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INTERACTIVE VISUALISATION OF THE CONE OF VISION AS A DESIGN TOOL

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1. Introduction

Lines of sight and cones of vision have been used both in architectural sketches and building plans to clarify aspects of visibility. Perspective view points of origin are denoted in plan views with small triangular cones, and ergonomics illustrations also make use of visibility triangles. Visualizing the field of view therefore belongs to the known vocabulary of design representations. Apart from these symbols, it is possible to use more flexible ways of illustrating visibility between points in plan drawings. The visibility between locations can be shown by simply drawing lines between points in a plan, or outlining the area that can be seen from one point.
This paper presents a study of augmenting plan drawings with graphic view cone shapes, *isovists*. Of particular interest is the mobile isovist and its application as a tool for designers to explore plan views. To study the phenomenon, a computer program was developed by the author to enable the moving of isovists on an interactive display. A user study was conducted where the software was tested with a spatial design student who was working with visibility-related problems.
Applications for solution-oriented tasks regarding visibility and occlusion are numerous. Isovist shapes are also an element of space syntax studies. A short exposition of these approaches is included in order to position the objectives in this paper. The use of isovists is discussed here in relation to specific, identifiable problems and in less well definable exploration of ‘design problems’. The paper discusses the use of plan view in spatial design, and the benefits of using isovists in plan drawings. This paper argues that the computer augmentation of two dimensional plan drawing, a powerful convention in itself, can complement or even negate the need for three dimensional natural view modeling.
The study is part of an ongoing research into the role of visual computer tools in spatial design. The intention is to support more designer-led creation of the digital design environment.

2. The isovist shapes

The first thorough description of isovist shapes in architectural context was made by Michael Benedikt. [Benedikt, 1979.] The isovist is a flat geometric shape that resembles the field of view. The form of an isovist is determined mathematically from already existing geometry, in this case, the plan drawing. The shape is similar to an area that would be visible from the chosen point, or conversely, the area from which the point could be seen. The term isovist is here seen as valuable in differentiating these ambiguously interpreted shapes from other visualizations of human field of visibility, such as the more symbolic view cones used in ergonomics illustrations.

James Gibson used similar shapes to illustrate what he called the ambient optic array, an element of his theory of affordances. [Gibson, 1978, 65-85.] Gibson's two-dimensional drawings feature view cones which are essentially isovists constrained by the human body shape.

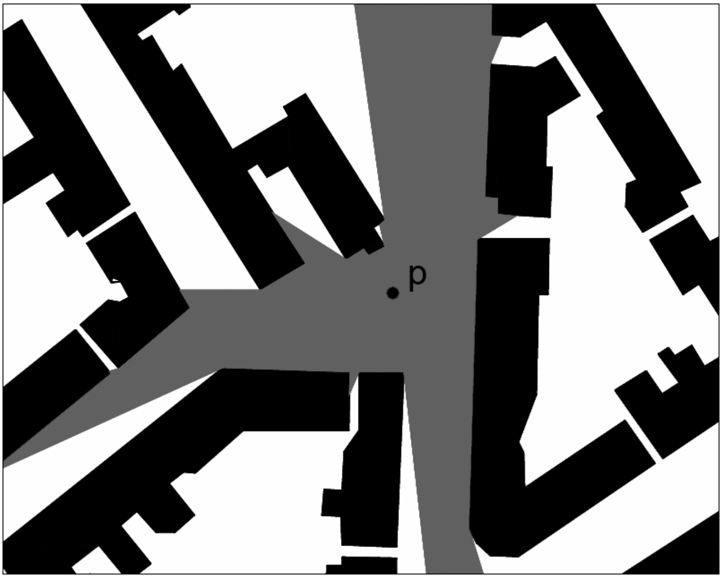

Figure 1. Isovist in a city plan. Point *p* indicates the isovist origin

2.1 The isovists and space syntax

With increased computing power, computed isovists have become available to wider audiences. At the same time isovists have been used in more complex spatial analyses. [Turner & Penn, 1999.] For example, isovists can be used to calculate the prominence of any given point in an area. Such graphs are material for finding correlations between probable human behavior, a branch of research in itself. Space syntax studies attempt to discover the unchanging in the spatial experience, and build analytic principles out of it. The human structuring of the spatial 'continuum' can be seen as somewhat analogous to the syntax of a language [Hillier, 1996].

