foo[2]

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This paper presents ongoing development for a novel integrated screening framework for flexibility analysis considering multi-domain uncertainty sources and multi-criteria for designing complex engineering systems. The proposed methodology aims to address two main issues in the design process for flexibility: 1) the complexity of exploring exhaustively flexible design strategies under multiple uncertainty sources, and 2) the multiple and possibly conflicting criteria inherent to design decision-making. The proposed screening framework is applied to a real-world capital-intensive project in the oil and gas industry. Current results indicate that the screening model offers better performance than a full exhaustive search of the design space in terms of the number of evaluations and simulation runtime, while providing good design solutions in terms of lifecycle performance. The work provides insights on how to analyze flexibility in the conceptual design of complex systems, especially when computational resources are limited, and design needs to consider multiple decision-making criteria.

Clarification of sustainability consequences of manufacturing processes in conceptual design

Sophie Hallstedt[1], Ola Isaksson[2]

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In the conceptual design of aircraft jet engine components, not only the product architecture and dimensions are set but the associate manufacturing processes are also defined. From a design decision point of view it is critical to identify and characterize the consequences of alternative solutions. This paper reports on a case, where a milling process needed to be selected in an early design phase of a jet engine component. An Electro-Chemical Milling process was considered but its impact on sustainability needed clarification.

An approach that combined a simplified Environmental Impact Assessment with a Strategic Sustainability Assessment was used. The main finding and contribution from the work is a method that helps to clarify consequences of sustainability-related issues by combining the two analysis tools with a risk analysis implementation. The results reveal that once the consequences can be clarified, increased attention and understanding are gained.

	P Podium Sessions				D Discussion Sessions		W Workshop Sessions		
08:45 - 10:15	**Design Cognition and Experience** Location: IH-90110	**Product Families and Architectures** Location: IH-90104	**Organisational Processes** Location: IH-9B218	**Development, Assessment and Management of Design Processes** Location: IH-9B217	**Information and Knowledge in Product Development** Location: IH-9B320	**Methods and Tools for Evaluation and Decision** Location: IH-9B321	**SIG Workshop: Modelling and Management of Engineering Processes** Location: IH-90109		**Tutorial-Style Workshop: Design for Usability - The Envisioning Use Technique** Location: IH-9B106
10:15 - 10:45	**Break** Location: IH-90101								
10:45 - 12:15	**Design Communication** Location: IH-90110	**Product Architectures and Platforms** Location: IH-90104	**Organisational Understanding of Product Development** Location: IH-9B218	**Ecodesign and Sustainability** Location: IH-9B217	**Knowledge Based Design** Location: IH-9B320	**Open, Participatory and Collaborative Product Development** Location: IH-9B321	**SIG Workshop: Types of Decision Making and Their Connections** Location: IH-90109	**SIG Workshop: Discovering the Design Theory SIG** Location: IH-90109	
12:20 - 13:20	**Lunch** Location: Cafeteria (AH-1B102) & International Conference Hall (AH-10501)								
13:30 - 14:00	**Keynote: Design Science - A Weltanschauung** Speaker: Panos Papalambros, University of Michigan, United States of America New Millennium Auditorium								
14:15 - 15:30	**Design for User Experience** Location: IH-90110	**Research Methods** Location: IH-90104	**Market and Business Implications** Location: IH-9B218	**Design for Special Care** Location: IH-9B217	**Challenges in Design Education** Location: IH-9B320		**SIG Workshop: Collaborative Design - Meeting Industry Requirements Through Research** Location: IH-90109		
15:30 - 16:00	**Break** Location: IH-90101								
16:00 - 17:30	**Design Society General Meeting** Location: IH-9B217								
18:00 - 20:00	**Young Members Event** Location: International Conference Hall (AH-10501)								

Design Cognition and Experience

Chair: Martin Steinert, NTNU - Norwegian University of Science and Technology, Norway

Triangulating front end engineering design activities with physiology data and psychological preferences

Martin Steinert[1], Kathryn Jablokow[2]

[1]Norwegian University of Science and Technology, Norway; [2]Penn State University, United States of America

This paper presents the experimental foundation, methodology, and pilot data from an exploratory triangulation of front end engineering design activities with physiology data and psychological preferences. The aim is to gain more measurement control over engineering design activities by "opening the black box" of the designer's cognitive state (prevalent problem solving style and momentary cognitive load measured by means of physiology data) as he/she engages in different design activities (divergent engineering activity vs. convergent engineering activity). Ultimately, we intend to contribute to the design community's pressing need for design performance metrics that will allow the comparison of various engineering design activities.
The aim is to understand and model the relationships between engineering design behavior (actual engineering activity), problem solving preference (individual psychological predisposition), and real-time physiological data of engineers (EEG, ECG, and other physiological telemetry data).

Analyzing the cognitive processes of an interaction design method using the FBS framework

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[1]University of Udine, Italy; [2]Politecnico di Milano, Italy

The engineering design community is debating since more than two decades on the development of models and methods suitable for analyzing the cognitive processes that occur within design activities. An acknowledged model in this domain is the situated FBS framework that describes the design process as consisting of elementary sub-processes defined in terms of modifications on functions, behavior and structures. This framework has been successfully applied to the analysis of the information gathered within industrial innovation projects and to the related design activities. However, it is definitely unusual to use it for analyzing a design method itself, so as to highlight its potential shortcomings and suggest directions of further development. In this paper, the authors investigate this original application through a detailed examination of the IDIM, an interaction design integrated method aimed at generating and validating innovative design suggestions related to interaction issues. The highlighted criticalities are discussed and some suggestions for possible IDIM improvements are depicted.

Does experience in design and innovation affect the perception of creativity?

Niccolò Becattini[1], Yuri Borgianni[2], Gaetano Cascini[1], Federico Rotini[2]

[1]Politecnico di Milano, Italy; [2]Università di Firenze, Italy

The assessment of creativity arouses increasing interest within design community. The literature witnesses efforts to quantitatively measure creativity, although commonly considered intrinsically subjective. Recent experiences show a good degree of convergence between assessments employing more objective metrics and evaluations of creativity made by experts in design and innovation. With the overall goal of determining whether such judgments are reliable and repeatable, the present paper analyzes creativity assessments of commercial products performed by skilled and novice designers in order to highlight further differences due to accumulated experience. The investigation is carried out by means of a suitable questionnaire asking to evaluate the creativity of 10 market successes and 10 commercial flops. The experiment tests also whether commercial results can strongly influence the perception of creativity. The outcomes reveal that experience is supposed to play a not negligible role in evaluating creativity, while the question about the impact of market success requires further investigation.

Overcoming design fixation through education and creativity methods

Reviewers' **Favourite**

Thomas J. Howard[1], Anja M. Maier[1], Balder Onarheim[1], Morten Friis-Olivarius[2,3]

[1]Technical University of Denmark, Denmark; [2]Copenhagen Business School, Denmark; [3]Hvidovre Hospital, Denmark

This paper reports an experiment on the topic design fixation using 12 teams of masters students working on three design problems from (Jansson and Smith 1991). The objective of the experiment is to determine the effectiveness of two interventions to help overcome fixation on example solutions. The first intervention consisted of educating each team on the phenomena and effects of design fixation. The results showed that this intervention reduced the number of fixation elements in comparison to the control group (p=0.025). The second intervention involved using Dix et als' (2006) 'Bad Ideas' method during a final design task. The results showed that the method did not help the teams as it caused the fixation ratio to increase and the number of ideas per team to decrease. In addition to the above mentioned interventions, the experiment also revealed a negative correlation between the number of ideas produced per group and the groups' fixation ratios, adding to the quantity breads novelty debate. Finally, the study also provided further evidence of the hypothesis by Agogué et al (2011) that example solutions constructed from restrictive partitions have a greater fixation affect.

Product Families and Architectures

Chair: Maik Maurer, Technical University Munich , Germany

Architecting systems for optimal lifetime adaptability

Avner Engel, Yoram Reich

Tel-Aviv University, Israel

System architecture decisions such as the assignment of components to modules can have a large impact on the system's lifetime adaptability and cost. We broaden systems architecting theory by considering components' option values and interface costs when making the assignment decision. We propose an analytical model to identify the trade-offs between an inexpensive but less adaptable system and an expensive but adaptable one. We demonstrate the model with a realistic example of an Unmanned Air Vehicle (UAV) and use a genetic algorithm to identify an architecture that optimally balances cost and adaptability. Finally, we compensate variations stemming from uncertainties in the input data by means of sensitivity analysis, depicting optimal architectures via lattice charts. By way of example, we demonstrate that optimization provides considerably more cost effective lifetime architectures. In addition, conducting sensitivity analysis combined with lattice charts enable the selection of significantly more robust architectures when the input data is inherently imprecise. The approach received preliminary validation in several real industrial pilot cases.

Semiotic basis for designing product architecture

Fei Hu[1], Keichii Sato[2], Xi Zhang[3], Taiping Zhu[3]

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On modular product architecture, use related issues such as usability and interactive experience have not been addressed enough in product architecture. This paper introduces a conceptual framework "Semiotic Approach to Product Architecture Design (SAPAD)" to incorporate how users embed, develop and interpret meaning and values in product use. In this framework, three dimensions of human-product interaction are introduced. The first is user behavior dimension that represents activity, process, action and operation; the second is object dimension that represents ensemble, object, unit and component. The third dimension represents significations that includes six worlds based on the concept of Semiotic Ladder by Ronald Stamper, which are physical world, syntactic world, empiric world, semantics world, pragmatics world and social world. A case study was conducted to develop a SAPAD model on Oolong tea making activity in a Chinese household. The case study demonstrated that SAPAD can effectively reflect semiotic aspects of the use process on the product architecture that leads to the enhancement of meaningfulness and effectiveness of the product in real use situations.

Process visualisation of product family development methods

Gregor Beckmann, Dieter Krause

Hamburg University of Technology, Germany

Development methods for modular product families have shown their usefulness in case studies, but are only seldom applied in practice. To support the active transfer of methods from research into practice an understanding of the working principles of methods is needed. In this contribution, a newly developed process visualisation approach is presented that allows design researchers to visualise and analyse existing methods to create this understanding. A special emphasis of the visualisation task is set to the analysis of interfaces that are used to include information and knowledge from different company stakeholders into method based development processes and back into the business. A visualisation nomination is presented that gives an easy and intuitive way of understanding this interaction. The approach is exemplary applied to the method "Integrated PKT-Approach for the Development of Modular Product Families". Finally an outlook on the possible use of the presented visualisation approach to foster methods transfer to practice is given.

Design for adaptability in multi-variant product families

Markus Greisel[1,2], Maximilian Kissel[1], Benjamin Spinola[2], Matthias Kreimeyer[2]

[1]Technische Universität München, Germany; [2]MAN Truck & Bus AG, Germany

Designing system structures for adaptability offers significant advantages for both customers and producers. But it is not simple, especially when the product is a highly complex product family, for example a heavy duty truck. This paper presents why the application of Design for Adaptability is problematic with existing approaches, if the product is complex. To close the outlined gap in methodology, a new methodical concept is proposed. This is based on Modular Function Deployment and strategic modularization, offering the opportunity for the necessary transparency, to make also very multi-variant products more adaptable. For making the complexity of high variant product families more tangible, this concept is applied on the components of a Generic Product Structure. The modularization is done by defining adaptability drivers and focusing not on interfaces, but on grouping components for distinct reasons. Therefore 'Strategic Modules' are defined offering a whole new perspective and transparency of component dependencies. This is shown on a real life product by MAN Truck & Bus AG. The result is a promising methodical concept that should be further developed by future research.

Organisational Processes

Chair: Sofia Ritzén, KTH Royal Institute of Technology, Sweden

Investigation of internal and external design teams during the product development process in footwear companies

Andréa Capra, Maurício Moreira e Silva Bernardes

UFRGS, Brazil

This paper aims to analyze the management of internal and external design teams during the product development process in two footwear companies of Paranhana Valley in Rio Grande do Sul, Brazil. A case study was conducted in both companies that worked with both types of teams. The study provided a valuable discussion about how a company can work with internal or external design teams or both of them once the literature does not provide sufficient background to this matter. It also discusses the advantages and disadvantages of working with each team. Results indicated that differences in the way of managing the teams are related with the decision-making autonomy given to the members of each design team at the beginning of the development of new projects.

Enabling organizational changes for development of product-service system offers

Reviewers' **Favourite**

Johanna Wallin[1,2], Koteshwar Chirumalla[2], Ola Isaksson[1,2]

[1]GKN Aerospace Engine Systems, Sweden; [2]Luleå University of Technology, Sweden

The manufacturing industry is going through a transition from developing of products to the provision of product-service systems (PSS). Earlier research has identified different types of PSS offers, from product offers that include services as "add-on", to the sale of services that include tangible goods as "add-on". This paper addresses what consequences this has on manufacturing organizations undergoing PSS transition. The purpose of the paper is to clarify key success factors for organizational changes needed in the transition process of developing different types of PSS offers. The results are based on a case study of a manufacturer in the aerospace domain; the analysis approached organizational changes from organizational theory perspective. The study identified four key areas that need to be considered in the organizational transformation to PSS development: Business strategy and decision-making, Internal organizational structure, Team composition, and External networks and customer relationship. Based on the analysis of empirical data from these four areas, the paper discusses the successful organizational changes that are required in the transition towards PSS development.

Design orchestration composer - A model base enabling holistic management of product, design process, and organization

Kazuya Oizumi, Kazuhiro Aoyama

The University of Tokyo, Japan

As the industries develop, product enlarges its scale and increases its complexity. To defeat past products, more functions and mechanisms have been installed. It requires more and more people involved, disciplines needed, which have to orchestrate toward the achivement of a better product. However, due to complexity of design, management of the design process and the organization becomes huge challenge. Considerable time and efforts are required for the better management. Failures of management appear as delays, over-budgets, inferior functionalities or defects. Literally, scale and complexity of a product are exceeding the limit that mankind can manually deal with.

The aim of this study is to establish the model base that enables model based management of product, design process, and organization. The major function of the model base application is realized by the domain specific calculations and analyses. By considering the domain specific rationales, it is possible to describe detailed relationships and give insightful translation of the analysed results.

The case study on a solar boat design project demonstrates the use of the model base and its applications.

Managing wicked design commissions

Reviewers' **Favourite**

Charlotta Linse

The Royal Institute of Technology (KTH), Sweden

Design is a core technical and creative activity for innovation. Design consultancy companies make a business out of taking on ill structured development work. Uncertainty is an integral part of this kind of fuzzy front end (FFE) development; the need for information and knowledge is to a large extent unknown and possible difficulties on the way is yet to be encountered.

The objective of this paper is to describe how commissioned FFE work may be managed in order to mitigate uncertainty. The basis for the article is a comparative case study at two design consultancy firms.

One of the companies have structured and standardized their work process in order to reduce uncertainty about what to do in a commission. Simultaneously, the process functions as a guarantee that they will reach an unknown but acceptable output.

The other company initiates their projects by first of all defining product characteristics that are crucial for business success. This product definition then functions as a beacon during the consecutive development; it reduces uncertainty of what output to reach whilst letting the team decide on the unique route for each commission.

Development, Assessment and Management of Design Processes

Chair: Dorian Marjanovic, University of Zagreb, Croatia

Idea relevancy assessment in preparation of product development

Milan Stevanovic[1], Dorian Marjanovic[2], Mario Storga[2]

[1]Markot.tel, Croatia; [2]University of Zagreb, Croatia

In order to maximize the prospects it is necessary to thoroughly evaluate a number of ideas proposed and estimate their potential for new product development. Ideas description, evaluation and selection methods were researched in the production companies with online survey. The objective of the study was to get insight into companies' innovation policies and practices particularly regarding methods and models used for verification and selection of the ideas. Results of the survey indicated attributes used to describe ideas, and potential criteria and methods for assessment and evaluation of ideas. The proposed ideas selection methodology is consequently based on the, by survey, determined needs of the practitioners.

In this paper a part of the study is presented explaining ideas processing suitable for product development and the assessment model of idea relevancy factor with associated criteria, attributes and metrics. Validation of the proposed method was carried out on a real case example by application of two multi-attribute ranking methods. The validation shows that the presented methods are very well suited for decision making in the early phases of product development.

Framework for the development of maturity based self-assessments for process improvement

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Increasing productivity and competitiveness are still major challenges for companies. One approach for performance improvement are maturity models. Their main principle is an objective performance evaluation and improvement that can be applied on different topics (e.g. innovation management, virtual prototyping & simulation). To simplify the application of the principle on new topics, this paper presents a framework that allows an efficient and standardised development of a maturity model that can be conducted as a self-assessment. The framework consists of a standardised architecture for the maturity model, a procedure model for its development and a software-tool. The application of the framework on the topic of Virtual Prototyping & Simulation resulted in the VPS-Benchmark, which serves as an example for a maturity based self-assessment throughout this paper. The paper concludes with an outlook on a future application of the framework in the course of the leading edge cluster it's OWL – Intelligent Technical Systems OstWestfalenLippe. Here a maturity based self-assessment will be provided to qualify the cluster partners for developing intelligent technical systems.

Spatial design supporting the management of radical improvements within the manufacturing industry

Jennie Schaeffer Andersson, Mats Jackson

Maelardalen University, Sweden

It is important for the manufacturing industry to become more innovative. Doing what we always have done is not enough. External pressure and the required speed of change, requires industry to improve the management of incremental and radical improvement work. There is thus a need for new methods, tools, and processes to improve the innovative capabilities.

In this paper we discuss the use of spatial design to support the management of radical improvement within the manufacturing industry. The designs of the physical spaces are in the paper presented as frames that are cultivating, facilitating and enabling radical improvement without imposing a regime of control and forced change. The spatial design enables the process and contributes to an ecosystem supporting radical improvement. To better manage radical improvement processes, one option suggested in this paper is to create five dedicated places - five enabling frames - for five phases in a radical improvement process, firstly to bring attention to the different phases of the process and secondly to support the actions in each part.

A methodical approach for designing innovative products based on computer aided functional modelling

Jan Erik Heller, Johannes van der Beek, Claudia Dittmann, Jörg Feldhusen

RWTH Aachen University, Germany

Creating innovative products is vital for the success of enterprises. Markets change constantly and force engineering departments to shorten innovation cycles. To be competitive, a methodical approach for systematic innovation is needed. One promising way to achieve this goal is to base development processes on functional modelling. In this paper, an overview of existing functional modelling approaches is laid out and advantages as well as disadvantages are discussed. Koller's methodology is presented in detail as it is highly suitable for systematic innovation. Although several methods seem to be published and well-documented, they currently are not widely adopted in industrial use. Reasons for this shortage are elaborated. An improved methodology for working with functions, physical effects and the morphological box is introduced. Different single aspects like disadvantages with the paper-based use of effect catalogues or the incorporation of magnitude influence with the composition of physical effects are shown. An implementation of a software prototype and its evolution is given. Thoughts on further improvement of both methodology and tool conclude the paper.

Information and Knowledge in Product Development

Chair: Steve Culley, University of Bath, United Kingdom

Assessment of information maturity during design, operation and maintenance stages within BIM use environment

Raymond Rui ZOU[1], Llewellyn C.M TANG[2], Mey GOH[3]

[1]University of Reading, United Kingdom; [2]University of Nottingham, China; [3]Loughborough University, United Kingdom

In construction, there is a prevalence of application of BIM (Building Information Modelling) involving in the processes and activities to contribute to a better output of lean production within construction projects, but there is still little emphasis on its application during the operation and maintenance stages. This paper proposes to discuss how the use of BIM can capture in use knowledge through the provision of a new information capture and visualisation tools for design, operation and maintenance stages in construction. In order to investigate this, a review of numerous literatures spanning multi-sectors has been undertaken by authors. The paper addresses the issues of uses of knowledge during design, operation and maintenance stages, and BIM's application at those stages and the limitations during its applications. Finally, this paper introduces the concept of information maturity and its form of visualization, through which its use can facilitate a better information management, regarding the generation, capture, use and retrieval of information, as well making optimized decision with provision of reliable, accurate information throughout design, operation and maintenance.

Sharing networked innovation approaches across companies

Reviewers' **Favourite**

Christiane Maurer, Rianne Valkenburg

The Hague University of Applied Sciences, The Netherlands

The paper discusses a workshop that has been set up to help companies that are struggling to get networked innovation projects started. In a guided one-day setting, three companies discussed their recent networked innovation cases with each other.

A step-by-step approach has been used, starting with baseline interviews prior to the workshop up to a multi-part workshop. By doing so, presenting information from the view of the case owners could be systematically compared to the effects of actively sharing information between professionals from different companies. Departing from the ambitions of each company, external trends, used processes and partners, the goals of each company were discussed. Then, the network that would make the value proposition work, was constructed and alternatives were discussed.

We describe the approach of trans-organizational knowledge sharing and the way of analyzing the gathered input. It showed that companies are willing to discuss their problems in depth, given a setting of mutual trust as well as shared understanding. The results also showed that the content of networked innovation projects became richer and more nuanced due to the discussions.

Using knowledge based engineering to support the design of smart products

Johannes Luetzenberger, Patrick Klein, Klaus-Dieter Thoben

University of Bremen, Germany

If products are no longer considered as being mere physical devices, it has to be analyzed if KBE (Knowledge based Engineering) approaches can be adapted or if KBE approaches become obsolete for the design of the so called "smart products".As a sub domain of Knowledge Based Engineering (KBE), Design Automation (DA) builds on the idea of deriving the physical design of a product automatically from codified, product related engineering knowledge. The authors believe that, by paying special attention to the potential interaction of products with different sorts of information and content, DA approaches can even play a major role for the development of smart products. Thus this paper aims to provide a concept for an enhancement of DA. Instead of case based and locally implemented solutions, the concept relies on a central knowledge-based system in order to process the smart layer on top of the geometrical design. The proposed system is be grounded upon an ontology in order to represent the physical and the virtual domain synchronously. Following this approach, different kinds of product development applications can rely on one central knowledge-base.

Supply chain eco-information sharing in the product development process through computer aided design software

Reviewers' **Favourite**

Idai Mendy Mombeshora, Elies Dekoninck

University of Bath, United Kingdom

As decisions made during the design of a product have a significant impact on environmental performance, it is imperative that environmental considerations become an integral part of the design process. The integrated software platform for Green ENgineering dESIgn and product sustainability (G.EN.ESI) project aims to develop a software platform, for use with CAD/PLM software, which simplifies the process of integrating environmental and economic requirements the design process. A key component, paramount to the success of the platform, is its ability to obtain eco-information directly from the supply chain through the use of a web based supply chain portal. This paper details the considerations and work undertaken in the early stages of the portal's development. Based on analysis of past and existing portals and data collected through a survey and a case study, possible architectures of the web portal, and their associated characteristics, were derived using scenario planning. Moving on, the next steps involve surveying more companies and using the insights gained, a detailed design brief for the portal which covers both technical and functional requirements will be created.

Information exchange along the product development process using the example of bimetallic corrosion

Martin Eigner, Joscha Ernst, Daniil Roubanov, Sebastian Sindermann, Thomas Eickhoff

University of Kaiserslautern, Germany

The reduction of the overall manufacturing costs and time-to-market is one of the biggest strategic goals for many companies. Both factors (time and costs) are incurred during the production but mainly determined during the design phase.
At the example of bimetallic corrosion the information exchange along the Product Development Process (PDP) is shown. Therefore this paper presents a concept and a prototype for detecting bimetallic corrosion in a CAD-System and describes a general way for storing information in a neutral data format, e.g. in a PDM/PLM-System. Thus the data could be used not only by designers but also by other departments, e.g. process planning.
Thereby this concept generates (nearly) no overhead for the involved departments. Though it still offers a real value added by presenting the information in a prepared and consumable way. This way the approach can scale down the "wall" still existing between product development and process planning.

New ways of integrating material knowledge into the design process

Anders Højris, Louise Møller

Aalborg University, Denmark

Throughout resent years a growing number of new materials have been developed. In the design studio context, this has led to the emergence of physical material libraries making the information much more accessible.
The access to information on new material possibilities has also changed the way designers integrate knowledge about materials into the design process. This means that the traditional design process model, where the selection of materials takes place after the design of form and function – based on technical performance, no longer apply.
Accordingly the approach in this paper is to view information about materials through the perspective of organizational memory and technology brokering.
This paper is build upon two cases from the design studio: designaffairs GmbH. The study reveals how the designers use socio-cultural tendencies to select specific materials before the products form and function are designed. The materials are selected based on the visual and haptic qualities of the materials rather than technical data. One of the cases further illustrates three types of material search strategies, which the designers apply in the early phases of the design process.

Methods and Tools for Evaluation and Decision

Chair: Wei Chen, Northwestern University, United States of America

A visualization methodology for evaluating parts made of short fiber reinforced thermoplastics regarding their lightweight potential

Georg Gruber, Johannes Kößler, Sandro Wartzack

University of Erlangen-Nuremberg, Germany

Injection molded, short fiber reinforced thermoplastics are a promising lightweight material. However, the component design is getting complex with this type of material due to the process induced fiber orientation. To achieve substantial progress in lightweight design, the resulting anisotropic material properties have to be taken advantage of effectively. The most important correcting variables influencing the fiber orientation are the part's geometry and the gate design (position and type of gates).
The goal of the present paper is introducing a new evaluation method, supporting the product developer at detecting the most appropriate geometry and gate layout. The basic idea behind the new approach is examining the deviations between the load path and the fiber orientation pattern. With the help of new quality criteria it can be rated to which extent load path and fiber orientation are in harmony. The methodology is implemented as a software tool, delivering a mean quality criterion per part as well as a contour plot enabling also the analysis of the local distribution of the focused quality criterion. The potential of the new approach is demonstrated within a brief case study.

Analyzing social influence through network simulations in choice modeling

Reviewers' **Favourite**

Peilin Tian, Wei Chen

Northwestern University, United States of America

In this paper, we study how to capture social influence on customer choice based on rich consumer data. The created choice model helps achieve a better understanding of consumer preferences in product design. Social influence attributes are employed to quantify the social impact a customer receives from interactions with other individuals in product selection. Data analysis technique is first adopted to identify critical social profile attributes based on a large amount of consumer information. To quantify social influence at the individual level, the paper presents a data-driven approach that integrates social network simulation based on consumers' social profile attributes in product choice modeling. Later the network is simulated to estimate the social influence on individual consumer's choice behavior. This paper provides new understanding of how consumers are socially influenced. A Hybrid Electric Vehicle case study is implemented to demonstrate the proposed methodology using National Household Travel Survey data. Choice modeling prediction results and consumers green attitude towards hybrid electric vehicle are examined over multiple years.

A decision support system for market segment driven product design

Ningrong Lei, Seung Ki Moon

Nanyang Technology University, Singapore

This paper presents a decision support system (DSS) for market segment driven product design. The input for the proposed system is historic market data and design parameters for a new product. Through market segmentation, with Principal Component Analysis (PCA) and k-means, as well as AdaBoost classification, the DSS determines to which market segment a new product belongs. To demonstrate the feasibility of the proposed system, we have conducted a case study, based on US automotive market data. In this case study, the proposed DSS achieved a classification accuracy of 92.40%. The high accuracy levels make us confident that the proposed system can benefit enterprise decision makers by providing an objective second opinion on the question: To which market segment does a new product design belong? Having the information about the market segment implies that the competition is known and marketing can position the product accurately. Furthermore, the design parameters can be adjusted such that (a) the new product fits this market segment better or (b) the new product is positioned in a different market segment. Therefore, the proposed system enables market segment driven product design.

An advanced procedure model for property-based product development

Thomas Luft, Hartmut Krehmer, Sandro Wartzack

FAU Erlangen-Nürnberg, Germany

Increasing functionality, increasing individualization as well as the enormous complexity of modern products lead to steadily increasing challenges in the domain of product development. This causes a necessity of a novel approach for a purposeful guidance to lead developers through the process of product development. Therefore the objective of this work is to present an advanced procedure model for property-based product development which is showing effects of characteristics specifications based on a structured mapping of product properties. Due to its structure and the integration of a multitude of individual approaches that are developed within this paper, the presented procedure model provides product developers with a detailed guidance to the process of product development. Moreover, developers are supported not only in the field of preventative avoidance of unnecessary design iterations but also in in dealing with unavoidable iterations. By continuously monitoring the product's degree of maturity information about the achievement of the required properties and about necessary changes can be deduced.

An approach to generate flexibility in engineering design of sustainable waste-to-energy systems

Junfei Hu, Michel-Alexandre Cardin, Kim-Leng Poh, Eng Seng Chia

National University of Singapore, Singapore

Designing an engineering system that is sustainable both environmentally and economically is a challenging and emergent task. This paper considers embedding flexibility into the engineering design of an upcoming waste-to-energy (WTE) system as a mechanism to ensure better sustainability in long-term lifecycle. A methodology is proposed to identify valuable opportunities to embed flexibility as a way to deal pro-actively with uncertain waste and consumer patterns. The proposed methodology helps to limit the number of flexible design concepts that decision-makers have to consider and analyze in the initial design phase. Application of the proposed methodology is demonstrated through the analysis of novel WTE technology in Singapore based on anaerobic digestion. Result shows that the expected net present value (ENPV) of the flexible design provides a 38.6% improvement over the fixed rigid design in terms of economic lifecycle performance. This design is conducive of better economic sustainability via additional power generation, and better use of resources. Results also indicate that the flexible design can reduce downside risks and capitalize on upside opportunities significantly.

Performance measurement in global product development

Thomas Paul Taylor, Saeema Ahmed Kristensen

The Technical University of Denmark, Denmark

An organisation looking to form collaborations across borders is a consequence of an increasingly competitive world market. Recent studies highlighted key challenges and success factors organisation's face when globalising stages of product development. To optimize performance along these factors there is a requirement for the process to be monitored and measured relative to the business strategy of an organisation. It was found that performance measurement is a process that helps achieve sustainable business success, encouraging a learning culture within organisations. To this day, much of the research into how performance is measured has focussed on the process of product development. However, exploration of performance measurement related to global product development is relatively unexplored and a need for further research is evident.

This paper contributes towards understanding how performance is measured in global product development. More specifically, results from a survey and interviews highlight a need for further development in current performance measurement frameworks used in product development to facilitate the key factors and metrics in global product development.

SIG Workshop: Modelling and Management of Engineering Processes

Modelling & Management of Engineering Processes

Chairs: Kilian Gericke, University of Luxembourg, Luxembourg
Sandor Vajna, Otto-von-Guericke University Magdeburg, Germany
P. John Clarkson, University of Cambridge, United Kingdom

Goal of Workshop

During the workshop invited experts will present different perspectives on Lean Development, which will be discussed with the audience. The goal is to contribute to a better understanding of the challenges and different perspectives related to Lean Development and to discuss what Value means in this context.
The second goal is to present the SIG and new developments in the SIG (new chairs, new online activities) to the SIG members and to attract participants of the event to become members and to contribute to the SIG activities.

Abstract

• About the MMEP SIG

Engineering processes are the "glue" that hold the activities within product development and design together. Engineering processes structure these activities appropriately, secure their reasonable processing, and ensure the correct and timely use of the appropriate approaches & procedures, methods, data, and tools in order to improve the design process, improve products and services, and properly document product development processes and the products themselves. It is the aim of this group to contribute to a smart and smooth definition, application, and navigation of Engineering Processes within the scope described above. Our membership is a diverse group of academics, researchers and practitioners from different industries.

• Focus of the Workshop

A central aspect of any business process is efficiency, i.e. the ratio of effort spent vs. value added. However, the value added by a development process is difficult to quantify. In that respect, product development differs very much from processes like e.g. production where established methods exist to measure and improve efficiency. The "lean" management philosophy, for instance, aims at increasing the efficiency of business processes by avoiding non-value adding activities whenever possible.
If an activity is done in order to avoid problems later, which never occurred – was it a waste of resources?
What does 'value' mean in product development? Is it sensible to strive for 'lean' or should we engender a culture of 'fat' in the product development context? What is appropriate?
During this workshop the concept of Lean Development and Value in product development will be discussed, different stances will be debated.

Event format

- **Presentation of activities and changes in the SIG (45 min)**
  - Brief summaries of activities since workshop at ICED'11
  - Online activities (LinkedIn, Mendeley, new web-page)
  - New chairs
  - Profile of the SIG
    - › overview of members
    - › addressed research areas
    - › expertise of its members
    - › access to publications
  - Acquisition of new members
  - SIG agenda planning (5 min)
    - › Upcoming SIG events (MMEP'13 conference)
    - › Further activities
- **Discussion on research topic: focus on lean development (45min)**
  - Invited presentation 15min
  - Discussion 30min

W

Tutorial-Style Workshop : Design for Usability

The Envisioning Use Technique

Chairs: Mieke van der Bijl-Brouwer, University of Tech. Sydney, Australia
Stella Boess, Delft University of Tech., Netherlands

Goal of Worshop

In this workshop, participants will learn how to execute the Envisioning Use technique: a workshop technique that allows multidisciplinary product development teams to generate a shared vision on product use.

Abstract

The Envisioning Use technique is a half-day workshop technique in which members of a product development team come together to create a 'shared vision on product use'. This is a common understanding of who future users will be, under which circumstances the product will be used, and which user experience or usability issues will be targeted for these use situations in the product development process. Our research in design industry has shown that the Envisioning Use technique provides a means to successfully create such a shared vision on product use, which in turn has a positive influence on team decision-making with regard to product use. As such it is a very useful technique to connect user centred design methods to actual product development processes. In this workshop we provide hands-on experience with the Envisioning Use technique as well as an opportunity to reflect on how to further integrate this in product development processes.

Workshop Agenda

In this workshop, hands-on experience with the Envisoning Use technique is provided by having participants work on a fictional design case.

- Introduction to the Envisioning Use technique and presention of evidence of its success in design industry
- Hands-on experience with the technique by applying it to a fictional design case. The technique is a combination of different types of techniques including storytelling, scenario exploration, role-playing, solution generation, reflection on the gathered knowledge and connection to the product development process.
- Discssion of the usability and usefulness of the technique within product development practices.

TUESDAY

IH-9B106

08:45 – 12:15

Cloud-based design and manufacturing systems: A social network analysis

Dazhong Wu, Dirk Schaefer, David W. Rosen

Georgia Institute of Technology, United States of America

A Cloud-Based Design and Manufacturing (CBDM) System refers to an information and communication technology (ICT) system that facilitates design and manufacturing knowledge sharing between actors (e.g., CBDM service providers and consumers) in the distributed and collaborative socio-technical network. The aim of this study is to address the challenge of information sharing and technical communication during the CBDM product development process. Specifically, we model a CBDM system as a socio-technical network. The research questions are: (1) What measures can be used to analyze the socio-technical network generated by CBDM? (2) How to detect communities/clusters and key actors in the socio-technical network? To answer these questions, a social network analysis (SNA) approach is formulated to analyze the socio-technical network generated by CBDM systems. The results indicate that SNA allows for visualizing collaborative relationship patterns of actors as well as detecting the community structure of CBDM systems.

The communication patterns of engineers within an SME in 2012

James Anthony Gopsill[1], Hamish Charles McAlpine[1], Ben James Hicks[2]

[1]University of Bath, United Kingdom; [2]University of Bristol, United Kingdom

The communication patterns of engineers has been well researched over the past decades. However, due to the rise of new communication technologies and their speed of inception within society, it can be argued that this research could be less relevant to modern communication patterns of engineers. In addition, the engineers may have a preference on the communication technology used depending on the subject or purpose of the communication. Therefore, this paper discusses the results from an exploratory study that has investigated the communication patterns of engineers within an SME in 2012. The instances of communication, subject of communication and the purpose of communication were of particular focus. From this, a list of subjects and purposes for the communications was generated, which engineers were able to assign their communication to.

Measuring sharedness of mental models in architectural and engineering design teams

Reviewers' **Favourite**

Hernan Casakin[1], Petra Badke-Schaub[2]

[1]Ariel University, Israel; [2]Delft University of Technology, The Netherlands

The study presented in this paper investigates the development of sharedness of mental models in situations of design problem solving. A basic assumption is that sharedness of individual mental models is attained through verbal communication. Thus, the basic theoretical framework we developed is based on the classification of verbal communication occurring during the design process. The application of the theoretically based classification focuses on the dynamic development of mental models in heterogeneous design teams. The empirical study is based on observational data from a meeting of two design teams belonging to the engineering and architectural discipline. Whereas sharedness is supposed to be attained from the earlier phases of the design process, this might vary for design acts in which explicit coordination is still necessary. We explore coordination in both teams through two main phases of the design meetings.

Mediating engineering design team performance through conscientiousness and cognitive style

Kelly A. Sprehn, Gretchen A. Macht, Gul E. Kremer, David A. Nembhard

The Pennsylvania State University, United States of America

Within a design context, team dynamics affect final product design, speed of project completion, innovation, and quality level. Despite the criticality of team composition, the formation of teams based directly on scientific findings remains relatively rare. Psychology has highlighted individual personalities and intelligence as potential inputs for determining the level of team performance. Design teams, in particular, are often chosen ad hoc, with membership often based more on niche expertise than with regards to interpersonal interaction.

