

STUDY OF THE EVOLUTION OF INTEGRATED DESIGN

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1. Introduction

Questions related to the emergence of new ideas, their density and location may be interesting when trying to understand the evolution of a given field. The design area is an “old” concept that holds lots of hidden and non-hidden sub-concepts. In this paper we present the latest results we got from the study of the evolution of ideas in this field. In fact, we are addressing the question related to the positioning of some new fields *vis-à-vis* the design master scheme. In order to achieve these goals, we have selected a set of international conferences (see table 2) where we attend regularly. We are of course aware about this restriction, however we consider that the results obtained and presented below do not concern the non-mentioned conferences and an update could be done as soon as we get the proceedings. We have started the identification process by building a subset of keywords starting from our background. The list is shown in table (Tab. 1). From this point we have considered a loop starting from a paper called P1, we updated the keyword list by those of P1. Then new search processe of papers matching the new list of keywords has been achieved. The more accurate paper has been chosen to update the concept (keyword) list and so one. The overall list of keywords include 2338 different keywords used by the design community. If we consider the pareto criteria that extract 80% of the more cited concepts we reach 400 concepts supposed to cover the main aspects in design but not necessarily the potential emerging ideas. We have also reported in Table (1) the score, in term of number of papers, of both the conferences and the international journals for this starting list.

Table 1. Starting list of concepts with their score in reviewed journals and conferences from 1995 to 2003

Concept	Conf	Jour	Concept	Conf	Jour
Systematic Design	24	7	Automatic Design	56	7
Ecological Design	7	2	Engineering Design	729	117
Concurrent Engineering	130	129	Assembly Design	227	11
Sustainable Design	25	0	Robust Design	718	21
Design for Assembly	190	20	Design for manufacturing	1205	6
Design for X	127	5	Design to Cost	15	10
Product Design	325	111	Advanced Design	43	1
Design Assembly	0	8	Optimal Design	562	88
Rational Design	64	1	Perceptual Design	125	0
Integrated Design	454	22	Virtual Design	200	8
Product Development	366	109	Uncertainty	39	719
Collaborative Design	142	59	Distributed Design	340	10

In the mean time, we have searched for the keywords used by the authors. Knowing that this approach is not sufficient and may lead to non consistent result we made a consolidation by a full text scan in order to confirm that a given concept is regularly present in the document as suggested by the authors in the list of keywords. For those papers that do not present a list of keywords, we have simply projected the document on the list of keywords built by the other papers. Figure 1 reports the Top 20 quantitatively most suggested keywords in the design community excluding the “Design” concept for which we have verified that it is massively present in all the papers.