A spatial analysis produces quantifiable numeric information, from which visuals can be derived. As the use of visual materials as tools is comes as natural in some fields of design such as architecture, it is likely that similar uses for isovists and space syntax graphics could also be found. The author's belief is that when using space syntax graphics as design tools the visual material should be central and the mathematical and analytical inference kept to the minimum. Therefore the approach of this paper cannot be said to have been construed out of space syntax and Gibson's studies of vision, but rather informed by them.

One way to apply isovists directly in design and architecture would be to use them in form generation. The figure 2 serves as an example of one novel way of generating forms out of isovist shapes. Instead of this direction, the focus of the present study is to find applications for the direct use of the isovist shapes in order to enhance the use of plan drawing representation.

2.2 Mobile isovists

Isovists are here discussed in their individual form. Interactive mobile isovists are suggested as a way to bring out qualities of the plan that are not immediately apparent to the viewer. Already an individual isovist added into a plan view can illuminate aspects of the plan, such as the extent of a vista opening from a window of a building.

Some terminology used in this paper should be clarified. The term *natural perspective* is used in this paper to refer to perspective images construed out of a specific view origin, with objects appearing proportionally smaller further away. Photographs are examples of such images. *Interactive* in this context means an element of an image on a computer screen that can be manipulated or navigated directly. Mobile isovists are therefore interactive view cone shapes that move in response to hand or other movement, as opposed to still images of such shapes.
Interactive mobile isovists are comparable to navigating a natural perspective. The specific point argued in this paper is that using mobile isovists opens possibilities for achieving an understanding of the plan drawing that would otherwise need three dimensional modelling and natural perspective navigation. To understand the reasoning in this, some comparison is needed between both of plan drawings and natural looking perspectives.

Gibson has put emphasis on the locomotory aspects of vision. A single image, as 'slice of time' cannot adequately describe the act of perceiving, as perception is rooted to the motion of the perceiving body. Figure 2 illustrates a way of stacking isovists in order to acquire a three-dimensional shape suggestive of the experience of moving through space. This is in accordance with Gibson's illustration of the transformation of the optic array in *The Ecological approach to visual perception.* [Gibson, 1978, 72.] Although Gibson explains the mechanics of seeing still images and motion pictures, he does not specifically ask what does it mean to look at the image of the shape of the optic array, or an interactive mobile image of the view cone?

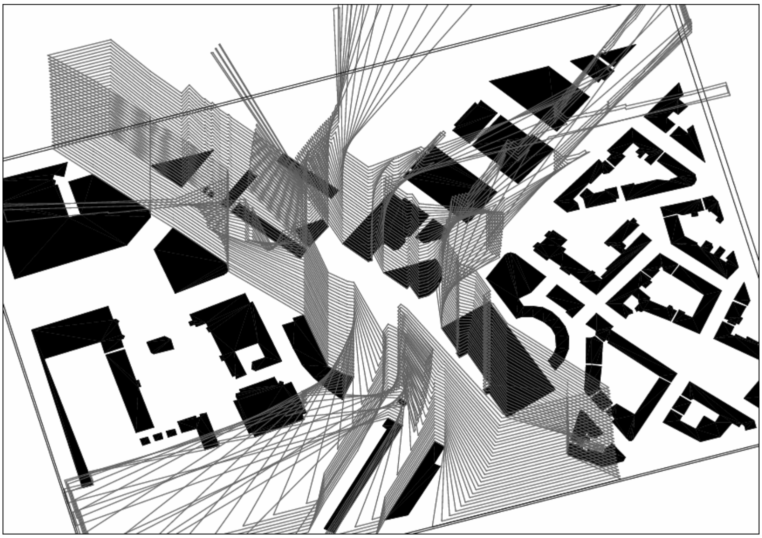

Figure 2. Stacking isovists across a straight line route results in a three-dimensional shape suggestive of the experience of motion