In this paper, we examine the link between conscientiousness as an aspect of human psychology and engineering design team performance with several cognitive style variables as potential mediating variables. Through regression modeling explored in the context of structural equation modeling (SEM), our model demonstrates a possible negative relationship between the object cognitive style deviation and team performance. This supports research claiming cognitive diversity as a detriment to team success. Finally, we explore the idea that cognitive style could be a mediating variable between conscientiousness and team performance.

Product Architectures and Platforms

Chair: Harrison Kim, University of Illinois at Urbana-Champaign, United States of America

Structural complexity: Quantification, validation and its systemic implications for engineered complex systems

Kaushik Sinha, Harun Omer, Olivier L. de Weck

Massachusetts Institute of Technology, United States of America

The complexity of today's highly engineered products is rooted in the interwoven architecture defined by its components and their interactions. Quantitative assessment of structural complexity is mandatory for characterization of engineered complex systems. In this paper, we develop a quantitative measure for structural complexity and illustrate its application to a real-world, complex engineered system. It is observed that low topological complexity implies centralized architecture and it increases as we march towards highly distributed architectures. We posit that the development cost increases super-linearly with structural complexity. Empirical evidences from literature and preliminary results from simple experiments strengthen our hypothesis. Preliminary experiments show that the effort increases super-linearly with increasing structural complexity (i.e., exponent, b = 1.69). We further introduce complicatedness as an observer-dependent property that links structural complexity to system level observables like the development cost. We further discuss distribution of complexity across the system architecture and its strategic implications for system development efforts.

Using PLM and trade-off curves to support set-based convergence of product platforms

Christoffer Levandowski, Anders Forslund, Hans Johannesson

Chalmers University of Technology, Sweden

Platforms may be used as an enabler for offering a variety of products to the market, while keeping the development cost down. Reusing design knowledge is a key concept of platforms, whether concerning reusing parts, ideas, concepts or technologies. In set-based design, trade-off and limit curves are an enabler to store knowledge about technologies developed earlier, and to highlight knowledge-and technology gaps.
This paper describes how trade-off curves derived from technology development may be used to incorporate technology knowledge in a product platform. The product used as an example is a Turbine Rear Structure of a jet engine.
Trade-off curves and a product platform based on the Configurable Component concept is implemented in a PLM architecture, integrating a Product Data Management system, a Computer Aided Design tool, two Computer Aided Engineering tools and a configurator. The analysis combines the trade-off and limit curves with CAE tools to create a comprehensive analysis of the set of possible solutions. The results are presented to the engineer as a means to aid in the convergence process through elimination of bad solutions from the set.

Towards the development of commonal product programs

Sandra Eilmus, Sebastian Ripperda, Dieter Krause

Hamburg University of Technology, Germany

Today many companies encounter the challenge of reducing internal variety by developing modular product families. Yet even more potential for reducing internal variety can be gained by even striving for carry-over across product families as industrial case studies showed. A holistic corporate product program strategy for reducing variety supports the identification and exploitation of this potential. How this strategy can be defined in specific corporate context is outlined in this paper. Based from the attributes of an ideal product program steps for definition of product structure strategies are proposed. The resulting development tasks need a deep understanding about a solution that suits corporate needs for differentiation and standardization best. This can be gained by analysis of tearing forces towards differentiation and standardization and comparison of possible solutions that enable commonality in different ways and by this have different effects. To support evaluation of these solutions a complexity cost estimation method is proposed complying with the lack of detailed information in the conceptual phase.

Extending product modeling methods for integrated product development

Martin Bonev, Michael Wörösch, Dagný Hauksdóttir, Lars Hvam

Technical University of Denmark, Denmark

Despite great efforts within the modeling domain, the majority of methods often address the uncommon design situation of an original product development. However, studies illustrate that development tasks are predominantly related to redesigning, improving, and extending already existing products. Updated design requirements have then to be made explicit and mapped against the existing product architecture. In this paper, existing methods are adapted and extended through linking updated requirements to suitable product models. By combining several established modeling techniques, such as the DSM and PVM methods, in a presented Product Requirement Development model some of the individual drawbacks of each method could be overcome. Based on the UML standard, the model enables the representation of complex hierarchical relationships in a generic product model. At the same time it uses matrix-based models to link and evaluate updated requirements to several levels of the product architecture and to illustrate how these requirements have an upstream (towards stakeholders) and downstream (towards production) effect on the product architecture.

Organisational Understanding of Product Development

Chair: Peter R.N. Childs, Imperial College London, United Kingdom

Current industrial practice of managing risks in product development project portfolios

Richard Weng[1,3], Josef Oehmen[1], Mohamed Ben-Daya[2], Gandolf Finke[3]

[1]Massachusetts Institute of Technology, United States of America; [2]King Fahd University of Petroleum and Minerals, Saudi Arabia; [3]ETH Zurich, Switzerland

Managing portfolios of development and engineering projects currently presents significant challenges to companies. This is even more the case in the management of portfolio risks, where both industry and academia currently lack a clear conceptual understanding of what portfolio risks are and what influences them.
The objective of this paper is two-fold: First, based on a literature review and industry focus group discussions, we introduce a new model for describing portfolio-level risks. It consists of three types of risks (escalated risks, common cause risks, and cascading risks) based on 9 types of interdependencies in PD project portfolios (Technology, Budget, Objectives and Requirements, Infrastructure and Equipment, Skillset and Human Resources, Process and Schedule, Supplier, Legal and Regulatory, and finally Market and Customer).
Second, we investigate how risk management on the portfolio level is currently executed in industry. The paper describes the results of a survey with n=43 participants, investigating the frequency and impact of portfolio risks, and the influence of the interdependencies on the portfolio risks.

The estimation of product-development project delay caused by imperfect communication in outsourcing

Gyesik Oh, Yoo S. Hong

Seoul National University, Republic of Korea (South Korea)

As competition in the market becomes fierce, companies are required to develop a new product within short duration. One of methods to accelerate the product development is concurrent engineering which allows overlapping interdependent development activities. However, the constraint of development capacity limits the number of development activities concurrently executed. In order to overcome the development resource limitation, companies outsource some of development activities. Due to culture and language differences and low media richness of communication channels, communication between the company and the outsourcing provider takes more time than that between in-house development teams. The different combinations of outsourcing activities result in different project duration since overall communication delay varies with the choice of outsourcing activities under complex product development architecture. We estimate the project duration in consideration of communication delay on overall project duration under concurrent engineering by simulating the product development process. The paper may help product development managers to estimate the project prolongation in outsourcing.

New key success factors for engineering technology transfer between research and development: Technology maturity and proof of usage

Iris de Fontaines[1,2], Didier Lefeuve[1], Guy Prudhomme[2], Michel Tollenaere[2]

[1]Eurocopter, France; [2]Institut Polytechnique de Grenoble - Université Joseph Fourier, France

Investment on Research and Technology (R&T) projects is a competitiveness key and contributes to study and develop innovative technologies. However, the success of the technology transfer between research and development projects is essential. In Eurocopter context, R&T projects are monitored thanks to the Technology Readiness Level (TRL) methodology. Developed by the NASA, it assesses the maturity of aircraft technology products in terms of efficiency, engineering, manufacturing and support means. The aim of this article is to enhance the technology transfer between research and development projects in the case of engineering technology product. Once developed, engineering products (DMU, PLM) are used by engineers during aircraft development programs. But how can teams manage with success the technology transfer of engineering products? In this paper, enrichments of current TRL methodology are proposed with a new key success factor: the proof of usage. The idea is to anticipate during R&T projects future usage of engineering technology products thanks to scenarios modeling. In this frame, a new approach is proposed and validated based on a Eurocopter case study.

Characterizing collaboration through online interactions within R&D communities

Marie Fraslin, Eric Blanco

Grenoble-INP, France

In global organisation, collaboration within distributed team is a crucial issue. Many companies are organizing communities of practice to improve experience sharing. These communities are mediated by collaborative platforms. Among collaborative functionalities, forum are expected to support distant asynchronous collaboration. But few studies show the effectiveness of this tool to support effective collaboration in the context of engineering design activity.

The paper study the interactions through forums of two Virtual communities of practices of experts within R&D teams of international company. A coding scheme is proposed to analyze and characterize the online interactions. Through these two case studies, we demonstrate that a forum can support asynchronous argumentative activities and thus enhance global collaboration in distributed R&D organizations. The proposed characterization of collaboration can be a step to dynamic evaluation team interaction.

Ecodesign and Sustainability

Chair: Tracy Bhamra, Loughborough University, United Kingdom

Using environmental segmentation to perform ecodesign with users

Reviewers' **Favourite**

Lucie Domingo[1], Francis Rasamoelina[2], Carole Bouchard[2], Daniel Brissaud[1], Améziane Aoussat[2]

[1]University of Grenoble, France; [2]Arts et Métiers Paritech, France

Market segmentation has been a crucial point for enhancing the success of new products. By grouping users with similar needs, manufacturers have been able to design products with much more appeal to a specific typology of users. Moreover, ecodesign process strives at developing products with lower impact on the environment. Actual ecodesigned products however do not completely fit with users needs.

This contribution proposes to use the segmentation approach to drive the process of product ecodesign. By differencing the users according to their sensitivity to environmental issues, this approach enables to design environmentally friendly products for a specific group. To this end, we intend to couple an existing segmentation definition for environmental policy with the Rokeach Values System. The result is a seven group representation of users with a specific set of values for each group that will allow developing products that match user needs with the environmental consciousness.

This segmentation and its benefits are applied to the adaptation of ecodesign strategies according to each users group. We illustrate our proposal with an application to the design of a coffee machine.

EcoM2 web portal: Collecting empirical data and supporting companies' ecodesign implementation and management

Daniela Pigosso[1], Tim C. McAloone[1], Henrique Rozenfeld[2]

[1]Technical University of Denmark, Denmark; [2]University of Sao Paulo, Brazil

Despite the recognition of the potential benefits of ecodesign, a promising approach to integrate environmental concerns into the product development process, its application has failed to reach large numbers of companies and sectors worldwide due to managerial difficulties. In response to that a comprehensive framework has been developed, with the aim of ensuring systematic management, implementation and continuous improvement of the ecodesign process. The framework, called Ecodesign Maturity Model (EcoM2), enables the diagnosis of the company's ecodesign maturity profile; the identification of strengths and limitations; and the establishment of strategic roadmaps for improved ecodesign implementation. This paper describes the development of the EcoM2 web portal, which will allow for the framework to be tested on greater numbers of companies and at the same time to provide a quick diagnosis of their current ecodesign maturity profile. Analyses of the collected data will allow the establishment of patterns on ecodesign implementation in regards to criteria such as sector and size of companies and the improvement of empirical knowledge on ecodesign implementation and best practices.

A concept for an intuitive and interactive fully PLM-integrated eco-efficiency assessment in real-time

Martin Eigner[1], Karl-Gerhard Faißt[1], Alexander Keßler[1], Patrick Schäfer[1], Peter Pickel[2], Fabienne Seibold[2]

[1]University of Kaiserslautern, Germany; [2]John Deere GmbH & Co.KG, Germany

To be competitive on the global market in a time of an increasing shortage of resources, companies have to develop not only good products but to make them also more sustainable. In the discourse on sustainable development, the potentials of product development are currently inadequately treated. Therefore, a holistic approach is required which accompanies the product from the initial idea, through the development phases and the entire lifecycle, to recycling or reuse. In this paper, a concept for intuitive and interactive eco-efficiency assessment is presented which also can be fully integrated in PLM solutions. It allows a prospective and holistic consideration of environmental factors. Also, this concept enables that the increased complexity due to environmental factors remains manageable and environmental potentials for a product can be identified and influenced early. Furthermore, an intuitive and innovative human-oriented visualization concept for an easy management and control of the appropriate required information is introduced. This new visualization concept makes the information included within today's PLM solutions accessible to a company's management level.

Communicating life cycle assessment results to design decision makers: Need for an information visualization approach

Praveen Uchil, Amaresh Chakrabarti

Indian Institute of Science, India

Most of the design interventions made in the pursuit of reducing the environmental impact of products, often merely results in shifting the burden from one environmental issue to another, rather than reducing the overall environmental impact. This necessitates the use of more quantitative, comprehensive, life cycle based approaches for eco design decision making. In this paper, it is argued that the complexity of the results of LCA due to their data intensiveness calls for a need for using information visualization approaches to enable interpret LCA results for eco-design decision making.The paper then argues for a support for communicating the results of LCA to various decision-makers in order to improve their chances of building better environment-friendly products.The proposed nove information visualizationl architecture is intended to serve as a basis for a better representation of LCA results and provide deeper insights into the results of LCA, thereby aiding design decision-makers to improve the chances of reducing the environmental impacts of product life cycles being designed.

Knowledge Based Design

Chair: Andy Dong, University of Sydney, Australia

Solution patterns to support the knowledge intensive design process of intelligent technical systems

Harald Anacker[1], Thomas Schierbaum[1], Roman Dumitrescu[2], Jürgen Gausemeier[1]

[1]Heinz Nixdorf Institute, Germany; [2]Fraunhofer Institute for Production Technology IPT, Germany

Recently, mechatronics as a self-contained discipline has undoubtedly shaped the development of technical systems. Mechatronics stands for the close interaction of mechanics, electronics, control engineering and software engineering. Due to the advancement of information and communication technologies, the functionality of mechatronic systems will go far beyond current standards. The increasing complexity requires a consistent comprehension of the tasks between all the developers involved. Especially during the early design phases, the communication and cooperation between the engineers is necessary to design a first overall system model. In addition, reusing of once successfully implemented solution knowledge is becoming increasingly important related to the overall context of the triangle of tension formed by time, cost and quality. Today the reuse is well established within the different disciplines. But usually, the sum of separate single solutions is rarely the best solution on a systems-level. This requires an approach, to support the knowledge intensive design process of intelligent technical systems by a new form of multidisciplinary abstract described solution patterns.

GINI index based attribute selection for product configurator design

Yue Wang, Mitchell Tseng

The Hong Kong University of Science and Technology, Hong Kong

Product configurator system is an important tool to bridge customer needs and company's offering. It has been widely accepted in industry to facilitate customized product design. However the efficiency of product configuring process has been a challenging issue, especially when the product is complicated. Current configuration systems often perform in a deterministic manner. They cannot adapt to each individual customer preferences by leveraging on the preferences information captured in previous configuration steps. This paper present a Gini index based attribute selection approach for configurator design. Product configuring is modeled as a sequential query-answer process. In each configuring step, Gini index is deployed to quantify the clarity of designer's belief about the customer's needs. The attribute which contributes most to the clarity will be select for the customer to configure. As a result, designers get clear about the customer's needs and preferences in an accelerated manner. An example is presented to test the viability of the method.

On design concept validation through prototyping: Challenges and opportunities

Soheil Arastehfar, Ying Liu, Wen Feng Lu

National University of Singapore, Singapore

Prototyping is widely used as a means to illustrate and exemplify design requirements and intents and interact with designers and users. This paper aims to review the role and function of prototyping particularly in design concept validation. It reveals that prototypes offer interactive communication of concepts where the sense and perception of design concept intended by users is of primary importance. Our review also illustrates the rising trend from a physical prototyping approach to a more digital or mixed prototyping means. Accordingly, product attributes, whose values are presented by a prototype in conceptual design, are categorized into two major groups, namely sensed attributes and experienced attributes. The values of sensed attributes are directly received by human physiological senses and the values of experienced attributes are perceived through man-product\service interaction. Finally, by summarizing many existing research efforts including the communication of attribute values, this paper presents several major challenges in design concept validation through prototyping. It opens up a discussion regarding potential opportunities associated in this direction.

Knowledge-based development: Introducing portfolio maps and product architecture as basis for implementation

Sören Ulonska[1], Torgeir Welo[1], Ulf Harlou[2]

[1]Norwegian University of Science and Technology, Norway; [2]Center for Product Customization, Denmark

Many companies experience that they use too many new-product development resources in (re-)developing products that are derivatives of previous ones. Product designs are sometimes uncritically copied into new projects and adjusted to match new requirements and needs. Since the products are not developed for reuse and improvement, unexpected modifications drive up the work load, leading to increased cost and lead time, and lower quality.

The standardization approach introduced in this paper uses the product architecture as a backbone for knowledge-based development, assuming that value is created within both the traditional product(ion) value stream and the knowledge value stream. Before applying this approach, however, it is necessary to (a) organize the product portfolio, (b) sharpen the product strategy and (c) establish a common product architecture. In this paper, the products of a case company have been analyzed, structured and modeled. The result is a product portfolio map, including variants on functional, physical and architectural levels-within and across modules. It provides a visual product model on system and module levels, including current and near-future variants.

Quantification of perceptual design attributes using a crowd

Yi Ren, Alex Burnap, Panos Papalambros

University of Michigan, United States of America

Crowdsourcing processes can be used for design concept creation and evaluation. They also provide opportunities to study and model quantitatively how humans deal with design problems. This paper explores the use of crowdsourcing to evaluate a perceptual design attribute and to create new design concepts using this attribute. As an example, we study how perceived automobile car safety can be modeled with respect to exterior car shape design using an efficient statistical learning algorithm. Experiments with subjects using Amazon's Mechanical Turk uncover several practical issues that must be addressed when applying machine learning methods to create safe-looking car designs using crowdsourced input.

A methodology for interoperability and information management in smart home environments

Alessandra Papetti, Margherita Peruzzini, Andrea Capitanelli, Michele Germani

Università Politecnica delle Marche, Italy

The environmental impact reduction and the growing world energy demand have generated a strong interest to smart home all over the world. Indeed, thanks to the recent developments in Information and Communication Technologies (ICT) and Internet of Things (IoT), it is possible to create smart home system by making several objects installed at home cooperate each other and offering new services to end users. However, smart home system design is not a trivial task: the increasing embedded intelligence of smart devices is generating a huge quantity of data, which needs to be properly structured and managed, and the related services must be designed and personalized according to the specific users' needs. This paper defines a methodology to support smart home system design and improve smart home information management by selection, aggregation and classification of relevant data, and their correlation to smart home services. The methodology implementation shows how it can support the design of services able to bring benefits to the subjects involved. It also represents the first step towards the creation of a standard by data management and device interoperability for smart home systems' design.

Open, Participatory and Collaborative Product Development

Chair: Thomas J. Howard, Technical University of Denmark, Denmark

Crowdsourcing in design research - Potentials & limitations

Soren Ingomar Petersen

ingomar&ingomar - consulting, United States of America

Crowdsourcing has by now proven itself particularly useful in the early phases of product design, outperforming traditional in-house R&D. However, little attention has been given to the application of crowdsourcing in design research where the cost and time of planning and executing studies, combined with inherent biases in selection of participants, unintentional priming of and inadvertent influence of subjects responses can ruin the outcome. Additionally, when unexpected and unexplainable findings occur, the value and validity of the study can be seriously undermined. Here lean, quick crowdsourcing experiments could aid in planning of conventional research or in some cases replacing these completely. We propose a Six Step Co-creation Cycle method and apply it to thirty projects with varying level of innovativeness. In doing so we uncover a range of pros, such as uncovering biases, collecting new knowledge and building a research network and cons, such as limited ability to synthesize ideas and the need to eliminating noise, of applying crowdsourcing in the early phases of design research.

Assumptions for incremental innovations in SMEs

Robert Watty

University of Applied Sciences Ulm, Germany

Innovation is an precondition for the success of companies in today's markets to differentiate from their competitors. Particularly 'radical' innovations are addressed in numerous research contributions, product contests and advertisements, although they are related to less than 10% of the innovations, carry a high risk of failure and often require a high investment in research and development.
Small and medium enterprises (SME) are often very successful in specialized market segments and with incremental innovations adapted to the needs of their customers. Prosperous product development in this context demands intense knowledge about the targeted market, competitive products and demanded objectives for new products as well as an appropriate development process starting.
This paper addresses the research question how to improve existing products in SMEs by incremental steps. It describes the context of radical and incremental product innovation, explains preconditions for the adoption of innovations, suggests an approach to systematically implement incremental product development in SMEs taken from Kaizen and describes a case study applying and verifying this approach in a SME.

Open innovation and idea generation in SMEs

Reviewers' **Favourite**

Silje Helene Aschehoug, Geir Ringen

Sintef Raufoss Manufacturing, Norway

Previous research in the field of open innovation is dominated by research on large and multinational corporations, research in the software industry, and in the consumer goods sector. However, few articles report on studies from small and medium-sized companies (SMEs) in the business to business (B2B) sector. This research gap is addressed by exploring how SMEs may engage in and organize inbound open innovation seminars most efficiently. The article outlines the results from an open innovation seminar conducted with basis in real-life challenges for a Norwegian SME. The results indicate such seminars may be an efficient and cost-effective way of providing SMEs ideas and information concerning new markets, new technologies, and new product ideas. Specific described and designed innovation challenges produced the highest quality ideas, based on the quality criteria novelty, usefulness, and feasibility. Factors such as personal motivation and capabilities, in addition to mutual trust and respect are believed to be important when organizing open innovation seminars as described in the article.

Three layers of openness in design: Examining the open paradigm in design research

Tanja Aitamurto[1], Dónal Holland[2], Sofia Hussain[3]

[1]Stanford University, United States of America; [2]Trinity College Dublin, Ireland; [3]Netlife Research, Norway

This article examines the open paradigm in design research and introduces a new conceptualization for 'open design' and a three-layer framework to demonstrate the degrees of openness in design practices. The conceptualization comprises all stages in the design process, ranging from need-finding to the openness of the design documents and the data gathered during the design process, and the commercialization of the end-product. The aspects of the product and the process merge in this framework, intertwining the aspects of technical, legal and commercial openness. Finally, the article proposes a research agenda for open design. The article builds on an extensive literature review about studies on 'open' in design: open-source software, open hardware, and participatory methods in design, such as co-design and participatory design, and user-engagement methods such as crowdsourcing and co-creation.

A unified approach for systematic and participatory design

Kentaro Watanabe, Tomohiro Fukuhara, Hiroyasu Miwa, Takuichi Nishimura

National Institute of Advanced Industrial Science and Technology, Japan

Engineering design has taken an important role in creating the industrial society. The systematic design approach which consists of the design methods and methodologies based on systematic models and processes is commonly applied in various design fields and industries.

Meanwhile, participatory design is another common design approach to explore the requirements of a product and its users' activities by participating in a user field based on the social science background. These two approaches have different disciplines and used to be separately studied, though they have a complementary relationship. To harmonize these two design approaches, it is necessary to understand their concepts, features and challenges, and to clarify the requisites to unify them.

In this paper, the authors introduce the systematic design methodologies and the participatory design approach based on the theoretical survey and explain their features and challenges. Then the authors suggest a possible way to unify both design approaches, propose a concept of integrated design approach named "User-driven Product/Activity Design (UPAD)" approach and discuss its effectiveness and uniqueness.

Collaborative product design and development for commercialization of invention

James Ah-Kat Tan

Ngee Ann Polytechnic, Singapore

In this paper, the framework and process of product design and development and commercialization of an invention are discussed. A method developed by the author, the 3P Approach (i.e. People-Product-Process), has been successfully used in design and development of innovative products. The 3P Approach connects the definition of people-centric and objective-driven design intent, identification of an ideal design direction and application of collaborative product design and development phases, in order to achieve an optimized design solution. In the paper, the author uses a case study to discuss the key concepts and methodology of the 3P Approach in the design and development of a patented product.

Types of Decision Making and Their Connections

Chairs: Julie Stal-Le Cardinal, Ecole Centrale Paris, France
Sandro Wartzack, University of Erlangen-Nürnberg, Germany

Goal of Workshop

The research activities contribute to the field of engineering design research especially in the development of methods, tools and methodologies supporting the decision maker or describing the decision making situation and their transfer into practice.
For the development of a roadmap with the goal of the adaptation of scientific approaches into the industrial practice, the idea was born to create a framework for the field of decision making. During the ICED13 workshop the following questions will be treated:

- What are the consequences of decision making processes and how are strategically decisions connected to engineering decision? How can this complexity of dependencies be described?
- How can different decision making situations be characterized and what are the key indicators for different decision making processes?
  Expected outcome of this workshop will be an understanding of types of decision making and their consequences, correlation and complexity. Based on the results of all periods the first layout of the Decision Making framework ("Rich picture"), will be created.

Abstract

The theme of the workshop will be "Types of decision making and their connections" and therefore the following topics will be treated:

- Consequences of decision making processes and their characterization
- Characterization of strategic and engineering decisions
- Correlation between of strategic decisions and engineering decisions
- Description of complexity of correlations between strategic decisions and engineering decisions. Are these connections unidirectional, bidirectional or multidirectional?
- Conflicts arising from these complexity of correlations

Workshop Agenda

Short oral presentations on research topics and enough time for discussion, SIG agenda planning, etc.

W

SIG Workshop: Design Theory

Discovering the Design Theory SIG

Chairs: Pascal Le Masson, Mines ParisTech, France
Yoram Reich, Tel-Aviv University, Israel
Eswaran Subrahmanian, Carnegie Mellon University, United States of America

TUESDAY

IH-9B312

10:45 – 12:15

Goal of Workshop

The general goal of the Design Theory (DT) SIG is to organize, collect and support research work that contributes to the renewal of Design theory by benefiting from new scientific advances, and by adapting it to highly innovative design situations.

Abstract

The DT workshop will deal with following four axes.

- Design theory, Mathematics and formalized models
- Design theory and new approaches of flexible structures of knowledge
- Theory-driven experiments:
- History of Design theories and contemporary context

Workshop Agenda

Single session presentations and discussions

Design Science: A Weltanschauung

Panos Papalambros

University of Michigan

Abstract

"Design" and "Science" are two words that have come together several times in the past, often with a certain degree of controversy. In this lecture we will trace some of this history and put forth a view of what is "Design Science" through specific examples of research work that can be classified as design science. We will also discuss what can be the role of the Design Society in propagating design science in research and pedagogy.

Bio-Sketch

Panos Y Papalambros is the Donald C. Graham Professor of Engineering, Professor of Mechanical Engineering; Architecture and Urban Planning; and Art and Design, at the University of Michigan. He holds a diploma in mechanical and electrical engineering from the National Technical University of Athens, and MS and PhD degrees in mechanical engineering from Stanford University. He conducts research in design science and systems design optimization, with applications to automotive systems and product design. He has co-authored the textbook Principles of Optimal Design: Modeling and Computation. He is a Fellow of ASME and SAE, and recipient of the JSME Systems and Design Achievement, ASME Design Automation, ASME Machine Design, and ASME Spira Outstanding Design Educator Awards. He serves as a member of the Design Society Board of Management.

Design for User Experience

Chair: Kee-Ok Kim, Sungkyunkwan University, Republic of Korea (South Korea)

Human-centric study of digital-paper transitions: Framing design opportunity spaces

Reviewers' **Favourite**

Euiyoung Kim[1], Victoria Stanton Kocsik[2], Cecile Eren Basnage[3], Alice Merner Agogino[4]

[1]UC Berkeley, United States of America; [2]UC Berkeley, United States of America; [3]UC Berkeley, United States of America; [4]UC Berkeley, United States of America

Although digital devices have their own unique features that differentiate them from other tangible types of resources for reading, writing and sketching, a majority of people still prefer traditional paper media as it provides better user experiences in many aspects: readability, portability, ease of making annotations, shared reading, tactile sensory experiences, etc. This paper identifies barriers and opportunities for paper-related features based on human-centric design research directed towards the overarching goal of providing insights for finding disruptive opportunity spaces. In framing our design research, we define journeys that tangible and digital media follow – from original form, transitions and final form. Our target populations are college students and professionals in diverse majors and work environments. Based on insights from our design research, we present personas and case studies.

The database of motion constructed by focusing on mimetic words—For designing a creative and emotional motion

Yohei Koguchi, Kaori Yamada, Toshiharu Taura

Kobe University, Japan

We have been developing a method to design a creative and emotional 'motion' that may resonate with deep feelings that are difficult to describe verbally. In our previous study, we proposed a method to design a 'motion' by blending 'base motions' from a database wherein motions were related to corresponding 'mimetic words'. Mimetic words may express motion and phenomena that are difficult to describe verbally. In this study, we attempt to investigate how people perceive the impressions of base motions using mimetic words; further, we attempt to validate the use of mimetic words. Experiment 1 was conducted to examine generalities in the process of relating mimetic words to base motions. Experiment 2 was conducted to examine generalities for evaluating the appropriateness of expressing each base motion by using related mimetic words. Results indicated that there is a tendency for subjects to perceive impressions from mimetic words while viewing base motions.

A theory of affective experience

Rohan Lulham

University of Technology Sydney, Australia

Theory that informs and invigorates designers in how to think about, research and understand human experience is increasingly important to the development of the field of design(Demir, Desmet & Hekkert 2009). In this paper I seek to contribute to the discourse in this area by presenting Affect Control Theory(Heise 1979, 2006) as an explanatory theory with substantial utility to the area of affect, emotion and design. Affect Control Theory is a theory of social interaction that suggests our desire to maintain affective meanings about the world is central to explaining and understanding how we feel, what we do and the emotions we communicate in social situations. In this paper I describe the Affect Control Theory framework and then start to open up its potential for research, practice and understanding in design. I suggest the theory's key premises of impression formation and affective control, coupled with the freely simulation program Interact, could be the basis of exciting developments to the area of affect, emotion and design.

Chair: Michael Schabacker, Otto-von-Guericke University Magdeburg, Germany

A bibliometric analysis of the DESIGN 2012 conference

Philip Cash[1], Stanko Škec[2], Mario Štorga[2]

[1]Technical University of Denmark, Denmark; [2]University of Zagreb, Croatia

Bibliometric analyses play an important role in reflecting on a research field and identifying areas of strength and weakness. This paper builds on recent reflective efforts within the community by presenting a bibliometric analysis of the DESIGN 2012 conference. Over 2700 citations were identified, classified and grouped in order to describe citation trends by field, type of work and distribution. Based on this multifaceted analysis three key conclusions are drawn. First, the uptake and impact of work from fields other than design is unexpectedly low given the research themes within the design research community. Second, where other fields are cited there is little focus, suggesting that citation and uptake of key principals is generally ineffective and is not then subsequently incorporated into the design research corpus. Finally, we conclude that it is critical that a concerted effort be made by the community as well as individual authors to consider the wider scope of work from related fields, and that this learning is incorporated into the design research corpus in a coherent and focused manner.

Structuring the process of design research - A necessary step towards ensuring scientific rigor

Imre Horvath[1], Els Du Bois[1,2]

[1]Delft University of Technology, The Netherlands; [2]University of Antwerp, Belgium

Almost every researcher is aware of less successful or even failed Ph.D. research projects or contracted industrial research projects. In most of these cases, there are methodological, structural and procedural reasons in the background. In this paper I argue that research projects need to be decomposed into procedural units and these procedural units should be complete from a methodological as well as from an epistemological point of view. The concept of research cycle has been considered as a practical manifestation of these procedural units. A research cycle comprises a part in which intelligence for generating a new theory is attained and a part in which the new theory is scrutinized by applying critical thinking. These parts can be transformed into a sequence of stages, having their own objectives. The activity elements of these stages are explained in the paper. The proposed approach enhances objectivity, reproducibility, rational scrutiny, empirical testability, reliability of theories, as well as justification and validity. The benefits of applying this approach have been observed in more than ten Ph.D. research projects and twenty graduation projects so far.

Action research in practice

Romain Farel

Ecole Centrale Paris, France

Action research might be one of the best strategies to undertake a PhD research on design. This method has been increasingly promoted recently within the design community in different fields such as human behavior, communication, new product development, etc. However, few researchers tempted to put themselves in the loop for exploring the design process. This paper provides a descriptive account of action research employed for studying the design process of user-centered new product development during a PhD research, and summarizes our main observations and return on experiment: 1) There are two distinct patterns for design and research in practice, 2) Transaction paths among action research steps are non negligible and need formalization, 3) Analysis should be added to the main steps, to take input from observation and to provide results for the reflection.

Market and Business Implications

Chair: Glenn Ballard, University of California Berkeley, United States of America

Criteria for selection of design management indicators in product development companies

Paulo Roberto Nicoletti Dziobczenski[1], Mauricio Bernardes[2], Keiichi Sato[3]

[1]University of Caxias do Sul, Brazil; [2]Federal University of Rio Grande do Sul, Brazil; [3]Illinois Institute of Technology , United States of America

The role of design in business has changed with the rapidly growing number of products and services available. Design management has emerged as a way of formally establishing design in organizations. This research was developed in this scenario in an attempt to contribute to discussions in the field of design management, by focusing on the selection of performance indicators to be applied to design management. The research consisted of case studies of three companies situated in (CITY, COUNTRY). In order to understand the criteria used to select the indicators, members of the product development department of each company were interviewed. The main contribution to the academic and professional field is the criteria for selecting indicators for design management. Conclusions pointed out that companies from different sectors of the economy select indicators that provide (a) customer feedback about the products launched in the market and evidence both their (b) team productivity and their (c) relationship with competitors.

Business model mining: Analyzing a firm's business model with text mining of annual report

Jihwan Lee, Yoo S. Hong

Seoul National University, Republic of Korea (South Korea)

As the business model is receiving considerable attention these days, the ability to collect business model related information has become essential requirement for a company. The annual report is one of the most important external documents which contain crucial information about the company's business model. Investigation of business description and their future strategies within the annual report, we can easily analyze a company's business model. However given sheer volume of the data, which is usually over a hundred pages, it is not practical to depend only on human's effort. The purpose of this study is to complement manual extraction process by using text mining techniques. In this study, the text mining technique is applied in (1) business model concept extraction and (2) business model evolution analysis. By concept, we mean overview of a company's business model within a specific year, and, by evolution, we mean temporal change of the business model concept over time. The efficiency and effectiveness of our methodology is illustrated by a case example of three companies in U.S. video rental industry.

Design based entrepreneurship

Louise Møller Nielsen[1], Anders Wikström[2], Christian Tollestrup[1]

[1]Aalborg University, Denmark; [2]Mälardalen University, Sweden

Designers are often recognized as natural entrepreneurs, due to their creative skills and competences in the idea-generation and product development processes. A number of studies shows that creative professionals are more likely to become self-employed. In general though, there are not many studies on design entrepreneurs, and those who has been made, focus on design entrepreneurs' lack business competences in administration, marketing and operation, as well as their lack of skills and priority, when it comes to the development of their businesses.

This study will nuance this picture of the design entrepreneur by building upon a new direction within entrepreneurial research, which focuses on entrepreneurial expertise and logic. At a theoretical level, we will show that there are some overlap between the expert entrepreneurial logic (effectuation) and the 'designerly ways of knowing and doing'.

We review three cases with novice design entrepreneurs, where we have been able to identify examples of the novice design entrepreneurs using 'effectual logic'. The examples are described and analysed using Sarasvathys 5 principles, showing that 3 of 5 principles are found in the cases.

Chair: Katja Hölttä-Otto, Singapore University of Design and Technology, Singapore

Fighting poverty through design: Comparing design processes for the base and the top of the world income pyramid

Reviewers' **Favourite**

Santosh Jagtap[1], Andreas Larsson[1], Viktor Hiort[2], Elin Olander[1], Anders Warell[1], Pramod Khadilkar[3]

[1]Lund University, Sweden; [2]Chalmers University of Technology, Sweden; [3]Indian Institute of Science, India

The base (BOP) and the top (TOP) of the world income pyramid represent the poor people and the people from developed countries, respectively. About two-fifths of the world population can be categorized as poor. Poverty is a trap because children born to poor parents are likely to grow up to be poor adults. In recent years, a poverty reduction approach that combines business development with poverty alleviation has received attention. The design of products for the BOP is an important ingredient of this poverty reduction approach. While companies are beginning to address the product needs of the BOP, there is limited practical and theoretical knowledge to support them. The current understanding of the design for the BOP is limited. This study, using a protocol analysis, compared the design processes for the BOP and TOP markets. The results indicate the differences between the design processes for these markets in terms of the design strategy employed by the designers (i.e. problem driven, solution driven strategy), their requirements handling behaviour, and their information behaviour. We have discussed the implications of the findings for design practice and education.

Design and testing of a new medical rail-adapter product

Xiaolong Wu, Young Mi Choi

Georgia Institute of Technology, United States of America

Injuries caused by medical device use errors were much more common than injuries resulting from medical device failures. There are many factors that contribute to device use errors such as device complexity or disorganization of the devices themselves. Rail-adapter systems are one way of helping to improve the organization and management of medical equipment. This paper discusses the current state of rail-adapter systems and the development of a new rail-adapter product based on issues in existing products. The performance of the new rail adapter is tested against other products to investigate whether the design updates contribute to real improvements in performance and efficiency for healthcare workers.