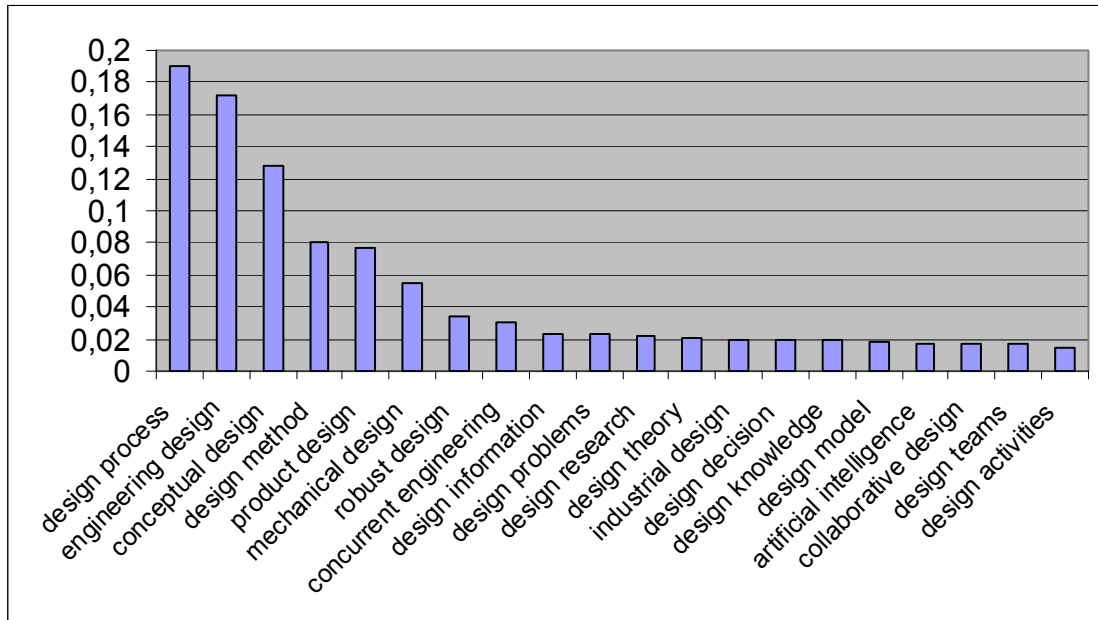


Figure 1. Top 20 keywords used by the design community in international conferences

One of the main ideas we used is that the concepts developed in journals are those mature and validated by experts, while those submitted in conferences are those emerging (even reviewed) and not yet mature. Thus there may exist a difference between the concepts from journal papers and those in proceedings.

We learn from Table 1. and Figure 1. that “Engineering Design” as a concept is one of the more important topics addressed by researchers in conferences as well as journals. “Virtual Design” for example is still at the beginning of its life cycle, while “Optimal Design” is considered widely in the papers and less represented in conferences perhaps because of its maturity.

Table 2. Identification of the conferences

CIE	DAC	DFM	DTM	MOVIC	DETC	EIM	VIB	VIBP	EDC
Computer & Information in Engineering	Design Automation Conference	Design Theory & Methodology	Mechanical Vibration & Control	Mechanical Vibration & Noise	Design Engineering Technical Conference	Engineering Information Management	Mechanical Vibration & Noise	Motion & Vibration Control	Engineering Design & Control
ISD	MECH	PTG	RSAFP	SERAP	IED	FLEX	DESIGN	IDMME	ICED
Integrated System Design	Mechanisms & Robotics	Power Transmission & Gearing	Reliability Stress Analysis & Failure Prevention	Safety Engineering and Risk Analysis	International Issues in Engineering Design	Flexible Assembly	(Dubrovnik)	Integrated Design & Manufacturing in Mechanical Engineering	International Conference on Engineering Design

2. Main issues

This preliminary study was the main step followed to build a list of 200 important keywords so that we could extract some interesting results. The objectives of this research have been expressed in term of questions we were supposed to answer:

1. What are the main conferences and journals considered by the design community?

2. What are the main consolidated concepts?
3. What are the emerging/disappearing concepts?
4. What are the main effective fields of a given conference/journal?
5. Is it possible to build a keyword reference list for the design community?
6. Is it possible to check the correspondence between a new paper and a given conference or journal?

3. Preliminary results

Considering that research is a dynamic event, pre-specified fields for a conference may move according to the pre-occupation of the researchers. The study of the concepts used may on one hand help the author to target the right conference, and on the second hand help the conference organizers to build new sessions, adapt the fields and detect emerging ideas.