3. Visibility as a design problem

In the following the use of plan drawings and isovists as tools for design is discussed. Whether isovists can increase the understanding of space in some general sense is not an issue that can be addressed within the scope of this simple study. However, visibility-related problems may emerge more concretely as a part of a larger spatial design task, and it is these occasions that this paper is concerned with.

Visibility graphics are useful in solving some specific problems, such as ascertaining visibility between two locations in a plan drawing. Computations can also reveal more complex relations, such as finding the most prominent spot in a given plan. Other similar computations have direct practical applications, for instance in determining optimal antenna positions for radio transmissions or mobile telephony coverage. These are all examples of solving a particular problem, where the intention is clear and the results can be compared in a quantifiable way. This is not wholly representative of the kind of problems designers and architects have to work with.

Peter Rowe in his book *Design Thinking* describes space planning in architecture as an example of a set of particular problems. An architect designing an apartment might have to place living functions within a given amount of square meters and requirements of adjacency [Rowe, 1987, 40]. Meeting these criteria can be achieved through computation, but this is not the totality of what designing an apartment is about. After the requirements have been met, possible solutions would still differ in quality. Several configurations exist that meet the set criteria, and there may not be a way to measure 'more good' solutions between acceptable ones.

Design processes cannot always be clearly defined, purposeful sequences of events. A problem may not even be understood without some initial solution. [Lawson, 2006, 48.] This can be taken to mean that the problem does not become identified as such before at least some design activities have taken place. Design knowledge does not form a simple body of knowledge. [Cross, 2001.] To describe architectural design task as a set of intermingled problems that influence each other can perhaps work as an tentative explanation to illustrate the complexity of the task.

Considerations about the nature of design problems have to be taken into account when complex computations are integrated into design processes. The design tool presented in this paper can either support in solving a particular problem, or be of assistance in a more general exploration. The concern here is to promote understanding of design representations and the process of exploring and finding problems, and not to provide tools for only solving particular problems.

3.1 The use of plan view in spatial design

Reading architectural plans requires practice, whereas natural-looking images are more suited for the public and clients to better understand the designs. Not even design professionals fully share the interpretation of a plan, if they are from different fields of design. [Kalay, 2004, 120.] This is to be taken as an indication of the delicacy of the plan drawing and also of its power.

The two dimensional plan is a design drawing which enables the viewer to have an overview of the spatial organization of a floor at a glance. Plan sketches can also be created quickly. When a building plan is not yet fully formed, sketching plan drawings help further the design. In this the plan drawing has advantages compared to natural perspective images, namely that measures and proportions can be inferred easily. Also, an overview of an building and its connections are more evident.

Material scale models need time to build and are more suited to depicting building space from the outside. Furthermore, displaying interior space with scale models is problematic, as the viewer may not easily grasp how the model would look from the inside. Natural perspective still images tend to restrict the viewing angle in some way or other. Both the location of the view origin and the near space is necessarily left out of the perspective image. An interior perspective image has to depict things from the 'outside'. The problem can be alleviated by using interactive, navigable views where an overall understanding of the spatial layout becomes more complete through active exploration.

In architecture, transitions are needed between many modes of representation before the designers can become familiar with the design. This is also reflected in how architectural designs are presented in multimodal way, combining natural views with plans and sections. Observations of architects and design students reveals that drawings and sketches have many minor roles within the larger design activity, and that the drawings often do not have a definite or permanent purpose. Augmenting two dimensional drawings and sketches can be a viable direction for developing computing tools.

3.2 Benefits from using interactive isovist shapes

What follows is a justification of using computer to draw isovists, and the interest of using them in conjunction with a plan drawing. In the present study, the benefits of using isovists are presented as hypothetical.