Development of a design process to design for people with dementia and their extended care network - Learning from a case study

Rens Brankaert, Elke den Ouden

Eindhoven University of Technology, The Netherlands

In Europe we face an aging society with a growing number of people suffering from dementia. This challenge we face as a society, because current healthcare systems are not ready for such an increase.

In this paper we propose a new design process to find new opportunity areas using an interactive experience flow based on the dementia care chain. This overview is based on multiple perspectives in the care chain, and reflects the different experiences people have in the process.

Design for dementia is difficult as user-driven techniques are challenging to apply with the impaired user group, surrounded by an extended network. The methodology proposed shows how we can include the shared perspective of all the people involved (including users). And in this way develop a design proposition together iteratively.

In the case study, about the design of a physical activity reminder, the methodology is illustrated and explored. It shows the overall design process is promising, arguing to use the methodology for future design projects as well. Eventually we aim to improve the quality of life for people living with dementia and keep them at home longer to unburden healthcare systems.

Challenges in Design Education

Chair: Johan Lars Malmqvist, Chalmers University of Technology, Sweden

Concept development for innovative products - A challenge for engineering design education

Thomas Luft, Benjamin Schleich, Sandro Wartzack

FAU Erlangen-Nuremberg, Germany

The complexity of new products steadily increases and therefore integrated engineering designers have to be skilled in various fields in order to develop innovative and successful products. This trend has to be considered in university education. Therefore, a new educational concept called "Concept Development for Innovative Products" (CIP) is proposed. In this subject the students are confronted with a vague task and are asked to develop and to present concepts for innovative products in teams of five. In this regard, CIP is a combination of three forms of teaching, which are presenting the working progress, discussing and lectures on demand. During mandatory working meetings the students have to present the project status to the supervisors and discuss the next steps with them. Furthermore, they can ask for lectures on specific engineering design methods which are presented using a comprehensive method catalog. The student feedback for CIP in the first semester was excellent and it is a very good enhancement for the curriculum. Consequently, the students are well prepared for a harmonic transition from university to their professional careers.

Enriching requirement-activities in design through French-US instruction comparison

Guy Prudhomme[2], Franck Pourroy[2], Joshua David Summers[1], Jean-François Boujut[2]

[1]Clemson University, United States of America; [2]University of Grenoble, France

Engineering requirements are taught through different approaches in US and French universities. In the globalization of engineering product development, these different approaches can introduce semantic challenges among the engineers. If the academic institutions are to educate future engineers for this global environment, then it is the responsibility of the institutions to begin to develop a shared, global understanding of central engineering issues, such as requirements and associated activities. This paper seeks to begin to reconcile and enrich these approaches by examining the activities that are supported through the steps and tools of each approach. Through this, it is found that there are opportunities for improvement in each, such by introducing (1) a requirement spreadsheet to the Grenoble approach for detailing meta-information and (2) the interactors graph to the Clemson approach to help guide engineers in discovering interaction centric requirements. Several other extensions and integrations are suggested to begin to develop a richer global approach, but a deeper study remains to justify and implement this integration.

Tracking productivity patterns in an engineering design project

Anders Berglund, Johannes Blackne, Niklas Jansson, Sofia Ritzén

KTH Royal Institute of Technology, Sweden

This paper aims to analyze if self-evaluation of perceived productivity could help detect alarming patterns in time and stop projects from failing. The study is based on descriptive quantitative data that has been gathered continuously throughout a student engineering design project, highlighting three factors of influence; perceived productivity, perception of stage completion and work activity distribution. The productivity data was analyzed by detecting patterns in form of peaks or lows and combining the patterns with qualitative data from observations and documented work activities. Measurements were done on 33 occasions during the project where 280 individual answers for productivity (P) and completion (C) and 115 individual answers for work activity distribution were collected. The findings provide extraction of peak values and low values that enable tracking of critical incidents. Through an in-depth activity back-log each value was enriched with an understanding of what took place and its project consequences. Over time the recognized pattern helped the design team to become more proactive in activity precision and execution, resource allocation and process reflections.

Reflections on the challenge of developing professional engineering designers and engineering design technologists – A New Zealand perspective

Antony John Robotham, John Kenneth Raine, Roy Jonathan Nates, David Edward White

Auckland University of Technology, New Zealand

This discussion paper reflects upon the 100+ years of experience of the authors in delivering tertiary level education to engineering designers. It compares the teaching approach taken for professional engineers and engineering technologists and promotes the need for T-shaped designers. The merits of a project-led approach to engineering design is discussed and an outline for an inter-disciplinary Masters level programme is considered. The discussion combines the reflections of the authors with some of the latest research into design education.

SIG Workshop: Collaborative Design

Meeting Industry Requirements through Research

Chairs: Ian Whitfield, University of Strathclyde, United Kingdom
Avril Thomson, University of Strathclyde, United Kingdom

Goal of Workshop

To identify and discuss the Collaborative Design requirements of industry and discuss how academic research can best meet these needs. This workshop is in response to a prioritised proposal for future events from the DESIGN'12 conference.

Abstract

Two industry case studies of Collaborative Design in industry will be presented. These have not yet been confirmed, but are likely to be one from a world-leading defense contractor BAE Systems Maritime – Naval Ships. This case study will focus on how a defense contractor collaborates with its supply chain in the development of engineering-to-order products. The other case study will focus on collaboration within Small and Medium sized Enterprises (SMEs). Hulley and Kirkwood consulting engineers are one of the UK's leading mechanical and electrical design consultancies.

Break out groups of approximately six members will then discuss their own experiences with industry and address the question of:

- How can academic research best meet the collaborative design requirements of industry?
  Break out groups will then come back together to discuss their findings and draw a conclusion.

Workshop Agenda

The workshop will follow the format of two short presentations followed by break out group discussions
Draft Schedule:

Schedule:

- 5 minute intro to the Collaborative Design SIG and workshop agenda
- 2 x 15 mins Industrial case study presentations highlighting the nature and challenges associated with collaborative design. Potential presentations from BAE Systems Maritime – Naval Ships and Hulley & Kirkwood Consulting Engineers Ltd
- 25 mins Break out groups to discuss the question:
- How can academic research best meet the collaborative design requirements of industry?
- 20 mins for each break out group to report findings back to wider group
- 10 mins summary and conclusions

Design Society General Meeting

Chair: Chris McMahon, University of Bristol, United Kingdom

Long Form

The Design Society holds its General Meetings every two years during the ICED conferences. At these Meetings the activities of the Society are presented, discussed and, if required, voted upon, and it is at General Meetings that the results of elections to the Society's Board of Management and Advisory Board are announced and ratified. The Agenda will include reports on the membership and financial status of the Society, on the activities that have taken place since the last meeting in Copenhagen and on plans for future development. All members of the Society are very strongly encouraged to attend the Meeting if they possibly can. Any member who is unable to attend the Meeting may, by informing the President in writing, constitute another member participating in the Meeting as proxy. Please leave any notice of proxy at the Design Society stand or contact the President by email at president@designsociety.org

Short Form

The Design Society General Meeting is a meeting of all members of the Society at which the activities and financial reports of the Society are presented, discussed and, if required, voted upon. All members of the Society are very strongly encouraged to attend the Meeting.

Young Members Event

Chair: Kristina Shea, ETH Zurich, Switzerland

TUESDAY

International Conference Hall (AH-10501)

18:00 – 20:00

Design Society Event for Young People: The Future of Design - Desiging the Future

This event will comprise a series of dynamic, short talks by young members giving their visions of design, with the aims of setting new or challenging established views of design within the community! It will be an opportunity to share opinions and exchange ideas on vital design community topics, and to meet international young people working in design research and practice. The talks will be followed by a Reception.

Aims

- Set new or challenge established views of design within the community!
- Share opinions and exchange ideas on vital design community topics!
- Meet international young people working in design research and practice!

Speakers

Speakers include participants of the ICED13 conference and the local design, engineering and business community such as Masters students, PhD students, Post Docs and other young people, i.e. up to and including seven years from their last degree. Total 10 speakers will give dynamic, short talks (7 min), and their talks will cover the following points:

- What is design for you?
- What is your vision for the future of design?
- What is your coolest project (past / current / future dream project) that illustrates this vision?
- How will your vision contribute to the future of design research and/or practice?

Jaewoo Joo

Republic of Korea (South Korea)

Talk Title:
Behavioral Economics for Design

Cassandra Telenko

Singapore

Talk Title:
Expect the Unexpected

Ilhoon Roh

Republic of Korea (South Korea)

Talk Title:
Replicating Nature's Design

Soodeh Montazeri

United States of America

Talk Title:
Design with Intent: An Effort to Design a Better World

Paul Egan

United States of America

Talk Title:
Designing Complex Biological Systems in the Human Body

Diana Schneider

Belgium

Talk Title:
Designing Future Privacy in Technology

Hao Wu

United Kingdom

Talk Title:
How Can 6 Billion Designers Work Together?

Andrea Luigi Guerra

France

Talk Title:
Design: The Ability of Making Dreams Come True

Diana Moreno

United States of America

Talk Title:
Design Common-Unity: Transformational Design for Life, for Living and for Others' Better Living

Rachel Kuhr

United States of America

Talk Title:
How Can We Learn from the "Other" 90% of the World?

	P Podium Sessions				D Discussion Sessions		W Workshop Sessions		
08:45 - 10:15	Design for Emotions Location: IH-90110	Green Considerations in Product Development Location: IH-90104	Management of Innovation and Complexity - 1 Location: IH-9B218	Enhancing System Values Location: IH-9B118	Modelling Processes in Product Development Location: IH-9B320	Design Information, Knowledge and Collaboration Location: IH-9B321	SIG Workshop: The Structural Repository – Improved Research on System Structures Location: IH-90109	SIG Workshop: Design Risk Whitepaper and Edited Book Location: IH-9B106	Tutorial-Style Workshop: Robust Design 1 Location: IH-9B208
10:15 - 10:45	Break Location: IH-90101								
10:45 - 12:15	Product-Service Systems - 1 Location: IH-90110	Modelling of Systems Location: IH-90104	Management of Innovation and Complexity - 2 Location: IH-9B218	Knowledge Intensive Design Location: IH-9B118	Early Design Phases Location: IH-9B320	Requirements Engineering Location: IH-9B321	SIG Workshop: Collaborative Design - PhD Student Forum Location: IH-90109		
12:20 - 13:20	DS AB Members Meeting Location: Conference Room 1 (AH-10305)				Lunch Location: Cafeteria (AH-1B102) & International Conference Hall (AH-10501)				
13:30 - 14:00	Keynote: What is Missing in My Recipe? Location: New Millennium Auditorium (AH-1B201) Speaker: Ji-Hye Park, Kwamecorp, United Kingdom								
14:15 - 15:45	Characterising Product-Service Systems Location: IH-90110	DfX Challenges and Solutions Location: IH-90104	Design Methods for Concept Design and Collaboration Location: IH-9B218	Product Planning and Requirements Clarification Location: IH-9B118	Creativity and Bio-Inspiration Location: IH-9B320	Design Theory and Methods Location: IH-9B321	SIG Workshop: Human Behavior in Design - Focusing Eye Tracking and Raw Data Location: IH-90109	Tutorial-Style Workshop: Additive Manufacturing - 3D Printing Processes, Applications, and Design Considerations Location: IH-9B106	Tutorial-Style Workshop: Robust Design 2 Location: IH-9B208
15:45 - 16:15	Break Location: IH-90101								
16:15 - 17:30	Product-Service Systems - 2 Location: IH-90110	Supporting Tools Location: IH-90104	Sharing and Disseminating Engineering Knowledge and Information Location: IH-9B218	Supporting Design With Computational and Analogical Reasoning Location: IH-9B118	Interactive Supports Location: IH-9B320	Theory Supported Modelling Location: IH-9B321			
17:30 - 18:30	Short Palace Tour Location: Gyeongbokgung Palace								
18:30 - 22:00	Conference Banquet Location: Millennium Seoul Hilton Hotel								

Design for Emotions

Chair: Yukari Nagai, Japan Advanced Institute of Science and Technology, Japan

On products shapes and personalities

Pablo Andrés Prieto[1], Gualtiero Fantoni[2], Riccardo Campolmi[2]

[1]Universidad Técnica Federico Santa María, Chile; [2]University of Pisa, Italy.

In this paper, preliminary results of the first stage of a long-term research that aims at systematizing the task of product design with an intended personality are reported. A survey was conducted to detect whether there is a correlation between product shapes and personalities. In the survey people were asked to associate personalities to shapes of different types of products. The data collected from the survey were analyzed using multivariate statistical techniques and the results obtained from correlation analysis between shapes and personalities are presented. At this stage, among the different aspects of the product appearance, the focus of the survey was on the shape of the product, as it is one of its most relevant features. The aim of this stage is to detect whether a high correlation exists between product shapes and product personalities. At the next stage if such correlation exists, the numerical description of the shape will be analyzed to identify common geometrical features of products sharing the same personality. This information can later be used as input for developing a new CAD system to assist designers to develop new products with embedded personalities.

Evaluating appearance-related product prototypes with various facial characteristics

Cheng-Hung Lo[1], I-Jan Wang[2], Szu-Hao Huang[2], Chih-Hsing Chu[2]

[1]Chang Gung University, Taiwan; [2]National Tsing Hua University, Taiwan

Design prototype evaluation is a key process in new product development. The characteristics of the product users are as important as the design features for products that might alter the appearances of these users. This paper proposes a product evaluation scheme that integrates design features and user facial characteristics in one evaluation process. We implement an experimental scheme to evaluate the design prototype of glasses frames. 3D scanning technology is applied to capture the facial features of users and reconstruct realistic 3D face models. Those allow us to post-process individual facial feature without changing the others. In the experiment, the subjects response on three affective measures related to personality attributes: confidence, friendliness, and attractiveness, signified by the faces wearing the factorized glasses frames. The results show that changing certain design features indeed influences the impressions of the faces with varied facial characteristics. The proposed scheme can be employed to facilitate the design of products related to personal appearance.

Exploring online reviews for user experience modeling

Yan Liang, Ying Liu, Han Tong Loh

National University of Singapore, Singapore

In the market-driven design paradigm which aims to serve customers with attractive user experience (UX), one of the important stages is to understand customer's feelings about products. Traditional techniques like questionnaire remain important approaches to collect data for UX analysis. However, the data captured are often limited and incremental costs are needed to acquire user's changeable experiences over time. In addition, with the wide use of social software, customers have generated increasing amount of online reviews to share their opinions. In this paper, we aim to investigate whether online reviews are suitable data sources for UX analysis and how useful reviews can be surfaced. Firstly, by considering UX elements and data processing, a faceted-based UX model is proposed. We then measure review content from several aspects, such as richness and diversity, and propose scoring methods to identify useful reviews. Using Amazon reviews as research data, we have reported our experiments on issues like a brief example of useful reviews suggested by the proposed methods, situation-based features concerned by customers and some key product features generated from reviews.

Differentiating positive emotions elicited by products: An exploration of perceived differences between 25 positive emotions by users and designersoration of perceived differences between 25 positive emotions by users and designers

Juan Carlos Ortíz Nicolás[1], Marco Aurisicchio[1], Pieter M.A. Desmet[2]

[1]Imperial College London, United Kingdom; [2]Delft University of Technology, The Netherlands

This paper reports semi-qualitative research on emotions from the perspective of users and designers. Twenty-five positive emotions were ranked regarding four relevant issues for product design: frequency of experience, preference for experience, preference for elicitation, and difficulty in elicitation. Based on the results from this research the emotions that users frequently experience and prefer are: satisfaction, inspiration, confidence, joy, amusement, and relaxed. These emotions ranked high also among those that designers prefer to elicit. Emotions that are infrequently experienced and not preferred by both users and designers are: lust and worship. In relation to the difficulty of eliciting positive emotions through durable products, the conclusion is that it is a challenging task and little knowledge exists to support designers. The knowledge developed through this project is expected to be useful for designers and researchers to understand the role of positive emotions in product design.

Green Considerations in Product Development

Chair: Tim C. McAloone, Technical University of Denmark - Technical University of Denmark, Denmark

Implementing scenario to better address the use phase in product ecodesign

Lucie Domingo[1], Daniel Brissaud[1], Fabrice Mathieux[1,2]

[1]Laboratory G-SCOP, France; [2]European Commission - Joint Research Centre, Italy

Some product categories, like electro-domestics, generate most of their environmental impact during use phase. Yet, the integration of this product life-cycle stage has been a challenge for ecodesign.
Scenario is a formalism that has been used for a long time for integration of the use phase characteristics, in term of actors, actions, and context, into product development process.
This paper presents an adaptation of the scenario formalism that can be used for ecodesign. Our proposal for implementing scenario into the ecodesign process is based on the separation of the use phase into seven "moments" that will cover product lifecycle from installation (ending of the distribution phase) to decommissioning (beginning of end of life phase). The scenario will be used first to evaluate the environmental impacts. Based on this evaluation of the use phase moments, examples of the most efficient ecodesign strategies are presented.
A case study on refrigerator used in Brazil was conducted to illustrate the implementation of scenario for ecodesigning product use phase.

Eco-design guidelines and eco-knowledge integration in product development process

Marta Rossi, Michele Germani, Marco Mandolini, Marco Marconi, Maura Mengoni, Alessandro Morbidoni

Università Politecnica delle Marche, Italy

The product eco-sustainability is recognized as a key factor for competitive products and recently lots of international directives (guidelines) have been issued. This paper aims to define a new methodology integrated in the product development process that, through the application of the most common eco-design guidelines and design past experiences, supports designers in the development of eco-sustainable products. Eco-design guidelines retrieved from the literature are subdivided according to a well-organized structure in "high level of abstraction" and "high level of detail" ones. In addition,
Eco-knowledge is defined as all the choices and their related environmental performances, designers made during the design process of a product.
The implementation of the proposed methodology in the product development process of an Italian cooker hood producer, allows to analyze the benefits achievable in terms of product eco-sustainability improvement. This analysis highlights that the proposed approach supports the implementation of eco-design principles, also in those companies without a specific background in eco-design.

Design for lifecycle profit with a simultaneous consideration of initial manufacturing and end-of-life remanufacturing

Reviewers' **Favourite**

Minjung Kwak[1], Harrison Kim[2]

[1]Soongsil University, Korea; [2]University of Illinois at Urbana-Champaign, United States of America

Remanufacturing is emerging as a promising solution for achieving green, profitable businesses. This paper considers a manufacturer that produces new products and also remanufactures products that become available at the end of their lifecycle. For such a manufacturer, design decisions determine both the initial profit from manufacturing and future profit from remanufacturing. To maximize the total profit, design decisions must carefully consider both manufacturing and end-of-life stages together. To help in the lifecycle design, this paper proposes a mathematical model using mixed integer programming. With an aim to maximize the total lifecycle profit (i.e., the sum of the profits from initial manufacturing and end-of-life remanufacturing), the proposed model identifies an optimal product design (i.e., design specifications and the selling price) for the new and remanufactured products. It optimizes both the initial design and design upgrades at the end-of-life stage and also provides corresponding production strategies. To illustrate, the developed model is demonstrated with an example of a desktop computer.

Do user driven innovation and ecodesign enrich or fight one another, and does sufficient methodologies for combining the two exist?

Mathies Herskind, Kristian Sidelmann

Technical University of Denmark, Denmark

This paper is a theoretical investigation and case study of the presently highly debated and much referenced terms 'ecodesign' and 'user driven innovation', with the aim of illuminating the juxtaposition of the two terms. The terms are briefly described, addressed further through a number of cases and discussed with regards to how they correlate to each other. In order to illustrate the area assumptions of the underlying design methodologies have been made. A possible connection between the two is established and the areas in which they collide are illuminated. It is shown how scripting can be utilized to help establish the intended product usage. Both by providing information to the users for them to act in a reasoned fashion and by behavioural steering that guides the users to act in a sustainable desirable manner without necessarily having to make a conscious decision regarding the matter. Finally it is proposed that the current set of methodologies of combining the two are insufficient, and that new methodologies would be beneficial for future product development

Management of Innovation and Complexity - 1

Chair: Steven Eppinger, Massachusetts Institute of Technology, United States of America

Modeling engineering interfaces in collaborative activities: A transactional model

Bertrand Nicquevert[1,2], Jean-François Boujut[2]

[1]CERN, Switzerland; [2]G-SCOP, France

In large projects such as the ATLAS detector at CERN, the complexity of organizational and decision making structures may endanger a safe management of such projects. An analysis of the ATLAS organization was conducted during several years. A map of the decision making structure of one of its sub-projects is presented in the paper. It shows that the so-called technical manager, a middle manager (most of the times an engineer) is in a position of interface and has to deal with complex socio-economic-technical problems. This paper proposes an interface model that aims to grasp the complexity of engineering management situations. Based on hologramic and recursive principles of complexity, a transactional model of the interface is proposed with the types of interfaces that derive from it. Nine types of translations are described together with six types of inward and outward transactions, as well as the exchange spaces established through the interface actor. This model is illustrated through the case study of the project introduced at the beginning of the paper. The conclusion opens towards the pooling of bilateral exchange spaces to the set up trading zones.

Building agile design teams

Matteo Vignoli[1], Gabriele Ferioli[2], Martin Steinert[3]

[1]University of Modena and Reggio Emilia, Italy; [2]University of Modena and Reggio Emilia, Italy; [3]Norwegian University of Science and Technology, Norway

One of the most common problem in many organizations that have reached considerable dimension and complexity is the lack of communication and collaboration between the different departments. When considering companies producing highly engineered and complex products the design communication problems can lead to cost overruns, schedule slippage, and quality problems.
Using a structured multi matrix approach to analyze the existing project component staffing and team interaction we are able to identify firstly understaffed critical components interfaces, secondly instances of missing critical team interfaces and, last but not least, thirdly we are able to generate an improved team member allocation, to build an agile design team.
To demonstrate the model's practical utility we discuss a case study of a company operating in the automotive sector.

A multiple case study of small business upstream supply chain uncertainties in rapid productization

Kai Hänninen, Matti Muhos, Harri Haapasalo

University of Oulu, Finland

This study aims at highlighting the use of upstream supply chain in Rapid Productization (RP) by analyzing upstream supply chain practices in small firms. RP is a process of quickly supplementing a company's product or service offering to meet unexpected customer needs.
A well-managed upstream supply chain network is a critical facilitator of RP for a small business. Selection of an upstream supplier during an RP process escalates the level of risk in fulfilling customer's needs. To avoid the mistakes resulting from the selection of the supplier, the company should use a smaller variety of suppliers and choose products that the suppliers know they can fulfill. Due to the nature of RP use, established supplier network resources are recommended. We also find evidence that a company's performance is positively associated with the use of RP.
This study contributes to the research domain of professional supply chain and product/service development by applying the development-as-practice approach to the study of practices that are resorted to by the company's management as well as sales, supply chain and R&D managers.

The impact of complexity on manufacturing performance: A case study of the screwdriver product family

Kijung Park, Gul Kremer

Penn State University, United States of America

Although many publications have addressed how to handle the increase of complexity in a modern manufacturing system, most researches have focused on complexity in either product design or production and the impact of complexity on manufacturing performance has not been clearly revealed. To complement the previous studies regarding complexity, this paper aims to investigate complexity in a manufacturing company from both product design and manufacturing perspectives and to elucidate the impact of complexity on manufacturing performance under various manufacturing conditions. Focusing on structural complexity, metrics for design and manufacturing complexity are proposed and applied to a screwdriver product family case. Then, single and multiple regression models are used to identify the impact of design and manufacturing complexity on lead time and total production cost under make-to-order and make-to-stock strategies and different demand levels. Results point to the fact that structural complexity negatively affects manufacturing performance only in the make-to-order system and the negative impact increases according to demand levels.

Enhancing System Values

Chair: David Rosen, Georgia Institute of Technology, United States of America

A case study on exploring energy user needs toward design for building energy saving

Yeon Koo Hong, Kee-Ok Kim, Yong Se Kim, Pil-Ho Lee, Dae Hoon Kim, Sang Won Lee

Sungkyunkwan University, Republic of Korea (South Korea)

In this paper, energy user needs are explored via the new user research method combining generative tools and focus group interview toward design for building energy saving. A number of needs for building energy reduction are extracted, and the needs tree is generated by classifying and structuring them. They can be classified into behavioral needs and solution needs in the highest level. The behavioral needs can further be decomposed into those in internal context and external context according to the motivations to generate them. The solution needs can be composed of those related with physical environment, regulation, and individual mindset. The E3 (economical, ecological, and experience) value framework is also introduced to classify extracted needs. When particularly considering energy users' experience values, it is demonstrated that those associated with rule (extrinsic social), reluctance/willingness (active emotional), contentment (reactive emotional), habit (intrinsic social) and knowledge (epistemic) values mostly occur. The results can provide the basis for designing and changing energy users' activities for effective provision of service for building energy saving.

Design principles for robot inclusive spaces

Rajesh Elara Mohan, Nicolas Rojas, Sue Seah, Ricardo Sosa

Singapore University of Technology and Design, Singapore

Social and service robotics deals with robot applications in, for instance, rehabilitation and health care, logistics, search and rescue, and homecare. The civil and economic relevance of these robots is more than evident. However, in spite of the tremendous advances in artificial intelligence, control, and sensing in the past decades; social and service robots are still far away of working autonomously in dynamic human-related spaces. Given this scenario, instead of developing robots with complex skills using a full suite of sensors to solve issues appearing in a real environment, the norm in robotics, we propose an augmentative approach that aims at designing social spaces of service robots through uncomplicated actions that would enable robots to overcome their limitations, and accomplish their missions with ease. In particular, we present a set of design principles namely, observability, accessibility, manipulability, activity, and safety for urban spaces involving sociable robots living and working alongside humans. The suggested principles are defined and analyzed using as case study a commercial mobile robot platform that performs a logistics task in a Singaporean hospital.

Value of virtual prototyping – A strategic resource based view

Simo-Pekka Sakari Leino[1], Tapio Koivisto[1], Asko Riitahuhta[2]

[1]VTT Technical Research Centre of Finland, Finland; [2]Tampere University of Technology, Finland

This conceptual paper proposes how business value of virtual prototyping (VP) could be modeled in the context of manufacturing industry and engineering design. The strategic resource based approach mapped data from industrial studies to public value theories and models in order to synthesize and model how technological features and benefits of VP could contribute to value creation and capture during a product-service value chain. In the model virtual prototyping is positioned as a strategic asset within value network and value shop configurations that have their own logic and processes related to value chains. The resource based strategic value of VP model emphasizes role of virtual prototyping as a media for better organizational knowledge creation and learning, which is today one of the essential competences of enterprises. In future the proposed model will be used as a reference in empirical studies. It will be iteratively improved and concretized in industrial strategy development projects. Aim is that VP business value modeling facilitates better adoption of VP, and reduces incredulous attitudes in manufacturing enterprises.

Adding product value through additive manufacturing

Robert Ian Campbell[1], **Haeseong Jee**[2], **Yong Se Kim**[3]

[1]*Loughborough University, United Kingdom;*[2]*Hong Ik University, Republic of Korea (South Korea);*

[3]*Sungkyunkwan University, Republic of Korea (South Korea)*

The term additive manufacturing (AM) refers to layer-based material addition technologies that have extended the approach of rapid prototyping (RP) technologies to end-use products and components. The application of AM technologies for this purpose is still rather limited at present but there are a few widely publicised examples. The authors believe that the wider use of AM is being inhibited by the inability of most designers to fully appreciate the contribution that AM can make to E3 (economic, ecological and experience) product value. Research has indicated that AM can contribute in each of these areas. This paper defines E3 value and then gives some examples of AM products that demonstrate different means of improving value. The conclusions drawn are that AM has an important role to play in adding E3 value to many products but that designers must be better informed as to how to integrate this added value into their designs.

Modelling Processes in Product Development

Chair: Peter John Clarkson, University of Cambridge, United Kingdom

Design and business model experimentation

Soren Ingomar Petersen

ingomar&ingomar - consulting, United States of America

A chasm currently exists between business and design, which involves transforming strategic business objectives and market opportunities into actionable design criteria. Poor feedback loops from new product development to strategy formulation hinder organizational learning and perpetuate outdated strategies. Leveraging pioneering theories in business management and design quantification this paper proposes a Design & Business Model Experimentation method for including design up-front in business experimentation. Applying a triple-loop iterative approach four levels of organizational capabilities are aligning business objectives with design criteria. The method leverages design in formulation of business strategies, conducting business model experimentation, while constructing a driver - enabler competitive matrix supporting the translation of business model elements into actionable design quality criteria. These in turn inform business plans and design briefs, providing the core criteria for initiating business-focused concept generation. The work contributes to new product development management and addresses the disconnection between business and design.

Case study: Evidence of prototyping roles in conceptual design

Tim Hess, Joshua David Summers

Clemson University, United States of America

The goal of this research is to investigate prototype use in conceptual design. In order to begin this line of study, we look first to current practices in industry. A case study involving two companies provides examples of prototype use in the conceptual design phase of their respective product development cycles. Six interviews were conducted at two different companies in order to help understand how prototypes are used by industry during the conceptual design phases of a product development process. This research finds evidence that prototypes are being used successfully in conceptual design, even though typical literature sources advise against it.

Exploratory study of the inclusion of territorial resources in design process

Romain Allais[1,2], Reyes Tatiana[1], Roucoules Lionel[2]

[1]University of Technology of Troyes, France; [2]Arts et Métiers ParisTech, France

This article describes an exploratory study of the inclusion of territorial resources in a business's value-creating process through the application of a global and systemic ecodesign approach. Incorporation of these new resources will enable businesses to improve their global performance. The context and the issues are described, after which we proceed to outline a theoretical model illustrated with examples of successful implementation that substantiate our presentation.

Investigation of the exogenous factors affecting the design analysis process

Martin Eriksson, Damien Motte

Lund University, Sweden

Computer-based design analysis activities are an essential part of most product development projects in industry. An effective integration of the analysis activity into the product development process is therefore very valuable. The current work shows that design analysis activities are constrained and influenced by many elements from their working environment. Factors exogenous to the design analysis activity, but that have an important effect on it, are identified and grouped along their levels of influence on the activity: some appear within the development project, some are at the enterprise level, and some are outside the sphere of the enterprise. The proposed classification has the advantage of indicating what leverage a stakeholder can have upon such factors: the farther from the analysis activity context, the more difficult it is to act upon them. Furthermore, a guideline presents how to deal with these factors during design analysis planning and execution within a product development project and in alternative enterprise configurations. Being aware of those factors should prevent fastidious iterations resulting from a poorly planned and organised design analysis task.

Designers' promises or users' expectations?

Donata Gabelloni, Gualtiero Fantoni

University of Pisa, Italy

Several frameworks describe the design process, such as the FBS model and its extensions. Some of them present a designer-centric view, while the most recent ones are more based on the user's point of view. This paper investigates and seeks to explain the different perspectives between designer and user after the first interactions with the product. In particular, the paper models how the designer's promises of functionalities match (or mismatch) the user's expectations. Thus twenty-four examples, including misuses, unperceived functions, hidden functions, failures etc., are mapped in a table.

The paper provides also a formal model based on Function-Behavior-Structure approach to describe the possible cases of misunderstanding between the user and the designer. Such a model formally links the designed product, as it is conceived by the designer, and the perceived product, as it is understood and interpreted by the user. Finally a series of redesigned actions are proposed to try to overcome some of the cases of misunderstanding between the user's and the designer's perspectives.

From product development to market introduction: A co-citation analysis in the field of ramp-up

Steffen Elstner, Dieter Krause

Hamburg University of Technology, Germany

Shorter product life cycles and increasing market competition have driven firms to cut their development times and accelerate the introduction of new products into the market. Deviations from the target can lead to significant economic consequences. The use of new technologies and implementation of innovative approaches entail the risk that unexpected problems in the development and manufacturing process may arise.

The literature review presented in this paper is based on a co-citation analysis and should help to understand the linkage between different research areas in the field of product launch. The co-citation analysis is a common tool for examining a body of literature and produces cluster-enhanced multidimensional scaling maps to visualize the subject's relatedness in an interdisciplinary literature field.

An analysis of various research streams in the interdisciplinary field of ramp-up is essential to create a better understanding of critical causes of delay in launching a new product, the correlation between factors that influence the ramp-up performance and possible gaps in the research.

Design Information, Knowledge and Collaboration

Chair: Chris McMahon, University of Bristol, United Kingdom

A metric to evaluate data maturity to help decision making: Application in preliminary collaborative design of mechanical systems.

Reviewers' **Favourite**

Nicolas Drémont[1], Nadège Troussier[2], Ian Whitfield[3], Alex Duffy[3]

[1]UTC, France; [2]UTT, France; [3]University of Strathclyde, United Kingdom

The design process is complex and dynamic due in part to the volume of handled data and models, the number of exchanges between the different design teams and businesses interacting during the. The design teams, organized in Concurrent Engineering (CE) don't wait to get the result of the later phases of the design life cycle; they anticipate them by making assumptions and by taking into consideration their experiences and know how. In that framework, quality approaches for the control of product performance, and collaborative engineering tools to support CE and collective decision making are required.
In order to support decision making in early design and product's performances management, this paper proposes a metric. It will enable to measure maturity in order to take into account the impact of lack of knowledge in decision making during preliminary collaborative design.

An empirical study on improving the understanding of email records by augmenting with information on context

Craig Loftus[1], Chris McMahon[2], Ben Hicks[1]

[1]University of Bath, United Kingdom; [2]University of Bristol, United Kingdom

Email fulfils an important role in facilitating distributed communication in engineering design projects and contributes to the persistent records of the project, but the nature of email communication may mean that records are difficult to understand by those who have not been involved in the projects. This paper presents an investigation into the effectiveness of augmenting emails with contextual information as a mechanism for improving such understanding. The work was part of an investigation into the effectiveness of email as a project communication method including the study of a large corpus of emails from a merchant ship design project and of the team that produced them. The work involved taking samples from the corpus and exploring the ability of readers with and without background contextual knowledge to understand and answer questions on the samples both as original email records and augmented with hyperlinks to contextual explanations. The experiments showed improvement in the understanding of the augmented emails by those with and without contextual knowledge. The experiment design is presented and the findings and their implications summarised.

Design with the developing world: A model with seven challenges for the future

Rachel Sara Kuhr, Kevin Otto, Ricardo Sosa, Nilanjan Raghunath, Katja Holtta-Otto, Kristin Wood

Singapore University of Technology and Design, Singapore

Design with the Developing World (DDW) brings a unique set of challenges as it asks people with very different expectations to collaborate on sustainable system solutions. Scoping for these design projects is therefore highly challenging, as there is little information on what needs to be considered in this vast collaborative and interdisciplinary process. This study identifies, and analyzes the barriers and enablers extracted from a selection of DDW literature, and clusters them into combinations of data effecting Users, Designers and Stakeholders. As a whole, we find that DDW projects need to grow relationships between each group. These groups must come to understand each other to create a new hybrid technology, as well as the supporting systems. Although gaps exist between Designers, Users, and Stakeholders in all instances where technology is created, we suggest here that larger gaps exist in the DDW domain. A transformation of these gaps is needed during development projects. These gaps stream into seven challenges we identified to create a methodical, well-leveraged, desirable, strategic, enabling, sustainable, and innovative solution.

Describing the engineering modeling knowledge for complexity management in the design of complex city

Egon Ostrosi[1,2], Fabien Pfaender[2,4], Denis Choulier[1], Alain-Jérôme Fougères[1,3], MonZen Tzen[2]

[1]Université de Technologie de Belfort-Montbéliard, France; [2]University of Shanghai, People's Republic of China; [3]ESTA School of Business and Engineering, France; [4]Université de Technologie de Compiègne, France

School of Business and Engineering, France; 4Université de Technologie de Compiègne, France
Engineering design and planning of the city of the future for its citizens of all ages with its fast and dynamic evolving structure is a complex problem. The goal of this paper is to propose a new model for describing engineering modeling knowledge using "what we want to achieve" and "how we want to achieve" relationships and transformations. This will help us to assist the complexity management in engineering design of the city of Shanghai considered as living laboratory. The proposed model is based on the principles of the axiomatic design approach, structured on four levels of modeling: (1) conceptual (2) mathematical (3) computational and (4) experimental. Our approach advocates that a complete engineering modeling framework is necessary for managing engineering design of a complex city. The model captures the knowledge of engineers through the building sixteen key models. It can be used for the development and the diagnostic of the engineering design process of a complex city. The paper presents some findings from the application of the proposed meta-model.

Designing and implementing a method to build innovation capability in product development teams

Sofia Ritzén, Susanne Nilsson

KTH Royal Institute of Technology, Sweden

This paper presents a framework and process (MINT) to support product development teams that have an ambition to improve their capability to manage both radical and incremental innovation. The driving force for the method was a clearly expressed need from teams to be able to measure and direct and change their own innovation work practice. The paper encompasses a longitudinal collaboration between academia and industry and aims to contribute to the development of a deeper understanding of how to successfully implement design research results in practice as called for by the design research community. The MINT method which is outlined in the paper has been developed and successfully adopted to the need of different teams in several companies. The learning outcome from the research project is analysed and three categories of critical factors which relates to the design, content and implementation process of the method are discussed and compared to relevant innovation and change management literature.

