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6th International Conference on Systems Research, Informatics and Cybernetics
(August 17-23, 1992, Baden-Baden, Germany)

PROCEEDINGS

VOLUME 1

ADVANCES IN COMPUTER-BASED DESIGN ENVIRONMENTS

(Focus Symposium, August 18-19)

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Preface

Commercial CAD software has evolved over the past decade in a fairly predictable manner. Driven mostly by the need for higher productivity levels initial emphasis was placed on drawing automation. Accordingly, early CAD stations were stand-alone units designed to serve the specific purpose of drawing production and manipulation. Recently, with a shift in emphasis on integration, more and more CAD vendors have been persuaded to provide linkages to database management systems. The marriage of CAD with external data and knowledge sources will have a profound influence on the evolution of knowledge-based design systems.

Within this context four generations of commercial CAD software can be identified. The first generation commenced in the middle 1970s with an emphasis on automating the functions that are associated with the production of drawings. However, industry soon realized that the value of drawings can be greatly increased if the objects that they contain are directly linked to the information that they represent. The objects are symbols that have not only geometric properties, but also a large number of descriptive attributes (e.g., functions, relationships to other objects, materials, cost, ownership, and availability) which are essential to their manipulation in any given context.

Early efforts to broaden the functional scope of CAD drawing systems led to the addition of attribute files (e.g., as symbol libraries) and spreadsheets. However, the asset management requirements of large companies and government departments created a need for more substantial and better organized database systems. This led in the early 1980s to the second generation of CAD software. Linkages to relational database management systems were integrated into 2-D CAD drawing and 3-D solid modelling packages. The addition of virtually unlimited amounts of attribute information to drawing objects has provided an opportunity to incorporate decision making assistance in the CAD environment. Initial attempts have been limited to the incorporation of single expert systems in mostly the in-house CAD systems of large engineering, aerospace, and construction firms.

These early explorations of knowledge-based CAD systems have led to the conclusion that effective decision making support will require multiple domain experts interacting in a multi-tasking, cooperative, and distributed environment. However, no cooperative models that can be readily integrated into existing CAD system are currently commercially available.

The papers included in these proceedings reflect the current state of CAD research, suggesting the gradual emergence of a third generation of multi-agent, knowledge-based CAD software. One serious obstacle facing the commercialization of these research efforts is the inability of CAD systems to recognize real-world objects, such as site, building, floor, space, wall, and opening.

Once multi-agent cooperative CAD software has become commercially available, attention is likely to focus even more intensely on the information (i.e., knowledge) component of these quasi intelligent computer-aided design systems. In particular, ownership of the knowledge embedded in the CAD system will be of critical concern. User-firms will quickly recognize the value of the knowledge that is added to the CAD system through the interaction of their employees with the system. To secure and protect the valuable knowledge assets of the employer, fourth generation CAD software is likely to focus on learning capabilities. However, unlike past research efforts in machine learning which emphasized the exclusion of the human element, CAD software with learning capabilities is likely to rely heavily on continuous interaction with the human designer. I look forward, with high expectations and a great deal of excitement, to the realization of a computer-based environment in which the human designer is assisted by a host of cooperating, intelligent agents.

Jens Pohl

June 16th, 1992

6th International Conference on Systems Research, Informatics and Cybernetics

August 17-23, 1992, Baden-Baden, Germany

SPECIAL FOCUS SYMPOSIUM

Computer-Based Design Environments

August 18th and 19th, 1992

SYMPOSIUM PROGRAM

TUESDAY, August 18th

8:00 to 8:20 **Authors' Meeting - all authors are requested to meet on the second floor of the Convention Center.**

8:30 to 9:45 **SESSION 1: Experience with Commercial CAD Systems**

'ArchiCAD in Housing Design'
R.Strittmatter and S.Todd; University of Salford, England.

'Using CAD Models to Reconstruct the Roman Villa at Poggio, Gramignano, Italy'
R.Dvorak and M.Ibrahim; University of Arizona, USA.

'CAAD Tools: Producers, Users, Educational Practice'
R.Pii; University of Florence, Italy.

10:00 to 12:30 **SESSION 2: Enhanced and Prototype CAD Systems**

'Production Model of a Construction Object'
M.Psunder and D.Rebolj; University of Maribor, Slovenia.

'An Alternative Approach to Computer-Aided Building Design: The Structural-Element-Based Method'
B.Lutar; University of Maribor, Slovenia.

'Computer-Based Cost Model for Structural Systems in Commercial Buildings'
S.Singh; National University of Singapore, Singapore.

'Computer Integrated Design Environment for the Modular Construction'
G.Hirasawa and T.Ohno; University of Tokyo, Japan.

