The role of media technology in the design studio

P.Purcell
Massachusetts Institute of Technology (U.S.A.)

ABSTRACT:

This paper refers to a program of work, which aims to integrate a range of computer-based multi-media technologies which has the overall goal of enhancing the processes of education in the design studio. The individual projects describe the development of visual information systems and intelligent design systems.

The framework of support for much of the work is Project Athena, a campus wide initiative to apply new technology towards enhancing the educational process project.

1. INTRODUCTION

The origins of the work, described in this paper lie in the awareness amongst university circles that the increasing pervasiveness of computers on the campus was not being matched by a concomitant thrust to use this facility in support of the processes of university education on the computer intensive campus.

The emergence in the early eighties of a number of similar initiatives to investigate the potential of computers and associated media technologies as a support facility to enhance the processes of university education was a direct response to a general awareness that the potential was simply not being exploited. In the case of Massachusetts Institute of Technology, this initiative emerged as Project Athena. Athena provides the umbrella support for most of the developments described in this paper. Its focus is the potential of computers and media technology in the design studio and in design education generally, (especially referring to architectural design & graphic design).

Design process and the visual image are key aspects of these disciplines and the work described here revolves around both of these elements.

In the case of the design process the development of advanced design systems has a twofold role, to provide design students, with experience and understanding of the role of advanced design systems in the design process.

A second level of the rational for development of such technology is to provide students with experience in the conduct of design research and gaining insight into the nature of design knowledge.

2. THE COMPUTER INTENSIVE CAMPUS: PROJECT ATHENA

Even amongst its peers in the major campus-based programs to ubiquitous computing, Project Athena is an ambitious project. In May 1983, Massachusetts Institute of Technology announced the establishment of a five year program to explore innovative uses of computing in the MIT curriculum and to improve the integration of new computational techniques with the undergraduate educational experience. The principal vehicle for application of innovative use is the Athena high performance computer graphic workstation.

The project is being carried out with support of the both Digital Equipment Corporation and IBM, who are providing the bulk of the hardware for the project and support totaling some fifty million dollars over the five year life of the project. This covers equipment, software service, technical support and research grants over a five year period. In addition MIT has raised twenty million dollars to complement the contribution of the industrial sponsors.

The Athena program extends to all the schools of MIT, namely Science, Engineering, Architecture and Planning, Management and Humanities and Social Sciences. Athena is now completing its five year time span and the pattern of its achievements are coming into view (1).

Athena has currently 700 plus workstations deployed across the MIT campus with an estimated thousand plus workstations by the end of the current academic session 1987/88.

The current Athena workstation has evolved from its original more modest 1983 specification and may still evolve further as computer technology changes.

At this point the Athena workstation is a single user computer with the following characteristics. It has a 32 bit processor capable of executing one million instructions per second. Each interfaces to a network communications interface operating at speeds of at least one million bits per second. Data storage devices hold 30 Mbytes with dynamic memory of at least 3 Mbytes of main memory.

The reason that Athena has opted for a more advanced work station is based on the belief that many of the educational opportunities will require sophisticated computation. For example the current year will see the development of a special video based workstation.

Athena's computational facilities are built on a system of LANs (Local Area Networks), each with servers and workstations. Network speeds are 100 Mbits p/second. Each local area network is linked to the MIT spine network, which provide gateways to most of the available science and educational networks worldwide (2).

By the end of the current year there will been completed a complete recabling of the MIT campus with the 5ESS system which will provide a high performance voice/data communication facility. The current user population is just over 5,000 users.

3. VISUAL INFORMATION SYSTEMS

"Pictures are worth a thousand words but they cost". The dictum still holds good in the world of computer graphics, but progressively the technology of picture storage, retrieval & transmission is proving to be increasingly effective in meeting the cost in computational terms.

Visual Information Systems (3,4) is the generic term being assigned to the systems linking large image files, typically on optical laser devices to data base management systems.

