THE TERMINAL CRIT

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ABSTRACT

Numerous attempts have been made to develop formal design methods with the purpose of increasing the predictability, consistency and dissemination of the design process and improving the quality of the objects produced. The ill-structured nature of design, and the perception of design activities as intuitive and experience dependent have frustrated many of the efforts to structure these process. The growing complexity of the built environment and advances in technology have led to a more rigorous effort to understand and externalize creative activities. Computer aided design tools have recently been playing an important role in the evolution of the design process as a rationally defined activity.

The use of computers for drafting, analysis, and 2 or 3 dimensional modeling is rapidly becoming an accepted method in many design schools and practitioners. A next logical step in the externalization of the design process is to endow the computer with the ability to manipulate and critique parts of the design. Under this scenario, the "terminal crit" is redefined to mean critiques that are carried out by both the designer and the computer.

The paper presents the rationalization of the design process as a continuum into which CAD has been introduced. The effects of computers on the design process are studied through a specific incorporation of CAD tools into a conventional design studio, and a research project intended to advance the role of CAD in design.
INTRODUCTION

Design has long been thought of as a uniquely human process which relies on the experience, judgment and intuition of the designer. The ill-structured nature of the creative process has hindered the development of formal theories of design. Consequently, design activities have often been described as "black box" processes that specify input and output, but do not explain the mechanism which transforms the input into output. Nevertheless, numerous attempts have been made to "externalize" the design process with the aim of developing a theory of design that can increase predictability, consistency, and dissemination of the process.

The earliest attempts to analyze the design process were probably made by the design guilds of the 13th-14th centuries. These guilds created descriptive theories and techniques for various arts and trades that were to be passed on through apprenticeship. The study of design as a conscious and ordered process began with the 17th century academic institutions in France that were founded on the premise that new methods were needed to transform the process of design into a rationally described activity (Tzonis, Lefaivre 1975). Further study of design continued through the 20th century with the formation of schools, such as the Bauhaus, that developed formal courses to teach various aspects of design. This trend peaked in the 1960's with the development of numerous rigorous methods for solving certain design problems. The incorporation of these methods into the mainstream of design practice has, however, been rather slow due to the difficulty of using the methods and the lack of perceived utility.

Recently the need to externalize the design process has become more pronounced resulting from the growing complexity of the built environment and the rapid advances of technology. Designers have been forced to compartmentalize design activities in order to develop a comprehensive and understandable model of the process. Models that have been developed include the Analysis, Synthesis, Evaluation cycle (Jones 1970; Koberg 1974), generate/evaluate cycles (Simon 1982; Mitchell 1975), and the State/Transition model (Newell, Simon 1972).

The strengths of formal design methods lie in their ability to structure design by systematically reviewing several alternative ideas. Such a disciplined approach improves techniques for gathering, processing, and distributing information, and increases the consistency of the process and the predictability of design solutions.

The fragmentation of the design process implicit in these methods has, however, led to severe problems in information management. The large amount of information required to be made explicit by formal design methods has hindered the designers' ability to maintain control over the process. In addition, the use of
design methods has been limited by the considerable time commitment necessary to learn and apply them to each problem.

The introduction of CAD tools addresses some of the shortcomings of the formal design methods by facilitating the management of information. The computer directly addresses the problems of information expansion with its ability to store and access large amounts of data rapidly.

Early researchers in CAD intended to completely automate the design process by developing computer programs to solve problems entirely without designer intervention. It soon became apparent that these ambitious attempts would not be easily realized because of the limited understanding of the design process, and the inability to computerize the existing design methods. These early uses of CAD did, however, reaffirm the complexity of creative design, and strongly indicated a need to further study the process itself, as well as the methods that could facilitate it.

THE DESIGNER TALKS TO THE TERMINAL...

