Intuition & Computer Visualization in an Urban Design Studio

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Abstract

This paper will present prototypical software being used in the teaching of urban design to students and for use by professionals in the early stages of a project. The system is intended to support a heuristic approach to design. That is, it supports a process of refining ideas and understandings through a process of trial and error. The support or aid to design comes in the form of a didactic real-time programme. Its power lies in its ability to provide instantaneous response to operations on the data that can allow one to develop three-dimensional spatial ideas in an intuitively driven manner. This condition appears to occur for both novice and expert computer operators.

The presentation will present our experience to-date in using conventional computer graphic tools to represent design ideas and contrast it with a video demonstration of our prototypical dynamic urban design modelling software for the Silicon Graphics IRIS computers [1].

Design Thinking

Interdisciplinary studies and synergistics, two fundamental aspects of landscape architecture and urban design practice, require the integration of massive amounts of information and the creative, selective combination of that information to produce better design. It is our experience that new knowledge and creative alternatives to development are extremely difficult to incorporate into real projects and conventional design studio teaching without comprising the attention paid to previously recognized issues. Coping mechanisms in normative design thinking used in most teaching and professional practice are typically stretched to the limit.

Normative design thinking as it is practiced in the various forms of landscape architectural design implies that with adequate skill, education, and experience a person can process and access enough knowledge through books, etc. to be able to conceptualize a problem and synthesize a solution. The reality of practice today is that without technological assistance in the acquisition of knowledge one has little opportunity to test the adequacy of new ideas. This situation arises in pan, due to technological change in the way urbanization and development are undertaken.

Information technology is needed to assist in the storage, communication and operation on design knowledge. The term computer-aided design is usually implemented as a subset of information technology. Even in its broadest definitions, CAD is usually described as a tool for professionals to use, not the layman or the client attempting to communicate their needs to a professional.

The opportunity exists in a computing environment to manipulate data and translate ideas about something in a vast array of representations. This scope should help us extend the brain's capacity to synthesize complex amounts of data and differing interpretations. The development of these intellectual prostheses will help people to understand and predict the implications of design actions on the complex environment we live in.

Using Computers To Support This Method

Our goal in using computers in design studio teaching is to extend the vision a student has of the problem they are working on and to maximize their capacity to experiment and correct mistakes. It is our belief that if a student can intelligently learn from mistakes that they can compress the time necessary for them to develop an adequate level of experience with a problem. They can come to know something through a process of dialogue and intense experience. It is our goal to compress these heuristics with the use of computing tools.

We have used a wide range of very effective tools to visualize complex phenomena and ideas [2]. Some of these tools allow us to produce conventional types of visualization faster and with greater accuracy, others have permitted the visualization of concepts impossible to create any other way. If one can be engaged in a process of examination and manipulation of design concepts that occur in a spontaneous, "natural" way then we find that one's ability to receive knowledge by direct perception, to intuit, is enhanced. Computer graphics can assist in the process of representation. They can support the mind with a variety of means of visual representation of the same thing and help to structure the mind's powers of imagination, description, and portrayal.

We believe that we have successfully applied computer graphics to the problem of improving our students perception of their work. However, in most circumstances the process of testing an idea takes as long as the process of building a physical model or drawing a perspective. In practical terms, a student often cannot test their perception of a scheme in the time frame they are given. Rowe states that, "Obviously, the concept of error requires the presence of some means of testing a solution for desirable properties" [3]. Existing computer graphic tools do little or nothing to support a process dependent making many errors. With this in mind, we are trying to get our computer graphic tools to cycle as quickly as the design process we use demands.

The T.U.U.M.S. Modeller

Expert users still have to devote too great a percentage of their mental concentration to the operation of the graphic information systems we use. They should allow one to concentrate judgement and creative thought - not compete for it. We have set out to create an urban design system that allows one to intuitively pursue form studies on a computer. Our goal has been to accomplish in a couple of hours what has been taking us several days to do using conventional programmes with experienced users. To create a system that handles most of the analytical and visualization activities that rob one's concentration during the early stages of an urban design massing exercise. A computer should allow us to work with a range of visual representations of an object or space. One should be able to choose to operate with symbolic, abstract or detailed representations in a picture. There is a high potential if we can rapidly switch between an infinite variety of visual information modes to support what ever type of inquiry the operator of the computer feels necessary.