In the case of work at MIT the application domain for much of this work is the Rotch Visual Collection, a repository of well over 300,000 images covering architecture, graphic arts & art history (5). The main goal in the development of such systems is to make the visual collection available to students, faculty & researchers both locally and remotely in the classroom, in the seminar room, at the designers console and in the studio.

Currently the media for the creation of such image files are several. They include the 12" analog disc, the 8" analog disc, the write-once CD-ROM disc (6) and the write-once gigabyte disc (7). These devices are being incorporated as networked and generally available facilities.

The format will be both digital and analog. Image size will also be variable ranging in scale from 50 Kbyte images to 3 MByte images. An IDS (Image Delivery System) will accommodate a range of images, including sketch, schematic, diagram, pictorial illustration in both digital and analog mode.

Current applications include several architectural collections with over thirty thousand indexed images.

In addition the MIT cable system is being investigated as a vehicle for image delivery from the Rotch Visual Collection to seminar room and to design studio. It is building on a program of work which started in 1985 as the Image Transmission Project (8).

This report describes a prototype network of independent computer nodes which are linked by a digital fiber-optic network and also by a cable television system. The report also included a review of the state of the art of similar projects exploring the potential of visual image transmission, as a vehicle for the dissemination of visual images from a central source.

The work of the VIS (Visual Information System) group has been primarily supported as a- set of Athena projects that relate to the School of Architecture & Planning. The varied spectrum of applications include topics in computer aided design, film editing, graphic design, urban planning and history of architecture.

4. DESIGN KNOWLEDGE & KNOWLEDGE ENGINEERING

The objectives here were to assess the educational impact of current computational techniques on design education, to assess the potential of new technology to enhance the study of the design process and to augment the techniques of design research.

The tools that we used were those, generically referred to as "shells", typically comprised of knowledge base, inference engine, inheritance traits, probability facilities & associated interface features.

Shells also had a special interest as tools for the development of formalisms for the representation of design knowledge. These formalisms included the conventions of knowledge based systems such as frames, 0-A-V triplets (object-attribute-value) and rule based procedures.

The strategy adopted was to select a representative set of the most powerful and versatile of these tools (9,10,11,12) and to make informal comparison between the ways in which each software package performed in the chosen design domain. We were also interested to investigate the mode in which the inference engine used general problem solving strategies to operate on design knowledge bases to generate results, review proposals or reach new conclusions.

In our representative selection of shells, some of the tools were rule based, some frame based and some hybrid in composition (including both rules and frames). Hybrid systems have the advantage of integrating frames and production rules into a single unified knowledge representation facility. One of the important advantages of the hybrid tool is that it makes the organizational & expressive power of object oriented programming available to domain experts who are not programmers.

4.1 Modeling, information systems, calculation:

A basic element of the designer's computational environment is the modeling package used in the course of the design project. In a manner, similar to the appraisal of the individual knowledge based system tools, a selection of computer aided design systems were used in several case studies.

A main task was to build an interface in each of the knowledge based systems between the CAD system and the knowledge based tool, so that an expert system could generate graphic information to the designer or conversely, that the human designer could present proposed graphic layouts for review by the expert system. An equally important feature of a designer's computational environment was to build an interface between the knowledge base and the information retrieval system (both visual and alphanumeric) (4).

As part of the studies described above several information systems (including two for libraries and cafeteria) were developed in design domains, relevant to the applications of the knowledge based tools. The data base managers used, included Ingres and Informix. In another case study, a VIS (Visual Information System) facility was developed. The image file on specific libraries were held as analog video images on a video disk under computer control and were accessed by the data base manager.

Also being appraised here was the capacity of the expert system to reference information or to present different types of data, effectively & coherently in the course of a consultation with the designer at different stages of the design process.

The ability of an individual knowledge based system to trigger & run external routines and effect calculations was also felt to be a very important part of their performance. Programs were developed to calculate space, structural behavior and fenestration patterns. These were used successfully by the knowledge based shells with which we were working.