Co-ordinated engineering: Design innovation through operational collaboration

Tijana Vuletic, Alex Duffy, Robert Ian Whitfield, Wenjuan Wang

University of Strathclyde, United Kingdom

Operational Collaboration Model (OCM) has been developed to provide net based, location and discipline independent solution for the exchange of design technology, service and information. Its development was preceded by the exploration of the state-of-the-art in the collaborative engineering design to provide the theoretical basis for the research, and the research of the current practices in European maritime sector. The OCM is facilitated through the Technology Collaboration Platform which provides the distributed integrated design capabilities and European Maritime Collaboration Platform which supports the collaborative capabilities for knowledge exchange. OCM allows for a variety of different modes of collaboration, provided by the integrated design framework. Six case studies are to be used for demonstration in engineering design environment and testing are currently in the initial stages of execution, and aim to demonstrate the capabilities of the model but also identify areas for improvement and potential issues in its implementation. Once thoroughly tested and validated in the maritime sector the OCM will be fit for wider implementation in engineering design community.

W

SIG Workshop: Managing Structural Complexity

The Structural Repository – Improved Research on System Structures

Chairs: Maik Maurer, Technische Universität München, Germany
David Wynn, Cambridge University, United Kingdom

Goal of Workshop

The SIG develops a repository for structural models, which are accessible for interested researchers. These models shall enable comparability of algorithms and approaches of structure analysis and interpretation. The repository represents a test basis for new algorithms; and system structures can be put up for discussion.

Basic functionalities of the repository have been implemented and will be presented in the session. Now, the usefulness of the status quo will be reviewed. Then participants will decide on future functionalities to be implemented.

Abstract

The SIG Managing Structural Complexity develops a repository for structural models, which shall be accessible by all interested researchers in the near future. Availability of shared models shall e.g. enable comparability of algorithms and approaches for structure analysis and interpretation. The repository also represents a test basis for new algorithms. And researchers can put up specific system structures for discussion.

Basic functionalities of the repository have been implemented (http://www.structural-repository.org/) and will be introduced in the session. After this, the main objective of the session is to review the usefulness of the status quo as well as to collect and prioritize future functionalities to be implemented. The expected session results shall assure that the future development of the repository accords to the needs of all focused users.

Workshop Agenda

Presentation of status quo by SIG leaders, followed by common discussion and interactive prioritizing of identified topics

WEDNESDAY

IH-90109

08:45 – 10:15

Design Risk Whitepaper and Edited Book

Chairs: Mohamed Ben-Daya, King Fahd University of Petroleum and Minerals, Saudi Arabia

Goal of Workshop

To discuss how to manage risk and uncertainty in design and product development

Abstract

All products experience variance. Whether it be variance due to production tolerances, due to imprecise assembly, or whether due to external disturbances such as temperature change and vibration, it is the designers' job to produce concepts that are insensitive to these variance

Workshop Agenda

- Introductions: "Meet & Greet" for attendants – snapshot of risk-related research activities (30 minutes total)
- Review of website and literature database, discussion of future direction (30 minutes total; sub-group will form to work 2-3 hours on website content after workshop)
- Finalization of content for whitepaper "Risk Management in Design" (1/2 day). Format will depend on number of attendees (less than 5: one group, more than 5: division of topics among sub-groups). Includes review and finalization of first drafts of
  - Risk SIG value to members
  - application context
  - research framework
  - definition of "risk"
  - types of risk
  - SIG mission statement
  - Products and services of SIG
  - Roadmap of activities
- Risk SIG / Design Society edited book on risk management in design. Workshop of editors and potential authors (those who submitted abstracts for chapters). Introduction and overview presentation by editors, then discussion and workshop to finetune direction of the book.

W

Tutorial-Style Workshop : Robust Design

Robust Design Methodology

Chairs: Thomas J. Howard, Technical University of Denmark, Denmark
Martin Ebro, Valcon, Denmark
Tobias Eifler, Technical University of Darmstadt, Germany

Goal of Workshop

To discuss design quality, reliability and key performance indicators during engineering design process based on robust design methodology

Abstract

All products experience variance. Whether it be variance due to production tolerances, due to imprecise assembly, or whether due to external disturbances such as temperature change and vibration, it is the designers' job to produce concepts that are insensitive to these variance through 'Robust Design '. However, it is the case that very few design engineers use, or know or any robust design methods, and as a consequence pass on unfeasible tolerance demands to the production department. The public/customers experience poor design robustness in terms of, product launch delays, product recalls, reliability issues and product quality loss. However, many of the robust design issues take affect within the company in terms of low production yields, slow production ramp-up times, late design changes and emergency commitment of R&D resources to firefight the design reliability issues. The Robust Design Methodology (RDM) provides the designer with quick and simple tools to be used at all stages of design, from the first design sketch to the final detailing and tolerancing. As well as being an aid to the engineers and designers, the RDM is also useful for Managers giving some quantifiable indicators of the current state of the reliability of the design. Furthermore, these indicators are leading indicators and thus it is possible to monitor the development and reliability of a product from the very early stages. Contrast this with current indicators of reliability such as production yield, which are only available once production has begun and the cost of design change is very high.

Workshop Agenda

- Presentations on Robust Design Methodology and Case Examples
- Case-based Hands-on Use of Software for Robust Design Methodology
- Group and Plenary Discussions

Product-Service Systems - 1

Chair: Cees De Bont, The Hong Kong Polytechnic University, Hong Kong S.A.R. (China)

Conceptual design of product service systems driven by performance

Zai Fang Zhang

Shanghai University, People's Republic of China

A product service systems (PSS) is a combination of product and service to create value for both customers and manufacturers. The paper proposes a new performance-oriented design framework for PSS development contrasted to function-oriented design in traditional product development. The framework includes three domains: requirement domain, performance domain, and concept domain. The concept characteristics can be determined based on the mapping between each two adjacent domains, which are implemented by a modified quality function deployment (QFD) tool. The PSS concept is established by using a variant configuration model based on generic bill of materials (GBOM). The proposed approach is applied in a real-world case of horizontal directional drilling machine.

Model-based framework for management of PSS design knowledge

Yutaro Nemoto, Ken Kawase, Fumiya Akasaka, Yoshiki Shimomura

Tokyo Metropolitan University, Japan

Product-Service Systems (PSS) are regarded as a new business concept for manufacturing firms to enhance the value of their products and build up strong relationships with their customers. Since both tangible products and intangible services are included in design object, a design solution of PSS has various alternatives especially in conceptual design phase. PSS design therefore requires a broader range of knowledge to generate several ideas for its design solution.

In this paper, for the purpose of supporting idea generation in PSS conceptual design phase, a knowledge management framework is proposed. The basic idea of the proposed method is managing and providing knowledge collected from PSS cases. The proposed knowledge management framework is defined by reference with the three design models of PSS: life cycle model, product-service function model, and actor network model. The effectiveness of the proposed method is presented on the basis of the application to an example: PSS using agricultural machinery in a developing country.

A product-service system design framework using objective-oriented concepts and blueprint

Seung Ki Moon[1], Hyung Sool Oh[2], Samyeon Kim[1], Jesun Hwang[3]

[1]Nanyang Technological University, Singapore; [2]Kangwon National University, Republic of Korea (South Korea);

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The objective of this paper is to propose a PSS design framework to identify design factors for developing products and services by integrating object-oriented concepts and blueprinting in context of a business ecosystem. The proposed design framework is developed based on relationship between products and services. Based on extending the concepts from object-oriented concepts, this paper introduces a methodology to identify design factors in developing a PSS. Object-oriented concepts provide PSS analysis tools for describing a business process or a workflow process in the PSS. The blueprint is used to identify the relationships between the products functions and the service processes that are offered as part of a job. Functions and processes can be categorized to identify the design factors in different levels using the object-oriented concepts. Interaction between products and services lies on a PSS platform to form a product service system in the blueprint. To demonstrate of the effectiveness of the proposed framework, we use a case study involving a smart phone.

A framework for enterprise-driven product service systems design

Namwoo Kang, Fred M. Feinberg, Panos Y. Papalambros

University of Michigan, United States of America

As products become service platforms, customers purchase both products and their associated services. Service attributes affect product choices, and product choices affect to service demand and profit during the products life cycle. Enterprises offering such product service systems (PSS) must co-design products and services to maximize overall profit. This paper proposes an Enterprise-driven Product Service Systems (EPSS) design framework that integrates models of design, choice, demand, and cost into a profit optimization problem. The EPSS framework is demonstrated on a study of product and service design for tablets, e-books, and cloud services. Optimizations results quantify the trade-offs between profits from product and service dependent upon design decisions and use scenarios.

Robust design proposal by the use of structural topology optimization considering uncertainties of input parameters and boundary conditions

Reviewers' **Favourite**

Thomas Stangl, Michael Walter, Sandro Wartzack, Thomas Schneyer

Friedrich-Alexander-University Erlangen-Nuremberg, Germany

Specifying a product's optimal mechanical and functional design primary depends on the requirements defined by the future operating conditions. In today's product design process the usage of topology optimization is a widely applied computer aided method to define an optimal design considering these requirements. However, in an early design stage, input parameters for this structural optimization process (e.g., operation conditions) are usually uncertain. Consequently, the resulting design is not optimal.

This paper focuses on a detailed investigation of uncertainties in structural topology optimization. Hence, the different kinds of uncertainties and their effects on the resulting designs are considered in detail. Furthermore, a methodology is presented, which enables the consideration of uncertainties using e.g., a statistical investigation of the topology optimization results and a sensitivity analysis-based result visualization. Therefore, a cam drive rocker arm of a combustion engine is analyzed in a case study. Finally, several recommendations are derived, supporting the product developer to define a robust initial design, causing less computational and time expense.

Comparison of low- and high-fidelity approach in model based design in the case of a portable motion platform

Asko Uolevi Ellman[1], Petter Krus[2], Ville Jouppila[3]

[1]Tampere University of Technology, Finland; [2]Linköping University, Sweden; [3]Tampere University of Technology, Finland

In this paper a low- and high-fidelity modeling approach was applied and compared in the case of design of a portable motion platform. In the low-fidelity design approach, a Design Analysis Tool was used for generating information about design sensitivity analysis and correlation of design parameters. In the high-fidelity design approach, the motion platform was designed using Matlab/Simulink/SimMechanics including the mechanical and pneumatic subsystem of the platform.

These approaches were compared in terms of required modeling effort to a relative error of predicted and measured system properties. The results of a low-fidelity model were achieved within one day whereas high-fidelity approach required three weeks of work. The relative error in low-fidelity approach was about 21-25 % and 4-6 % in high-fidelity modeling. Based on experiences achieved in this design case both of these modeling approaches were justified. Low-fidelity model can be seen especially important in early design phase when design alternatives were speculated with design constrains. High-fidelity model was useful on detailed design when dynamic properties of the system were considered more detailed.

SysML-based model integration for online collaborative design of mechatronic systems

Hongri Fan[1], Yusheng Liu[1], Ying Liu[2]

[1]Zhejiang University, People's Republic of China; [2]National University of Singapore, Singapore

This paper introduces an online collaborative design platform to support mechatronic design. SysML-based system modeling method is employed to support system level design. Based on the system model, domain-specific model generation method is provided to facilitate the designers to enable the next design phase. The proposed unified recognition algorithm for changed model and dynamic model integration method enable efficient data flow to characterize the design intents in collaborative design activities. This platform is implemented on existing commercial tools to promote the practicability. Finally, a simple work piece conveyor system is taken as the case study for demonstration.

Uncertainty modeling to enable software development platforms that can automate complex mechanical systems design

Kevin Otto[1], Christoffer Levandowski[2], Anders Forslund[2], Hans Johannesson[2], Rikard Söderberg[2]

[1]Singapore University of Technology and Design, Singapore; [2]Chalmers University of Technology, Sweden

Development platforms are automated software tools used to synthesize new designs. They are prevalent in the embedded system design domain, with applications ranging from integrated circuits, circuit boards, electro-mechanical controls, and entire networked systems. Historically, this has enabled rapid and error-free design of very complex embedded software and electronics hardware, even those that control mechanical systems such as aerospace and automotive controls through automation of the design process. The state of mechanical design automation has far less commercial adoption or industrial demonstration of development platforms in mechanical design. This paper elaborates on what challenges mechanical design automation faces to reach the level of design automation in the embeded systems domain. Given a design library approach, it is concluded that uncertainty management is a key issue for future research, including model uncertainty for mechanical design modeling. These issues are then contextualized using a case from the aerospace industy.

Chair: Gaetano Cascini, Politecnico di Milano, Italy

Testing the value of TRIZ and its derivatives for knowledge transfer in problem solving attempts by multidisciplinary teams

Malte Schöfer[1,2], Nicolas Maranzana[1], Ameziane Aoussat[1], Giacomo Bersano[2]

[1]Arts et Métiers ParisTech, France; [2]Active Innovation Management, France

The design process of ever more complex products requires an increasing amount of knowledge originating in ever more distant domains of expertise. However, in order to make the knowledge transfer (KT) process more effective, researchers ask for processes which foster the transformation and translation of knowledge. In this respect, KT approaches which are based on the systematic use of electronic databases have their limits.

Therefore we claim that there is a need for a framework capable of facilitating multidirectional knowledge sharing and thus knowledge transfer during face-to-face working sessions. We think that the well recognized performance of TRIZ and its derivatives in technological problem solving can be transferred to problem identification, modeling and solving in other domains like life sciences. Thus the said methodologies could contribute significantly to innovative product design by linking problems to solutions in distant domains.

In this article, we report on a large scale experiment to test this assumption and present some interesting findings on the influence of group composition and methodology on KT during problem solving attempts by multidisciplinary teams.

Development of an engineering change management capability framework for enterprise transformation

Simon Haahr Storbjerg[1], Anita Friis Sommer[1], Thomas Ditlev Brunø[1], Jesper Thyssen[2]

[1]Aalborg University, Denmark; [2]Grundfos A/s, Denmark

With the current financial crisis focus of product development in industry has centred on efficient variant development and increasing the utilisation of existing products and platforms. Together with this change in focus the handling of engineering changes has grown in importance. Several studies however document a slow and inefficient handling of engineering changes, indicating a general low maturity of this area in industry, e.g. (Sharafi et al., 2012), (Huang, Yee & Mak, 2003). Although a noticeable amount of work has been published on engineering change, the literature, as highlighted by Jarratt et al. (2011) in a recent extensive literature review, overwhelmingly points to the need for more comprehensive guidance in how engineering changes can be handled more efficiently. This paper seeks to address this gap using a capability perspective. Based on literature review and a case study, the process areas especially important to develop capabilities within to ensure an efficient change handling are identified, and an ECM capability framework is proposed. This paper thus enables further research to focus on clarifying ECM capabilities, maturity levels and levers.

Configuring the development space for conceptualization

Louise Broennum, Christian Clausen

Aalborg University, Denmark

This paper addresses issues of conceptualization in the early stages of concept development noted as the Front End of Innovation [FEI]. We examine this particular development space as a socio technical space where a diversity of technological knowledge, user perspectives and organizational agendas meet and interact.

Based on a case study from an industrial medical company, the paper addresses and analyses the configuration of the development space in a number of projects aiming to take up user oriented perspectives in their activities. It presents insights on how the FEI was orchestrated and staged and how different elements and objects contributed to the configuration of the space in order to make it perform in a certain way.

The analysis points at the importance of the configuration processes and indicate how these configurations often may act as more or less hidden limitations on concept development making it difficult to bring forth new concept ideas.

Towards a new perspective of managing ideas in front-end innovation as actor networks

Anna Rose Vagn[1], Christian Clausen[1], Liv Gish[2]

[1]Aalborg University Copenhagen, Denmark; [2]Technical University of Denmark, Denmark

For decades the innovation process in R&D organisations has been discussed. Product development processes is well-established in R&D organisations and improvements has been implemented through theories as Lean product development and agile methods. In recent decades, more diffuse processes have been identified as front-end innovation processes. The front-end innovation is distinguished from linear product development and characterised as more informal, unstructured, and unpredictable. This paper presents the preliminary results of a PhD project concerning idea management in front-end innovation of R&D organisations. Through theoretical and empirical investigations of managing activities of idea processes an indicative analysis in the perspective of actor network theory is performed. The analysis show how managers and employees navigate in a complex environment of organisational structures, technical features and design, creativity and social interaction. The analysis inputs an initial conceptualisation of a new theoretical framework of idea management. The theoretical framework suggests a dynamic network structure comprised of the dimensions of space, content, and process.

A concept of direct knowledge acquisition for multi-agent design systems

Martin Kratzer, Alexander Crostack, Reem Kadadihi, Michael Rauscher, Hansgeorg Binz, Peter Goehner

University of Stuttgart, Germany

In this contribution, the paradigm of direct knowledge acquisition as a possibility to enable experts to integrate user-specific knowledge is applied to multi-agent design systems (MADS). A pure adoption of existing approaches is not sufficient due to the fact that MADS have a distributed knowledge base as opposed to centralised knowledge bases of other knowledge-based systems (e.g. case-based systems). The result is a concept which brings the intentions of design engineers by modifying the knowledge base (e.g. adding a rule) in accordance with the inherent processes in the knowledge integration component of MADS. Thus, an action of a design engineer is followed by certain operations which have been inherently carried out in order to realise the modification of the knowledge base and to keep the knowledge base consistent. In order to do so, an overview about the direct knowledge acquisition is outlined. Moreover, the structure of the distributed knowledge base is presented wherein the ProKon-knowledge forms are used. Finally, the functionality of the direct knowledge acquisition is presented in detail using the example of a key connection.

Using web crawler technology to support design-related web information collection in idea generation

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Imperial College London, United Kingdom

Effective information gathering in problem and task related fields with which designers or design teams may not be familiar is a key part of the design process. Designers usually consult with subject experts to access expert information. An Effects Database system that includes design-related effects to provide ready access to expertise at any stage within the design process can be used to prompt areas to consider and explore. To maintain the efficiency of the system, its data must be regularly updated and new effects populated from the open source knowledge base. Web crawler technology has integrated into an information gathering and analysis system to rapidly mine design-related information from published data sources in order to update an effects database for use in design. This paper describes the effectiveness and efficiency of the system for updating the database. Comparing with manual information collection, the test results demonstrate that this system can dramatically increase the efficiency on selecting design-related information from un-restricted internet sources.

A multi-agent based framework for multi-disciplinary conceptual design synthesis

Reviewers' **Favourite**

Yong Chen, Zelin Liu, Jian Huang, Zhinan Zhang

Shanghai Jiao Tong University, People's Republic of China

It is encouraged that designers should explore in wide multi-disciplinary solution spaces for finding novel and promising principle solutions to desired functions during conceptual design. However, due to lack of sufficient multi-disciplinary knowledge, it is often difficult for human designers to explore in such a wide multi-disciplinary solution space. Therefore, it is desirable to have an automated conceptual design system, which can automatically achieve multi-disciplinary conceptual design synthesis for human designers. Based on the multi-disciplinary conceptual synthesis approach developed before, this paper proposes a multi-agent based framework for achieving the conceptual design synthesis of multi-disciplinary systems. The roles of different kinds of agents and the collaborative mechanisms among them are elaborated. A conceptual design case is employed to illustrate how the multi-agent-based design synthesis framework works, which also shows that the proposed multi-agent based framework can achieve better efficiency than our previous approach.

Supporting multiple engineering viewpoints in computer-aided design using ontology-based annotations.

Chun Lei Li[1], Chris McMahon[2], Linda Newnes[1]

[1]University of Bath, United Kingdom; [2]University of Bristol, United Kingdom

This paper describes an approach to supporting, in computer-aided design (CAD), the multiple evaluations that occur when engineers bring their expertise to bear, especially in the later phases of the design process. The aim of the support is to reduce the work in integrating external tools with CAD systems, and to increase the coordination between the different tools. The paper presents a general-purpose ontology-driven annotation approach to record viewpoint-dependent information such as manufacturing process and costing data. The annotation data are contained within a consistent ontology framework which supports the integration of multiple specialist viewpoints by associating annotation content with anchors in a boundary representation model. The ontology also allows checking of data structures and other reasoning. The paper gives an overview of the relevant background in CAD technologies, annotation and ontology, and then describes the embedding of an annotation tool based on the Web Ontology Language OWL in a commercial CAD system. The usefulness of the tool is evaluated through a case study of the incorporation of cost estimation tools.

Naturally emerging decision criteria in product concept evaluation

Reviewers' **Favourite**

Jan B. Nikander, Lassi A. Liikkanen, Miko Laakso

Aalto University, Finland

Successful concept selection is of paramount importance in the early phases of new product development. Concept decisions define the success of both the project and the product to a great extent. Previous research has shown that structured methods are often not used properly or at all in design practice. To shed light on the dynamics of concept selection in real life, we studied decision strategies and the use of decision criteria in concept selection. The experiment involved sixteen professional designers and utilized mixed methods, including verbal protocol analysis. The participants used a great variety of evaluation styles and criteria, sometimes changing them in midst of evaluation. Furthermore, some internal conflicts appeared between different concept evaluation tasks. These findings put designers' ability to make rational and good concept decisions under some doubt. Further research on human behavior in concept selection is deemed necessary and some prospective research questions are introduced.

Storyboarding - Framing the "frame" of opportunity

Anders Wikström, Amanda Everskog, Amanda Forsberg Wallin, Maja Hyltefors, Sofie Larsen, Roberto Verganti

Mälardalen University, Sweden

The design brief is commonly a written description of a scope for a design problem that requires some kind of visual design. The exploration of opportunities before formulating the design brief results in framing and reframing the problem to create a common shared understanding of the problem. In this paper the applicability of Storyboard, the actual making of the storyboard, and its values to the front-front end of innovation is examined. Experiments has been performed in order to test three hypotheses and validate the results, in total four experiments was performed consisting of 25 teams developing 17 concepts. The three hypotheses focus, regarding type of innovation, scope and level of ambiguity, creates understanding of the values storyboarding can add with regards to framing opportunity for innovation in the front-front end of innovation. The result shows that storyboarding contribute to a narrow focus in creating the brief. Regarding the innovation type the hypothesis could not be confirmed, but storyboarding enables a reflection on both meaning and function. There were also some indications on ambiguity in the brief, but this hypothesis was not confirmed.

Eye tracking, a method for engineering design research on engineers' behavior while analyzing technical systems

Sven Matthiesen[1], Mirko Meboldt[2], Anne Ruckpaul[1], Moritz Mussgnug[2]

[1]Karlsruhe Institute of Technology, Germany; [2]Eidgenössische Technische Hochschule Zürich, Switzerland

The analysis of technical systems is a central activity in design processes. Engineers need to understand the functions of a system in order to gain inputs for further development. In using design research methods in the area of acquiring functional understanding, data is usually gathered through interviews or observations. Since vision is tightly related to cognition, eye tracking may provide deeper insights into the analyzing behavior of humans. This paper investigates the applicability of different eye tracking technologies for research into function recognition. Pilot studies were conducted to show the practicability of the proposed technologies. In addition to that, the paper introduces relevant analysis methods for raw gaze data. The results suggest that remote and head mounted eye trackers are well suited to observing the behavior of engineers who are analyzing a technical system in different representation forms. Based on these findings, the authors propose the use of eye tracking technologies in qualitative and quantitative empirical studies of how engineers build up understanding of technical systems.

Distribution of mental stresses during conceptual design activities

Thanh An Nguyen, Xu Xu, Yong Zeng

Concordia University, Canada

In this paper, we study how different mental stress levels are distributed in a conceptual design process. Firstly, we reviewed a Stroop Test experiment conducted earlier in our lab to confirm the use of heart rate variability (HRV) as a reliable index of mental stress. Secondly, we reported our experiment on seven designers; HRV data and body movements were recorded along with design processes. Design data was segmented and HRV parameter as indicator of mental stress was computed for each segment. Then the mental stresses were classified into seven levels. The result showed that most of the activities in a design process were performed at low levels of mental stress. The design activities reduce as the level of mental stress increases. No correlation was found between types of design activities and mental stress.

What do the concept generation techniques of TRIZ, Morphological Analysis and Brainstorming have in common?

Reviewers' **Favourite**

Udo Kannengiesser[1], Christopher Williams[2], John Gero[3]

[1]Metasonic AG, Germany; [2]Virginia Tech, United States of America; [3]Krasnow Institute for Advanced Study, United States of America

One of the goals of design research is to identify regularities across different design processes. This paper presents experimental evidence that there exist commonalities between three separate concept generation techniques: TRIZ, Morphological Analysis, and Brainstorming. This evidence is based on protocol studies involving mechanical engineering students that use the three techniques for performing different design tasks. The protocols have been coded using the function-behaviour-structure (FBS) scheme and then analysed in terms of the cumulative occurrence of FBS design issues. The commonalities found are related to the first occurrence of certain design issues, and to their continuity and linearity.

Functional characteristics of running shoes for different user groups

Patrick Clifton, Aleksandar Subic, Mike Burton, Anthony Bedford, Adrian Schembri

RMIT University, Australia

The main objective of this research was to characterise the different runner groups and to determine the key functional design characteristics of running shoes for each distinct group. A comprehensive qualitative survey methodology has been developed and implemented worldwide for this purpose. Consequently, a large volume of data was collected from respondents in relation to running habits, performance and shoe characteristics. Classification of distinct runner groups has been determined based on discrete performance parameters and validated using statistical discriminant analysis. For each user group classification, the relevant functional running shoe characteristics were assessed and ranked, and design innovation opportunities mapped. The results of this research will be used by a running shoe manufacturer to inform the design of new generation sports shoes customised for specific market segments and user preferences.

Multistakeholder analysis of requirements to design real innovations

Reviewers' **Favourite**

Marco Cantamessa[1], Francesca Montagna[1], Maria Messina[2]

[1]Politecnico di Torino, Italy; [2]MEDALLCARE, Italy

People are generally influenced in their purchasing choices by diverse stake-holders and these influences are often not related to "use situations". Learning processes, product diffusion dynamics and externalities in fact frequently complicate innovation processes. "Design for Innovation" means considering that design cannot focus only on buyer's preferences and on "product use" because this could limit diffusion of products, besides bounding in general innovation opportunities. The "Design for Innovation" approach drives to study "beyond use situations" and the influences among the actors involved in the innovation processes. This paper describes the application of the "Design for Innovation" approach to MEDALLCARE, an Italian start-up company of the biomedical sector. What resulted is a more original list of needs that would have not emerged with more traditional approaches for the requirement management.

A system-level thermal design specification development of electronic products considering software changes

Yoshio Muraoka, Kenichi Seki, Hidekazu Nishimura

Keio University, Japan

Realizing the market demand for small size and fast processing speeds, thermal design is one of the major challenges in the development of electronic products. In addition, there are many software changes necessary to adapt to the rapid-moving trends in customer applications. Therefore it is difficult to develop a product design specification in the early stages of product development. In this study, we first introduce a typical system-level thermal design simulation method, coupling activities among modules related to software, electrical parts, and mechanical structure. In particular, this method allows us to evaluate risks related to thermal burn injury depending on the software's application. Then, we investigate this method by applying it to a design process case for electronic products that require software changes, such as having additional applications. The system-level simulation can be used to evaluate the thermal risk that may rise by the applications. We verify the design control to satisfy product quality using Systems Modeling Language (SysML) and the resulting design specification of the system architecture.

Customer focused requirement engineering and system design for plug-in hybrid electric vehicles (PHEV)

Benedikt Johannes Nies[1,2], Orawski Robert[2], Prof. Udo Lindemann[2]

[1]BMW Group, Germany,; [2]Technische Universität München, Germany

This paper focuses on the quality of requirements dependent on the level of system abstraction. Chosen example is the design of a Plug-In Hybrid power train. The requirements to specify the scaling of the high voltage storage (HVS) for Plug-In Hybrid vehicles (PHEV) is the focus of this paper.
The shown approach discusses important quality characteristics of requirements to answer the needed information and system quality and to identify the required information for the system scaling. Therefore, the system level PHEV is abstracted in an appropriate way to merge it with the available customer data set. The abstraction and a concluding description of the requirement space based on the "Münchener Produktkonkretisierungsmodell" is presented. Furthermore, the recorded data are prepared to derive the required information for the system scaling.
The approach offers a methodology to integrate a customer behavior in the early stage of product design. Goal is to rise in this case the energy efficiency of the system to offer the customer a power train with reduced fuel consumption.

Robust conception of vehicles considering region-specific requirements

Frank Nehuis, Jafet G. Sánchez Ruelas, Carsten Stechert, Thomas Vietor

TU Braunschweig, Germany

Changes in automotive markets and technologies amplify the issue of fulfilling requirements for all customers within a single vehicle concept. An increasing development of regional markets demands vehicle concepts, which fit the customer's wishes and satisfy the environmental conditions.
In this paper, a requirement-driven approach is proposed. The approach introduced deals with the issue of relations between the customer's requirements and the technical characteristics and properties, especially in the early stages of product design. Here, the vehicle requirements are determined and related to the vehicle environment. And together with experts in each vehicle field the relationships between components, among requirements, and between components and requirements are traced and analyzed. With this approach, vehicle concepts can be compared based on the level of satisfaction that their different selected components achieved in specific markets.
The analysis is achieved by modeling all these relationships in the Systems Modeling Language (SysML), which is common practice in system and software engineering where multiple systems need to be described

Reuse of requirements: An approach with a generic requirements pool

Robert Orawski[1], Christoph Hein[2], Dieter Polenov[2], Maik Holle[1], Sebastian Schenkl[1], Markus Mörtl[1], Udo Lindemann[1]

[1]Technische Universität München, Germany; [2]BMW Group, Germany

This paper deals with the implementation of a methodology which describes how to reuse given requirements in an industrial company. With an increasing rate of new products projects and an increased number of variants or product family members, the amount of requirements gets unmanageable. Therefore, there is a demand in the industry for an approach for how to get the raising amount of requirements manageable. We focused on a department in the automotive industry which is responsible for the stability of the electrical power system of a vehicle. We observed several challenges of handling the design process of a battery-electrical car. In order to deal with the challenges, we propose a generic requirements list out of which there can be derived specific product specification lists. We depict a process model which addresses the essential activities of the requirements engineering and management. We describe how this process was implemented in the observed department. The proposed approach reduces the time which is needed to achieve a validated specification list and enhances the correctness of the chosen specifications through known description of the planned concept.

PhD Student Forum

Chairs: Ian Whitfield, University of Strathclyde, United Kingdom
Avril Thomson, University of Strathclyde, United Kingdom

Goal of Workshop

To provide a forum in which PhD students can discuss and receive feedback on their work in a supportive and constructive environment

Abstract

This aim of this workshop is to allow PhD students working in the area of Collaborative Design to come together to discuss their work and receive feedback from their peers and experienced researchers in the area of Collaborative Design.

Workshop Agenda

Introduction 10 mins - About the Collaborative Design SIG, Explanation of Workshop Format

Ideally this workshop will take place in a round table setting. With 4 PhD students and 1 or 2 members of the Collaborative Design SIG Management Team at each table. Each student will give a 5 minute overview of their work which will be preceded by 10 minutes discussion and questions from everyone round the table.

Summary - highlighting key issues and discussion points at each table

What is Missing in My Recipe?

Ji-Hye Park

Kwamecorp

Abstract

As ever, we are seeing floods of new digital services calling out for our attention. They promise to remove doubts, make us more efficient, help us connect, and in general to better our lives in small and big ways.

What's new is the speed at which these services appear and disappear. Everyone is joining the race to design and build, choices are multiplying and consumers are becoming picky. Technology is moving on faster than we can follow. Designing in today's fast and furiously changing market requires shift in the mindset on how we work; from 'developing the ultimate solution' to 'developing MVP (Minimum Viable Product) solution.

In this talk, Ji-Hye looks at some of the latest digital services whose success was not about sophisticated engineering solutions but in identifying a sweet spot and filling it quickly to fine-tune later, highlighting how we can build profitable digital services in an environment where everything is variable with designer & engineer collaboration.

Bio-Sketch

Ji-Hye Park is a design director at Kwamecorp, an end-to-end service design consultancy and R&D Lab that designs and engineers services and products that have a positive impact on people's lives. She manages multi-disciplinary team to deliver services across different industries. She is an expert in designing for multi-platforms, with a wide range of experience from ethnographic research and concepting to delivering design solutions. With her recent move to Kwamecorp she is expanding her experience in working with engineers.

Characterising Product-Service Systems

Chair: Sang Won Lee, Sungkyunkwan University, Republic of Korea (South Korea)

Strategy, business models or tactics – What is product-service systems (PSS) literature talking about?

Wiebke Reim, Vinit Parida, Daniel Örtqvist

Luleå University of Technology, Sweden

Product- Service Systems (PSS) and business model share the emphasis on value creation. Still PSS literature uses the term business models vaguely without being clearly understood. Therefore, the purpose of the study is to develop a framework that structures and integrates the various ways the term business model is used in PSS literature by pointing out the connection to strategy and tactics. This is done by conducting a systematic literature review. The findings are aggregated in a framework that proposes that a business model is chosen based on the strategy and that tactics are the residual choice after the business model is chosen. Four tactical sets, contract, marketing, network and product design, have been identified from the literature to be most relevant for PSS business models. The analysis of the tactics relates them to the PSS categories.

Interplay between offering, provider and customer in product-service system design

Tuomas Ritola, Eric Coatanéa

Aalto University, Finland

Customer value creation is pivotal for a company in order to be able to create value for their shareholders. Product-service systems (PSS) offer new ways for creating added value in comparison to selling traditional products with added services. The goal in this article is to study a product-service system design project and identify different interactions in the three dimensions of product-service systems – the offering, the provider, and the user/customer. Being able to identify interactions between the design elements in the three PSS dimensions would advance our understanding about PSS development in general and facilitate designing higher-value product-service systems. The research utilizes first-hand data of an availability-oriented reverse vending machine design project undergone in the research group during 2011-2012. The research resulted in identifying concrete interactions with potentially complex dynamics between the elements from the three dimensions. The interactions between the dimensions play an important role in PSS development, they may provide interesting openings for value creation, and they definitely deserve more attention and further research in the domain.

Developing business models for extended products in manufacturing service ecosystems

Klaus-Dieter Thoben[1], Stefan Wiesner[1], Sergio Gusmeroli[2], Jens Eschenbaecher[1]

[1]BIBA - Bremer Institut für Produktion und Logistik GmbH, Germany; [2]TXT e-Solutions S.p.A., Italy

The growing demand for integrated solutions forces manufacturers of industrial goods to combine their products with service components to Product-Service Systems, or Extended Products (EP). The new value proposition of the EP also requires an extended network of business partners, which are both not included in the traditional business models of manufacturing companies. The purpose of this paper is to investigate classic business models in manufacturing and create an EP Business Model Framework based on the Business Model Canvas to help manufacturers transform their business models in the servitization process. A special focus is given to value innovation and collaboration in Manufacturing Service Ecosystems (MSE). In an MSE, different organizations and individuals can work together with common or complementary objectives on new value added combinations of manufactured products and product-related services. The approach is exemplified by the evolution of the business model of a machine tool manufacturer.

Playful conceptual design of industrial product service systems: An Experiment

Daniel Meuris, Michael Herzog, Matthias Köster, Tim Sadek

Ruhr-University Bochum, Germany

It is known well that the development of industrial product-service systems (IPS2) is a challenging task for solution providers. In order to enable the full potential of these new systems the companies have to establish a new mindset among their developers. This is necessary to overcome the barrier of thinking in separate product and service domains. This leads to the fact that new ways of teaching the aforementioned cross domain thinking need to be broadened. This paper describes an experiment which aims at the evaluation of such an approach. Based on principles of business games it supports the development of initial concepts of an IPS2. In the experiment 122 students were asked to create a concept of an IPS2 solution by using either this gamestorming or a traditional brainstorming method. The research hypothesis states that the game-based approach supports a better exploration of the underlying solution space and so the adoption of the new IPS2 mindset is more effective. Results have shown that this hypothesis has been approved to be right. Further work will ask more precisely after certain details of this process in industrial environments.

Chair: Sandro Wartzack, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

Statistical tolerance analysis of mechanisms with interactions between deviations – A methodology with 10 easy steps

Michael Walter, Sandro Wartzack

FAU Erlangen-Nuremberg, Germany

The time-dependent motion behavior of a mechanism is essentially affected by different kinds of deviations. Consequently, the product developer has to analyze the mechanism and its kinematic behavior as early as possible to ensure the product's functional capabilities. However, possible interactions between the deviations and their effects on the system's motion, and thus the functionality are not considered yet.

