An Integrated Computing and Video-Imaging Environment for Architectural Practice

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CAD/CAM (Computer Aided Design, Computer Aided Manufacturing), Accounting System, Videodisc, Integrated Computer System.

ABSTRACT

An integrated computer system may be implemented as a result of interfacing:

a) A CAD system which will provide graphic representation and multiple manipulations of building elements, e.g., standard building components, elements, sub-systems, or systems (i.e., a catalog);
b) An accounting system which will be more appropriate for alphanumeric data storage and calculations (structural, quantitative, environmental, physical, etc.), e.g., allocation of various "attributes," such as cost number, weight, quantity, etc. to proposed design solutions;
c) A visual information system which will store a set of images in a laser videodisc, showing the actual or simulated representations of the building fabric (components, elements, sub-assemblies) and/or the display of sequences related to the construction process or assembly, including two sound tracks.

Vers un Environnement Graphique Crée Par l'Image Synthétique et la Visualisation Par la Vidéo Dans la Pratique Architecturale.

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MOTS-CLÉS

Conception Assistée à l'Ordinateur, Système de Logiciel Mathématique, Videodisque, Image Synthétique, Système Intégré d'Informatique.

SOMMAIRE

Un systeme intégré d'informatique pour la CAO (Conception Assistée a l'Ordinateur) appliquée à la demarche architecturale est conçu à partir de trois composantes essentielles:

a) Un système de logiciel graphique qui produirait diverses représentations volumétriques ainsi que multiples manipulations de différents éléments du bâti -- ces derniers étant par example des composantes de systèmes ou de sous systemès d'un bâtiment.

b) Un système de logiciel mathématique qui soit approprié à la gestion des données alphanumériques exprimées dans le langage architectural en termes de pondérances, de quantités, de coûts ou de contraintes structurales.

c) Un système d'informatique visuel qui est une banque d'images électroniques, dynamiques, comparable à la notion habituelle de banques de données alpha-numériques. Ce système utilise la technologie du laser pour stocker sur mémoire optique des photos ou images filmées en video qui seraient des représentations véritables ou simulées de la construction d'un édifice.

INTRODUCTION

Computer technology has improved enormously in performance, especially in the world of microcomputers and software development. It seems clear that these trends will continue. Hostility among architects to the idea of incorporating computers in the design process is caused in part by ignorance of the potentials of computer technology, but the fundamental reason undoubtedly is economic. Earlier CAD design systems required investments far beyond the means of architects, because architectural firms tend to be relatively small and unable to mobilize capital to invest in expensive equipment with a reasonable payback period.

However, a new situation has evolved over the last decade due to the most significant development in computer technology: the emergence of very small, cheap, and powerful microcomputers. The increasing improvement in microcomputer hardware and software development have opened a powerful potential for the field of architecture. Several factors have contributed to the emergence of this potential:

First, an increasingly broad range of performing software in CAD/CAM* is designed to be flexible enough for use by architects.

Second, the rapidly decreasing cost of software and hardware, due to a very competitive market, has made this technology available for even very small architectural firms.

Nevertheless, there is still not available in the market any integrated software which is designed specifically for integrated architectural design/decision making. In the face of this "computer/architecture" phenomenon, the profession of architecture should think about strategies which would take advantage of this technology in an optimal way. Such a strategy should have as its target two objectives:

A new way of thinking and teaching architecture, as well as merging architectural design process with computer-aided design programs.

Awareness of the limitations of current software in terms of architectural use.

Therefore, an obvious need exists for an integrated system, which will use off-the-shelf software, but will be designed to be better suitable for architectural use and practice. The objective of this paper is an attempt to define such a new methodology. It will present an integrated computer system, based on current state-of-the-art computer and video technology.

1. Principles of the Integrated Computer System for Building Design

Comprehensive integrated systems implemented so far have some basic requirements, such as:

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* Computer Aided Design, Computer Aided Manufacturing

From the building side:
- Design rules for location of components;
- Design rules for location of spaces, adjacencies, etc.;
- A building description data base, related to components, assemblies, sub-assemblies, etc.;
- Evaluation and optimization criteria of design, related to components used.