The prototype software developed at the university, T.U.U.M.S. Toronto University Urban Modelling System, allows one to not only manipulate built form dynamically in shaded colour images, but to also provide real-time feedback of planning information such as economic costs and floor-space-index as one adds or subtracts space to a building with a movement of the computer's mouse. This programme is being used in the planning of the Bathurst-Spadina Neighbourhood Study in the Rail Lands District of the City of Toronto.

The programme is composed of four types of graphic representation. The primary window on the data is a three-dimensional perspective window that illustrates the exact geometry of the objects and spatial constraints such as zoning set backs on each parcel of land. The observer has complete freedom of movement through this view of the geometric "world" shown on the screen. The second window on the data is a "spreadsheet" window that provides alph-numeric parameters of the buildings and conveys zoning information such as density ratios. The third window is a diagrammatic representation of the database hierarchies. Some respecification of relationships between components of the massing models can be undertaken using this view of the data. The fourth type of representation are two dimensional views of the geometry such as a plan. All of these views run in real-time. A change in one mode instantly updates all of the others. The system imports AutoCad DXF files to begin a session and ends the session by exporting either an AutoLisp file that can build. the data as an Automated session in AutoCad or in the data format used in our lab for other graphics software we have written [1].

This tool has been used to successfully generate volumetric massing studies by a variety of people that have never used a computer before. Professional designers involved in the study have been able to operate the system effectively within a few minutes of being introduced to it with no manuals or tutorials. We have had similar success with the system in a variety of teaching situations. In all cases, a five minute demonstration combined with a few minutes of direction from a familiar user is all that is necessary to get people started.

We believe that the key to this success lies in the semantics of interaction and the extremely fast response to users inputs that the Silicon Graphics IRIS computers are capable of providing. The dialogue a user has with the system is not the obtuse language of computer graphics or computer-aided drafting. Typical graphics systems use a vast array of strange terminology to a designer. Terms such as translate vertex, or rotate line about the xz axis are extremely common. Even when these operational concepts are expressed as graphic icons, the array of options is confusing to most people we encounter. In order to operate typical modelling software one must first, develop an understanding of the language of the system and then formulate a strategy to marshal the graphics tools to construct a collection of graphics entities such as lines or polygons to adequately represent the idea that one has. Their difficulty for the user is that the user is forced to undertake all or most of the translation of ideas into a computable form for the programme and unless the user has a deep understanding of how to harness the system, one will find it very difficult to use the parametric capability of the system if their conception of the design idea changes during the session. A change of that type normally requires a complete recrafting of the data base used to create the graphic representation on the screen.

The interface design for T.U.U.M.S. attempts to remove from the user the burden of translation between design ideas and the specific demands of computer graphic semantics necessary to construct an image. It uses constraints on types of geometric operations and attempts to use the everyday language of an urban designer to get the machine to change the image. In addition, hand gestures with simple pick operations using the computer's mouse are used where ever possible. We are trying to simplify interaction to a set of elements familiar to the user. The simplicity of action is matched with the extremely sophisticated capacity of the IRIS computer to handle three-dimensional graphic computation in real-time.

The hypothesis of this interface is that since most learning in design occurs through a heuristic process (trial and error) the best way to introduce people to the tool is to make it easy for people to correct mistakes by allowing them to use the cognitive understandings of space and modelling that they already have in place. We have discovered that by supporting the process of learning about spatial modelling through trial and error where the person learning is directed as much by their immediate feelings or intuition as by the structure of the system. And the structure imposed by the system is a language specific to design not computer graphics or drafting. The user has complete freedom to use intuitive curiosity about the forms generated limited by the didactic structure imposed by the urban design semantics of the T.U.U.M.S. interface.