The general failure of comprehensive attempts to automate design led to the redirecting of research efforts to specific well defined tasks that were more readily computable. A major task of computers in design became, and remains, the representation and communication of designed objects. Designed objects are constructed in the computer as a 2 or 3-dimensional database. The communication between the designer and the database model typically occurs through a graphic computer terminal. This form of communication has led to the definition of the "TERMINAL CRIT"; the computer terminal is the medium through which designs are manipulated and critiqued by the designer.

The terminal crit scenario has been implemented in many schools of architecture and architectural design firms using analysis tools, basic design tools, or drafting and modeling systems [Kemper 1985; ACADIA 1986]. The effects of CAD on the process of design are currently being studied through the incorporation of the tools in an undergraduate design studio at the School of Architecture and Environmental Design. The use of the CAD tool in the studio environment has led to the observation of several interesting effects on the process of design. The most noticeable effects are from students who use the modeling capabilities of the computer throughout the process as an additional tool for studying their emerging solutions.

Conventionally, students develop their projects on trace paper where the design is a mental interface between the plans, sections and elevations (unless a physical model is built). While using the CAD tool, the 3-D model stored in the computers' database is the represented and manipulated object. The use of
computers to store a 3-D database would be similar to designing in physical model form which is a very time consuming task for undergraduate students. Working with the the 3-D model on the computer also allows for earlier investigation and manipulation of the solution in three dimensions. An added benefit is that the designs can be viewed from the surrounding context and the surrounding context can be viewed from the interior of the proposed design as well.

The generate/evaluate cycle of design seems to be much more evident and clear to the students using the CAD tool. Since manipulation of the model is very easy on the system, the students investigate alternatives that they normally wouldn’t when designing conventionally. The ability to view many alternative choices and to easily “undo” an attempted feat encourages enthusiastic students to generate and study many more potential solutions.

Currently the benefits of using a sophisticated modeling tool in an undergraduate studio environment for TERMINAL CRITS are positive, however, the shortcomings have led to a somewhat limited level of enthusiasm on the part of many students and instructors. One of the biggest frustrations of using the computer modeling/drafting tool has been the inability to analyze the solutions generated using available energy, structure, lighting and cost analysis tools. These analysis tools require the input of alphanumeric data, so the students using the computer for design have no advantage over those designing at their desks. Another problem that the students have faced is the sometimes unstable nature of the hardware which may cause several “crashes” during their process. At times students would lose some or all of their work and at other times the system would be too loaded to perform tasks rapidly enough.

...THE TERMINAL TALKS BACK...

To address the current shortcomings of CAD in design related fields, researchers are attempting to give the computer the “intelligence” to assist in some of the creative and judgmental aspects of the design process. This use of CAD redefines the TERMINAL CRIT to mean a critique offered by the computer. The terminal critiques are meant to give feedback to the designer on certain aspects of the emerging design solution throughout the process. An analogy can be made to a design firm with a group of consulting specialists reviewing the emerging design at any level of its development, or to typical frequent conversations between student and instructor in a design studio (Schon 1983).

Such an approach requires a design method with the flexibility to allow the designer to work at any level of abstraction, and to allow the computer to evaluate the solution at any of these levels.
The development of a paradigm of design as a computable process has been the focus of a research team in the School of Architecture. The goal of the research is to endow computers with the ability to assist in the generative, evaluative and representational functions of the design process by providing "knowledge" and "experience" similar to that used by designers. The knowledge about design is represented in the form of design plans, goals and performance criteria. The approach taken depends on the dynamic allocation of tasks between the designer and the computer, exploiting the particular strengths of each in critiquing the emerging solution.