This paper presents a methodology, consisting of 10 easy steps, which enables the product developer to perform a statistical tolerance analysis of a system in motion, which underlies different kinds of deviations as well as several interactions among them. Therefore, the identification as well as the determination (statistically) of the interactions is required, which can be done using numerical simulations like multi-body-dynamics or manufacturing process simulations. An appropriate mathematical representation of the interactions is done using meta-models (like Artificial Neural Networks). These can be easily integrated into the tolerance analysis' functional relation. A case study of a non-ideal cross-arm window regulator illustrates the methodology's practical use.

Evaluation of standardization level of mechanical systems in engineering design

Reviewers' **Favourite**

Pavlos - Christoforos Sinigalias, Argyris Dentsoras

University of Patras, Greece

The level of standardization of products and systems affects production process and the cost for their operation and maintenance. In reverse engineering and design, the systematic consideration of standards leads to better evaluation and efficient synthesis of parts and assemblies. Taking into account standardization during design leads to systems with better operational characteristics, high quality and low cost.

The establishment of metrics for estimating the standardization level of systems can provide valuable tools for analytic and synthetic engineering processes. The present study introduces such a metrics that is based on system analysis and decomposition into hierarchical structures of parts and assemblies. Procedures search exhaustively that structures and perform calculations of standardization indices. A PC-based platform implements the proposed method and provides estimations of standardization levels and multiple graphical outputs that visualize the obtained results. Then the designer may inspect the standardization level of parts, components and assemblies and proceed with necessary modifications. The method is exemplified with a study of a robot base subassembly.

Reasoning before testing the hypothesis: How to preserve the reality of the industrial context

Reviewers' **Favourite**

Emilene Zitkus, Patrick Langdon, P John Clarkson

University of Cambridge, United Kingdom

The paper discusses the challenges encountered defining suitable methods to test the hypothesis for research investigating inclusive design in the industry. It outlines the outcomes of an exploratory study with designers and clients in order to describe how the research hypothesis was formulated. The hypothesis considers the impact of information about inclusivity into the design decisions made by clients and designers during design meetings. The paper reflects on ways in which the hypothesis could be tested in order to preserve the scenario as closed as possible to the reality of the industrial process. It considers the advantages and the disadvantages of industrial and laboratory settings. The overall focus is to identify the setting and methods that would result in realistic answer to the research question. The paper concludes by proposing a scenario which could benefit from the current research context without affecting their applicability to design practice in industry.

Design for durability - Designing with advanced ceramics

Anna Kerstin Usbeck, Dieter Krause

Hamburg University of Technology (TUHH), Germany

The demand of sustainable products - not only in transport, but in manufacturing and building industry - results to the necessary of improving the reliability. The MTBF-index (mean time between failures) and MTBM (mean time between maintenance) have been introduced, to include the reliability of products in the profitability analysis. On the technical side, international standards describe how to test the reliability of a product or component by means of constant failure rate or constant failure intensity.

The demand of sustainable products results in a redesign with new targets. The challenge for the designer is to (re-) design the technical system with improved material and/or optimized shape. Therefore the paper will discuss the material selection methods for a "design for durability". As a consequence it will show the influence of embodiment design when designing with advanced ceramics.

The autor has worked on failure criteria of multi-axial loaded ceramics and investigated several cyclic and static load cases on ceramic structure specimen. Based on this experiences a guideline will be proposed for the embodiment design evaluation of cermic parts.

Design Methods for Concept Design and Collaboration

Chair: Dieter Krause, Hamburg University of Technology, Germany

Evaluating the failures criticality in collaborative design with suppliers

Hélène Personnier[1], Marie-Anne Le Dain[1], Richard Calvi[2]

[1]Grenoble-INP, France; [2]Savoie University, France

Innovation helps companies to increase their competitive position. Suppliers are an important source of innovation. Thus, successful collaborations with suppliers in New Product Development (NPD) can lead to competitive advantage and many companies try to involve suppliers in early stages of their design process. Potential benefits of Early Supplier Involvement (ESI) for collaborative design do exist only if this practice is managed effectively. However, such factors as low level of trust between buyer and supplier or inappropriate selection of the supplier can have negative impacts on ESI and lead to unsuccessful projects. It is obviously necessary to identify potential failures in collaborative design with suppliers impacting project performance. This paper describes the development of a criticality assessment of those failures obtained through literature results, collaborative work with 2 NPD project teams of a French company and an academic-practitioner consortium. The method proposed enables to tackle potential failures in future projects and to reduce costs by identifying improvements early in the development process when changes are relatively easier and less expensive.

Market performance prediction based conceptual design of mid-sized passenger aircrafts

Soon Young Han, Hae-Jin Choi

Chung-Ang University, Republic of Korea (South Korea)

In this paper, we introduce a design method applicable to the early development stage of a new product of long life-cycle time. Customer requirements employed at the early stage of a design process is critically important; however, those are easily outdated due to relatively long product development time and/or rapidly changing market situation. Addressing this critical issue, we provide a framework, strategic product design, in which one may design a product to be sustainable from unstable global economic situation, maximizing his or her profit. In the strategic product design, historical trends of customers' preference are analyzed and modeled as a market performance metric, incorporating economic factors. The established model is then used for predicting the future market performance of a new product (or concept) to be developed. For the validation of our approach, we employ a case of conceptual design of mid-sized passenger aircrafts, which requires more than 5 years of product development lead-time, assuming a number of scenarios with different future economic situations.

Approaches for mapping between preferential probabilities and relative design preference ratings

Haifeng Ji, Tomonori Honda, Maria C. Yang

Massachusetts Institute of Technology, United States of America

Assigning preferences to a set of design choices is an important activity in the design process. Previous research proposed a probabilistic approach to extracting preference information from transcripts of design team discussion in a low overhead, implicit way. However, the preference information that was extracted took the form of a "preferential probability," rather than a more traditional preference rating. Preference ratings describe the strength of how much a design team prefers a design choice, and several formal design techniques require such preference ratings. This paper examines the underlying theoretical mappings between preferential probabilities and relative preference ratings, and explores the feasibility of converting preferential probabilities into to relative preference ratings. The paper presents an algorithm for performing this conversion, and then illustrates the use of the algorithm by applying it to a case example. The method proposed in this research has the potential to link implicit preference information generated by real world design teams with formal design decision-making tools.

Continuous design FMEA – Proposal for a new perspective on FMEA

Luiz Fernando Segalin de Andrade

IFSC, Brazil

This paper presents a method that assists in concept evaluation during the conceptual design phase, called the continuous FMEA tool. The use of this tool allows for better execution of integrated design, including the use of concurrent engineering, because it involves a design team in diverse stages of the product lifecycle. The proposed method includes a bibliographical survey regarding the use of the FMEA, and this study lays a theoretical base for the structure of the method. Therefore, we evaluated the method by means of a case study that pointed to positive aspects of the technique. These include simplicity of application and recognition of the best solution principles according to reliability criteria beyond the reduction of subjectivity in the selection of the concepts.

Product Planning and Requirements Clarification

Chair: Christian Weber, TU Ilmenau, Germany

Bringing objectivity to requirements – Using property networks for a more complete requirement acquisition

Benjamin Röder, Tim Gläßer, Herbert Birkhofer

Technische Universität Darmstadt, Germany

The acquisition of requirements is a crucial phase during the product development process. The created list of requirements determines costs, necessary time and iterative steps needed during the product creation. However the level of standardization during the acquisition of requirements is very low due to the vastly different circumstances in every project. This paper elaborates a new systematic approach to acquire a more complete list of requirements based on the use of objective requirement clusters. The use of property networks as basis for the clustering of requirements allows to define clusters in a standardized and highly automated manner. By improving the standardization during the requirement acquisition the amount of unnoticed implicit requirements can be reduced, and incomplete or incorrect requirements can be prevented.

An empirical investigation of requirement evolution in an industrial project

Weili Dai, Marco Aurisicchio

Imperial College London, United Kingdom

In the development process of complex systems, a range of design and system engineering methods are typically applied to analyse and validate requirements. This paper has reported an empirical investigation of documents which have been generated as a result of applying these methods. The investigation focuses on requirements evolution, one of the components of requirement analysis. Requirement evolution involves checking and structuring of requirements and leads to their refinement. The aim of this research is to understand how requirements evolve as a result of applying engineering methods, and to draw insights towards capturing requirement evolution. The motivation behind this work is to establish gaps in the current requirement analysis support tools in order to create an effective requirement analysis workflow. Four operations performed on requirements were used to characterise requirement evolution. The research has revealed that current computational support for design and systems engineering methods lacks means of visualising and capturing requirement evolution. The paper has also highlighted the opportunities to provide justification and clarification in the requirement analysis process.

Modeling systems of objectives in engineering design practice

Albert Albers, Simon Klingler, Bjoern Ebel

Karlsruhe Institute of Technology, Germany

Objectives are central elements of product development processes. The multitude of objectives forms a system of objectives, which is characterized by a high complexity and dynamic. In engineering design practice, modeling systems of objectives is a challenging task the designers are confronted with.

The research presented in this paper focuses on modeling systems of objectives from a designer's perspective which means that user-friendliness and acceptance of the approach is a central aspect. Based on a literature review, we deduce a lean methodology for modeling systems of objectives and realize an implementation of the approach within an intuitive mind-mapping software-tool.

The results of an application in engineering design practice imply that the approach is user-friendly and mainly accepted by designers in practice; the performance however has to be further improved.

Overview of methods supporting product planning: Open research issues

Daniele Bacciotti, Yuri Borgianni, Federico Rotini

Università di Firenze, Italy

The capability to innovate and thus to renew the commercial offer, is becoming the mission of several companies in order to dramatically increase the customer satisfaction. To this aim, the design activities should be effectively supported, paying specific attention to the earliest phase of design, i.e. product planning, in which the designers have to identify the user needs and translate them in product requirements. In the last decades, there have been some attempts to systematically support this critical design activity. The authors undertook an analysis of these methods, highlighting how they support the product planning phase, their strengths and weaknesses. The comparison of the collected contributions shows a plurality of viable research directions, poorly investigated up to now, in order to effectively support the task of product planning. The paper suggests new functionalities to be introduced in the methodologies proposed so far and stresses the attention on performing further tests to increase the reliability of a great amount of poorly validated, although promising, design approaches.

Creativity and Bio-Inspiration

Chair: Amaresh Chakrabarti, Indian Institute of Science, India

Idea matrix and creativity operators

Victor Tang[1], Jianxi Luo[2]

[1]i3nsight LLC, United States of America; [2]Singapore University of Technology and Design, Singapore

Creativity begins with ideas. Scholars have addressed the conditions, factors, and processes to generate creative ideas. However, a formal technical framework to systematically manipulate ideas for exploration, evaluation and ranking against competing creative ideas remains a challenge. The present paper addresses this gap. We ground our work on scholars' definition of creativity. Next we formalize the notion of an idea as a construct of attributes and features using our matrix representation. We then propose a set of idea operators, which use matrix-expressed ideas as operands, to generate new ideas. We follow with structured matrix-algebraic methods used to assess, rank and measurably improve the new ideas in terms of creativity. To illustrate the application and utility of our methods, we assess, compare and improve two real-world competing product ideas. This approach, of using idea matrices and creativity operators to systematically generate and evaluate new ideas, presents a repeatable method to operationalize creativity.

An assessment of personality traits and their implication for creativity amongst Innovation Design Engineering masters students using the MBTI and KTS instruments

Yanliuxing Yan[1], Peter R N Childs[1], Ashley Hall[2]

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Creativity and its realisation are vitally important to industry as identified, for example, by the Capitalizing on Complexity report undertaken by IBM. The scope of this study is to explore masters level design engineering students' creativity in terms of personality correlation. A personality survey conducted on Innovative Design Engineering (IDE) masters students by applying the MBTI and Keirsey Temperament Sorter (KTS) to investigate individual creativity is reported.

The results reveal that intuition, which is suggested to potentially strongly link with creativity, is quite prominent among the IDE students. That extraversion is positively correlated with creativity in the engineering domain is modestly confirmed. Contrary to expectation, perceptors did not outnumber judgers. From KTS theory, although Idealists and Rationals account for a small part of the whole population, they mark exceptional appearances in IDE sample. It is reasonable to speculate that more creative potentials, which lead to better creative outcomes, exist among people who belong to those personality groups and possess certain personality traits in the design engineering fields where creativity is desired.

Bio-inspired ideation: Lessons from teaching design to engineering students

Romain Farel, Bernard Yannou

Ecole Centrale Paris, France

Biologically inspired design uses inspiration of natural systems to develop solutions for design and engineering problems. We experienced teaching bioinspired method to engineers in the context of problem solving course in Fall of 2012. The aim of this study was to investigate and understand the perception of bioinspired design by engineering students and to provide insight into problem driven and solution driven approaches as a type of design ideation pedagogic method. This paper provides the detail of analysis of ideas and summarizes our main observations: 1) Difficulties to follow problem driven approach rather than solution driven; 2) Distinct preference of inspired ideas for product, process, service and system domains.

A deep dive into creative thinking: The now-wow-how framework

Åsa Ericson, Peter Törlind

Luleå University of Technology, Sweden

Innovation strategies are becoming even more vital for manufacturers that wish to turn their business into a service based one. Integration of product and service aspects in early design stages insists on approaches where all competences are used for to provide the foundation for new solutions. Often such creative work is expected to randomly come from ordinary work tasks or from passionate geniuses. Few companies apply an intentional and coherent process for bringing together mixed teams to create ideas for radically new product and services.
Besides describing the background for the development of a radical innovation workshop format, this article presents a three-step framework for a collaborative process in which the participants' diverse competences and skills are seen as the source of creativity. The framework, called now-wow-how, allows a workshop to be planned, designed and conducted in order to analyze an existing situation (now), a preferred alternative future (wow) and elaborate on how these two can be bridged (how). The paper provides examples of creative methods that can be used to conduct each stage, and also a guide for how to facilitate a creative workshop.

Seeking bioinspiration online: A descriptive account

Reviewers' **Favourite**

Swaroop Vattam, Ashok Goel

Georgia Institute of Technology, United States of America

Biologically inspired design, which espouses the use of analogies to biological systems in generating conceptual designs for engineering problems, is emerging as an important movement in modern design. A key initial task in the design paradigm - seeking bioinspiration - identifies relevant biological systems to use as analogies. Current efforts at supporting designers in this task tend to be technology centric and do not take sufficiently into account the actual practices and the everyday context of designers engaged in this task. As a result, there is a disconnect between the reality of seeking bioinspiration and the technological interventions for aiding it. Here we present two studies that focus on describing the current practices and challenges of seeking bioinspiration. We find that seeking bioinspiration is significantly situated in online information environments where designers are confronted with three main challenges: findability, recognizability and understandability. We also indicate how this descriptive account leads to an information-processing model of online bioinspiration seeking which may be leveraged to developing more human-centric approaches for technological interventions.

Save a napkin, save a tree: The role of metaphors in product design to change behavior

Soodeh Montazeri, David Finkbiner, Panos Papalambros, Richard Gonzalez

University of Michigan, United States of America

In this paper we study the role of metaphorical design concepts in triggering a mindful consumption behavior. Through a retrospective study on persuasive metaphorical designs for behavior change, we identified 7 persuasive heuristics for using metaphors for behavior change. According to the ELM of persuasion and persuasive effect of visual metaphors, we hypothesized that the use of persuasive metaphors in design of a napkin dispenser increases the mindfulness of the users, presumably through a central route and would increase the probability that people make more informed decisions and use fewer napkins. We used persuasive metaphor heuristics to design a metaphorical napkin dispenser to inform people about the consequences of their excessive consumption on the environment and encouraged them to use fewer napkins. In a local coffee shop, we measured napkin consumption using three different napkin dispensers: the original dispenser with no metaphor, one dispenser that shows metaphorical connotations of sustainable consumption, and a dispenser with a non-conservation metaphor. The results suggest effective behavior change in response to the consumption related metaphorical design.

Towards a unified theory of properties in engineering design science

Seppo Suistoranta

Wartsila Finland Oy, Finland

This study deals with the current theories of properties that are introduced and presented in the literature of engineering design science. Based on the findings, the paper addresses four fundamental theses, which are separately discussed and commented.
Our sole research question aims at amending the basics of the property theory in EDS. The main outcome of this paper is as follows:

- Definition of the property should be specified and expanded. It should be unambiguous at all abstraction levels of a technical system.
- Terminology of properties, especially the naming of ontologically important property classes, should be agreed on.
- The theory should not be limited only to a particular system model but should rather apply to the whole world. It should also address the properties related to the observer and environment, and they should together make a unified and unambiguous system.

These amendments will help the theory work in its principal tasks, which are explaining, describing, and evaluating objects and events. Further studies are needed. Likewise, the outcome of this paper should undergo exhaustive discussion within the community of engineering design science.

Modeling parameter analysis design moves with C-K theory

Ehud Kroll[1], Pascal Le Masson[2], Benoît Weil[2]

[1]Technion, Israel; [2]Mines ParisTech, France

The parameter analysis methodology of conceptual design is studied in this paper with the help of C-K theory. Each of the fundamental design moves is explained and defined as a specific sequence of C-K operators and a case study of designing airborne decelerators is used to demonstrate the modeling of the parameter analysis process in C-K terms. The theory is used to explain how recovery from an initial fixation took place, leading to a breakthrough in the design process. It is shown that the efficiency and innovative power of parameter analysis is based on C-space "de-partitioning". In addition, the role of K-space in driving the concept development process is highlighted.

On the co-existance of FBS and TRIZ for simplifying design process in an iterative way

Davide Russo, Christian Spreafico, Stefano Duci

University of Bergamo, Italy

Functional design model and in particular FBS model are, in recent years, most commonly accepted design theories to support design process. However, with regard to their use it remains widespread skepticism especially by industry engineers, more inclined to use problem solving methods. Reasons are varied and come from the way in which they approach design problem, often considered too abstract and far from everyday design reality.
This paper contains a number of measures to bridge this gap. In particular is proposed an integration between FBS and TRIZ to best rationalize designer efforts in a design process based on a large set of initial requirements. The considered method addresses the determination of the main function and its implementation on the device, and then it starts to iteratively overcome the other requirements (functions) by solving contradictions. In order to obtain more practically feedback, each phase is described with technical parameters. Furthermore the method allows a quickly and economic screening of the alternatives. A design process for a chips waste compactor is carried out by using that process.

Understanding fixation effects in creativity: A design-theory approach

Marine Agogue[1,2], Mathieu Cassotti[2]

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Despite diverse studies grasping at different aspects of fixation in creativity and design reasoning, the underlying mechanisms of fixation, i.e. the processes that lead to being fixed on a small number of unvaried solutions, are still unclear. We propose a theoretical framework to model fixation based on C-K design theory, in which fixation is characterized as a set of restrictive heuristics activated in a creative reasoning. Thus, a restrictive heuristic is a design reasoning that uses only spontaneously activated knowledge in the K space and restrictive partitions in the C space. Any expansion in the design reasoning will then lead to explore solutions outside of fixation, characterizing expansive reasoning. We then use a creative task to test our framework. We apply our theoretical frame on this task to characterize the fixation effects that can occur and we confront this model with a set of experiments, where 142 participants where asked to generate solutions to this task. We show how different populations can be fixed in different ways and how the theoretical framework we propose allows making sense of this variety of fixation in design processes.

On the effectiveness of experimenting with C-K theory in design education: Analysis of process methodology, results and main lessons drawn

Philippe Michel Blanchard[1,3], Patrick Corsi[2], Hervé Christofol[1], Simon Richir[1]

[1]Arts et Métiers ParisTech, France; [2]IKBM Sprl, Belgium; [3]L'école de design Nantes Atlantique, France

This paper experiments a transdisciplinary design innovation way in educational contexts through workshops implementing a C-K Theory-based co-evolution between Concepts and Knowledge spaces. At l'école de design Nantes Atlantique EDNA, a 'posture for humans' concept subject was prescribed to students working half time in industry as a preparatory phase to the development of a contemporary day bed. The workshop permuted halfway C-K groups' yields: cross-contents swaps brought ruptures in groups' bias and enabled locating and addressing cognitive fixations. A log scale expressed relative ΔK increments in mobilized knowledge. Groups' innovation capability was graded on innovation capability maturity levels relative to C constructs. Engineering students often opened large K gaps while designers amplified C jumps even if bounding K operations. The process improves C-K implementation processes for small organizations and hybridizes competencies. With its primary power to orderly address the known and the imaginary, C-K Theory helps going beyond known design innovation approaches and supports educational settings not far from what is possible about everywhere in all specialty domains.

Investigating elementary design methods

Reviewers' **Favourite**

Sebastian Zier, Herbert Birkhofer

Technische Universität Darmstadt, Germany

The aim of investigating elementary methods is to increase the acceptance of methodical working in practice by developing a systematic approach for the deduction, description and improvement of design methods. The purpose of this paper is to give an overview about the goals and modularization methods of design methods with the Genome Approach.

Focusing Eye Tracking and Raw Data

Chairs: Petra Badke-Schaub, Delft University of Technology, Netherlands
Mirko Meboldt, ETH Zurich, Switzerland
Sven Matthiesen, Karlsruhe Institute of Technology, Germany

Goal of Workshop

In order to arrive at theories, based on data which are much closer and more directly gained from the designer attention to different behavior. We will conduct a collaborative research focus over a longer period of time, with focus on raw data based human behavior research.
Thus, we might arrive at not only reliable but also valid data. The long term objective is to develop human centered design methods.

The direct goals of the SIG for now are:

- Sharing experience with new researchers
- Learning more about these kind of methods, data analysis and interpretation
- By this improving the almost a-theoretical situation of design science
- Establishing research collaborations, by sharing raw data and build up experimental setups for research studies
- Working on the interpretation of raw data and finding the reasons/models of different raw data interpretations.

The SIG will continue offering a workshop each year but the people who attend should contribute to the workshop. We plan a three years program with the contribution of all set participants and the aim of a common publication in this field. Here at ICED13 the SIG will start with an intensive Eye Tracking program. Eye Tracking is understood as a pilot, in order to adapt new raw data based research methods from cognitive science (like functional magnetic resonance imaging (fMIr), electroencephalography (EEG), electromyography (EMG) etc.).

Abstract

Product development, design and innovation processes are determined in process and outcome by characteristics of human beings and their interaction with the intentional context. Inventions are created, new solutions are synthesized and decisions are made by humans. Researchers undertake a lot of efforts to have a closer look on human behavior in order to:

- Develop approaches to understand human behavior in decision making and problem solving
- Find empirical foundations and theoretical complementarities to explain humans' (in)ability of considering multiple possibilities and select one optimal course of action in specific situation
- Develop models and methods which are usable and accepted in practice and educations

Up to now most research on human behavior in the area of engineering design uses research methods: such as interviews, discourse analyses, observations, participant observation, document analysis and protocol analysis. In recent years, methods and techniques, which are developed in behavioral and cognitive science, made an enormous step forward.

Techniques like Eye Tracking (ET) achieved a high level of maturity and are increasingly applied in different research fields. The SIG group will start a research focus on Eye Tracking, to observe engineers during the design process or customer during the usage of a product.

Workshop Agenda

30 min	Introduction into the new way of collaboration
15 min	Creating the SIG research vision
70 min	Eye Tracking: Analysis and interpretation of eye tracking raw data and Human Behavior insights
60 min	Definition of experimental setup and stimulus for experiment
30 min	Planning of research studies, timing to share the data and papers on the analysis and interpretation of data for the SIG Design14

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Tutorial-Style Workshop : Additive Manufacturing

3D Printing Processes, Applications, and Design Considerations

Chairs: David Rosen, Georgia Institute of Technology, United States of America
Robert Ian Campbell, Loughborough University, United Kingdom
Carolyn Conner Seepersad, University of Texas at Austin, United States of America

Goal of Workshop

To identify and address the characteristics of additive manufacturing and discuss design for additive manufacturing issues, in particular, concering 3D printing processes, applicatioins and design considerations

Abstract

The workshop will begin with an introduction to additive manufacturing (AM) processes and technologies. Example parts from a wide range of processes will be passed around. Processes will be categorized based on whether they deposit material or deliver energy as their primary method of part fabrication and by whether material is processed using 1D vector scanning, parallel 1D raster scanning, or area filling approaches. Mechanisms of material processing will be summarized. Applications will be surveyed. Differences between prototyping, tooling, and production manufacturing will be highlighted.

A wide ranging exploration of design opportunities will be presented that is available with AM, such as unlimited geometric capability and heterogeneous material property for better design performance. Strategies for exploring design options will be provided through a series of examples. Current computer-aided design (CAD) tools (e.g. Pro-Engineer and SolidWorks) will be examined for their capabilities and limitations in serving the range of device designs that AM enables. Several design systems will be surveyed that were developed for AM. Attendees will have the opportunity to apply their knowledge of AM and design opportunities through a design exercise. Attendees will redesign a common consumer product to take advantage of the capabilities of AM processes. Instructor feedback will help guide the exploration of new design opportunities. An introduction will be provided to an effort to standardize design guidelines, through the ASTM F-42 AM committee activities.

The presentation will conclude with a summary of results from the 2009 NSF/ONR Roadmap for Additive Manufacturing Workshop that will describe some research directions and expected capabilities.

Workshop Agenda

Presentation, examples, design exercise

Chair: Janet Theresa McDonnell, Central Saint Martins, United Kingdom

Design activity and team interaction characteristics: A case study of protocol analysis on team-based product-service systems design processes

Reviewers' **Favourite**

Sang Won Lee, Jun Lee, Nanhyeon Jo, Yong Se Kim

Sungkyunkwan University, Republic of Korea (South Korea)

In this paper, the protocol analysis on team-based Product-Service Systems (PSS) design processes is conducted to study the characteristics of design activities and team interactions. For protocol analysis, the detailed coding scheme of design activities of PSS design process is proposed and the interaction process analysis (IPA) coding scheme is utilized. Two design teams are composed to conduct team-based PSS design sessions. In the protocol analysis, the patterns of design activities during the PSS design are characterized, and it is demonstrated that the individual team member leads specific design activities and spends more times on them based on his/her knowledge level in turn. In addition, the team interaction patterns seem to depend on the personalities of the individual members due to its social nature. These findings can be used for composing design teams and guiding their design process for effective PSS design.

Interactive modeling and evaluation of product-service systems

Philipp Herzberger, Florian Georg Hans Behncke, Sebastian Schenkl, Udo Lindemann

Technische Universität München, Germany

Product-Service-Systems (PSS) are an opportunity for differentiation within the globalized producing industries. The design of PSS concepts challenge companies and question their generic business model. As a result, companies have to cope with complex activities 'opportunity recognition', 'PSS design' and 'business planning' without the support of an integrated approach that is easily understood and applicable by all collaborating stakeholders with a minimum of training. The objective is the development of a modeling procedure for PSS which supports a systematic variation of its typical properties and allows interdisciplinary interaction in teams. The paper presents a business model canvas, a PSS-life-cycle and PSS-configurator imbedded in a procedural model. The methods as well as the procedure are evalueted by 3 case studies with industrial partners. Furthermore, the case studies investigate the influence of the derived methods on the product/service-ratio of the provided solutions of the industrial partners within the case studies. Finally, the paper gives an outllook on the enabled strategic evolution of a company's generic business model to a business model of a PSS provider.

Industry specific PSS: A study of opportunities and barriers for maritime suppliers

Jakob Axel Bejbro Andersen, Tim C. McAloone, Adrià Garcia i Mateu

Technical University of Denmark, Denmark

Product/service-System (PSS) business models are finding applications with suppliers and manufacturers across industries, but the models have yet to establish a strong foothold in the maritime sector. A number of metrics for evaluating the attractiveness of PSS business models have been proposed in chiefly design research and operations management literature. This paper applies a number of these metrics to the maritime sector using data from a number of maritime suppliers. It is found that the industry is, at least in some aspects, attractive from this PSS metrics standpoint. To explain the inherent lack of PSS maturity in the industry despite this metrics-based conclusion, the discussion moves beyond the quantitative factors and considers a number of organisational, structural and cultural issues that stand in the way of PSS. This paper is based on the initial responses provided by maritime suppliers in a maritime research consortium in (name of country removed).

Supporting Tools

Chair: Kikuo Fujita, Osaka University, Japan

Are companies ready for the revolution in design – Modelling maturity for virtual prototyping

Susanna Aromaa, Simo-Pekka Leino, Juhani Viitaniemi

VTT Technical Research Centre of Finland, Finland

Companies are meeting growing demands for readiness to respond rapidly to changes from the outside world. Companies actively manage and develop their competences by applying new technologies and methodologies such as virtual prototyping (VP). Nevertheless, no general, structured guidelines for VP implementation are available due to novelty of the use of virtual reality technologies in machine industry.

The purpose of our research was to improve the use of VP in companies. In this paper, we describe two company cases from the machine industry that are implementing VP for everyday use. During the research, it became clear that the companies had quite intuitive ways for the VP implementation, and they experienced many challenges. This paper describes how companies can improve VP implementation in a more structured way using the virtual prototyping implementation maturity model (VIRMA). VIRMA supports companies in improving their adaptations of VP and benefitting earlier from VP use in design.

Research on design idea generation support through design practice

Tamotsu Murakami, Shota Higashihara, Takamasa Fukuda, Kazutaka Ueda

University of Tokyo, Japan

The purpose of this research is to propose a method and a computational tool to support designer/engineers' idea generation so that they can find or discern potential but essential design problems and needs and devise creative and innovative design solutions to solve or meet them. As the first step of study on Design Idea Generation Support (DIGS) software tool which actively DIGS up ideas from designer/engineers' mind by stimulating their conscious/subconscious memory with word association suggestion, the experiments of word association by students working on design project (1) by heart, (2) by referring concept relationship type information, and (3) using software with computational concept dictionary. Word association by referring concept relationship type information turned out to be effective to increase variety of association link types when the computational dictionary does not always contain ideally rich vocabulary and association links. Word association using software with computational concept dictionary turned out to be effective to obtain associated word which user cannot think of by heart.

Co-evolution of design tactics and CSCWD systems: Methodological circulation and the TATIN-PIC platform

Andrea Luigi Guerra[1,2], Thierry Gidel[1,] Atman Kendira[1], Enrico Vezzetti2, Alistair Jones[1]

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This paper proposes a design strategy and a Computer Supported Cooperative Work in Design (CSCWD) system, which have co-evolved together to meet the goal of improving the Preliminary Design Process (PDP). Because there is no consensus for a definition of PDP, here we define it as an evolutionary, iterative and heuristic process.

Methodological Circulation is a design strategy where multidisciplinary design teams explore the solution space of a problem, while a project manager facilitates this heuristic and effectual exploration by determining the way forward through appropriate decision-making.

Creating a computer support system for this design strategy requires considering 4 factors at the base of this co-evolutionary approach: the problem-solving cognitivist posture, the dynamic of the preliminary design activities, the nature of collaboration, and the composition of the design group and management. We present how these factors have mutually influenced our CSCWD system called TATIN-PIC and the MC. We present the preliminary results of ethnographic observations of design teams performing project planning within the TATIN-PIC environment and a traditional designer's environment.

Sharing and Disseminating Engineering Knowledge and Information

Chair: Dorian Marjanovic, University of Zagreb, Croatia

Application framework for traceability of engineering information

Reviewers' **Favourite**

Mario Štorga[1], Tino Stanković[2], Neven Pavković[1], Nenad Bojčetić[1]

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The work reported here builds on the TRaceability of ENgineeringINformation - TRENIN (www.trenin.org) project by discussing the the application framework for engineering information traceability. Traceability as a property of the product development should provide a context by which the engineering information evolution can be better interpreted. In the TRENIN project context is explored from two different viewpoints. The first is the context of capturing engineering information evolution including the recording and explanation of the conditions around design activities. The second is the context of using recorded engineering information traces as a basis for identification and understanding of the captured engineering information evolution. Prototype TRENIN application framework is presented consisting of: Traceability Engine, Utilisation Explorer and Visualisation Tool. Results of the framework validation and feedback from industrial partners are discusses and based upon this experience, further research directions are defined.

Meeting the requirements for supporting engineering design communication - PartBook

James Anthony Gopsill[1], Hamish Charles McAlpine[1], Ben James Hicks[2]

[1]University of Bath, United Kingdom; [2]University of Bristol, United Kingdom

The Engineering Design Environment is evolving in many ways. Considerable amounts of data, information and knowledge are 'building up' within engineering companies and engineers are becoming involved in ever-more distributed collaboration activities to tackle complex multi-disciplinary challenges in the design of new products requiring the need to share knowledge. These changes are placing further challenges on Engineering Design Communication (EDC, a fundamental knowledge sharing activity) as the current methods of communication were never specifically designed to support such technical and highly-contextual communication. Much research has been performed on understanding EDC, thus enabling a list of requirements to support EDC to be generated. Therefore, this paper proposes a prescriptive tool, (PartBook) which instantiates these requirements and looks at the next steps being taken to evaluate the tool in meeting the requirements.

Procedure for selecting knowledge elicitation methods with regard to knowledge types

Daniel Roth, Hansgeorg Binz

University of Stuttgart, Germany

The intention of this paper is to propose a procedure that illustrates how elicitation methods appropriate for knowledge types (domains) might be selected. Analysing existing literature suggests that it is mostly possible to provide a statement about more frequently used knowledge acquisition methods. Furthermore, there are studies that show that certain knowledge acquisition methods are significantly more efficient than others. The attempt to link knowledge acquisition methods and knowledge itself is still missing.

For this purpose, knowledge types have been analysed according to their content. As a result, it is possible to assign specific characteristics to each knowledge type. Furthermore, each acquisition method offers specific abilities. This paper discusses how acquisition methods and their related abilities should be connected with the specific characteristics of knowledge types. Thus, the proposed procedure helps knowledge engineers to identify the suitable acquisition method for specific knowledge types.

Supporting Design with Computational and Analogical Reasoning

Chair: Serena Graziosi, Politecnico di Milano, Italy

The creative act is done on the hybrid machine

Robert E. Wendrich

University of Twente, The Netherlands

Ideas are hard to find, people love to have ideas! Having lots of ideas looks like you really are very creative and that you must posses very special talents more than anybody else around you. Often you are praised for being so highly creative and so smart, that you indulge yourself in all kinds of happy thoughts about how good you are consequently daydreaming about having many more ideas in the future. We believe that anybody can be creative and has the capacity to have ideas or think thoughts that if brought to bear are so creative and ingenious that we could become envious of such a person. Our hypothesis is that if you could externalize ideas with the aid of computational machines and bring out the creative act in harmonized and holistic ways such that people can benefit and gain from it. Sharing and spreading your ideas, showing creativity without being inhibited, having confidence to open yourself up and feel free to convey your thoughts no matter how 'ridiculous' it may sound has an immediate affect on people's behavior, self-esteem and psychological condition. Creativity, imagination and inspiration go together well with doing, taking action and being motivated to carry on.

Using design database structures to characterize freedom-to-operate in a design space: A legal case study

Reviewers' **Favourite**

Katherine Fu[1], James Dilmore[2], Jonathan Cagan[3], Charles H. Dougherty Jr.[4]

[1]Massachusetts Institute of Technology, United States of America; [2]Reed Smith LLP, United States of America; [3]Carnegie Mellon University, United States of America; [4]Beck & Thomas, P.C., United States of America

Novelty, and specifically freedom-to-operate (FTO), assessment is crucial step in launching and patenting a new product. We compare a traditional FTO analysis performed by a patent lawyer and expert in chemistry and pharmaceutical technology with the outcomes of a computational method. The computational method discovers the structural form of a set of patents using a text-derived similarity data, creating a descriptive space of the potentially relevant prior art. A test formulation of a fabricated new pharmaceutical drug was developed for the FTO and computational analysis, and strengths and areas for improvement of the computational method were identified. FTO analysis is time consuming and labor intensive, and results indicated that with further development, the computational method could aid patent lawyers in getting a faster and fresh snapshot of the space of prior art, and even point to patents most relevant to a proposed new product. Areas for improvement are intrinsic knowledge of the computational method in the field of application, and finding which sections of patents lead to most accurate representations of the space, and further automation and efficiency.

Towards an approach to integrate technological evolution into product design

Yannick Chapuis, Frédéric Demoly, Samuel Gomes

Belfort-Montbéliard University of Technology, France

The development, manufacturing and production of high value-added products, such as intelligent product, technological product and product-services, are part of the highest priority of today's competitive industries. This challenging objective highlights technology introduction issues in the development of current complex products in large-scale companies, especially in product design and manufacturing phases. In a recent past, researchers has been inspired by biology, mathematics, artificial intelligence and so on, so as to propose new models, algorithms and approaches for advanced product design and manufacturing. In such a context, new product development still requires an external vision. An analogical reasoning with medical transplantation is addressed in the present paper in order to describe the integration/evolution of technology in product design, from conceptual to detailed stages.