There are seven basic rules used to govern the fundamental mouse interactions. Most people can pick these up in the first few minutes of experimentation. Feedback to the user is instantaneous so most people can correct a wrong movement before they are even consciously aware that they are correcting a mistake. Conventional computer-aided design systems require that one stop the operation and invoke an undo operation if experimentation is attempted. This typical interface design rewards those that know what they want to craft before they begin to craft it. This self limiting condition prevents the computer from being used to widen the scope of design speculation.

Given the success of this prototype with our users we are in the process of trying to generalize the concepts and not make the package specific to urban design massing. The first step will be to extend the scope of the tool from massing to the modelling of abstract and detailed representations of specific buildings on full three-dimensional terrain. This capability requires that the computer we use move from a 1000 shaded polygon per second draw rate to a 20,000 - 100,000 polygon per second draw rate in order to convey the appropriate amount of visual information necessary to visualize this type of problem in real-time.

The second step in our work is to extend the range of types of visualization available to the user. We believe that the the addition of a powerful diagrammatic editor/modeller is critical to a robust visual thinking environment. It is necessary for a designer to be able to develop ideas and arrange concepts as simple text, numbers, graphics symbols, 2-dimensional diagrams & drawings, 3-dimensional diagrams and perspectives, and to simulate processes [4]. This approach to using computers is only just becoming feasible to explore. Intuitively driven 3-dimensional modelling is only now a viable activity on a professional workstation with the advent of the IRIS 4D-70-GT. This machine can provide 3-d images conveying significant amounts of visual information fast enough to support iteration in design. Previously, the feedback interval has been ponderously counterproductive to creative thought.

The third step in the project is the combination of these capabilities into a spread sheet-like set of integrated tools for a designer. It is our contention that unless CAD integrates both systematic and intuitive operations on data then it is not CAD.

Conclusion

This work explorers a real-time hypothesis. It is our contention that the user of a computer should not be hindered or devote a significant amount of mental energy to the translation of basic ideas into computable form. The machine must be a useful support to dynamic thought before it can radically alter the practice of design thinking.

The T.U.U.M.S. prototype has provided us with instantaneous response to operations on the data that has allowed us to begin to develop three-dimensional spatial ideas in an intuitively driven manner. This is the first time that we have been able to engage such mental faculties while working on a real project in front of a three-dimensional computer modelling system. We believe that the costs of the hardware required to implement this capability will be comparable to the cost of systems currently being purchased for drafting functions. Once that cost threshold is crossed we believe that computers will be used at all stages of design thinking.

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References

[1] colour reproductions of previous project work and the T.U.U.M.S. modeller are presented in;

J.W.Danahy, R.Wright, Exp1oring Designs Through Three-Dimensional Simulations, Landscape Architecture Magazine, the American Society of Landscape Architects, July/August 1988.

[2] Detailed descriptions of the techniques, projects, and impact on decision-making of our previous work can be found in the following papers;

J.W. Danahy, *Sophisticated Image Rendering in Environmental Design Review*, Human Factors in Computing Systems and Graphics Interface, CHI + GI Conference Proceedings 1987, Pages 211-218.

J.W. Danahy, *The Parliamentary Precinct Study: Visual Simulation In Urban Design Decision-Making and The-Need for GIS-CAD Linkages*, *GIS'* 87- San Francisco Second Annual International Conference Exhibits and Workshops on Geographic Information Systems, Post Conference Proceedings, Volume 111 1987.

[3] Peter *G.* Rowe, Design Thinking, MIT Press, 1987, Cambridge Mass

[4] note we define real-time for design as being one iteration of a picture per second, our experience to date shows this as a typical threshold where machine lags interfere with most of our designers natural thought process. This work is documented in;

R. Wright, *A Prototypical Study on the Use of Computer Simulations For Decision Making In the Canlands Competition Ottawa*, Unpublished Report, 1988