'The Use of Computer-Assisted Learning in the Teaching of Design Economics: A Study of the CALDES Project'
B.Sloan and N.Schofield; University of Salford, England.

'Improving NAVFAC's Total Quality Management of Construction Drawings with CLIPS'
A.Antelman; Naval Civil Engineering Lab., California, USA.

13:30 to 14:45 **SESSION 3: Characterization of the Design Activity**

'Requirements for Computer-Based Design'
J.Pohl and L.Myers; Cal Poly, San Luis Obispo, California, USA.

'Aspects of the Character of Knowledge in Architectural Design Education in the Age of Computers'
T.Chu; University of Melbourne, Australia.

'Toward a Concurrent Architecture: Applying Recent Developments in Concurrent Engineering to the Practice of Architectural Design'
T.Lin and J.Protzen; University of california, Berkeley, USA.

15:00 to 17:00 **SESSION 4: Computer-Based Design Agents and Assistants**

'On the Role of Drawing: Some Philosophical Questions Applied to Computer-Based Design Environments'
C.Calvo; Auburn University, Auburn, USA.

'A Fundamental Tradeoff in Intelligent Design Support'
D.Corne, B.Logan; University of Edinburgh, Scotland; and, T.Smithers; Universiteit Brussel, Belgium.

'Computer Based Generative Systems in Engineering Design'
T.Lewis; University of the West Indies, Trinidad/Tobago.

'A Building Massing Intelligent Design Tool'
G.Brown, M.Meacham, P.Miller, M.McDonald, J.Kline and B.Sastry; University of Oregon, Eugene, USA.

'Development of a Design Tool for Sprinkler Installation in Hong Kong Using HyperCard'
J.Gilleard and Y.Lee; Hong Kong Polytechnic, Hong Kong.

17:15 to 18:00 **SESSION 5: Development Environments and Tools**

'A Procedural Mechanical Design Language'
H.Borklu, N.Juster and A.Pennington; University of Leeds, England.

'GXI: A Graphical Interface Builder with Distributed Inter-Process Message Management Capabilities'
K.Pohl; Cal Poly, San Luis Obispo, California, USA.

WEDNESDAY, August 19th

8:30 to 10:15 **SESSION 6: Representation and Integration Issues**

'The Elevation of the Abstraction Level in the Procedure Oriented Program Environment with the Object Shell Method'
D.Rebolj; University of Maribor, Slovenia.

'Object Recognition in the Design Environment: A Neural Network Approach'
D.Yang and D.Shaw; University of Illinois and US Army CERL, USA.

'An Object-Based Modeling System Coupled with Design Information System'
U.Kim; Hong Ik University, Korea.

'A Spatial Representation of Architectural Models'
M.Bonn; The Premisys Corporation, Chicago, USA.

10:30 to 12:15 **SESSION 6: (Continued)**

'Horizon Design: Affecting a Design Paradigm Shift'
D.Stoker and D.Jones; Virginia Polytechnic Institute, USA.

'Conceptual Models for Urban Quality and Assets Management Using GIS'
M.Esposito; Universita di Firenze, Italy.

'An Agent-Based Approach for Integrated Design Environments'
T.Khedro, M.Genesereth and P.Teicholz; Stanford University, USA.

'On Structuring Primitives and Communication Primitives for Design Environments'
N.Ritter, B.Mitschang, M.Gesmann, A.Grasnickel, T.Harder, C.Huff, C.Hubel, W.Kafer, H.Schoning and B.Sutter; University Kaiserslautern, Germany.

13:30 to 15:15 SESSION 7: Knowledge-Based Approaches and Systems

'Indexing for Precedent-Based Design: A Case-Based Approach'
R.Oxman; Technion, Israel Institute of Technology, Israel.

'A Knowledge Based Design Environment for Mechanical Applications: A Case Study for Plastic Injection Mold Design'
D.Lecluse, E.Sleeckx, J.Kruth and K.Vlaminck; Katholieke Universiteit Leuven, Belgium.

'Using Construction Planning Knowledge Based Systems for Improving Design Decision Making'
C.Formosa; Federal University of Rio Grande do Sul, Brazil.

'A System for Supporting Kiln Design'
P.Mclaughlin; Staffordshire Polytechnic, England.

15:30 to 17:00 SESSION 8: European Construction Agency Proposal

'Proposal for the Establishment of a European Construction Agency'
C.Mathurin; Ingenieur General, Des Ponts et Chaussees, France.

The introduction of this proposal, which is based on a 'Vienna Charter' signed by 11 EC and EFTA countries on February 21st, 1992, in Vienna, will be followed by general open discussion.