Chair: Keiichi Sato, Illinois Institute of Technology, United States of America

A framework for effective human-to-machine communication for artificial interactive systems

Siang Guan Lee, Peer Sathikh

Nanyang Technological University, Singapore

Most artificial interactive systems are designed by technical experts and not from the point of view of human-to-machine (H2M) communication.
This paper discusses how two foremost human-to-human (H2H) communication theories – Speech Act Theory and the Theory of Communicative Action, are employed to propose a framework for the design of interactive artificial systems.
The proposed framework embodies five attributes: the user's intentions and the context of the transaction; employing strong directive language while minimizing indirect speech, and assuring trust.
The framework was tested on four interactive machines: a bank ATM, a subway ticketing machine, a registration kiosk & a customer feedback kiosk. The GTM best complied with the attributes of the framework: the ATM the least.

The effect of digital media on design communication and creativity in a design group: A studio as a case study

Zi Ru Chen

National University of Singapore, Singapore

Design is a group behavior and creativity is the result of social interaction. Digital media are regarded both as the environment in which designers accomplish creative ideas and as a platform of design communication for designers in a social group. This study aims to investigate the phenomenon of design communication in the group design process using digital media. The study was conducted by observing a design group in a case study. A practical design "studio" was selected to serve as the observation environment. The observed results were used to promote understanding of how digital media inspire design thinking and facilitate the communication of design ideas.

Design for functional requirements enabled by a mechanism and machine element taxonomy

Szu-Hung Lee, Pingfei Jiang, Peter RN Childs

Imperial College London, United Kingdom

A process providing an option for engineers and designers to separate the consideration of functional requirements and movement requirements to encourage diverse thinking has been developed and implemented in a graphical interface. In order to assist in consideration of attributes, a database, mechanism and machine element taxonomy (MMET), has been constructed. MMET is composed of the functional attributes, movement attributes, and advantages and disadvantages of machine elements and mechanisms. It provides engineers and designers a wide range of component selection to fulfil design requirements and reliable references to make decisions. Three different interfaces such as hierarchy, functional-oriented and movement-oriented are defined to allow users to explore different options and purposes. This taxonomy also provides comparative information between elements, mechanisms with the same main technical functions. With this information contained in MMET and with the additional aid of a functional analysis diagram (FAD) approach, engineers and designers are able to explore flaws in current designs and deliver alternative solutions by following a proposed creative optimizing process.

Mediating technology: How ICT influences the morality of the digital generation

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An increasingly important theme for ICT designers is in what way ICT interferes with moral reasoning. ICT has given us new possibilities and it has simplified our lives. However, it is also influencing our experiences and morality, especially with the young generation. In this article, we present an exploratory empirical study of the relation between morality and ICT among adolescents and young adults. Using focus groups and diary research we studied the perceived impact of ICT on their daily lives and their level of cognitive moral reasoning within ICT related situations.

We observed, conform our theoretical outline, that when ICT is considered impersonal and does not strongly obstruct the own perception of freedom most of our respondents reasoned in a consequentialist and pre-conventional way. Simultaneously, when ICT mediates in personal relations and interferes more with the own perceived freedom, higher moral arguments were demonstrated. This was particularly the case with the older age group. They were better able to identify the impact of ICT on their lives. With these findings, suggestions for a design process that takes this influence on morality into account are offered.

Development of the digital storage Fuon

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This paper ties to Fuon Theory, where functional icons are suggested to phrase standardized functional units. Having functional unit parameters at hand, products that can be described by these parameters can be put into one family. This further helps to compare the environmental performances of products that fall into the same family.

In this paper, a fuon for digital storage devices is developed and tested. The fuon can be used to phrase the functional units of a variety of products such as magnetic hard-discs, USB flash drives, SD cards or SSD drives. The functional unit parameters are derives for the fuon and its applicability is tested through different statistic tests.

Effect of expectation on affective quality perception

Reviewers' **Favourite**

Hideyoshi Yanagisawa, Kenji Takatsuji, Natsu Mikami

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A user's experience of a product involves a set of transitions from one sensory state to another. In such state transitions, a disconfirmation between prior expectation and posterior experience evokes emotions such as surprise, satisfaction, and disappointment. A noteworthy phenomenon in the perception of expectation disconfirmation is that the expectation affects the perceived experience itself. In this paper, we propose a theoretical model of the expectation effect. We hypothesize that amount of expected information, i.e. entropy, determines the occurrence of the expectation effect and that the amount of gained information is positively correlated with the intensity of the effect. We further hypothesize that a conscious level of expectation discrepancy distinguishes between two types of expectation effect, namely, assimilation and contrast. To verify these hypotheses, we conducted an experiment in which participants responded to the tactile qualities of surface texture. Based on our hypotheses, we analyzed the causes of the visual expectation effect on tactile roughness during a sensory modality transition from vision to touch and found the appropriateness of the proposed model.

Preliminary simulations of scale and value of legitimation in design practice

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This paper presents preliminary simulation results on the effects of scale and value of legitimation in design practice. The paper describes a basic simulation model, which adopts legitimation code theory as the underlying conceptual framework. This model simulates a society of design agents with different backgrounds. Based on the given legitimation values of their discipline, agents are attracted towards knowers or knowledge. The force of attraction towards the knower or knowledge varies across disciplines. The emergent design practice is plotted in a two dimensional space defined by the knower and knowledge axes. The effect of scale is studied by changing the number of agents. The effect of value is studied by comparing scenarios where legitimation values of a design agent remain constant throughout the simulations to scenarios where legitimation values increase at a constant rate, as a function of time spent in a multi-disciplinary environment. Preliminary results indicate that both scaling up and changing values can lead to cohesive design practice in multi-disciplinary societies. The underlying assumptions and limitations of the simulation model are discussed.

Adapting the IFM framework to functional approaches across disciplines

Boris Eisenbart, Kilian Gericke, Lucienne Blessing

University of Luxembourg, Luxembourg

Conceptual design is considered one of the most demanding design tasks requiring a joint effort of the involved designers, particularly in interdisciplinary design. The IFM framework intends to support interdisciplinary collaboration of designers, by linking the different functional modelling perspectives, which are prominent in the different disciplines. The presented analysis aims to answer the question, which particular adaptations are required, in order to enable and improve the application of the IFM framework across disciplines. The paper presents a comparison of the framework with established functional approaches proposed in literature. It is shown, in which ways the specific contents addressed in the individual steps of the reviewed functional approaches can be mapped onto corresponding views in the IFM framework. The findings suggest that the IFM framework is interoperable with the reviewed functional approaches without necessitating fundamental changes. Furthermore, specific potentials for the improvement of its applicability across disciplines are derived. Finally, the paper discusses specific adaptations of the IFM framework, in order to improve its applicability.

	P Podium Sessions				D Discussion Sessions			W Workshop Sessions
08:45 - 10:15	Knowledge and Information Sharing and Transfer Location: IH-90110	Tools and Methods for Communication and New Product Development Location: IH-90104	Design for Effective Resource Management Location: IH-9B218	Modelling of Processes Location: IH-9B118	Customer and User Experience Location: IH-9B320	Design Practice Location: IH-9B321		
10:15 - 10:45	Break Location: IH-90101							
10:45 - 12:15	Representation of Design Knowledge and Information Location: IH-90110	Design Research and Research Methods Location: IH-90104	Design for X (Weight and Cost) Location: IH-9B218	Methods for Validation and Decision Location: IH-9B118	Design for User Experience Location: IH-9B320	Management of Innovation Location: IH-9B321	Product Architectures and Families Location: IH-9B312	
12:20 - 13:20	Lunch Location: Cafeteria (AH-1B102) & International Conference Hall (AH-10501)							
13:30 - 14:45	Management of Complexity Location: IH-90110	Functional Modelling Location: IH-90104	Early Stage Methods and Tools Location: IH-9B218	Service Innovation in Organisations Location: IH-9B118	Understanding Organisational Needs in Product Development Location: IH-9B320	Design Aesthetics and Comfort Location: IH-9B321		
14:45 - 15:15	Break Location: IH-90101							
15:15 - 15:45	**Keynote: Research the Designer - Which Concepts Explain the Designer's Activities and Provide Support for Successful Processes and Outcome?** Location: New Millennium Auditorium (AH-1B201) Speaker: Petra Badke-Schaub, Delft University of Technology, The Netherlands							
15:50 - 16:30	Closing Ceremony Location: New Millennium Auditorium (AH-1B201)							
16:30 - 17:30	Closing Reception Location: IH-90101							

Knowledge and Information Sharing and Transfer

Chair: Mario Storga, University of Zagreb/Faculty of Machanical Engineering and Naval Architecture, Croatia

A white book approach as support for sharing experiences

Johan Holmqvist, Åsa Ericson

Luleå University of Technology, Sweden

Knowledge transfer is hard to manage in technical projects due to the fact that a lion part of the knowledge is based on experiences gained in daily work. The lessons learned depend on the individuals' distinct perceptions of their experiences. This provides learning, but complicates sharing and the build up of an organizational knowledge base. One effort to capture and disseminate experiences is a white book approach. Simply, white books consists of written text stored in documents, which is used to both reflect upon a previous project and to learn for a new one. The purpose for this paper is to find out how experiences are perceived and formalized in technical projects. Two types of empirical data provide the basis, namely text analysis of white books and interviews with engineers. The result shows that there is an evident difference between what engineers write about their experiences and what they say about them. Implications for the white book approach as a mean for sharing experiences are discussed, for example since pre-knowledge and context for the experiences are lacking in the written text the author and the reader of the text are likely to interpret it differently.

Modeling the knowledge flow network for collaborative design process

Zhinan Zhang[1], Wei Ma[1], Gang Liu[2], Yong Chen[1]

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The design and development of a complex product involves various designers with multidisciplinary knowledge. Knowledge flows between individual designers or teams play a crucial role in determining how well a design task can be performed, and hence the cost and quality of the designed product. Therefore, this paper is devoted to developing a dynamic planning approach for the modeling of a knowledge flow network. Based on the process analysis techniques from Petri Nets, it first defines the concept of a knowledge flow network. The graph based approach is then adopted to represent a knowledge flow network. A dynamic multi-matrix construction method is then developed for the analysis of the knowledge flow network. The approach is especially suitable for describing large-scale design processes involving numerous tasks, designers (or automated computer agents), resources and identifying potential knowledge flow bottlenecks.

The value of design information in collaborative design networks

Katrine Mahlamäki

Aalto University School of Science, Finland

Collaborative design requires efficient communication, but the value of design information for the collaboration partners is difficult to predict. The dimensions of design information value and challenges related to them need to be identified in order to improve the value of design information for collaboration partners. We analyzed literature in order to understand the value of information in general. We conducted four case studies in four collaborative design networks in order to understand and model the value of design information in this industrial context. The results of our case studies reveal that the challenges of design information exchange in collaborative design networks lie in the capture and reuse of design information, access to information and targeting design information exchange. We found timeliness, relevance, accuracy, credibility, frequency, comprehensibility and accessibility to be important dimensions of design information value. Maximizing information value based on these carefully selected attributes seems to offer us a feasible approach for designing information management processes for collaborative design.

The language of collaborative engineering projects

Reviewers' **Favourite**

Ben Hicks

University of Bath, United Kingdom

The challenges of managing large, long-life, distributed engineering projects are discussed and the need to improve monitoring and control in order to reduce over-runs, improve productivity, better manage IP and monitor risk is highlighted. In order to achieve this, it is proposed that the outputs of the communications and the digital objects generated as part of the project are fundamentally related to performance and that analysis of their content can provide understanding, insights and predictions about the project. In order to explore this proposition an exploratory study of the content of a project email corpus and its relation to the project schedule and project performance is presented. This study demonstrates a series of eight trends (termed signatures) between longitudinal traces of problem solving, information transactions and management that corresponded to project states and modes of management intervention. Although the project-related rationale accounting for the signatures seen in this project may not accurately characterize all projects, their alignment with actual events points to the potential value of email content for improving project management.

Tools and Methods for Communication and New Product Development

Chair: Georges M. Fadel, Clemson University, United States of America

Linking of function carriers with physical contradictions

Milosav Ognjanovic[1], Jasmina Babic[2], Sanja Vasin[1]

[1]University of Belgrade, Serbia; [2]Military Technical Institute, Serbia

The current trend in the new product development is horizontal integration of various fields of technical solutions and principles of action (mechanical, electrical, software, etc). In order to provide integrated (multidisciplinary) products of higher quality level or to enrich the existing technical systems with electronic control or with artificial intelligence, the design structure should involve function carriers with various physical and other principles. Linking of function carriers with principles of action in conflict (physical contradictions) presents an important problem. The article contains the analysis of contradictory principles of action and identification of the ten groups of function carriers with contradictory principles. The cases study of existing technical solutions, support the basic hypothesis for established CFL methodology for linking solutions development. The methodology is based on the TRIZ and WOIS integration and a corresponding software application. For the new principle solutions search the application of bionic (biomimetic) approach is proposed. The integration and the new linking solutions development is based on cognitive decision making.

Supporting communication in the supply chain with design rationale maps

Marco Aurisicchio[1], Rob Bracewell[2], Gareth Armstrong[3]

[1]Imperial College London, United Kingdom; [2]Cambridge University, United Kingdom; [3]Rolls-Royce plc, United Kingdom

In modern engineering projects collaboration between organisations is increasingly common for the purpose of sharing expertise, technology, resources, risk and responsibilities. Design communication between collaborating organisations, which is central to the successful development of the design process, takes place over distributed environments, and a range of computer and communication technologies are available to support it. However, none of existing technologies aid engineers in the communication of the nuances and subtleties of engineering design work. This research, in collaboration with the engineering business of a large power system company, argues that for design communication to be effective, stakeholders have to have shared understanding and this is formed by interpreting design rationale. In the paper, this argument is used to explain the success of a software tool, known as DRed, to support the communication between engineers in the collaborating company and those from partner organisations. Case studies of practical application of the DRed tool to support communication with organisations in the supply chain of the partner company are presented and discussed.

Implementing collaborative crowdsourcing in different design problems

Donata Gabelloni, Gabriele Montelisciani, Gualtiero Fantoni

University of Pisa, Italy

The new product development process increasingly involves multidisciplinary teams, that frequently do not belong to the same institution. Innovation often comes from external actors, as suppliers, end-users etc., according to the paradigm of Open Innovation. Crowdsourcing is one of the new trends in the Open Innovation philosophy. The main aim of this study is to present how and for which design activities crowdsourcing is useful for the new product design. After a brief definition of benefits and limitations of collaborative crowdsourcing, the paper presents a new web platform that allows the collaborative design of new products. The main features of the platform are tools suitable to overcome some of the presented criticalities of crowdsourcing, such as an IPR tracking system. These tests have been used to evaluate the developed tools, as well as to identify the typologies of product design problems that can be advantageously solved through crowdsourcing. For each class of problems some guidelines to manage the problem solving sessions are provided.

Applying models of help desk conversations to the design of a customer sales support interface

Stan Ruecker[1], Gerry Derksen[2], Ted Pollari[1], Piotr Michura[3], Amanda Geppert[1], Lauren Braun[1], Kwame Green[1], Samia Pedraça[4], Scott Audette[1]

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In this paper, we describe a case study using 3D conversational modeling as an approach to the design of an online interactive system. The system was intended to help customers select electric motors from a wide range of options, and to be used on its own by a customer, or else in conversations between customers and salespeople or motor experts. The primary function, however, was to encourage selection and input of relevant information from the customer. It was in meeting this goal that the conversational modeling was most useful, since it suggested not only the types of information that were central to the process, but also an appropriate structure. Our user study had 17 participants matching motors using the current online Motor Match system and two prototype versions produced by the research team. One of the most significant findings was the participants' interest in the ranking of near-match motors displayed as 'possible matches'. In addition, people using the prototype systems found the correct motor as often as the current online system (prototype 1), or more often (prototype 2), and ranked their level of confidence higher than users of the current system.

Design for Effective Resource Management

Chair: Carolyn Conner Seepersad, University of Texas at Austin, United States of America

Energy efficiency as design objective using utility-based Indicators

Paul Martin, Albert Albers, Johnny Ply

Karlsruhe Institute of Technology (KIT), Germany

In engineering design, Energy Efficiency (EE) has been part of systems of objectives mainly due to economic relevance of the energy required to provide a desired utility value or by ecological aspects with holistic claim and intention. However, increasing economic impact, power intensities and legal regulations related to EE as well as the raising number of mobile systems lead to various motivations and according understandings of EE as a design objective. This causes a need for methodical approaches to support designers and deciders in handling EE as a design objective in a differentiated and target-oriented manner.

This paper discusses the different motivations and perspectives regarding the relevance of EE as a design objective and presents an approach to systematically quantify targets for in-use EE. This is achieved by means of utility-based indicators, that describe the efficiency's numerator by an operational reference characteristic and the sum of weighted utility values as functions of fulfillment of task-specific utility-characteristics. Further validation must conclusively prove its consistency and suitability to represent in-use EE as a design objective.

From environmental assessment to usage centered eco-design: taking into account the real impact of container-content system for the liquid laundry detergent

Audrey Abi Akle[1,3], Gwenola Bertoluci[2,3], Stéphanie Minel[1]

[1]ESTIA, France; [2]Agroparistech, France; [3]Ecole Centrale Paris, France

It is shown in a study focusing on the use laundry detergents that are eco-designed provide no environmental gain (Chapotot et al., 2011). However, in this work aforementioned, there is no influence consideration on the environmental assessment of laundry detergent packaging themselves, nor the effects of logistical impact is expected to be also reduced by eco-designed solutions (insurance gain weight to transport). Here we study how this behavior influences the environmental impact of the packaging itself and of the complete product (washing, packaging and logistic). Taking into account the container-content system of laundry detergent, we show that neglecting the real behavior of users induces the risk of underachievement design. The eco-design of packaging cannot be reduced to a material choice or mass limitation of this package. It is in the way it performs on the effective consumption of the material contained that it has its greatest usefulness and influence.

Scenario design approach to envisioning regional electricity networks with photovoltaics and electric vehicles

Reviewers' **Favourite**

Yusuke Kishita, Naoto Kurahashi, Yohei Yamaguchi, Yoshiyuki Shimoda, Shinichi Fukushige, Yasushi Umeda

Osaka University, Japan

Toward realizing a low-carbon society, a variety of green products have been disseminated, such as photovoltaics (PV) and electric vehicles (EVs). While the dissemination of such green products will result in changes of electricity demand in a region, it is unclear to what extent the dissemination of these products will influence on regional electricity networks (or electrical grids) in the future.

To explore regional electricity networks that might occur in the future, this paper describes plural scenarios that illustrate different situations in terms of the diffusion of PV and EVs. A simulation model is developed for estimating the diffusion of PV and EVs as well as regional electricity demand.

As a case study, five scenarios of regional electricity networks in Toyonaka City, Osaka, Japan are described assuming the year 2030. The results demonstrate that the numbers of PV and EVs largely differ depending on social situations surrounding the electricity networks, such as national energy policies. Moreover, it is shown that utilizing EVs as batteries has the potential of reducing the peak of electricity demand from the electricity network by 46-48%.

Environmental selection of materials for product end-of-life

Christian Mascle, Fabien Deneu

École Polytechnique de Montréal, Canada

This paper presents research conducted on the environmental selection of materials for product end-of-life. The literature review establishes the state of art in the field of environmental material selection. Several issues are studied: existing environmental material selection methods, parameters and validity of these parameters in terms of their influence on the product's life cycle. Subsequently, we describe the proposed method which allows the designer to select materials during preliminary design. This method is based on fuzzy logic data processing. The product end-of-life personalizes material assessment to select the best materials for the studied product. Fuzzy logic is the core of the proposed method: it allows easier processing of preliminary design data than traditional numeric methods. Then, we present a computer implementation of the method (software ECMSPEOL). The various operations performed by ECMSPEOL are detailed. Case study is presented to verify the method's validity. Results are summarized and discussed. Finally, we conclude this paper by proposing different avenues of potential research.

Modelling of Processes

Chair: Kristin Paetzold, University Bundeswehr Munich, Germany

Suitable methods for process modeling and process optimization

Michael Schabacker, Nikoletta Szélig, Sándor Vajna

Otto-von-Guericke University Magdeburg, Germany

The current situation in product development is characterized by increasingly dynamic and complex tasks. The development of a product is not a linear process, continuously guided by well-defined steps to the target. Few products are newly designed; most are adaptations, modifications, or variant designs. However, there is a common requirement for each case when the processes have to be deposited for the first time in a process management tool: that it must be done quickly and relatively easily. Various modeling techniques and languages exist: among them network diagrams (e.g. flowchart representation as Business Process Model and Notation (BPMN)), container modeling and Design Structure Matrix (DSM). These process modeling methods are brought together into the Tri-Process-Modeling-Tool described in this paper. The benefit of each process modeling method is shown, together with the main tasks associated with it. Furthermore, it is demonstrated that the application of those different process modeling methods is also useful for process optimization.

Lean product development in practice: Insights from 4 companies

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[1]University of Cambridge, United Kingdom; [2]Technische Universität München, Germany

This paper aims to elucidate practitioners' understanding and implementation of Lean in Product Development (LPD). We report on a workshop held in the UK during 2012. Managers and engineers from four organizations discussed their understanding of LPD and their ideas and practice regarding management and assessment of value and waste. The study resulted in a set of insights into current practice and lean thinking from the industry perspective. Building on this, the paper introduces a balanced value and waste model that can be used by practitioners as a checklist to identify issues that need to be considered when applying LPD.

The main results indicate that organizations tend to focus on waste elimination rather than value enhancement in LPD. Moreover, the lean metrics that were discussed by the workshop participants do not link the strategic level with the operational one, and poorly reflect the value and waste generated in the process. Future directions for research are explored, and include the importance of a balanced approach considering both value and waste when applying LPD, and the need to link lean metrics with value and waste levels.

An integrative design analysis process model with considerations from quality assurance

Martin Eriksson, Damien Motte

Lund University, Sweden

Computer-based design analysis activities are an essential part of most product development projects in industry. An effective integration of the analysis activity into the product development process, especially when the design analysis is performed not by the engineering designer but by an analyst, internal or external to the company, is therefore very valuable. The contribution in this work is a design analysis process model that tries to eliminate some integration issues (transmission of incorrect information, disagreement on activities…) through the use of quality assurance techniques and procedures: quality checks, verification and validation, and uncertainty treatment. The process model is formulated in general terms so that it can be adapted to particular product development processes available in the industry.

Design process commonalities in trans-disciplinary design

Reviewers' **Favourite**

A.J. Qureshi[1], Kilian Gericke[2], Lucienne Blessing[2]

[1]Newcastle University, Singapore; [2]University of Luxembourg, Luxembourg

Contemporary product development has transformed from being mono-disciplinary to increasingly trans-disciplinary. Technology convergence and specialization of the knowledge are two distinctive trends that have become pronounced. These two trends are implicitly visible on a cross-disciplinary interaction level in industry. However, trans-disciplinary design has not been considered sufficiently in earlier work on design methodology.

This paper presents results from an empirical study to identify shared elements of current design practice in industry and identification of transdisciplinary elements of product development. A framework based on key findings from the transdisciplinary consolidation of academic design process models presented by Gericke and Blessing (2012) and Eisenbart et al. (2011) is developed and used to provide answers to the following research questions:

- How well does the literature based trans-disciplinary design process apply to the trans-disciplinary industrial context?
- Are there commonalities between design processes across organisations regarding presence of process stages, design states, and the form of the process model?

Customer and User Experience

Chair: Don Norman, Nielsen Norman Group, United States of America

Pre-acquisition clustering of requirements – Helping customers to realize what they want

Benjamin Röder, Markus Jürgen Heidl, Herbert Birkhofer

Technische Universität Darmstadt, Germany

This paper introduces a new method to group requirements according to different topics to create a catalog of requirement clusters, which lead to an easier and more complete process of requirement acquisition. The creation of the requirements list of is one of earliest and most important steps in the product development process. The quality and quantity of the requirements have a high impact on the costs, the time needed and the required iterative steps in the product development process. Standards for this process are hard to find, for every development project is inimitably and therefore happens under significantly different conditions. Up to now the clustering of requirements is only used to structure the product-requirements after the detection for further and more systematic use. The method presented in this paper will help to structure requirements before the process of acquisition to create specific clusters, which lead the customer to a more complete and more efficient acquisition process. These clusters help the customer to substantiate his wishes. Furthermore the generated clusters represent a storage of implicit knowledge, in which information is recorded.

Instrumenting the user: Needfinding by combining data logging and immediate self-reporting

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This paper proposes a quantitative exploration and evaluation method for needfinding that may be used in situations where the classical quantitative methods – interviews and direct observation – may not be effective on their own. "Instrumenting the user" combines sensor data logging with periodic, immediate self-reports. The purpose of instrumenting the user is to enable the longitudinal collection and subsequent analysis of data that will aid in the identification of needs that are not apparent to the designer based on prior experience, talking to users, or observing them. When used to generate hypotheses, this quantitative approach retains the open-ended, non-standardized aspects of qualitative methods. A case study from the hearing aid industry illustrates an implementation of the method and explains how instrumenting the user can yield unexpected insights.

A method for capturing and translating qualitative user experience into design specifications: the haptic feedback of appliance interfaces

Reviewers' **Favourite**

Serena Graziosi[1], Francesco Ferrise[1], Monica Bordegoni[1], Ozan Ozbey[2]

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The paper describes a methodological approach specifically developed to capture and transform the qualitative User Experience (UX) of a consumer product into quantitative technical specifications. Merging the potentialities of Virtual Prototypes (VPs) and Digital Mock-Ups (DMU), a flexible design scenario is built to interpret users' desires. Visual, sound and haptic stimuli are reproduced in order to let users live a realistic multisensory experience interacting with the virtual replica of the product. Parametric models are defined to acquire users' preferences while optimization algorithms are used to transform them into technical specifications. The aim of the approach is to propose a robust technique to objectify users' desires and enable their direct and active participation within the product development process. The methodology is derived merging insights coming from four case studies as well as indications available in literature. Specifically the paper describes how to design the multisensory UX with household appliance doors and drawers with a specific focus on the haptic/force feedback objectification.

Learning from a design experience: Continuous user involvement in development of aging-in-place solution for older adults

Chaiwoo Lee[1], Richard Myrick[1], Daisuke Asai[2], Joseph F. Coughlin[1], Olivier L. de Weck[1]

[1]Massachusetts Institute of Technology, United States of America; [2]NTT Service Evolution Laboratories, Japan

Involving users during product development has been discussed as an important approach to user-centered design, in particular to avoid overemphasis on using "technology for technology's sake". This paper presents a case study of the user-driven processes and methods involved in a product development research project, the e-Home for Seniors study. The case study maps the development activities to phases of a generic product development framework. The specific methods of continuous interaction with users, research experiences, and team characteristics are examined in detail, as well as mechanisms to allow user input to be easily incorporated throughout the development cycle. Insights for development of products targeted at older adults, many also relevant to the general population, are discussed to inform researchers and practitioners.

Consumer needs on smart artifacts for their dream lives

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Sungkyunkwan University, Republic of Korea (South Korea)

The purposes of this study are to search for consumer needs on smart artifacts for their dream lives by the Generative Tools and to give insights for designers of innovative and creative products and services. Fourteen participants are divided into three groups and actively participated in three-step-sessions of the Generative Tools with workbooks, collages, and 3D modeling. All the voices expressed in the three steps are recorded and transcribed into Excel files. The statements containing any clues of consumer needs are highlighted and mutually exclusive need statements are extracted with a series of bottom-up clustering until no more clustering is possible.

As a result, 159 extended needs are extracted and categorized into 14 sub-attributes and, finally, into five main attributes. The main attributes that are required for fulfilling their needs on smart artifacts for their dream lives are Empowering, Efficiency, Ubiquitous, Boostering, and Peacefulness. The results imply designers and developers to take importance in improving functionality to usage whenever is wanted in life and in focusing on parts that could be self-controlled and self-made, and even sensitive and aesthetic.

Consumer preference estimation from Twitter classification: Validation and uncertainty analysis

Reviewers' **Favourite**

Thomas Michael Stone, Seung-Kyum Choi

Georgia Institute of Technology, United States of America

In recent years, the membership and activity of Twitter, Facebook, blogs, and other user-generate content sites has experience significant growth. Users express their opinions regarding a wide range of topics, including consumer products and services. Thus, these sites have the potential to facilitate product design via the extraction of consumer opinion and sentiment regarding product features. A key challenge is how to appropriately extract consumer preferences from the messages. This challenge is addressed with respect to Twitter using a smartphone case study. Twitter messages regarding particular smartphone attributes are classified according to sentiment: positive, negative, or neutral. This sentiment information is then used to develop an estimate of consumer preference for particular smartphone attributes, such as battery life or screen size. Uncertainty analysis is conducted in order to assess the effects of sentiment classification accuracy. Validation techniques indicate that a revised framework would be useful for predicting consumer decisions and facilitating product design; however refinement in terms of comprehensiveness and accuracy or needed.

Design Practice

Chair: Bernard Yannou, Ecole Centrale Paris, France

Understanding the context of product development

Kilian Gericke[1], Moritz Meißner[2], Kristin Paetzold[3]

[1]University of Luxembourg, Luxembourg; [2]Technische Universität Berlin, Germany; 3Universität der Bundeswehr München, Germany

Adaptation of design methodologies to the context in which they should be actually applied is seen as a necessity in order to enhance its acceptance and to widen its application. Even though, a context dependent adaptation is seen as a suitable means to make a substantial improvement of current design methodologies, only few contributions were made over the last years, and it often remains somewhat fuzzy what context actually means.
This paper is intended to consolidate the different meanings of context, ways to represent and specify the context and ways to structure the different views on the context.
A scheme for categorising influencing factors is presented. The scheme consolidates factors from literature which have been identified as having an influence on design projects. It is seen as a means to support understanding of a design approach and its context. Therefore, the scheme is a consolidation of existing work, which allows a more comprehensive description and analysis of the context than the more specific lists and schemes from literature.

Product strategies in merchant ship and airliner industries

Jouni Lehtinen, Timo Lehtonen, Jarkko Pakkanen, Asko Riitahuhta

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Despite interesting similarities, there are major differences in the way products of airliner and merchant ship industries are developed, sold and delivered. The fact that these both industries manufacture equipment for transportation and have similar design targets brings up a question, why applied industrial paradigms are so different? Theories about evolution of industrial paradigms and product strategies linked to them suggest that over a time change is towards more sophisticated methods. The examples from merchant ship and airliner industries however show that in reality the development is anything but straightforward.
This paper will specify the factors and present reasons for differences in applied industrial paradigms and present concept map analysis about the existing causalities within merchant ship industry. Based on the differences in historical and existing factors it can be seen that the ultimate reasons for different industrial paradigms are due to the customers' behavior and industrial regulation, fostered by national and industry specific causalities that maintain the existing situation.

Critical factor indentification in medical device development through supervised learning

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This paper investigates the impact of different variables in Medical Device Development (MDD), where FDA (Food and Drug Administration) approval time is considered as a performance variable. To analyze the significance of the variables supervised Bayesian learning, the Minimal Description Length (MDL) algorithm, is used. A set of real FDA data, representing 474 different companies in USA medical device markets, from 2400 FDA approved orthopedic devices is used. The aim of the study is to identify which product, company and regulation factors contribute most to the variations in FDA decision time.

Product design in latecomer firms: Case of turkish medical device industry

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Mimar Sinan Fine Arts University, Turkey

Medical devices is a new and developing market in Turkey. However, it is dominated by import trade products. Although there is an increasing number of Turkish producers, they face certain problems about global competition in the local market. In this study, focuses on the latecomer characteristics of medical devices industry in Turkey an its influence on design of Made in Turkey (MiT) medical devices. For this purpose, firstly the Turkish medical device industry was analyzed through sector reports. Then, an interview study was conducted with 12 medical device retailers to understand general perception on medical devices produced in Turkey regarding the market and design related issues. The results suggest that, although general image of MiT medical devices improves, at the time being the influence of latecomer characteristics on design can be sensed in this industry.

What happens to rejected ideas? – Exploring the life of ideas following the completion of projects

Reviewers' **Favourite**

Anna Karlsson[1,2], Peter Törlind[2]

[1]Sandvik Coromant; [2]Luleå University of Technology

In an ongoing development project there is a risk that promising ideas are rejected due to time constraints. Given that ideas are the carriers of innovation, and that novel and radical ideas are, to a greater extent, exposed to rejections and resistance than more conservative, those ideas, previously rejected from projects, could be seen as a potential goldmine of innovations. The aim of this paper is to explore the 'life' of rejected ideas following the completion of design projects. An exploratory approach was chosen in order to gather information about companies' ways of working with rejected ideas. Respondents from seven companies were interviewed, and two main routes for managing rejected ideas became apparent: codification and personalisation. All participating companies had some sort of codification approach, but this was always complemented by a personalisation approach, whether implicit or explicitly stated. This is important as an idea management system is unable to fully carry an idea forward as it lacks intent, insight, and argumentation. Furthermore, responsibility for rejected ideas and maturity of ideas both seem to affect the processing of rejected ideas.

Performance measurement supporting closed loop tolerance engineering – An industrial case on tolerance and variation collaboration

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Tolerances and Variation are interlinked and omnipresent throughout any engineering organization dealing with design and manufacturing of physical artefacts, but is disproportionally visible in recent academic literature. This industrial case obtains its empirical findings from focused and structured in-depth interviews with industrial professionals within a high precision manufacturing company. Qualitative analysis of data provides insight and understanding in the underlying reasons for repeated deviations related to tolerances and variation. The resulting proposed outline of Performance Measurement (PM) metrics for the engineering team is expected to contribute to a strengthening of focused collaboration on tolerance and variation related activities. Low level PM metrics supporting Closed Loop Tolerance Engineering (CLTE) are of academic and industrial interest as such tolerance and variation metrics have a direct or indirect link to top level metrics via their influence on product quality and product function. The novelty of the paper is found in applying the CLTE-model for data gathering and in the addressing of PM in industrial improvement actions on tolerances and variation.

Representation of Design Knowledge and Information

Chair: Ying Liu, Cardiff University, United Kingdom

Method for inferring latent functions

Hiroki Mori, Toshiharu Taura, Akira Tsumaya

Kobe University, Japan

Latent functions are functions that are implicitly included in products. A consideration of latent functions at the conceptual design stage has become increasingly important from the perspective of product safety and sustainable manufacturing. This paper discusses and proposes a method to infer the latent functions at the conceptual design stage. First, as a framework to capture the latent functions, the function dividing process is systematized from a linguistic viewpoint into decomposition-based dividing and causal-connection-based dividing. Next, three types of latent function inferring processes are formulated, and the concepts of basic and secondary functions and word match methods are introduced to make the inferring more flexible and appropriate. Finally, a computer system to infer the latent function is developed and a case study is conducted using the system. The case study shows the feasibility of using the proposed method to help designers or consumers to infer latent functions in advance.

Discovering contextual tags from product review using semantic relatedness

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Nowadays, online product reviews has enabled product designers to better understand product related issues from the users' perspective. In the design community, there are a number of studies that have focused on studying product reviews in various analysis perspectives. While these are essential, we noticed that contextual annotation of tags has not been fully explored. We reckoned that such an annotation is equally important to better clarify the tags' context where tasks such as design experience analysis and faceted product comparison can be made possible. However, the challenge lies in automatic discovery of contextual tags from product reviews. Consequently, this paper proposed a learnable approach to address this issue. A ranking algorithm is proposed to rank important key terms along with an approach to discover contextual annotation of a given term. The performance evaluation of our proposal is done using two annotated corpus. A case study using a small laptop reviews corpus is also reported to showcase how our algorithm can be applied towards product understanding and product ontology development. Finally, we conclude this paper with some indications for future work.

Grounded knowledge representations for biologically inspired design

Michael Helms, Ashok Goel

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Over the last decade or so, biologically inspired design has emerged as a major paradigm in engineering design. In our work on biologically inspired design we generate grounded descriptive accounts of design, which then scaffold explanatory models of biologically inspired design processes. In this paper we use Structure-Behavior-Function (SBF) representations as a "conceptual seed" to develop a knowledge representation called SR.BID that can capture complex problem-solution relationships in biologically inspired design. The evolution of SR.BID (for Structured Representations for Biologically Inspired Design) from SBF is grounded in empirical data gathered in a classroom biologically inspired design context. SR.BID empowers us to more deeply study the breadth of processes entailed by biologically inspired design including the use of biological analogies for both solution generation and problem formulation. This paper explains in detail the process of building the content account of SR.BID, and provides a glimpse into the utility of the representation..

Towards structured integration of maintenance knowledge in industrial equipment design

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University of Twente, The Netherlands

Industrial equipment requires maintenance to remain operational. The level of maintenance that is required, and how easily it can be executed, is affected by the characteristics of the equipment. Therefore, design decisions have a strong influence on the effectiveness and efficiency of the maintenance process. Ideally, the design of the equipment should be aligned with the design of the maintenance service. Relevant knowledge about the relationships between them is available in both the literature and in practice. It is essential to bring this knowledge into the equipment design process, but suitable design support for this remains lacking. Therefore, we propose to conduct research on how this knowledge can be systematically integrated into the design process. The final goal of the research is to develop design support that leads to an improved quality of design decisions, so that production systems with an increased life cycle performance will be achieved.