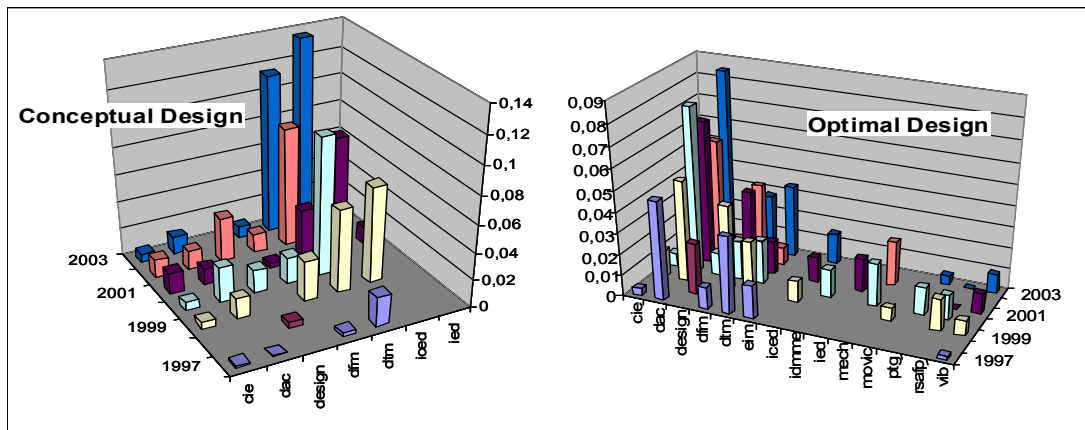


Figure 2. Distribution of the-Conceptual and Optimal Design-fields

Let us, as an example, consider the concept of “Conceptual design”. According to our results, there are many places where we talk about this subject, however The Design Theory and Methodology conference and ICED are those with an historical interest by the field (see figure 2). These results are obtained using the ratio calculated as the frequency of papers that deals with this concept in an annual event. “Optimal Design” that is a classical field is much distributed, among several conferences (in term of regularity) such as “Design Automation Conference”, “Design Theory and Methodology” that are hosted by the IDETC within the ASME general conferences. All the ratios are normalized so that the number of papers presented in the conferences do not affect the result.

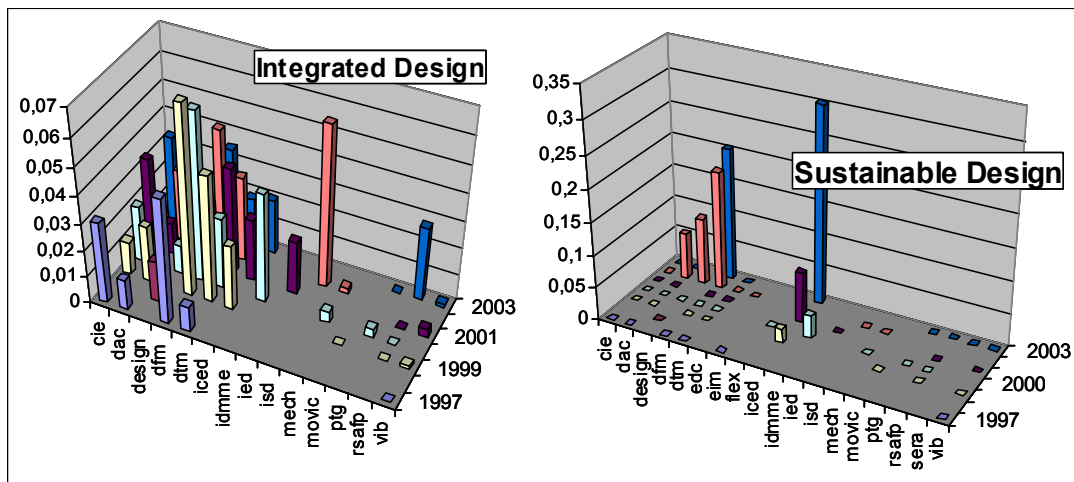


Figure 3. Integrated and Sustainable Design cards

If we consider the “Integrated Design” concept that defines a large area of design and especially the process that are related, one can notice the increasing interest expressed by the DESIGN conference (see figure 3- left). In the mean time this concept is now present with a significant number of papers in journals (see Table 1.) while it doesn’t reach the top 20 most significant terms currently used by the design community. This express the fact that “Integrated Design” is now mature. Mainly we do not access to the related works by the mean of the corresponding keyword.

We have also studied the case of “Sustainable Design” an area that seems to be emergent.