SECTION 1: Experience with Commercial CAD Systems

'ArchiCAD in Housing Design'
R.Strittmatter and S.Todd; University of Salford, England.

'Using CAD Models to Reconstruct the Roman Villa at Poggio, Gramignano, Italy'
R.Dvorak and M.Ibrahim; University of Arizona, USA.

'CAAD Tools: Producers, Users, Educational Practice'
R.Pii; University of Florence, Italy.

addressed. It is unlikely that the metaphors system will benefit from a 10,000 mips compute available in the future. What is needed is the new techniques and paradigms that reflect the computer power will be available at very littl for developing systems have come a long way Analyzer (PLAN) system used to develop BOP. languages such as C++ provide much greater fl previously available.

The Horizon Design approach is one that is power. The primary ideas are: (1) to substitu decision inertia, (2) incorporate the process of design as a data base schema and (3) to affect a paradigm shift by providing a means to interact with the ultimate consequences of those design decisions. The embodiment of OOPS concepts in such an approach offers a strategy for implementation and a direct method for expansion as new deterministic applications are developed.

While such a system is theoretically capable of generating complete buildings with little interaction with a human designer, it in no way attempts to usurp the authority or responsibility for the design. Rather, Horizon Design attemps to capture a fundamentally different design paradigm from the incremental approach commonly in use today. By expanding whatever data is available into complete, understandable expressions of buildings, even buildings with obvious inconsistencies, a new level of communication evolves that is not dependent upon the abstractions of construction drawings, specifications, renderings or even a complete definition of those buildings. This expanded communication between diverse parties in the building process must result in an expanded dialogue in the design process and, hopefully and expanded role of the designer as the coordinator of all the parties involved.

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Conceptual Models for Urban Quality and Assets Management Using a GIS

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Abstract

Environmental quality management is an exciting GIS application area and one that will become more and more important in the future. The powerful instruments that GIS technology offers, applied to multi-functional projects, facilitate a correct analysis of a situation and the definition of a conceptual model. This is, then, an important first step for an efficient application in the area of urban and assets representation, where the information might be used in planning or in existent building management. In this regard there are three basic methods of analysis which can be used: a) macro-analysis (background data referred to the system); b) micro-analysis (information modules referred to the organization of the user); c) performance-analysis (functional model specification). This paper shows that final information system design methodology is a combination of these basic level outputs.

Keywords

Geographical Information Systems; conceptual models; urban quality representation; asset management.

Introduction

After the development of the Geographical Information System (GIS) there have been numerous applications in sectors very different from the one which generated the original technology. A GIS is defined in a general sense as "a system for capturing, storing, checking, integrating, manipulating, analyzing, and displaying data which are spatially referenced to the Earth. This is normally considered to involve a spatially referenced computer database and appropriate applications software. (AGI, 1991[1]) The GIS technology originated in Canada in the early sixties and successively developed in the U.S. and Great Britain in order to create digital tools in the area of cartography. Technological intruments were invented, both hardware and software, able to read, interpret and convert geographical information into computerized archives. In fact the basic elements of the system which characterize these technologies even today are those developed in the early years: the optic scanners, the digitising tables, the raster to vector conversion, the separation of levels, etc. However it was only twenty years later, with the increased operative capacity of the hardware, that the wide applicability of these technologies became apparent. As a consequence, commercial systems were developed and circulated. Today the main focus of new research with the GIS is in its use as a support system by public administrators in decisions involving the planning and governing of their territories.This is in response to a growing demand, especially in industrialized countries, for decisions based on rational and quality-oriented analyses. Cartographic databases turn out to be highly useful in approaching an ever-growing number of problems whose solutions require an analysis of the relationship between a specific object and interrelated systems (for example urban development and either the transportation or basic services infrastructure, etc.).Thus, applications are always multiplying among the various government agencies (the Military, the Ministries, the Regions, the Cities, the Cadastre, Municipal Groups, etc.) and in Italy there has not yet been developed a standard of exchange of cartographic data as exists in the U.S. The dizzying increase in capacity of the personal computer has allowed new developments of the GIS also in this area, something which accentuates the fundamental problem for applications on this scale: the cost of collecting data and in general the difficulty of making geographic data accessible in compatible formats. It is necessary also to point out that there is no specific research on conceptual models connected with diverse applications This is a relevant fact both from the point of view of the subject matter of each particular discipline (usually dealt with sector- by- sector, individually, ignoring the potential of using interrelated systems of information offered by these applications) and from the point of view of associated technologies (which could be more greatly considered in the development of applications for the various sectors, as in the design of data banks which simplify the organization and manipulation of data, in the improvement of user interfaces, in the compatability of systems, etc.). (DoE, 1987,[2]) Lastly, the organizational aspect cannot be overlooked as this influences both the development and the functioning of these systems at least as much as the informatic aspects (such as problems due to a lack of previous experience with computers as occurs sometimes with city planners). The use of GIS technology implies a global approach to information internal to an organization and a new attitude towards an interdipartimental vision of the territory they are responsible for, as in the case for example of public administrators. It is often unfortunately the case that responsible parties strongly resist this approach of sharing data as a substantial erosion of their own decisional power, autonomy and political image. (Craglia, 1991[3])