Design Research and Research Methods

Chair: Lucienne Blessing, University of Luxembourg, Luxembourg

Shaping the design research revolution

Kees Dorst[1,2]

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In 2008 the author published a paper that critiqued the state of design research. It contained an anatomy of design research, analysed its assumptions and considered the anomalies that were emerging at the time, making a case for revolutionizing the field, and mapped out two directions for further development.
Over the last 5 years, that paper has sparked keen interest and it has been quoted extensively. In this paper we will pick up the thread and report on the development of a research centre that embodies some of the changes proposed in the paper, shaping a specific version the design research revolution. This paper is built up as follows: first, the arguments of the original paper will be retraced briefly. Then the question that drives the exploration of the current paper will be elaborated and the central case study will be introduced, by describing the methodological research program and the applied research centre that serves as its platform. We will end with an informal evaluation, and position the conclusions within the broader discussion on the role of academic research in today's society.

Assessing design research quality: Investigating verification and validation criteria

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Engineering design research spans many disparate approaches to study, from simulation to case studies. A challenge for the community is to ensure and evaluate the research quality, taking into account the variety of approaches. This paper explores four classes of evaluation criteria, truth value, applicability, consistency, and neutrality, based on interdisciplinary research literature. These are decomposed into several elemental metrics and distinguished by validation or verification type. The metrics are applied to two reported research studies (empirical and simulation) on similar topics. In the comparison, it is found that the authors of both papers explicitly addressed validation related criteria on the results of the research. However, the empirical study authors also included more details on the verification based metrics as they relate to the research process. The issue of how the verification and validation criteria can be operationalized according to the research method is identified as critical future research.

Sustainability, design and engineering values

Reviewers' **Favourite**

Paul Martin Winkelman

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Sustainability issues are slowly being integrated into the design process. What is frequently overlooked is that the pre-existing value system of engineering may be hostile to sustainability principles. To explore this value system, the engineer is presented as a wearer of many hats (e.g., that of a soldier or dépanneur) who hypothetically develops a sustainable solution involving the installation of latrines in Rajasthan in India. The question is then whether this engineer is able to foresee the social issue where the latrines lead to the disempowerment of women. As a soldier, the engineer models the world after hierarchies; Maslow's hierarchy of needs suggests that one can deal with the physiological and worry about the social later. As dépanneur (owner of a corner store), the engineer values convenience; the latrine, though convenient, led to increased seclusion of women at home as they had lost their reason to leave the house. These engineering values are offered as possible "constraints" on the road to re-creating engineering design more in the image of sustainability.

Using qualitative research methods in engineering design research

Shanna Daly, Anna McGowan, Panos Papalambros

University of Michigan, United States of America

In order to support successful strategies in design education and practice, we must have a deep understanding of the complex dynamics of design processes, teams, contexts, and systems. Facilitating this understanding of engineering design requires research methodologies that can capture the nature of the design process from a diversity of aspects such cognitive, creative, social, organizational, and experiential. Traditionally, research in engineering design has focused on quantitative methodologies whose constructs are familiar to engineers. Our assertion here that qualitative research methodologies that are less familiar to engineers can provide unique scientific insights into the study of engineering design, enabling new findings not obtainable via quantitative methodologies. In this paper we provide an overview of qualitative research methods, outline key opportunities where qualitative methods can be used to enhance engineering design research, and present a case example of a qualitative study on interdisciplinary interactions in complex system design.

Design for X (Weight and Cost)

Chair: Hansgeorg Binz, University Stuttgart, Germany

Operationalisation of the value analysis for design for lightweight: The function mass analysis

Reviewers' **Favourite**

Benedikt Posner, Hansgeorg Binz, Daniel Roth

University of Stuttgart, Germany

The mass has a great influence on the value of products from different industries. For example, by reducing the mass of a product, the energy consumption and CO2 emissions can be reduced. These influences, which the mass has on different product properties, show why lightweight design is becoming increasingly important.
Designers have to establish goals regarding mass in the early phases of the product development process, as otherwise the product may be too heavy after its design is completed. Nearly each function needs mass for its fulfillment but functions which are not important to the customer raise only the mass and not the customer value of the product. If designers had information about the importance of functions and the mass which is needed for their fulfillment, they would be able to discuss with their customer whether the functions are so important that they want to accept this extra mass in the product. Therefore, a method which supports designers in establishing goals regarding mass, and in analysing optimisation potentials, the importance of functions and the mass which is needed to fulfil the function based on the Value Analysis is operationalised in this paper.

A holistic design for excellence model based on life cycle costing and design scorecards

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Baker Hughes Inc., Germany

Demand for shortened design cycles, higher quality and reliability, reduced production costs and at the same time maintaining predictable, on-time delivery of new products and services, has forced companies to re-examine their product design and development processes. This paper presents a DfX model developed and implemented at Baker Hughes Incorporated. The DfX model is aimed at developing products and services that meet or exceed the business case by horizontally integrating experts from all relevant enterprise disciplines and holistically focusing on reducing life cycle costs early in development. It allows effective reaction to customer demands by focusing on rules and data based decisions throughout the entire product lifecycle.

Consideration of weight properties during the design of weight-optimized mechatronic products

Tobias Luedeke, Michael Vielhaber

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Existing process models for the development of mechatronics products are not or only insufficiently considering the task of weight optimization during the design process. The measures of weight optimization are mostly applied at the end or in late phases of the development process with a consequence that a large number of macro-iterations are necessary when design changes regarding weight properties have to be done. These points result in an increase of development cost and time.
In this contribution, a proceeding model for the design of weight-optimized mechatronic products is proposed which considers a holistic monitoring and management of weight properties throughout the process. The process is structured in a way that between and within the main design stages different analysis points ensure an estimation and calculation of future product weight properties. Furthermore, these analysis gates can also provide input for weight optimizing potentials.

Target weighing - A new approach for conceptual lightweight design in early phases of complex systems development

Albert Albers[1], Daniel Wagner[2], Anne Ruckpaul[1], Benjamin Hessenauer[1], Norbert Burkardt[1], Sven Matthiesen[1]

[1]Karlsruhe Institute of Technology, Germany; [2]BMW AG, Germany

This research suggests a new approach in early stages of product development, aiming at a lightweight orientated functional concept design. Based on the systematic approaches of target costing and value engineering a functional analysis is proposed to match mass and function. This allows the identification of where the most promising weight reductions could be achieved without focusing single components. Search fields for further investigation are identified based on the resulting weight of functions. By including the significance of functions for internal and external customers this approach points out opportunities for product optimizations. Furthermore, the created data enables a systematic way to evaluate the target weight of new concepts and makes a selection easier. This proposed approach was validated in two projects regarding a car climate control system and a high voltage battery for plug-in hybrid electric vehicles. This method raises the awareness to lightweight potential within early product design and determines target values for weight, cost and volume of new concepts.

Methods for Validation and Decision

Chair: Julie Stal-Le Cardinal, Ecole Centrale Paris, France

Operationalization of the quadrant-based validation in case of a designerly software development methodology

Els Du Bois[1,2], Imre Horvath[2]

[1]University of Antwerp, Belgium; [2]Delft University of Technology, The Netherlands

Systematic validation of design methods is important to advance the professional practice of engineering design. In contrast, we lack structured approaches for validation of design methodologies. In this paper we present the adaptation of an existing validation framework to external validation of a new, composite, designerly software development methodology (DSDM). A major challenge was that a comparative validation approach could not be considered in our single-case study. Literature review was done to find an appropriate reflexive validation method and useful validation criteria. Yet no effective software validation methodologies were found for our context. The validation quadrant approach however lent itself as framework of the sought validation method, which was adjusted, extended and operationalized by introducing series of validating steps. The quadrant-based external validation method (QEVM) combines structural and performance assessment actions in both the theoretical domain and the application domain. Our conclusion is that QEVM is useful in our single-case, reflexive assessments for the validation of the DSDM. Further research should focus on a context-less use of QEVM.

Proofs of utility, innovation, profitability and concept for innovation selection

Bernard Yannou[1], Benjamin Zimmer[2], Romain Farel[1], Marija Jankovic[1], Julie Stal-Le Cardinal[1]

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Selecting innovative ideas or projects and comparing them in terms of their potential of value creation in business contexts is a fundamental design task. To that end, we propose to assess four proofs of Utility, Profitability, Innovation and Concept at different levels of maturity along the innovation process. This model has been successfully applied in two situations of practical size. A first experimentation has validated its usefulness for providing a common analysis framework to a multidisciplinary jury of a National innovation grant within an innovation cluster. A second experimentation has validated that an aggregate indicator of the four proof ratings averaged on a set of representative jury members is highly correlated with the estimated potential of value creation of this innovation. This work is a first step towards an automation of innovation selection in a collaborative manner.

Agent-based consistency check in early mechatronic design phase

Michael Rauscher, Peter Goehner

University of Stuttgart, Germany

Mechatronic design is a multidisciplinary design and has to face several challenges. One challenge is to provide a common understanding of the mechatronic system to be developed to all participating disciplines. This is done by sets of models which have many relations between them. If there are inconsistencies in the models, the whole mechatronic development project is endangered. This paper presents an agent-based concept for an automated consistency check of the models of the early design phase, which enables the providing of a reliable base for the further design process. After presenting the challenges of mechatronic design, the design models are abstracted to provide a broader application range of the presented concept. The structure of the consistency rules is presented and the agent-based concept is shown.

Predicting the behavior of solution alternatives within product improvement processes

Michael Abramovici[1], Andreas Lindner[1], Susanne Dienst[2], Madjid Fathi[2]

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Nowadays an increasing number of industrial products are equipped with sensors, allowing a complete monitoring of the product and its working conditions during the use phase. The data generated by such sensors is mainly used for maintenance purposes. The evaluation of that data can offer valuable input for the improvement of existing product generations.

The presented approach offers a methodology to identify improvement potentials and to support decisions within product improvement processes. This approach is based on prescriptive decision theory and uses feedback data in addition to product-specific characteristics and properties. A prediction of future product solution alternatives behavior is realized on the basis of object-oriented Bayesian Networks. The validation of the proposed solution has been demonstrated on the basis of decision processes for the improvement of centrifugal pumps.

Design for User Experience

Chair: Jonathan Cagan, Carnegie Mellon University, United States of America

Tolerance optimization of a mobile phone considering consumer demand for quality and sustainability in china, sweden, and the united states

Steven Hoffenson, Andreas Dagman, Rikard Söderberg

Chalmers University of Technology, Sweden

Dimensional tolerances are chosen during the product development process to balance quality requirements against manufacturing costs. Designers typically judge how much variance should be allowed while still maintaining the perception of a high quality product or brand, but this is rarely based on an understanding of how consumers perceive that variance. Additionally, ecological sustainability priorities are often chosen without knowing how they will be received by consumers. This paper presents a survey-based technique for understanding how tolerance and pricing decisions influence a product developing firm's profits, accounting for consumer perceptions of quality and environmental friendliness. A case study of a mobile phone design is explored, including variance propagation modeling, the design and administration of an online choice-based conjoint (CBC) survey, construction of consumer demand models, and profit maximization for the markets in three different countries. The results show a slight preference for high quality products compared with stronger preferences for other product attributes like low price, and the differences among the three markets are highlighted.

Extending the product specification with emotional aspects: Introducing user experience stories

Ioanna Michailidou, Constantin von Saucken, Udo Lindemann

Technical University Munich, Germany

Emotional aspects of products play a vital role for the purchasing decision but are often neglected in conventional product development processes. In the task clarification design phase, in particular, many challenges need to be faced: task clarification is an interdisciplinary and user-centered process, where a communication platform for the non-tangible, affective characteristics is essential. Additionally, the product specification as output of this phase does not capture important aspects for User Experience (UX): contextual and temporal aspects, user motives and goals and interrelations among product attributes or other system components affecting the holistic experience. UX stories are introduced as a tool to face these challenges and overcome the weaknesses of existing approaches. A definition of UX stories, descriptions of the elements composing them as well as their possible integration in the engineering design process are proposed. The paper highlights how the use of UX stories can enrich product specification regarding UX and reinforce creating consistent product experiences that go beyond the product itself.

A comparison of product preference and visual behaviour for product representations

Duncan Boa, Ben Hicks, Aydin Nassehi

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It is critical to understand how the means of representing a product can affect an individual's preference for it. This paper investigates the effect of varying a product's representation on an individual's preference for it.

Five buildings, cars and electrical appliances were shown to 20 individuals as sketches, renders and photos. Individuals rated their preference for the product/artefact in the representation after a fixed viewing time. To provide additional context to the participant's preference, and to investigate if they perceived them differently, eye tracking was used to record their gaze as they inspected the representations.

One of the 15 groups of representations showed a significant change in preference by the participants across the representations. Ten of the 15 groups of representations showed significant difference in engagement for a limited proportion of the regions in the stimuli images.

This suggests that the process of viewing a product is independent of the means of representation and that a sketch is sufficient for an individual to form a consistent opinion of a product.

Glass and wine: The indissoluble marriage

Francesca Venturi[1], Angela Zinnai[1], Gualtiero Fantoni[2], Donata Gabelloni[2], Armando Viviano Razionale[2]

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The FBS model describes theoretically the design process of a product. Only few papers present real industrial case studies, which are generally finalized to illustrate theoretical concepts.
The aim of this paper is to show a methodology and its testing on the design of new tasting glasses, based both on the FBS model and on experimental analysis. This is an interesting theme in the food design area. Indeed a tasting glass is the interface used to convey wine characteristics to human senses (sight, taste and smell). The glass influence on the evolution of sensory perception of wine is not fully understood and rarely evaluated.
The analysis is composed of: (i) an experimental activity to understand the evolution of sensory profiles of a well-structured red wine maintained in different types of glasses through expert testers, (ii) the selection of one of the most important function carried on by the product, and therefore the study of the related behaviours, (iii) the identification of the correlation between the behaviours and the design parameters of the glass. Finally a method and tools to extract and measure the geometrical feature of the glass are presented.

Sensory metrology: when emotions and experiences contribute to design.

Patrizia D'Olivo[1], Barbara Del Curto[1], Jenny Faucheu[2], Dominique Lafon[3], Jean-François Bassereau[2], Sébastien Lê[4], David Delafosse[2]

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The analysis of users' experience is indispensable in order to catch the subjectivity. For this reason the industrial designer needs to take into account these new qualitative properties, and translate them in a concrete way during the creative process. Firstly the sensory information acquired need to be coached by the material experience. The user is able to construct his relation with the product primarily interfacing himself with the skin of the object by touch and sight, and after that explore its functionality. The work aims to improve the development of emotional and feeling investigation by the use of an holistic approach that take into account all the product's aspects. To realise this investigation has been chosen to apply the technique offered by Sensory Metrology discipline and two methods derived from the Classical Sensory Evaluation. In this paper the test experiences done in order to read users' subjectivity have been described. The different proofs have been structured in three different moments. Results have shown the possibility to use the sensorial sphere as a constructive matter to achieve user's affection to the products always from an holistic point of view.

Design for privacy – Design tool to map perceptions, conflicts and strategies of privacy in mobile technology development

Diana Schneider[1], Tanja Kornberger[2]

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This paper investigates the area of tension of privacy versus technologically enabled ubiquity, in order to align both into improved product and service design solutions.
Through an iterative process combining theoretical, empirical and design research, using transdisciplinary methods from social sciences, design thinking and engineering, the authors propose a design tool to comprehend and visualize the implications of privacy in high-tech applications.
The empirical insights substantiating the theoretical classification system were gathered in two phases: (a) a survey-based quantitative study identifying mobile technologies as the main privacy concern and (b) an interview-based qualitative study with software developers further exploring privacy issues in mobile technologies.
The gathered theoretical and empirical insights were structured into a four-point "privacy in technology" reference model for mobile developers and design professionals to solve conflicts arising from the privacy/ mobile technology correlation. These four elements consolidate (1) privacy perceptions, (2) common mobile technology development processes, (3) privacy conflicts, (4) strategies to solve privacy concerns.

Management of Innovation

Chair: Marco Cantamessa, Politecnico di Torino, Italy

The network topology of open innovation freelancing

Morteza Pourmohamadi, Andy Dong

University of Sydney, Australia

eLancing is an emerging paradigm for outsourcing technical services wherein freelancers bid on projects posted in a large-scale online marketplace. When viewed in concert with other open innovation services such as kickstarter.com, a new networked innovation model is emerging: "very large scale innovation". "Very large scale innovation" networks supported by the Internet are a large-scale form of innovation networks connecting producers and inventors to investors and retailers. In this paper, we study the statistical mechanics of the network structure of the projects and providers in eLancing to ascertain structural preconditions for their effective operation. The unipartite project and provider networks and the collaboration network exhibit the properties of a homogeneous network whereas the associated skill networks exhibit the properties of an inhomogeneous, scale-free network. All of the networks except the provider network are small-world networks. These results point to the lack of coordination and collaboration between providers, which could provide an opportunity for them to pursue more complex projects, and a need for systems integration services.

Situative open innovation – A model for selecting the right external actors and involving them in an efficient way

Matthias R. Gürtler, Udo Lindemann

Technische Universität München, Germany

Open Innovation describes the opening of companies' innovation process towards their environment (e.g. customers, suppliers, even competitors). Besides other benefits described in literature, companies profit by more radical innovations, shorter time-to-market and better satisfaction of customers' needs. In the context of an explorative interview study with several German large enterprises from different industries we surveyed the application and the transfer of Open Innovation from research into practice, regarding benefits and potential impediments. Besides the overall positive experience of companies using Open Innovation, the majority of them stated that it is still a big challenge to select and involve the right extern actors, fitting to the specific company's situation/condition and issue, as well as to select an appropriate way of involvement. To fulfill this demand, the paper presents a guideline methodology for selecting the right external actors for a specific company's situation and issue, and for selecting the right method for involvement. The concept combines Open Innovation with elements from Requirements Engineering and stakeholder analysis into a holistic approach.

Innovation roadmapping: Building a theoretical framework from multiple cases of industrial firms

Lianne W.L. Simonse, Jan A. Buijs, Erik-Jan Hultink

Delft University of Technology, The Netherlands

This paper investigates the phenomenon of innovation roadmapping from the dimensions of activity and performance. We employed a multiple case analysis on 12 cases of industrial firms to identify the commonly shared roadmapping characteristics in a systematic way. Drawing on the strategic innovation management theory, we define five concepts that are constructed from the richness of clarifications and descriptions of roadmapping experiences.
As results, we found that innovation roadmapping is established by a (1) strategy of time pacing, (2) synchronizing dialogues and (3) mapping innovation elements to a timeline. Furthermore, our findings indicate that innovation roadmapping affects either (4) competitive timing or (5) industry synergy, in innovation performance. This led to the development of a theoretical framework for innovation roadmapping with the formulation of six propositions.
The key insights for innovation managers in industrial firms are that, in striving for competitive timing or innovation synergy, roadmapping provides a means to achieve these objectives and, in deploying roadmapping in the organization, dialogue and pacing are critically important.

Innovation differences between new venture startups and incumbent firms

Reviewers' **Favourite**

Katja Hölttä-Otto[1,2], Kevin N Otto[1], Jianxi Luo[1]

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Innovation is critical to the long term success. Research suggests that new ventures create more innovations than larger established companies. Yet, engineering methods and technical focus areas for new product development are deemed no different from new ventures than established firms. Design to cost, increased functionality and optimized performance for example are all deemed important irrespectively. We empirically compare a sample of 92 award-winning innovative products from either new ventures or incumbent firms with respect to these five categories of product-level characteristics – cost, functionality, user interactions, external interactions and architecture. We show that, on average, award-winning products from the new ventures exhibited more characteristics of innovation than the ones developed by incumbents. This indicates that new ventures need to be more innovative than incumbents. Also interestingly, the distribution of innovation characteristics exhibited by innovative products remained unchanged between new ventures and incumbent firms; most innovations occur in the user interaction, external interaction and architecture categories, irrespective of firm type.

The influence of technical expertise on managerial activities throughout the innovation process

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This paper investigates the management activities of the project managers of six new product development projects based on a longitudinal, interview-based study. The study compared how the managerial activities of managers with a technical background differed from those with a non-technical background, and how these activities evolved throughout the different innovation process phases.

The results illustrate clear differences between the two types of managers related to decision-making, participation in the hands-on execution of the project, and role allocation. In addition, project managers with non-technical backgrounds had to tolerate more uncertainty due to limited ability to predict and solve development problems. They also had to redefine their roles as the project proceeded to later development phases, unlike the technical managers who had a strong involvement in technical execution throughout the project. On the other hand, many activities common to all managers, related to for example creating an open and trustful atmosphere and coordinating the whole, differed between the front-end, early development and late development phases.

Innovation diffusion categories and innovation-related needs

Vishal Singh

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This paper proposes a typology of innovation-related needs to explain the innovation diffusion patterns observed in the empirical studies conducted in Architecture Engineering and Construction (AEC) sector. Three types of innovation related needs are identified. The 'need for the innovation' and the 'need to innovate' are directly related to innovation, while the 'need for the diffusion of innovation' is indirectly related to innovation. The three innovation-related needs are used in conjunction with Maslow's hierarchy of needs to explain the individual and organizational response to ICT innovation diffusion efforts. Congruence between Maslow's hierarchy of needs and actor categories in innovation diffusion networks is demonstrated. Findings have implications on how diffusion of systemic innovation should be planned, designed and managed.

Product Architectures and Families

Chair: Olivier Ladislas de Weck, Massachusetts Institute of Technology, United States of America

PLM support for development of modular product families

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[1]Technical University of Denmark, Denmark; [2]Center for Product Customization, Denmark

Most modern manufacturing companies use a PLM/PDM system for documenting and managing product data. Companies use their PLM/PDM system for management of CAD files, documents, and drawings, but they do not take advantage of the full potential of the system to support modularisation. The objective of this research is to develop an approach for improving the role of PLM/PDM systems as supporting tools for developing modular product families. The approach is based on a visual product architecture model; representing a product family seen from a functional system perspective and a physical modular perspective. By means of a software program, product structures visual modelled can be imported to a PLM system, forming so called upper structures. Data associativity between upper structures in the PLM system and CAD models is described, as well as other types of associated product information. The key result of the research is the approach of using companies' PLM systems to build up and define product structures that support the activities of creating modular product families.

An analysis of decomposition approach applications in design engineering & suggestions for improvement

Junfeng Ma, Gul Kremer

The Pennsylvania State University, United States of America

Modular design attracts great attention because of widely implementation in industry and academe. The benefits of modular design include shorter assembly process, easier manufacturing and cheaper maintenance. The modular design also connects both the gains of standardization and customizations since it can reponse to market requirements rapidly. Therefore, many authors concentrate on developing modular design methods. The most widely used method is decomposition approach and one of this type method is classic decomposition approach which proposed by Huang and Kusiak in 1998. Classic decomposition approach provides a new perspective of modular design with designer's desire taken into account, however, there are still some potential improvements for this approach. In this paper, we figure out several limitations of CDA (classic decomposition approach) first and then the revised algorithm is offered regarding to some of these limitations.

Geometric and topological modelling of 3D crumpled structures

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Crumpling is a new method derived of the origami techniques that transforms a single paper sheet into a three-dimensional structure by a systematic generation of random folds. The resulting crumpled object is an innovative answer to packaging industries that need attractive and dynamic products in a sustainable context. In order to understand the performances of crumpled structures and their applications in the field of packaging, this paper firstly details the fundamental characteristics of crumpled surfaces by expressing categories of crumpled creases patterns and patterns networks. The crumpled surfaces connectivity is then studied in an Extended Attributed Adjacency Graph by adding new faces and edges attributes.

Determining module replacement timing of product for balancing quality and production cost

Jae Hun Jeong, Daeyoung Kim, Wooseok Jang, Jihwan Lee, Yoo S. Hong, yongtae Park

Seoul National University, Republic of Korea (South Korea)

As the world has entered the era of limitless competition, most manufacturing companies are trying to reduce the product cost using a modular design strategy. In this environment, the company frequently replaces the subcontractor of modules with other who offers cheaper production cost. Due to insufficient production experience of newly changed subcontractor, adopted module shows higher failure rate than original one. In result, it is important to consider quality cost with production cost. In this paper, we propose a model for determining optimal module replace timing considering both production cost and quality cost through numerical tests.

An approach for cycle-robust platform design

Wolfgang Bauer, Fatos Elezi, Maik Maurer

Technische Universität München, Germany

Product platforms are frequently applied in industry for designing product families. The product platform builds the basis for the derivation of the offered variants. As the platforms are characterized by a long life cycle, changes induced by internal and external influences will occur to the product family during the utilization phase. This results in new variants which often cause a lot of effort for implementation. To avoid these time-consuming and costly efforts, the dynamic changes and variations during the life cycle of the platform must be anticipated and considered in the planning of the platform. The platform structure can be planned and designed according to the expected changes and decrease their later change impact. The revisions of the platform can be scheduled in accordance to the changing context. This paper presents an approach to anticipate the influences which cause changes to the platform structure and consider them in the design of the platform and module structure. Thereby, occurring changes during the life cycle of the platform have lower impact and can be implemented in fast and cost-efficient way.

Examination of modularization metrics in industry

Markus Heilemann[1,2], Steve J. Culley[2], Meike Schlüter[1], Hans-Joachim Haase[1]

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It is the aim of this paper to examine applicability of modularization metrics in industry. For this purpose, two studies were designed. The first study collects requirements in industry for the application of modularization metrics. The second study mirrors modularization metrics from literature to main application requirements from industry. It has been revealed that efficient calculation of modularization metrics is a main requirement of industry. However, there is a gap between information needed to calculate existing metrics and product architecture relevant information that is available in standard IT-Systems like PDM- or ERP-Systems. Thus, only few existing metrics meet the main requirement of efficient calculation. This gap can be closed by developing modularization metrics that either have a diligently selected information content or by introducing product architecture relevant information into standard information systems of companies.

Management of Complexity

Chair: William Ion, University of Strathclyde, United Kingdom

Interpreting knowledge maps using structural criteria

Danilo Marcello Schmidt, Sebastian Alexander Schenkl, Martina Carolina Wickel, Michael Braun, Maik Maurer

Technische Universität München, Germany

Companies have to develop their knowledge to provide more complex products to fulfill changing market's requirements. We have chosen a Multiple-Domain-Matrix (MDM)-based knowledge mapping approach to visualize companies' knowledge distribution, which divides company knowledge in three areas: tasks, knowledge and employees. From knowledge maps, weaknesses and strengths of knowledge distribution can be derived. In literature, only methods of graphical visualization were suggested to interpret such knowledge maps. These criteria are used to identify certain characteristics of knowledge structure. The developed methodology was applied in a department of a mechanical engineering company and critical knowledge elements were identified.

A contribution to advanced knowledge-based design in the development of complex mechanical products

Severin Stadler, Mario Hirz

Graz University of Technology, Austria

Management of product complexity under consideration of parallel performed working tasks in virtual development establishes as an important challenge that has to be considered to ensure efficient product development processes. The main goal is to develop a virtual environment based on the approach of centralized 3D-CAD master models, which efficiently allow the simultaneous representation and alignment of involved parts and components. The present publication introduces to different levels of knowledge-based design methods, reaching from parametric geometry models up to comprehensive interactive applications including CAD-templates. As a key aspect of this publication, a knowledge intensive approach is presented, which points out the potential of advanced knowledge-based design methods. In particular the highly integrated approach uses a novel configuration of a design-related master model that connects several development disciplines and simultaneously enables the handling of complex product-related interdependencies. A central problem-oriented application offers a user-friendly interface that supports the automation and control of the entire product design process.

X-in-the-loop: A framework for supporting central engineering activities and contracting complexity in product engineering processes

Albert Albers, Matthias Behrendt, Jens Schroeter, Sascha Ott, Simon Klingler

Karlsruhe Institute of Technology (KIT), Germany

Emerging complexity of vehicle development is expected not to be faced without supporting development methods, processes and tools. Extensive interactions of vehicle components and the vehicle as well as those with the driver and the environment have to be considered. Whereas the maturity level of the product and the applied models changes permanently within engineering process. The objective is to provide a new, integrative method that supports the engineering process during analysis, synthesis and validation by means of strategic resources 'information' and 'knowledge'. Thus, a related framework is regarded to be mandatory in order to be flexible and to perpetuate engineers for developing, priorizing, deciding and finally innovating. The presented XiL-Framework accommodates actual and prospective challenges of vehicle development and consequently compiles existing methods, processes and approaches. Extended by optimizing procedures recurring engineering activities can be partially automatized and carried out time-efficiently especially for complex interdependencies. XiL is based on long-term experience at IPEK and provides a perception for engineering as well as a management.

Chair: Joshua David Summers, Clemson University, United States of America

Potentials for realising a consistent transition between functional modelling with the IFM framework and early system simulation

Boris Eisenbart[1], Fabio Dohr[2], Kilian Gericke[1], Michael Vielhaber[2], Lucienne Blessing[1]

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Conceptual design is considered one of the most demanding design tasks requiring a joint effort of the involved designers, particularly in interdisciplinary design. Sound decision-making across disciplines on alternative solution concepts may be considerably facilitated through early system simulation. A consistent transition of the available information in functional modelling to early system simulation may thus support designers in this task. The IFM framework intends to support cross-disciplinary collaboration of involved designers by providing an integrated functional modelling approach. In the paper it is analysed in how far a consistent transition from the IFM framework to established modelling techniques for simulation may be realised. The paper compares the information required for early system simulation in an interdisciplinary design context to the specific information conveyed in the different views of the IFM framework. The analysis identifies specific potentials and barriers for a consistent transition between them. Finally, the implications of the derived insights are discussed.

Function in engineering: Benchmarking representations and models

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This paper presents the requirements and needs to establish a benchmarking protocol for systematic comparison of different function modeling representations. This benchmarking protocol includes representation characteristics, supported cognitive dimensions, and enabled reasoning activities. Problem types are also defined as: reverse engineering, familiar products, novel products, and single-component systems. It is recommended that researchers and developers of function modeling representations work together to define a canonically acceptable set of benchmark tests and evaluations so that clear benefits and weaknesses for the disparate collection of approaches can be compared. This paper is written as a call to action for the research community to begin to look at establishing a benchmarking standard protocol for function modeling comparison purposes. This protocol should be refined with input from developers of the competing approaches in an academically open environment.

Beyond models and decisions: Situating design through generative functions

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This paper aims to situate Design by comparison to scientific modeling and optimal Decision. We introduce "generative functions" characterizing each of these activities. We formulate inputs, outputs and specific conditions of the generative functions corresponding to modeling (Gm), Optimization (Go) and Design (Gd): Gd follows the classic view of modeling as a reduction of observed anomalies in knowledge by assuming the existence of unknown objects that may be observed and described with consistency and completeness. Go is possible when free parameters appear in models. Gd bears on recent Design theory, which shows that design begins with unknown yet not observable objects to which desired properties are assigned and have to be achieved by design. On this basis we establish that: i) modeling is a special case of Design; ii) the definition of design can be extended to the simultaneous generation of objects (as artifacts) and knowledge. Hence, the unity and variety of design can be explained, and we establish Design as a highly general generative function that is central to both science and decision. Such findings have several implications for research and education.

Early Stage Methods and Tools

Chair: Joze Duhovnik, University of Ljubljana, Slovenia

Promoting void-based design concept generation through computer-supported interactive structurization of verbal and drawing expression

Yutaka Nomaguchi, Tatsuya Ogawa, Kikuo Fujita

Osaka University, Japan

An iterative process of externalizing ideas in verbal and drawing expression is a crucial activity for design concept generation. This paper proposes its systematic methodology focusing on 'void' of concepts. The proposed methodology supports classification of expressed ideas according with their related concepts, structurization and finding unnoticed combination of concepts, which this research calls 'void'. Those steps promote a designer to reflect their own ideas within designers' mind so as to notice potential of new design solutions. This paper also proposes its implementation plot. It incorporates a concept network model, which integrates verbal and drawing expression, and manages a draw layer that is a unit of combination and associates it with a verbally-expressed concept. The tool provides user-friendly interface to cut off a part of drawn sketch, and associate it to concepts. Behind those back-and-forth sketching process, the tool captures alternatives of sub functions' solutions and automatically generate a concept matrix so as to clarify voids. A design example of a wheelchair is demonstrated in order to show the effectiveness of the proposed method.

Combining surveying patent information, reappearing problem and discovering breakthrough for design-around

Hsiang-Tang Chang, Chen-Yen Chang, Yuan-Po Yang

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This research is to make an idea combining surveying patent information, reappearing problem and discovering breakthrough for design-around. Many researchers have made their efforts to develop faster and more precise approach to analyze the patent information. The idea, which introduces a keyword recognition approach based on a specific keyword bank and its corresponding TRIZ parameters and inventive principles, is proposed for resolving that situation. After analogizing the original problem of the objective patent by the keyword bank, a scenario of the problem could be showed clearly and new other candidates of solution could be found through the TRIZ contradiction matrix, and then those candidates would be beneficial to design-around and even lead an innovation. Further, this research constructed a computer tool for making the proposed idea practical, and it could assist designers to inspire new ideas for their design-around projects. So far the test database of the proposed tool involves the Taiwanese patent information of assisting-rising chairs. A demonstrative design case has been successfully developed through the computer tool, and it would pass the infringement test.

A classification of the industrial relevance of robust design methods

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The use of Robust Design Methods in industry is limited. Based on statements from industrial surveys and the authors' experience from working with industrial design in industry, it is suggested that the barriers for industrial implementation of RDM is the lack of early-stage methods that can provide the design team with leading and quantifiable metrics in a simple and fast manner.

Using this assumption, success criteria for the implementation of RDM in industry and a classification of the current body of robust design methods are presented. The presented classifications show that only a limited number of methods focus on the reduction on sensitivity to variation and that especially in early design stages, there are almost no leading and quantitative methods available. Existing methods most often rely on data from previous projects and the experience of the design team.

It is concluded, that the low use of RDM in industrial practice can be explained by the lack of operational tools to fulfill the existing Robust Design principles. Consequently, a suitable framework with leading, early-stage, and quantitative methods and metrics must be developed.

Service Innovation in Organisations

Chair: Klaus-Dieter Thoben, University Bremen, Germany

Characterizing and comparing service innovation in manufacturing firms and service organizations

Oskar Rexfelt, Lars Almefelt, Johan Lars Malmqvist

Chalmers University of Technology, Sweden

One of the major trends within manufacturing industries is initiatives to expand service and aftermarket businesses. Goods and services are integrated in total solutions, and the customers pay for delivered functions rather than hardware. However, many traditional manufacturing firms have found it difficult to make decisions about what service to develop and launch. Challenges include assessing the quality of the service, customer value, and personnel and equipment requirements. Service organizations have more experience in assessing such qualities and it may be possible to transfer their approaches to manufacturing firms. This study compares processes and methods for service innovation at a manufacturing firm with those at three service organizations. Similarities and differences are identified. A framework is then constructed that proposes a basic typology of service innovations. The framework enables a firm to analyze its service innovation situation and proposes suitable methods dependent on the characteristics. The framework is applied to the situation of the studied manufacturing firm and strategic pathways for this firm are discussed.

Enhancing supply chain collaboration in automotive industry by value driven simulation

Reviewers' **Favourite**

Massimo Panarotto[1], Tobias C. Larsson[1], Andreas Larsson[2]

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This paper presents a computer-based approach for conceptual design that aims to enhance collaborative supply chain development in the automotive sector when dealing with product-service development or radical innovations. The focus of the research has been to design a simulation approach that will enable designers and managers to simulate and evaluate the value of different design options for the different stakeholders involved in the development process and to have insights about the implications between business model innovation and the engineered aspects of the solutions early in the conceptual phase.

The approach is presented using a case study within the current project, after following a team responsible for the car cockpit. Four possible scenario have been simulated and evaluated using a commercial simulation software.

The main advantage of the proposed approach is to enhance the awareness among designers and managers of the value of different design options, and allow them to explore further how business and design aspects profoundly affect each other, in order to support early decision-making in the design process.

Jùjū, an enabling solution to guarantee digital inclusion in the perspective of the smart city

Diego Dalia

Eindhoven University of Technology, The Netherlands

Shanghai is a modern environment in which modernity coexists with tradition. Expo 2010 provided a huge contribution to this transformation, accelerating its development and improving quality of life. Although, the rapidity in which these changes occurred created an imbalance that brought out the existing gap between social groups and urban areas.

Local government settled on the Shanghai Smart City project that prefigures the pervasiveness of technology in every aspect of urban life, in order to create a smart city.

In this framework of exhaustive renewal, I decided to investigate the effects that these changes will have on the citizens both before and during its implementation.

The aim is to understand if the users are ready to accept this umpteenth change that will have a great fallout on their lives.