4.2 Knowledge bases in a design environment:

In the course of working with four selected knowledge based shells a number of projects were implemented for specific design topics. These included a knowledge base on the design of corporate cafeteria CAPES (15), the layout of book stacks in a library STACKS (16), the design of fenestration in a LWINDOW (17) and lastly, the design of a business graphic system.

The experience of building these several expert design projects has been extremely useful, particularly in terms of the feedback which they created on the performance of knowledge engineering shells as development aids in a variety of design domains. It is clear that as far as knowledge engineering is concerned, the technology has application from pre-design through the final stage of design realization & design detailing.

4.3 The outcome: knowledge based design systems

The two main areas of interest in the conduct of this exercise have been the intersection of knowledge engineering with the design process and secondly the form & operational characteristics of a new generation of design systems which have been designated as KBDS (Knowledge Based Design Systems) [16].

Design is a distinctive application domain and particularly so from those topics normally associated with knowledge based systems. Applications in design typically require digital modeling facilities, information processing and calculation throughout successive phases of design.

The individual components of the integrated KBDS (Knowledge Based Design Systems) are shown in fig 1 . The constituent elements are a modeling package, information management systems (both alphanumeric and visual), a knowledge system and a user interface.

The individual phases of design employ knowledge based systems in a variety of modes, synthesising solutions, reviewing proposals, r consulting with the end user. Design with its strong visual component has an increasing need for high quality graphics, videographics and video imaging generally. Consequently, the computational environment in design can be very diverse. This is why, when we looked at each of the chosen knowledge engineering shells for application in a design domain, considerable emphasis was placed on each ones ability to act as the coordinating core of an integrated system linking a variety of functions and technologies.

The KBDS roles may be characterized as follows. It may operate on a variety of local and remote databases and image libraries. It may review predictively the future performance of the proposed design in several areas such as operational costs, structure & energy. It may propose outline design solutions including automatic design detailing.

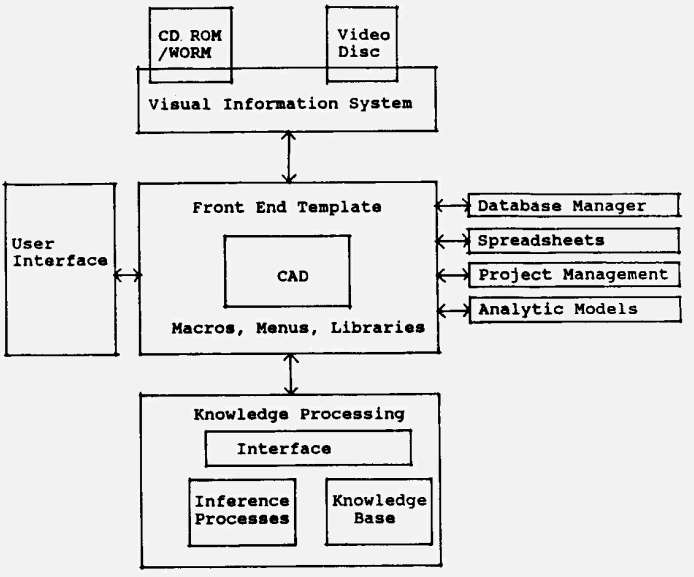

Fig 1. Diagram of an integrated Knowledge Based Design System

A future direction will be to develop the capacity to maintain an evolutionary design expertise, sustained by continuous updating and renewal by feed-back from successive generations of completed design projects.

4.4 Further integration of the KBDS: next phase

Building on the experience of developing knowledge based design systems represents the main thrust of the ongoing program of work. The current program & the objective of the next phase is primarily concerned with the issues generated by the integration of the knowledge based design system with specific design processes. These issues occur in two areas. The first area to be addressed is the problem of interfacing the knowledge of the designer with that of the designer's consultants. This will entail much more formal & detailed effort to investigate the skill, knowledge and experience of the designer.