From the computer side:
- A graphic representation, simple, but comprehensive enough to show plans, elevations, and details;
- A data-base structure which has efficient data factoring for ease of access as well as multiple levels of access;
- A high capacity for storage of building descriptions.

State-of-the-art computer technology, especially by means of optical videodisc technology combined with microprocessors, allows a new approach to handling such problems. Currently, the combination of a microprocessor with a videodisc provides two computer capabilities which have, until recently, substantially limited computer power, i.e.:

A large amount of data can be stored on the disc (the equivalent of 1,000 floppy diskettes, i.e., 360 megabytes);

A relatively rapid random access to that data, which is made possible by the disc format.

In addition, since this data base is terminal based, and the computer system independent, it is possible to have a portable system as well as a shared resource system. For example, a building system description can be accessed by different computer systems.

A new application is also possible, as the basis for a new data image management system, which will combine image storage on the videodisc and image retrieval by means of a computer graphics package. Linking a videodisc with a microcomputer creates a new dimension, which provides a powerful new architectural visualization tool for the design process. Thus, it is no longer limited to use for final presentation only, but helps to optimize design decisions in all stages of the architectural design process. It enables the architect to proceed simultaneously with optical (image processing with videodisc) as well as electronic simulation (computer graphics generation with a CAD system). The first allows the user to view an animation sequence prestored on videodisc, whereas the second allows the user to generate various views of the building from different stations, print, and manipulate them interactively by a device, such as a light-pen or a mouse.

Additional use of a digital decoder will enable the system to process the image stored on videodisc. In that case not only slides of actual built environments or standard slide libraries can become part of the data file, but vector drawings can be stored on videodisc and downloaded to the local computer system for manipulation. For example, the user will be able to build up a floor plan, using standard parts of any standard building construction system, which can be stored as vector drawings on the videodisc.

Suffice it so say, that the computer's memory can be filled from the disc at any address in order to control specific sequences as "viewer/motion-picture" interaction unfolds.

Use of such an integrated computer system will significantly change the traditional process of architectural design. Traditional design procedures are labor-intensive; tasks are executed with simple drafting equipment. On the new system, tasks are performed separately and sequentially. The architect will be able to design a project by working more on the qualitative criteria instead of worrying about quantitative factors. The graphical representation phase is presently not concurrent with the quantitative evaluation of the cost and quantity-performance factors of a proposed project. Performance and cost analysis, for example, are only performed, once the schematic design has been finalized. Continuous feedback from one phase to the other is currently difficult to manage without major effort in time and cost. An alternative to the linear sequence of such functions is using a computer system which will produce higher quality results at lower cost and higher speed. Such an integrated computer system will link graphic representation to a numeric data base and the use of an appropriate estimating program, which can easily perform a cost analysis for each design sketch, take off quantities, as well as list other technical attributes of the materials and methods to be made compatible with intended design ideas.

2. Description of the Integrated Computer System

The concept of such an integrated computer system is based on the interface of modular components, using as much as possible off-the-shelf software and standard micro-based equipment. The conceptual key elements of the architectural design process are determined by the ability of the system to generate graphic representations, store and compute numeric information in a data base structure, and visualize contextual images.

2.1 Representation

A CAD system with an extensive library of drawing primitives will allow the user to generate graphically plans, elevations, sections, and details. These entities can be represented on screen and manipulated in terms of different configurations, elements, or space combinations.

2.2 Computation and Data Processing

Actual construction work needs a detailed description of the proposed building or building system to be designed. Generally, this description is presented as a data base, consisting of numeric information (e.g., one related to a bill of quantities, technical specifications, cost estimates, structural analysis, etc.).

2.3 Visual Information System

The visual information system operates by means of an image file, stored on videodisc, and presents major advantages such as:

High memory, i.e., it is possible to store more than 2 gigabytes (2 billion bytes) of digital data on each side of a videodisc. The storage capacity of both sides is equivalent to 1,000 double-density floppy disks.