One can notice that the DESIGN conference is giving a growing place to this field while older conferences are maintaining the same level of interest for this concept. Even if it is premature, we can consider from this result, and for this concept, that this field may benefit from this openness.

In figure 4, we have reported two other results. In fact, it is not possible to consider all the outcomes we got from this study in the frame of this paper.

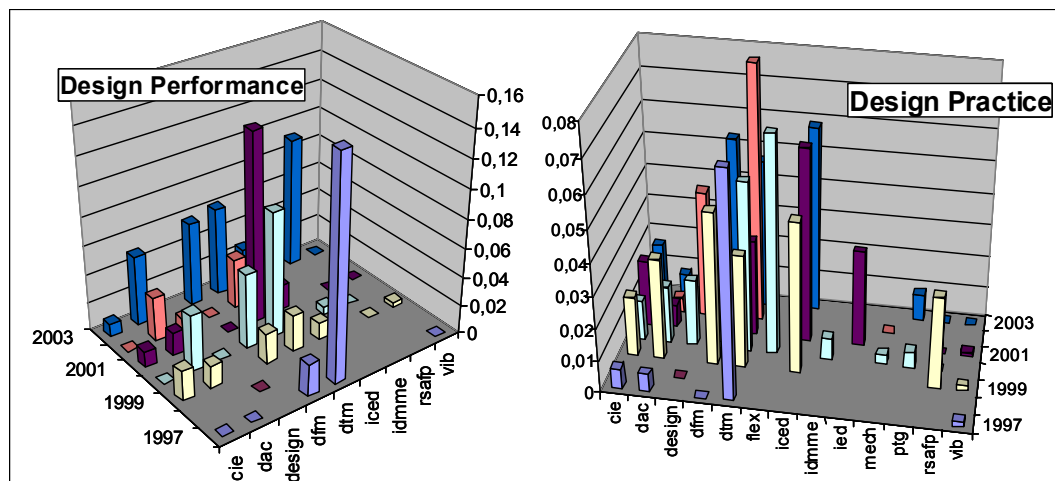


Figure 4. Design performance and Design Parctice cards

We have also developed the concept of “signature” of a conference (may be also used for journals) that helps to position an event among others. As an illustration figure 5 shows that the DESIGN conference share the same fields as DAC and DTM, however we also learn that DESIGN is an intermediate stage between DAC and DTM From another point of view, the list of 2338 terms used by the design researchers is a “brut” result and may benefit from some effort to structure it. However, at this stage we can consider that it should be an entry point to the colleagues for the next events (at least for the Design Society).

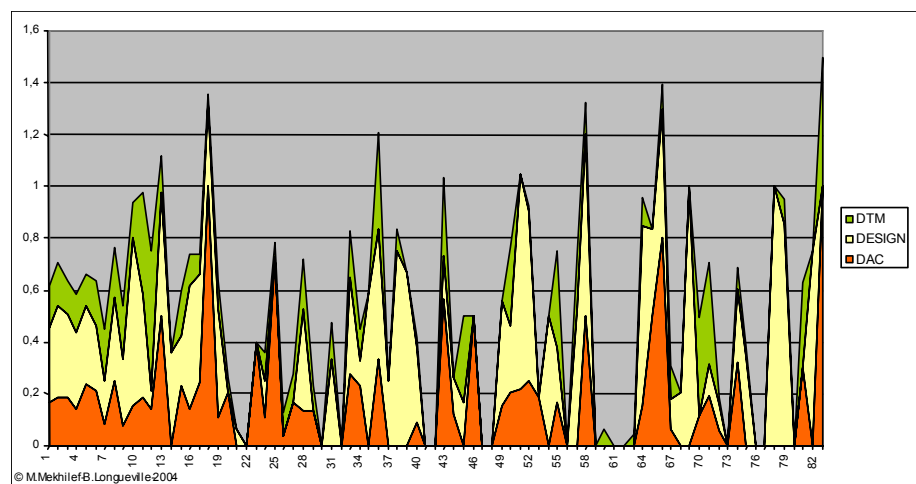


Figure 5. The DESIGN conference seems to be positioned between the DAC and the DTM conferences