The data collected during the research phase has been analyzed and interpreted in order to find design opportunities useful to develop an output along the design phase.

The final outcome is a computer based platform made to deliver an enabling solution that can guarantee to users digital and social inclusion in the perspective of the Smart City.

Understanding Organisational Needs in Product Development

Chair: Lauri Jaakko Koskela, University of Salford, United Kingdom

Analysis of organisations to integrate multi-agent design systems into IT landscapes

Martin Kratzer, Hansgeorg Binz, Daniel Roth

University of Stuttgart, Germany

Recent contributions in engineering design research demand qualitative and quantitative criteria to analyse organisations in order to judge whether information systems in engineering design (i.e. knowledge-based engineering systems) are generally applicable within these organisations. This analysis should be carried out within the early stages of the development of these systems.

The present paper is taken up this idea and focuses on multi-agent design systems (MADS) as one kind of knowledge-based engineering systems. By using the design engineering transformation system from design theory, suitable aspects of organisations (so called success factors) are developed. The actual results are qualitative criteria, which are subordinated to the success factors. In order to operationalise the criteria, applicable questions are derived. Finally, the criteria and questions deliver support to knowledge engineers in the early phases of the development of MADS. After a practical relevance has been evaluated, the success factors, criteria and questions are prepared for using them in the development of all knowledge-based engineering systems.

Customer integration in the pre-development stage of new products: Management process proposal

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[1]Federal University of Rio Grande do Norte, Brazil; [2]Federal University of São Carlos, Brazil

The aim of this paper is present a process management support to customer integration in the pre-development of new products. The proposal was conceived from a literature review and case studies in five Brazilian companies of the capital goods sector. The process consists of three stages: prospecting customers and their needs, selection of customers and customer integration in pre-development. Each phase involves specific activities and tasks. Decisions and operationalization of this management must occur in Managers level, responsible for the functional areas of Marketing, Sales and Engineering. The main focus of the customer integration en the pre-development of new products is to obtain information more accurate on market needs current and future, thus enabling: 1) translating those needs into opportunities to generate new products and / or new businesses with low risk of failure, 2) improve the attributes and its perception in the market of products offered by the company.

A methodology to support strategic design and management decision-making in entrepreneurial systems: A case study in mobility on demand (MoD) transportation

Mark P. De Lessio, Michel-Alexandre Cardin, Angel Astaman, Valerie Djie

National University of Singapore, Singapore

This paper introduces a methodology to support strategic design and management decision-making in entrepreneurial systems that are called to evolve towards more complexity. It describes a framework to capture the early dependencies between the components and stakeholders of an enterprise organization that faces a wide array of uncertainty in a start-up environment. The methodology consists of two steps: 1) a layered DSM representation, and 2) flexibility analysis. The first step provides a systems-level representation of the enterprise, and enables quick identification of opportunities for flexibility. The second step enables thorough and quantitative analysis of opportunities for flexibility to support strategic design and management decision-making. The concept of flexibility, often associated to real options, is exploited as a way to deal pro-actively with uncertainty, which is prevalent in a startup environment. It provides entrepreneurial systems with the "right, but not the obligation, to change and adapt over time as uncertainty unfolds." The proposed methodology is applied as demonstration to the analysis of a startup system in the sector of mobility on-demand transportation.

Improving eco-design projects through better understanding of the company characteristics and business context

Molly Buckingham[1], Elies Dekoninck[1], Chris McMahon[2]

[1]University of Bath, United Kingdom; [2]University of Bristol, United Kingdon

This paper examines the role of the supported pilot project in introducing and embedding eco-design practices. This is achieved through the documentation of a pilot project that failed to achieve a desired level of embedded change.
A comprehensive review of this project identifies the often overlooked impact the company's characteristics and business context, had on the project outcomes achieved. The level of impact observed within this review suggests that more successful outcomes would be have been achieved if the pilot project had been more closely aligned to the company's specific situation.
With this in mind the paper develops a Company Characterisation Process and identifies key company features that should be documented and addressed within eco-design pilot project briefs.
This research encourages a more customised approach to eco-design pilot projects with the aim of supporting environmental design change from within an organisation rather than imposing it externally.The goal is to help future eco-design pilot projects achieve more embedded outcomes that lead to lasting change within industry.

Design Aesthetics and Comfort

Chair: Saeema Ahmed-Kristensen, Technical University of Denmark, Denmark

Perception of aesthetics in consumer products

Marta Pérez Mata[1], Saeema Ahmed-Kristensen[1], Hideyoshi Yanagisawa[2]

[1]Technical University of Denmark, Denmark; [2]University of Tokyo, Japan

In today´s highly saturated consumer markets, competition among products is high. Emotional design, kansei engineering and aesthetics are tools increasingly used to make products stand out from their competitors. This study investigates how the desire to own a product is related to the perceptions and aesthetics of the product. Surveys were conducted with 97 participants to gather their perceptions of 11 vases. Findings from the case study indicate that there exist significant relations between the desire to own a product and how the product is perceived; and also between the perceptions and the parameters of the vases. The results from this study are a set of design guidelines for creating products, in this case vases, targeting desire for ownership and evoking specific perceptions. The results are specific to vases or similar product categories although the method can be applied to other product categories.

An investigation of vehicle interface operation comfort

Georgi V. Georgiev[1], Yukari Nagai[2], Saori Noda[3], Deny W. Junaidy[2], Toshiharu Taura[1]

[1]Kobe University, Japan; [2]Japan Advanced Institute of Science and Technology, Japan; [3]DENSO Corporation, Japan

Comfort of operation is essential for product success. In particular, the evaluation of comfort can be difficult because variations exist in product interface operations. In this paper, we investigated the elements of comfort by capturing comfort during-the-operation as subjects operated a vehicle device interface. We focused on Skin Conductance Response as an indicator of human comfort. We conducted an experiment to investigate the operation of three types of devices contained in two different vehicles. We analyzed a set of quantitative parameters of Skin Conductance and compared them to conventional evaluations of comfort of devices that were collected using a questionnaire. With respect to the operation of these three types of devices, the results revealed a common tendency between these parameters and subjects' evaluations. Investigation of comfort based on Skin Conductance Response can assist in the comparison of the comfort of different devices operations. We also outline suggestions for future research related to evaluation of comfort during vehicle interface operations.

Formulation and use of criteria for the evaluation of aesthetic attributes of products in engineering design

Lampros Roussos, Argyris Dentsoras

University of Patras, Greece

Constant and rapid technological progress, along with the evolution of design and production methods, permits the adoption of technological achievements and the embodiment of new features in products. Some of these features pertain to aesthetic attributes that make the key difference when competitive products are considered by customers and users. Evaluation of products with respect to these attributes may be done by forming proper criteria that could be used in engineering design process.

In the present paper, four (4) distinct groups of criteria are presented that address multiple aesthetic aspects of products. The criteria can be used for the aesthetic evaluation of product alternatives in combination with other conventional criteria from the field of engineering design. These aesthetic criteria - which are presented analytically and their formulation is also explained - refer to issues such as form, materials, color and simplicity that attract the focus of consumers and product users before making their final choice. The merit gained from their application is exemplified through a case study of the evaluation of three (3) coffee machines, performed according to Pugh's Method.

Investigating the role of aesthetics for interaction design

Konstantinos Stavros Stavrakos, Saeema Ahmed-Kristensen

Denmarks Technical University, Denmark

Two important aspects when designing products is to focus on comfort and to define the aesthetic and emotional value of the product. The main purpose of this research is to answer the question of how attractiveness perceived through the sensory inputs affects the assessment of comfort as well as to explore associations between comfort and product descriptors. The findings of this research are expected to assist designers in developing successful new products by focusing more on softer factors. A study of twenty three respondents assessing comfort in three phases found that comfort scores increase when the levels of attractiveness increase and vice versa. The findings further indicate that there are strong, significant correlations between scores of comfort and product adjectives commonly used to describe product attributes such as size, weight and surface material. Hence, there is an emotional dimension of comfort which is initiated by the visual input during a human – product interaction and is affected by the attractiveness towards the product. In their endeavor to develop successful and comfortable products designers should focus more on attractiveness.

Research the Designer: Which Concepts Explain the Designer's Activities and Provide Support for Successful Processes and Outcome?

Petra Badke-Schaub

Delft University of Technology

Abstract

This contribution aims to take a closer look at the current state of design research when it comes to explain the activity of designing. The question to be answered is: Focusing on the designer as focal figure in the design process: What is the knowledge which we build on to educate design students in the most appropriate way and can we use the same knowledge to support the designer in order to improve the design process and results in daily practice? To be able to answer these questions we should critically make a kind of scientific disclosure and discuss accordingly which concepts explain the designer's activities and provide knowledge to support successful processes and outcomes in design.

The question to be followed points into the future: Does that knowledge help to educate the designer for the future? Do we have a shared understanding about the requirements of the future and do promising new concepts exist to face the highly complex and uncertain developments of the future?

Bio-Sketch

Dr. Petra Badke-Schaub is Professor of Design Theory and Methodology at Delft University of Technology, NL. She has a background in cognitive and social psychology and did her PhD on 'Groups and complex problem solving' at the University Bamberg in Germany. The main research aim of her research group at the Faculty of Industrial Design Engineering is to analyse the designer and the activity of designing as social-cognitive process in context. The research methods encompass long-term interdisciplinary projects in the field as well as laboratory experimental studies. Her publication list includes more than 100 refereed journal and conference papers and the editorship of four books on human factors, critical situations in design and the designer as the key success factor in product development. Overall, publications encompass topics such defining and analyzing critical situations, problem solving and decision making of individuals and teams in complex environments, the sketching process and the development of team mental models, experience and creativity in design.

	19 August 2013 MONDAY	20 August 2013 TUESDAY	21 August 2013 WEDNESDAY	22 August 2013 THURSDAY
07:30 – 09:00	Registration	Registration	Registration	Registration
08:45 – 10:15	Opening Ceremony 09:00 – 10:15	Podium Sessions / Discussion Sessions / Workshops	Podium Sessions / Discussion Sessions / Workshops	Podium Sessions / Discussion Sessions
10:15 – 10:45	Keynote	Break	Break	Break
10:45 – 12:15	Break 10:45 - 11:15; Podium Sessions / Discussion Sessions / Workshops	Podium Sessions / Discussion Sessions / Workshops	Podium Sessions / Discussion Sessions / Workshops	Podium Sessions / Discussion Sessions
12:20– 13:20	Lunch 12:50 – 13:50	Lunch	Lunch	Lunch
13:30 – 14:00		Keynote 13:30 - 14:00	Keynote 13:30 - 14:00	Podium Sessions / Discussion Sessions
14:00 – 15:30	Podium Sessions / Discussion Sessions / Workshops	(14:00 - 14:15); Podium Sessions / Discussion Sessions / Workshops	(14:00 - 14:15); Podium Sessions / Discussion Sessions / Workshops	Break 14:45 - 15:15; Keynote 15:15 - 15:45
15:30 – 16:00	Break	Break	Break 15:45 - 16:15	Closing Ceremony 15:50 - 16:30
16:00 – 17:30	Podium Sessions / Discussion Sessions / Workshops	Design Society General Meeting 16:00 – 17:30	Podium Sessions / Discussion Sessions / Workshops	Closing Reception 16:30 - 17:30
17:30 –	Welcome Reception 17:30 - 19:30	Young Members Event 18:00 – 20:00	Short Palace Tour 17:30 – 18:30; Conference Banquet 18:30 – 22: 00	

Social Activities

We have arranged a variety of social events including a welcome reception, a banquet, a closing reception and optional Gangnam-Style tours, which will enrich networking experience. In addition, Korean traditional culture experiences are available in the old Korean traditional buildings

Welcome Reception

Date & Time: 19 August (Mon), 17:30 - 19:30

Place: International Conference Hall (AH-10501)

Dress Code: Informal

Type: Cocktail & Standing Buffet

Entertainment: Sungkyunkwan University Dancing Team (Lim Hak Sun Dance We)

- There will be a standing cocktail reception with snacks allowing you to mingle with friends and colleagues while enjoying the Korean Traditional Performance.

Lim Hak Sun Dance We

Short Palace Tour

Date & Time: 21 August (Wed), 17:30 - 18:30

Place: Gyeongbokgung Palace

Gyeongbokgung Palace remains as the core nucleus of autocratic rule through much of the Joseon Period. Unlike other palaces in Seoul, the rectangular area is flanked by large entry gates on all four sides, and three granite walkways extend from the front entry gate, or Geunjeongmun, to Geunjeongjeon, the main hall of Gyeongbokgung Palace

- This tour will be on the way to the Banquet Venue, Millennium Seoul Hilton Hotel. Please keep in mind that the shuttle bus from Sungkyunkwan University departs at 5:30pm

Banquet

Date & Time: 21 August (Wed), 18:30 – 22:00

Place: Millennium Seoul Hilton Hotel

Dress Code: Informal

Type: Western Set

Entertainment: Korean Art-Pop Concert, Folk Rock Group – SALTN PAPER

Fascinating performances and food are prepared for you at the Banquet of the Conference. The dinner will present a memorable night in Seoul with delightful food and wonderful performances.



Korean Art-Pop Concert

Folk Rock Group – SALTN PAPER

Closing Reception

Date & Time: 22 August (Thu), 16:30 – 17:30

Place: Lounge (IH-90101)

Dress Code: Informal

Type: Drinks & Snacks

A chance to say goodbye and tie up loose ends over a few drinks and snacks.

Korean Traditional Culture Experience

Date & Time: 19-20 August (Mon-Tue), 12:00-16:30

Place:
12:00-13:30 - International Conference Hall (AH-10501)
14:30-17:00 - Myeongnyundang

Social Activities

Optional Gangnam-Style Tour Program

Date: 20 August (Tue) / 22 August (Thu)

Time: 17:30 – 22:00

Fee: EUR 70

PSY's world hit song 'Gangnam Style', explores and pokes fun at Gangnam, an area South of the Han River in Seoul, and its style. In response to many inquiries regarding Gangnam and spots to visit, the ICED 13 organising committee created a special itinerary for delegates and accompanying persons to have their own "Gangnam Style" experience. The tour will be offered on Tuesday, August 20, or on Thursday, August 22.

If you want to join, please sign up the optional tour at the 'Registration Desk' (IH-902Lobby) during the conference.



Bank (Woori Bank)

Bank opens between 9:00 and 16:00, Monday to Friday. When the bank is closed, you can take cash from ATMs. You can withdraw and deposit money using ATMs with your card. Each bank has slightly different machines, but the major functions are the same. Most machines offer English service.

- Address: 1F, Yurim Hoegwan near Main Gate
- Tel. :+80-2-740-1901

Currency & Exchange

The unit of the Korean currency is the Won. Various notes and coins are used: notes include 1,000 won, 5,000 won, 50,000 won, and 10,000 won denominations, while coins include 10 won, 50 won, 100 won, and 500 won denominations. As of July 2013, the exchange rate is approximately USD 1 to KRW 1,109 and EUR 1 to KRW 1,473.

Foreign bank notes and traveler's checks can be converted into the Korean won at foreign exchange banks and other authorized money exchange outlets. The exchange rate is subject to market fluctuations.

Tipping & VAT

Tipping is not customary in Korea. Sometimes, expensive restaurants and luxury hotels may add a service charge of 10%. Value-Added Tax (VAT) is mostly included in the retail price. However, in hotels and some big restaurants, the price may not include VAT.

Language

The official Korean language is Korean. Street signs, transportation signs, and travel information in Korea are usually provided in both Korean and English for visitors' convenience.

Time Zone

The time in Korea is 9 hours ahead of the Greenwich Mean Time (GMT+9).

Climate

During the month of August, the temperature in Seoul averages 26-28 °C (78.8-82.4 °F).

Electricity

The standard electricity supply is 220-volts AC/60 cycles. Most hotels may provide outlet converters for 110 and 220 volts. It is advised to check with the hotel beforehand.

Business Hours

Government office hours are usually from 9:00 to 18:00 on weekdays and closed on weekends. Banks are open from 9:00 to 16:00 on weekdays and closed on Saturdays and Sundays. Most stores are open every day from 10:30 to 20:00, including Sundays.

Postal Service

The intramural post office provides local and international postal service including Express Mail Service (EMS), as well as a banking service.

- Location: Humanities and Social Sciences Campus: 1F, 600th Anniversary Hall

Miscellaneous

Emergency Call

- 1339: Medical Emergency
- 119: Emergencies for Fire / Rescue & Hospital Services
- 112: Police
- 120: Dasan Call Center Service - Seoul's Call Center for Processing Civic Requests

Free Shuttle Bus

Free Shuttle Bus is operating between venue to official hotels. For specific bus schedule, please refer to the bus time table where you receive with your name tag from the registration desk.

University Shuttle Bus

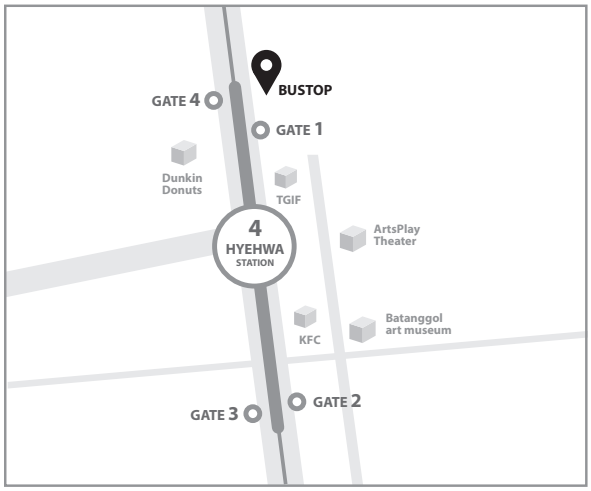
There is a university shuttle bus station near by Hyehwa subway station.
If you get out from exit number 1 and go straight, you will see the sign of shuttle bus.
You can see the shuttle bus stations in the campus on the campus map.

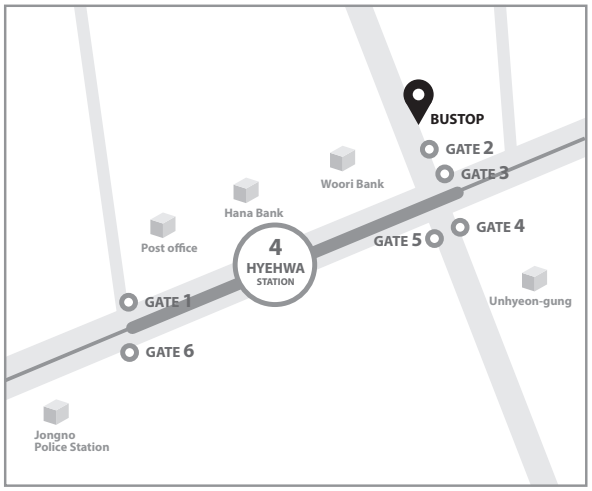
- Fair: 300KRW (cash), 250KRW (ticket)
- Operating hour: 7:00 - 23:00 (Weekdays) / 7:00 - 19:00 (Saturday)
- Interval: 15 - 20 minutes

A little before you reach the shuttle bus station, there is a green town bus stop.
This bus is run by Seoul City. If you take Daehangno bus number 7, it will take you to in front of Seoul campus main gate.

- Fair: 700KRW (cash), 600KRW (T-money card)
- Interval: 10 minutes

If you take subway and then take the bus with T-money card, you'll get transfer discount





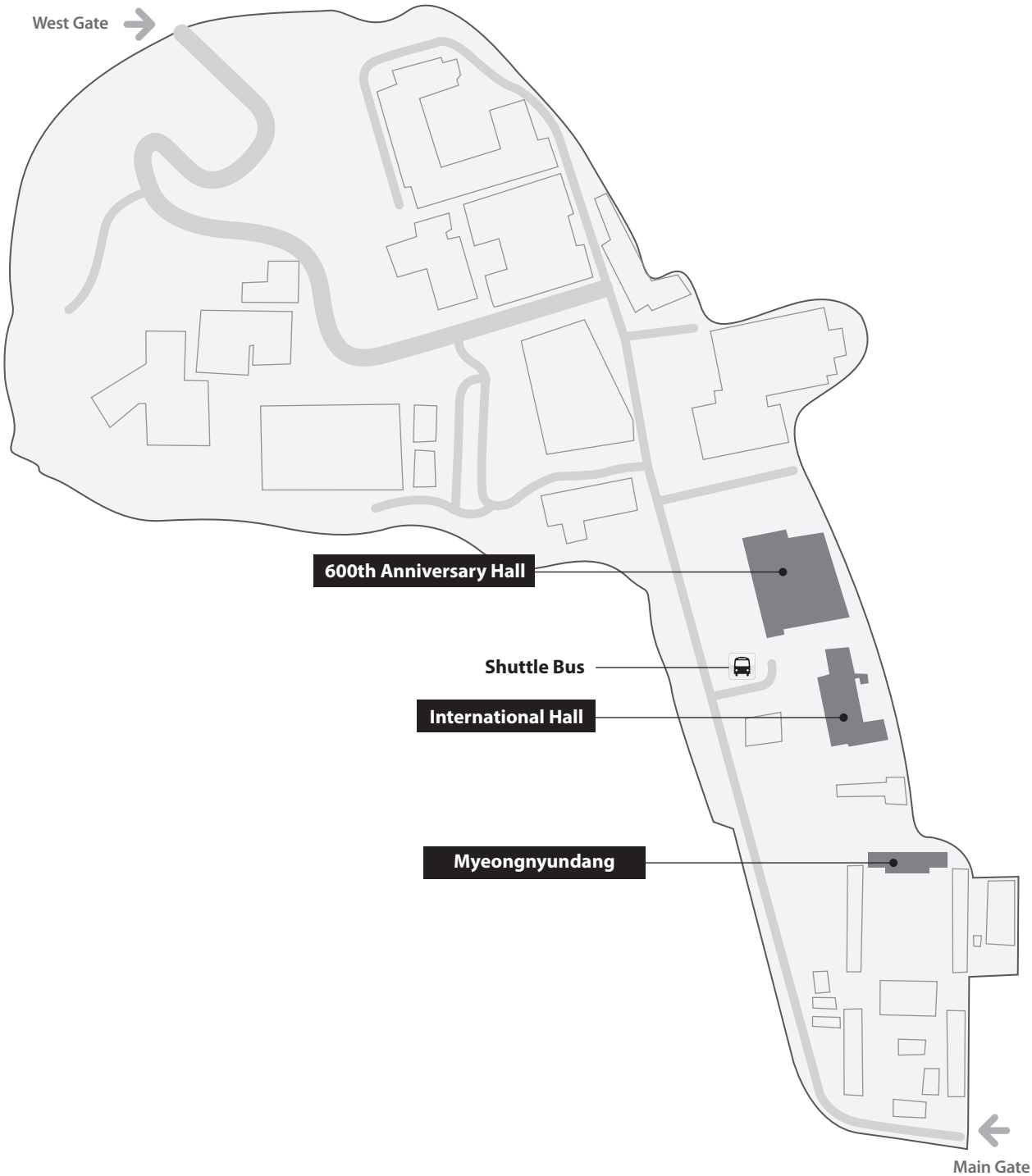
If you come by Anguk station, get out from exit number 2. As soon as you get out, you will be able to found a town bus stop sign easily. There are 2 buses. Jongno bus number 1 and Jongno bus number 2. Only Jongno bus number 2 takes you to our campus. It comes in through West gate of Seoul campus and the final stop of this bus is parking space in Seoul campus. Fares and Interval of this bus is same as Daehangno town bus number 7.

Taxi

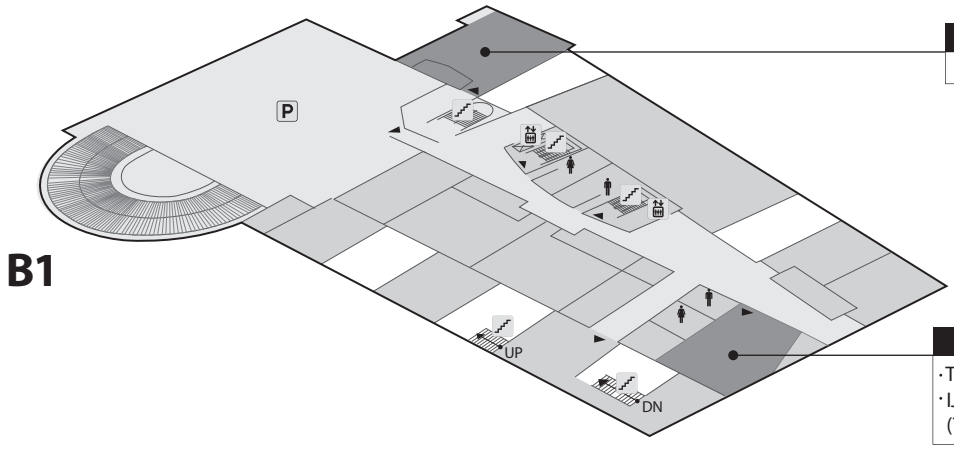
Taxis are plentiful, clean, safe, and inexpensive in Korea and can be found at taxi stands in most busy city areas or easily hailed on the streets. It costs approximately 3,500KRW($3) from official hotel to the venue.

Conference Venue

Sungkyunkwan University (25-2, Sungkyunkwan-ro, Jongno-gu, Seoul, Tel: +82-2-760-0819)



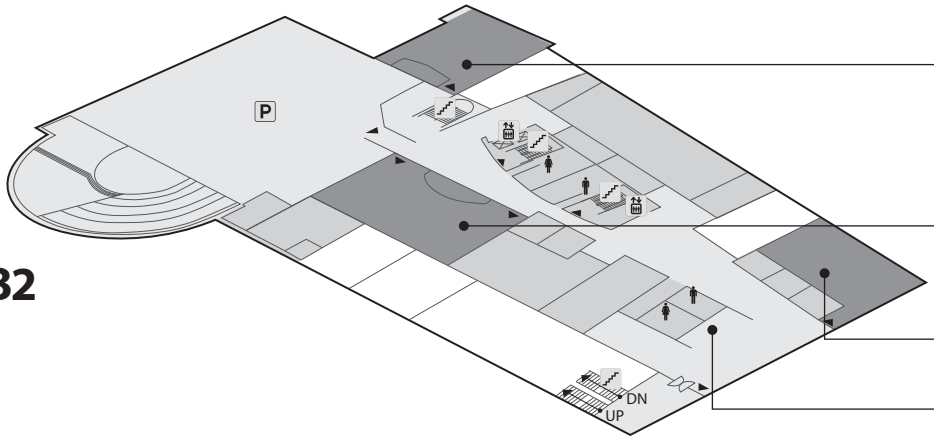
Floor Plan : International Hall (IH)



B1

IH-9B118
Podium 4

IH-9B106
· Tutorial 1
· IJDCI Editorial Board Meeting
(Thu.10:15-11:45)



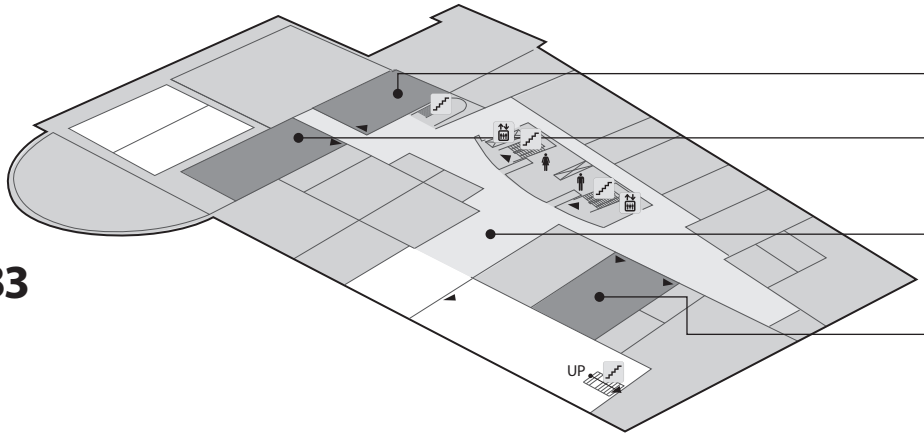
B2

IH-9B218
Podium 3

IH-9B217
· Podium4
· DS General Meeting
(Tue. 16:00-17:30)

IH-9B208
Tutorial 2

IH-9B212



B3

IH-9B321
Discussion 2

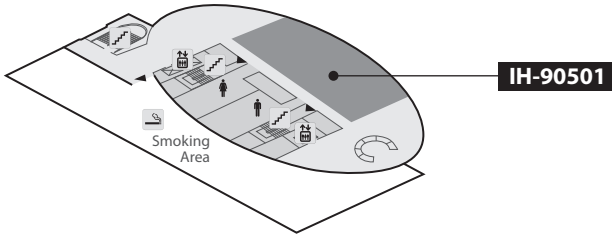
Faculty Club (IH-9B320)
Discussion1

IH-9B314
. Coffee/Tea break
· Lounge

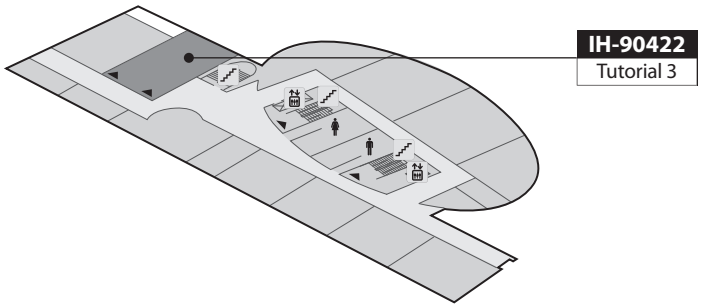
IH-9B312
Discussion 3

Floor Plan : International Hall (IH)

5F



4F



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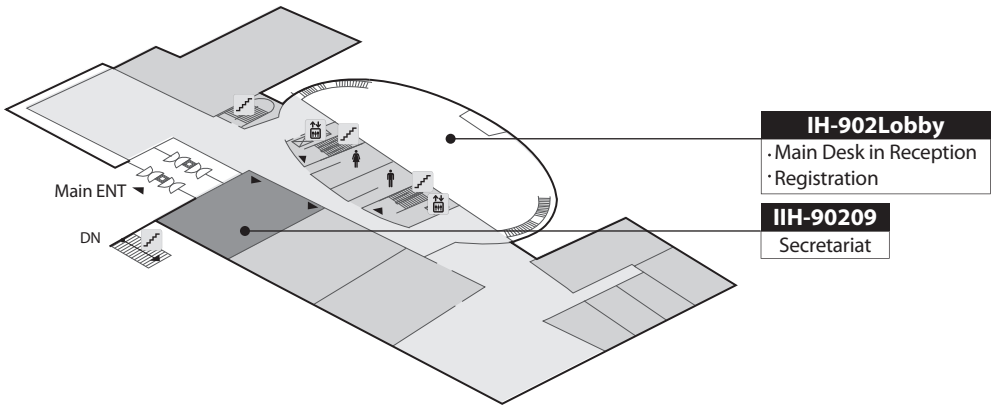
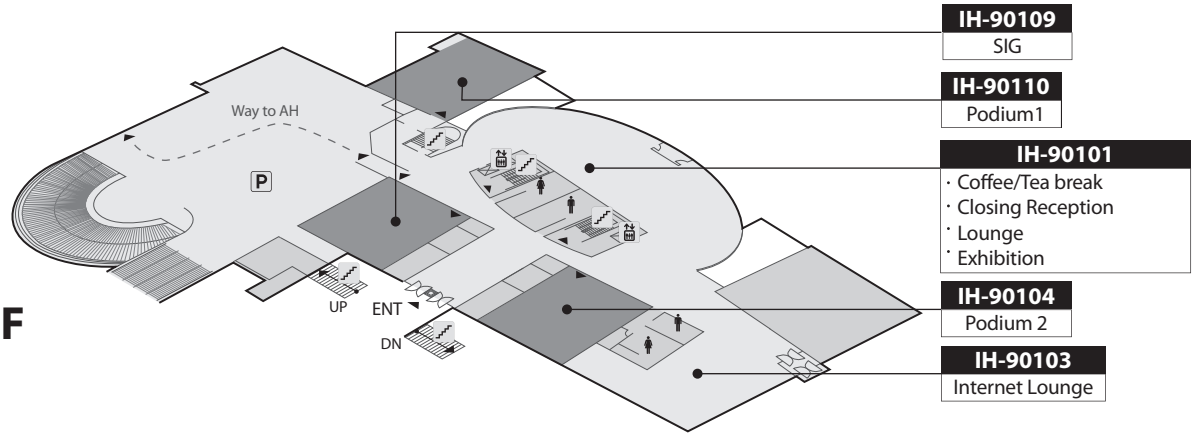
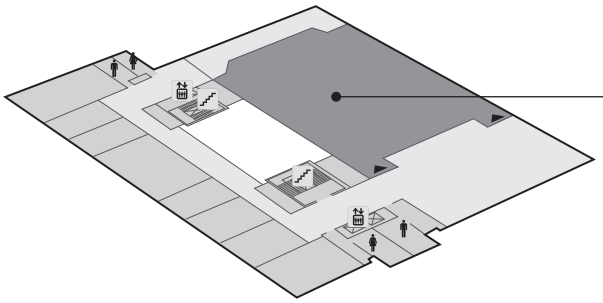


1F



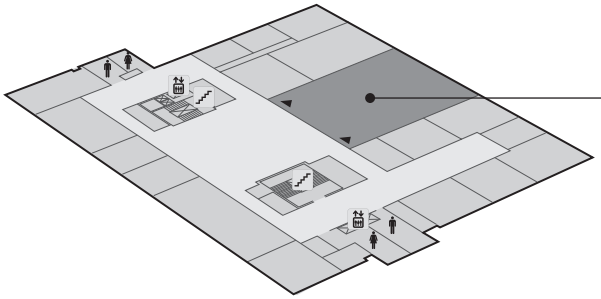
Floor Plan : 600th Anniversary Hall (AH)

5F



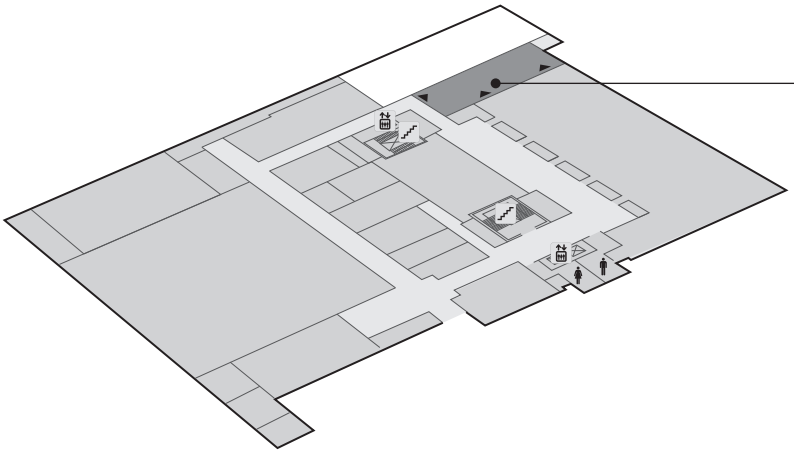
International Conference Hall (AH-10501)
- Lunch
- Opening Reception
- Young Members Event

3F



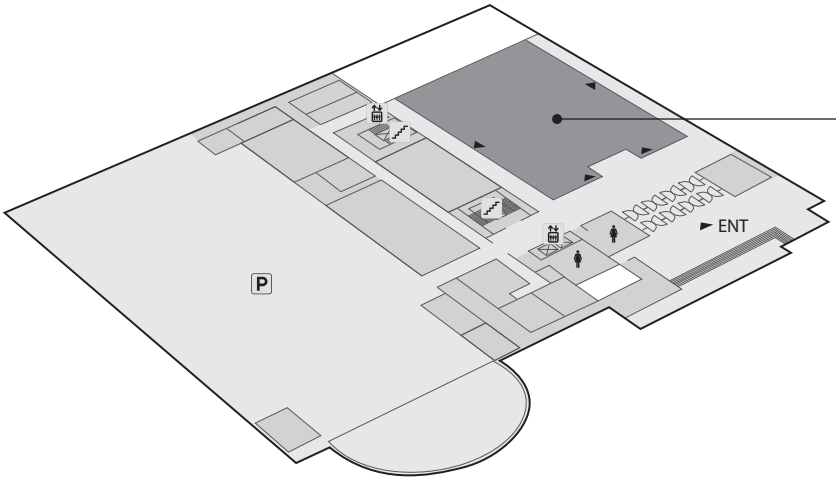
Conference Room 1 (AH-10305)
DS AB Members Meeting (Wed. 12:20-13:20)

B1



Cafeteria (AH-1B102)
Lunch

B2



New Millennium Auditorium (AH-1B201)
- Opening Ceremony
- Keynote Speeches
- Closing Ceremony

Venue

Sungkyunkwan University (25-2, Sungkyunkwan-ro, Jongno-gu, Seoul, Tel: +82-2-760-0819)

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