Computed isovist shapes have benefits over similar hand drawn geometry. The computer calculates the shape in an instant, enabling animation and manipulation in ‘real time’. This would be difficult to implement without computer graphics, possibly involving planting of light sources into a material model. The intent is not to claim benefits through increased efficiency, but to lower the threshold of using the shapes in a design-related task.

Adding an isovist into the plan drawing makes the plan comparable with a natural perspective image. The isovist introduces a point of origin and explicates what can be seen from that given point, both qualities of a perspective view. This suggests that using *mobile* isovists makes the plan drawing comparable with a *navigable* perspective view. By using interactive isovists in a plan view, desirable aspects of an navigable perspective view and plan drawing are combined. The plan still functions as an overview of the space, yet some aspects of the perspective view are also gained. Augmenting the plan with an isovist puts the focus on one location of the plan view, emphasizing a point of origin. Mobile isovists enable the active exploration of the plan drawing in a similar way as natural perspective view allows the exploration of a three-dimensional modeled space.

4. The study: Exploring the plan with a mobile isovist

A user study was conducted to test the software in a design task. The case took place within a university course that was part of a spatial design curriculum. The student was working with a concept for a two-story building, the major feature of which was curved wall with regular vertical apertures. The expressed intent of the student was to create a type of wall that would permit the people inside the space to see outside, but not the other way round. To develop the idea the student had built a scale model of the building in the scale of 1:20 and some additional detail models of the aperture elements. In an early critique the tutors noted that even though the intended effect would probably work in some way, the models could not reveal exactly how. The type of wall would permit interesting variations of the theme, but that it was difficult to explore through the built model.

4.1 The mobile isovist software tool

A computer program was written by the author to display interactive isovists in a plan view. Free software already exists for creating isovist shapes, but for the purposes of the wider research topic of the author the program needed to be self-developed and easily adjustable to new tasks. Besides, existing software tends to rely on existing CAD formats, a functionality which may be beneficial for some purposes, but would limit flexibility when exploring a variety of drawings rapidly.

Upon running, the program loads a bitmap drawing of the plan view. The isovist point of origin can be moved with the mouse, and the shape is transformed accordingly without delay. Interface was kept deliberately simple to allow direct manipulation and to concentrate on the use of the isovist. The bitmap approach was chosen to enable simplicity of importing plans, sketches and other drawings. The program is not capable of loading CAD files nor is the resolution suitable for large building plans.

At this stage, the program was meant to elicit responses and see if new insights can be generated, suggesting ideas for more fruitful cases of use and development. The intention was not to provide a full functional product comparable to a modelling or painting program, but a platform for further developments or alterations based on the responses.

4.2 Some initial responses

The software was tested with a spatial design student who was working on a model with a strong element of visibility-related problems. Although the program aroused interest, using the program hands-on was not met with great enthusiasm. The situation quickly became such that the researcher assumed the position of an operator, and the student could then suggest ways of use, resulting in a co-designing session. This was because even if the moving of the isovist itself is simple, in the present version there still remains the need to actually draw the plan. Having the student learn the functionality of a drawing program would have been problematic, as the use of isovists was of prime interest in the study.