Secondly, the achievement of a more effective interface between the expert system and the individual design project to be solved will require an extended study of the sequence of design stages as the initial concept progresses to design realization.

These two areas, design process and design knowledge will be the subject of an empirical study combining a repertoire of observational methods for recording design activity with techniques for eliciting the knowledge representations of a designer when confronting a design problem.

This emphasis on the designers skill, will complement the recent work where the emphasis has been on knowledge acquisition from those experts or consultants, with which the designer engages in the course of a design project.

In the CAPES project it was the cafeteria expert whose knowledge was elicited and which later became the basis of the CAPES knowledge base. In the STACKS project the expert was a library specialist. In LWINDOW, the expertise was specific to the issue of fenestration layout. The method of knowledge acquisition used was a conventional method of interviewing the domain expert, translating those interviews into a knowledge base and interfacing that knowledge base with the inference engine, the data bases and lastly, the external programs that were needed to run the expert system.

We will be seeking to develop a more effective interface between the tools of knowledge engineering and the design process. A more extended study of these process is presently being undertaken.

Documented case study will form the basis of this phase. Individual techniques to be used within the study will include flow analysis charts, communication histograms and goal resolution diagrams. This latter technique portrays the sequence of goals and sub-goals with which the designer is faced during the design process, as well as the particular constraints operating at each level.

Originally, the computational environment for design and designing was a data processing venue. Information processing succeeded data processing offering the discipline of design a set of techniques and a theoretical framework which regarded design as an information processing task.

Today, we have in knowledge engineering both a powerful application technology & a structural framework for the conduct of design research. This initial encounter with the tools of knowledge engineering has been valuable in providing experience of the capacity of the technology to enhance the educational environment of the designer.

The experience has shown that the intersection of knowledge engineering with design occurs on a very wide bandwidth. Knowledge based design systems can play the roles of consultant, critic and designer. Unlike expert systems in other knowledge domains which tend to be cast in a single role and communicate in alphanumeric mode, design systems have many roles to perform & communicate in various media, including graphics, videographics and video.

A second thrust of the project has been geared to the performance of knowledge based technology in terms of its ability to integrate with and to coordinate full sequence of design processes. .In that respect design has been a challenging test bed for the tools which we selected. However promising results were achieved in the form of an integrated design system.

Knowledge engineering tools have come from different backgrounds including medical prognosis, actuarial prediction, geological exploration. Design has shown itself to be a uniquely distinctive application area and indeed may yet have to develop its very own knowledge engineering tools and methodology.

To create such technology will require an extensive program of design research which will focus in the following related areas, namely, knowledge acquisition in design, interfacing knowledge based tools with graphic and video media and lastly interfacing knowledge based design systems with individual phases of a design process.

5. ENTERING THE FINAL PHASE

Athena is approaching its final phase and full evaluation of the program has yet to be completed. However, studies have been carried out to make some appraisal of the effect of the five year Athena program on the educational program at MIT. For example, the paper "Project Athena: Assessing the educational results" (16) reports that the faculty-led Athena research has resulted in the software output of the program being very much productivity oriented rather than pedagogical in character. An associated more detailed survey of student responses (17) found that the effect of this productivity oriented software was distinctly positive. There was a caveat expressed that the investment of learning effort in this software was quite high on the part of each student.

This paper has been primarily concerned with describing work in progress aimed at providing new technology to disciplines where the design process and the visual image is of crucial importance.

The primary objective is to provide experience of advanced tools in the design studio. These tools will provide experience of intelligent design systems and *extensive visual* information *references to* the design student.

At a more advanced level the experience of building such tools provides a valuable learning experience in the area of design theory and methodology to the student groups involved in the development of these design systems.

Overall, the result of bringing together of such a varied group of techniques into an integrated system has enabled us to demonstrate a result, which is much more versatile and powerful as a design support system than the mere sum of its parts.

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