Capacity of storing real-life images. These images can be still (slides), moving pictures (videotapes), vector drawings, computer graphics, collages, simulations, etc. In addition, two sound tracks allow the insertion of music, comments, or instructions associated with the display of images, including two language tracks.

The proposed integrated system, which combines these three components, becomes a very powerful tool, specifically designed for architectural use in education and practice. Such a system will allow the user to work simultaneously on graphics, data processing, as well as spatial visualization programs. It is also the most effective and economical use of available computer P.C. technology, which combines powerful videodisc microprocessor technology with extremely high-capacity of videodisc storage memory that does not require direct computer power. We have chosen to integrate AUTOCAD (as a CAD system) and LOTUS123 (as a data processing system), simply because both systems have a structure flexible enough to program in an integrated manner.

Graphic and numeric data are entered into the AUTOCAD environment (CAD system). A library of graphic data is stored as drawing files within the AUTOCAD environment. Later on (in the further development of the project) the library of graphic data can also be stored as vector drawings on videodisc and be downloaded to the AUTOCAD environment for geometric manipulation by means of a data decoder. The reason for using a videodisc is its high memory storage capacity (approximately 300 megabytes).

Numeric data, associated with each drawing file, are extracted and transferred as a data file into the spreadsheet environment, i.e., LOTUS123. The latter can then generate subprograms, using the data for video control subroutines, bills of quantities, cost estimates, and even structural analysis subroutines (see Figure 1).

Interfacing with the image file, stored on videodisc, can be performed either from the AUTOCAD environment, the LOTUS123 environment, or from both simultaneously. The interface program for the videodisc player can also be written in the LOTUS123 environment, in which case it plays the role of video control subroutines within the integrated system environment. The input data, called for by the interface program, are generated at the same time as drawings are created within the AUTOCAD environment.

While designing a project, such an interface will allow the user to view on a TV monitor a whole set of images associated with a library of parts, to decide which part he is going to use. In short, the CAD system he is using also allows him to access, simultaneously, an image data file. The video control display program also allows the user to view an animation sequence, accompanied by narrative instructions, at the speed he chooses, i.e., to stop any image he is interested in, to play back a sequence or to listen to one of the two sound tracks.

3. Hardware and Software Requirements

The hardware configurations of the system have four major components:

- A user input device, i.e., keyboard and digitizer (or mouse).
- An IBM PC-AT (640 RAM) working with the operating system DOS version 3.0, a digital memory and storage system:
  - Asynchronous Communication Port 1 (to be connected with the digitizer);
  - Asynchronous Communication Port 2 (to be connected with the videodisc player);
  - Two monitor adapters;
  - Two video displays.
- An optical videodisc player which acts as an image and sound storage system containing analog memories of images (SONY LDP-1000A).
- A videodisc display, a cathode ray tube TV.

The software requirements are:

- DOS version 3.0 operating system;
- AUTOCAD, Autodesk, Inc.;
- LOTUS123, Lotus Development, Inc.;
- WORDSTAR (or any other text processor).

4. Overview of Case Studies

A few pilot case studies have been implemented using the principles of such an integrated system for different purposes and environments. Among those applications can be cited a program called "SITECAD" which has been developed as a pilot project for "The World Bank."[1] "SITECAD" is intended for designing site plan layouts together with the capability of calculating affordable development costs and land use patterns for desired target groups. Another example is "MASONRY COMPUTE" which is a computer program developed for the International Masonry Institute (United States).[2] "MASONRY COMPUTE" allows the user to view a catalog of images showing different masonry elements, to learn about rules for different types of walls, to do sketch designs as well as produce final document drawings together with a cost estimate or summary report. The possibilities offered by "MASONRY COMPUTE" are oriented towards:

- A more efficient way for the user to learn about masonry;
- A better interaction and participation by the user than reading a book;
- More interactive involvement of the user, since the tutorial provides the capability to check decision-making on one level, say design, against another level, say cost. The user's final product can generate three-dimensional drawings as well as reports which summarize costs, quantities, and selected material attributes (size, weight, unit volume, etc.).