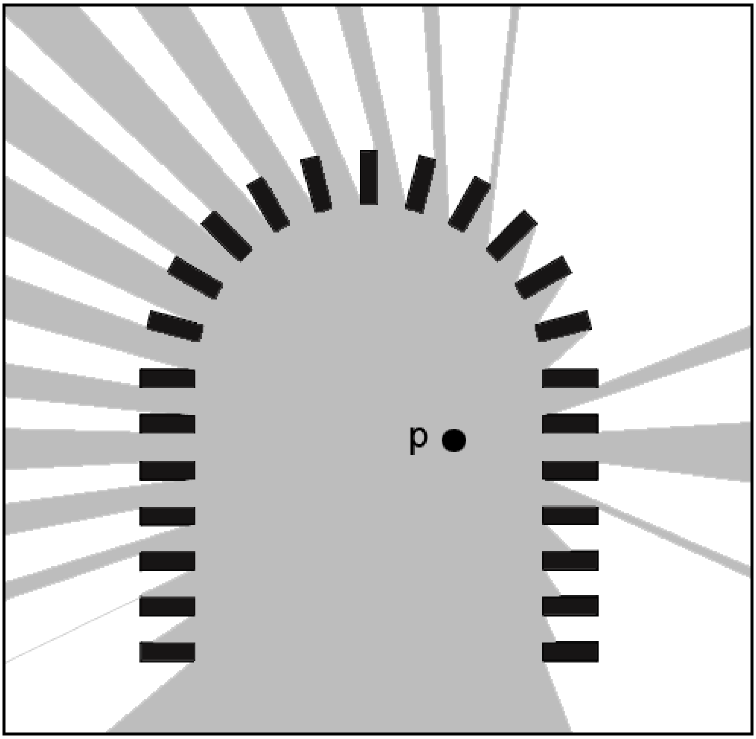

Figure 3. Plan drawing. Exploring a type of wall with an isovist. The ability to see through the wall depends on the viewer distance and the wall curvature. An approximation of a part of a student design

4.3 A visibility-related design problem and findings

Figure 3 shows an approximation of the wall type the student was working with. The building model presented an environment where the program could provide illumination, as the building was flat plan without much complexity in vertical dimension. The most prominent feature in this student work was the evenly apertured wall that was meant to permit visibility from one direction but not from the other. This intention is to be interpreted as an particular problem identified by the designer, with a fairly simple answer. In addition, it was suspected that the type of wall would lend itself to interesting variations and compositions, but that these could not be tested with a scale model.

With the software it could be seen that the wall type would function as assumed, and that the working of the apertures would be related to the density and shaping of the aperture elements in relation to the wall curvature. Not only was the identified problem solved, but some of the parameters influencing the solution were found. The apparent overall opaqueness of the wall was shown to be related to the distance of the point of observation from the wall, as seen in figure 3. Reaching a solution requires a balancing of multiple variables, such as the thickness, depth and density of the elements. With the software, the effects of positioning the viewer and its effect on visibility could be more easily grasped. It was possible to see how the wall apertures would function from varying observation distances.

Building a material model had proven to be unsatisfactory, as it was not possible to really 'go inside' the model. Another problem was that inaccuracies resulted from the scale of the model and the chosen materials, cardboard and non-rigid plastic. As the building model was fairly simple, it can be argued that the aperture wall could have been easily created in a three-dimensional modelling program, and that the same results could be inferred from navigating the model in natural perspective. However, the significance of the user study was in revealing that *the three-dimensional modelling could be avoided in finding these results.* To be critical, it has to be said that it is difficult to prove what part exactly the interactive mobility of the isovist played in producing this finding.

4.4 Discussion and further study

In addition, some opinions about the software tool were gathered from design students. As isovist shapes were not generally well known, suggestions mostly arose regarding what the shapes could be used 'for'. The researcher's intention was interpreted as trying to find a purpose for the isovists. As the software was usually introduced or otherwise presented, these reactions might be understandable. It appeared that people were more likely to consider applications of the program for solving particular problems. The suggested applications include finding optimal positioning of adverts, traffic signs and fire extinguishers, which are all fairly obvious uses for visibility and occlusion computation. The idea of the shapes being analogous to natural views did not arise by itself.

Making the software even less dependent on an interface could be one possible route for development. Replacing the loaded bitmap file with a constantly captured image from a camera can further minimise the interface. The plans could then be then inserted under the camera or drawn with traditional media.

As the observation of the use of interactive isovists is of most interest, the question arises how to best isolate or focus the ways for using them. Existing research has already shown that particular problems related to visibility-related questions can be handled with computed isovists. In order to prove the effectiveness of mobile isovists a comparative study between interactive and static isovists is needed.

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