The effort to computationally structure the design process has been based on a description of design as a state-transition problem solving process; a process of searching through a set of states for a final solution state. A flexible model is achieved by defining states as goals. These goals are comprised of context-dependent sets of constraints that define the conditions that a candidate solution must meet, but do not define the solutions themselves. For example, schematic design may be considered as a goal containing several constraints that constitute achievement of the schematic design phase of the process. One constraint within the schematic design goal might be the placement of doors in the floor plan. At this level of architectural design, the only relevant information is the width, height, location, and type of operation. It is recognized that this information is only a fraction of the total information required to completely describe the door. To facilitate the data management and maintenance a "criteria tree" containing data relevant to the design has been developed. These criteria become constraints when they are incorporated into the goals. Shown below is an example of a partial criteria tree for a door.
The criteria tree allows the designer to advance to a very detailed level of design during an early design phase. For example, if the designer wishes to incorporate antique door hardware in the design of a new house, the information can be entered at any time during the process. If the hardware information is added prior to the selection of the schematic design goal, the data is stored until it is required by a goal as a constraint for satisfaction. Since hardware is not an essential part of schematic design, it does not appear as a constraint in that goal. When the designer reaches the contract document phase of the process, the constraint which requires the definition of the hardware will already have been satisfied.

To determine the satisfaction of a goal, the design is evaluated against the criteria in the tree by independent evaluators for specific aspects of design. For example, one evaluator may be concerned with only the minimum areas of rooms in the emerging design and will evaluate the solution in the database reporting the level to which the criterion in question is satisfied. This value is compared with the user or goal defined level to which the criterion is constrained in that goal. Also contained in the goals are sets of rules and weight factors which define the relative importance of the various constraints and the knowledge about conflicting requirements of the constraints. For example, the minimum room area constraint may be relaxed slightly if a specific room excels in other criteria such as light, storage space, efficiency of layout etc.
The problem solving design process, or sequence of transitions through a set of goals, is defined by design plans. The complex nature of design creates a process that is constantly changing in response to circumstances that cannot always be predicted. Design can therefore rarely be planned in the sense of completely specifying a sequence of goals a priori. Certain generalized aspects can be planned depending on the context while others must be determined at design time. A design planning strategy is mapped out using both predefined goal sequences, when they exist for particular problems, and dynamic goal sequences supporting creativity and unexpected situations. The complex interactions between these structured and creative strategies are highly characteristic of the process of design. Shown above is a diagram of the relationship between goals, criteria, evaluators and the emerging solution.

Currently, the TERMINAL CRIT paradigm which places the computer and designer as partners in the design process seems to have great potential. The capitalization of the strengths of each should yield the optimum design experience and the an improved product. Continued research and application will verify this methodology and lead to further refinement and development.

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We have presented the progression in the study of the design process as a continuum from an intuitive unstructured activity to the present attempts to explicitly define and computerize certain aspects of the process. CAD is continuing to emerge as a powerful and useful tool in design, and is strongly influencing the externalization of a once and indescribable process.

The proliferation of drafting, modeling, and analysis tools is rapidly increasing as they have become less expensive and have demonstrated the ability to improve the efficiency of production. In an information rich society, computers are now necessary for storing and processing information in many areas. However, the prospect of design tools that provide substantial assistance in making creative decisions remains on the horizon.

It seems inevitable that the widespread use of computers in design will continue to expand; what is still unclear is the direction that this expansion will take. Many issues concerning the incorporation of computers into design remain obscured by the controversy over the computability of the inherently human process of design. Some designers argue that the use of computers should remain limited while others argue for the more opulent role of computers as design partners [Kalay 1985a; Orr 1985]. Such a major shift would require an acceptance by designers of the possibilities of "intelligent" design machines that would perform some of the tasks previously restricted to humans.

With the acceptance of the potential computability of the design
process, will the final step in the evolution be the total automation of the process, thereby fulfilling the early intentions of using computers? The issues which are raised by such a possibility address the very core of the creative process. Can or should creativity be computerized? What roles shall computers, therefore, assume in the design process? What tasks can or should be computerized? Who decides which tasks will be computerized or whether or not the entire process should be automated? Will society and the built environment be better served by the total automation of design? Will design continue to be taught in schools or will design by humans become unnecessary, placing them in the role of assistants to the machine?

REFERENCES