The last case study to be mentioned has been developed for a workshop on "Building Systems Design" at the Massachusetts Institute of Technology.[3] The program is to help students in their process of designing a building system and test various design configurations against the building system rules. The structure of the program is based on the criteria stated in Section 2 (Description of the Integrated Computer System). To give an

example, the rules of the structural system would state that it would only allow spans of 8'x8', 8'x12', and 12'x12'. In that case, the computer system could display different options of positional grids which accept any combinations of the allowable spans, and the user will not be able to place any structural elements in a position which is not acceptable within the technical specifications of the structural system. The program will also allow the user to view a catalog of library components (such as prefabricated facade panels, floor panels, wall panels, etc.) on a TV monitor. Those components are stored as images on a videodisc and also as vector drawings (drawing file) in the computer mass memory. Such a system will give the user the flexibility to visualize the components before actually using them and inserting them into his or her drawing.

Finally, it should be noted that all these capabilities are achieved by means of "off-the-shelf" hardware and software (albeit combined in a new way), at reasonable cost, and thus affordable even by a small design practice.

REFERENCES

1. T. Vien, "SITECAD," (Pilot Project for The World Bank, Washington, D.C., 1985).

2. E. Dluhosch and T. Vien, "MASONRY COMPUTE," (International Masonry Institute, Washington, D.C., 1985 - present).

3. T. Vien, "Investigation of an Integrated Computer System for Architectural Design," (S.M.Arch.S. Thesis, Massachusetts Institute of Technology, Cambridge, 1985).

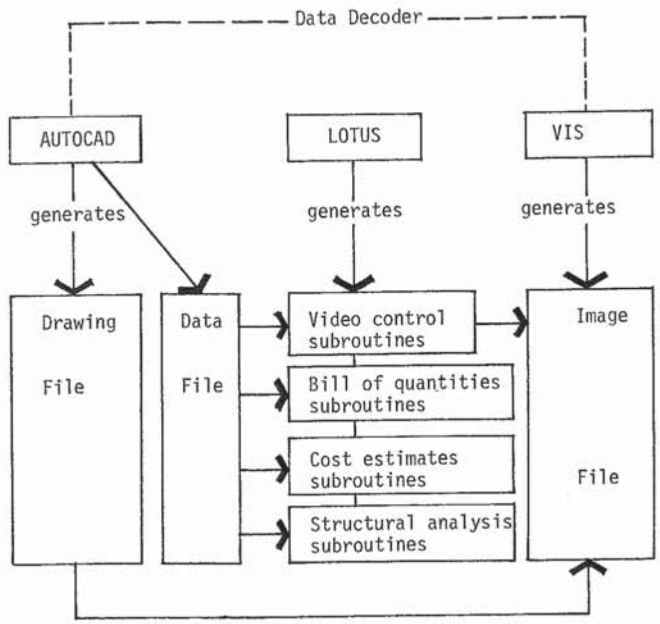

Fig. 1 Representation of the overall interface conditions.

CADD for Steel and Reinforced Concrete Buildings and Structures

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KEYWORDS

Computer-aided Frame Analysis, Design, Deflection Control, Plotting, Drawing, Graphics.

ABSTRACT

CHIYODA has developed a CADD (Computer-Aided Design and Drafting) system named IFADS and is currently using it for the design of many steel and reinforced concrete buildings and structures. IFADS (Integrated Frame Analysis and Design System) consists of the following subsystems; (1) frame analysis (2 and/or 3 dimensoinal); (2) code check and/or member design using the latest codes of AIJS (Architectural Institute of Japan-Steel), AISC (American Institute of Steel Construction) and ACI (American Concrete Institute); (3) plotting for visual checks of the input data and for stress diagrams; (4) automatic drawing (framing plan and elevation, and member schedule using graphics); and (5) material take-off. IFADS also has the capabilities to design composite structures of steel and reinforced concrete, to automatically control deflection of steel members and to design reinforced concrete shear walls and slabs. Large savings in manpower and costs, assurance of quality and standardization has been achieved by using IFADS.