This preliminary study, even if it is still at a quantitative level, shows that it is possible to give answers to at least the five first (among 6) questions addressed initially by this project. In fact, mapping the whole results on a list of selected concepts (selection that may be settled by any user) give the profile of a conference or a paper. This mapping is to be understood as a correspondance between the terms used within a paper and its relation to a concept.

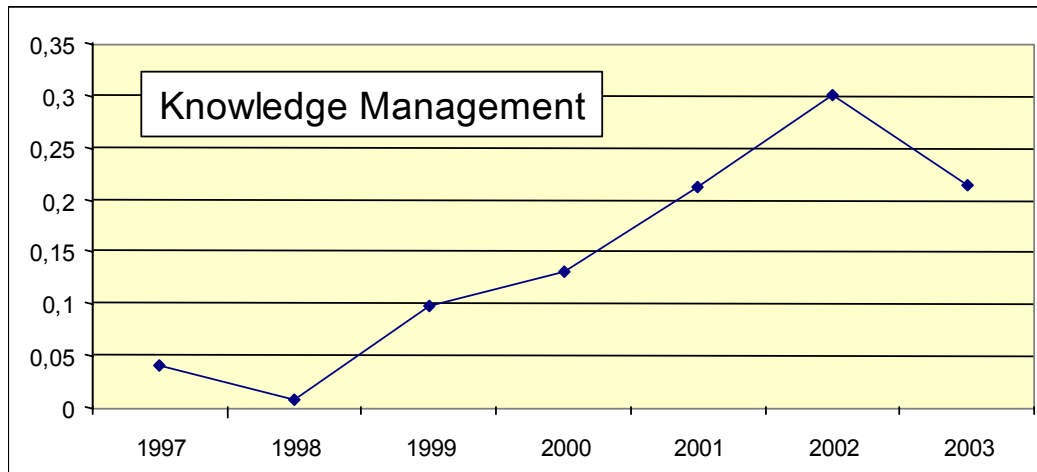


Figure 6. The Knowledge Management is an example of concept that emerges early and is still of interest. The next coming years will confirm or not the new tendency

The comparison between papers submitted to journals and papers submitted to conferences is a significant way to extract the concepts that are enough diffused and accepted by a large part of the design community. This hypothesis may be improved using other tools such as semantic tree building or ontologies.

The less technical aspect is the answer that we can provide to the need expressed by a large number of researcher: How to build a reference keyword list? In fact ontologies, if built as an open system, give a good answer to this question. The fact is that the existing ontologies are closed and do not progress continuously with the research development. The approach we developed here, may be used as a “concept watch” tool. A syntactical and semantical filetering are however needed for a complete inclusion of new design concepts in an ontology.

4. Conclusion

By this work we started a long process that aims to answer different questions with the overall perspective to build a tool based on a methodology to support the understanding of what is going on in the design field. The addressed users may be different and situated at different levels. From the ground, the end user may be a new researcher who has to learn the design history before developing new ideas. At a level above, a systematic updating process gives handles to the senior-researcher to convince and look for funding. From the conferences point of view, the organizers may use this approach and the corresponding tools in order to build a dynamic and updated list of keywords suggested by the authors. This problem is also the one of the journal editors.

The current situation of the system we have developed is closely connected to the design area, however few efforts are needed in order to generalize or to move to another scientific or technical domain, or to go through a more detailed point of view in a given area.

We point also that this study is based on a quantitative approach and benefit from the techniques and tools already available. We are still working on this topic in order to extract more knowledge from these huge databases.

The whole system will soon be available online and the services delivered to the design community for evaluation and feedback.

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