A technical profile and applications in the urban and building sectors

As was previously stated, the initial scope of the GIS technology has been expanded to include new applications where

it is useful to relate objects to territory based on common geographic factors. In particular, another characteristic of this technology takes on relevance: the results derived from a GIS system provide other "free" information, derived from the connection between data banks (even external to the system) on which it is based.
This aspect is important in understanding how applications of this technology in the building sector can be studied: for example, in a description of urban environmental quality or in the representation and manipulation of assets (as in the case of a real estate census). To make this clear it is necessary to describe synthetically the structure of an advanced GIS: the heart of the system is a "relational topologically-structured data base which is object-oriented" (Bagini, 1991[4]). This is the basis of the geo-relational model and presents itself as a user interface, eliminating the necessity of coordinating two data base structures for a user who may not be an expert. At the same time there is still the possibility of liberally defining the structure as a function of the requirements; while both the expandibility (the possibility of adding new classes of objects or attributes), and the manipulability of data, along with extended functions of interrogation, are guaranteed.([5]) The manner in which it is possible to organize information in this type of structure closely adheres to our everyday vision of both urban and building realities. In fact, a GIS models geographic realty through classes of recognizable objects such as streets, buildings, blocks, squares, rivers, zones, which we will define also as entity classes. To these objects are referred procedural options of the system which permit associating packages of information to them (for example, for buildings: location, size, performance standards, data on the quality, state of repair, etc.) and actions to be carried out with such associations and groupings (in terms of the relationships among objects belonging to different classes: for example, building/owner). Other technical characteristics such as data abstraction, inheritance, etc. allow the creation of models representing complex situations while conserving the consistency of the system and the non-redundancy of the data. An example of the use that can be made of these options is the creation of new logical groupings of entities which, still belonging to diverse classes and conserving the same relation to the package of attributes, will form a new class. The network of streets and the lines of transportation could form a new class of "urban mobility", or school buildings and the various zones could form the class "districts". The cases mentioned are represented through a definition of complex objects which contain other objects. The efficiency of a data model for urban management and building is based on two general requisites:
-its capacity to represent the characteristics of the objects in relation to other disciplines;
-the possibility of sharing information derived from other known systems (even external to the original system).
This structure of attributes and relationship between objects permits this type of representation. One example could be the definition of a model of school building management at the regional level in which school buildings can be grouped in sets

by type and grade level (as classes of simple objects) and then with their attributes (location, age, size, state of repair, environmental comfort level, etc.), one can form a data base relative to the transportation network, to school zones, etc. (as classes of complex objects). (Esposito, 1991 [6,7]) (fig.1)

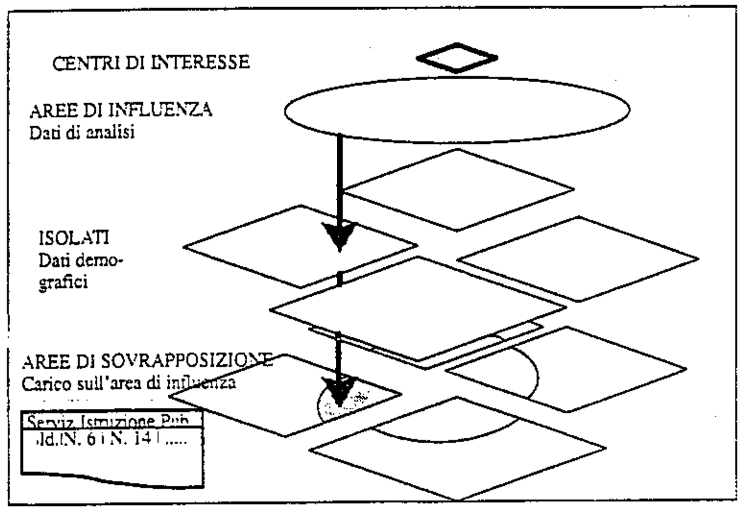

fig.1- determination of the users of a service (BAGINI, 1991)

In the study of specific problems relating administrative data to territorial objects, the relationships can be defined between objects of the system and other objects from external data bases. In the same way, appropriately structuring the relative data and the attributes of the objects, such as age and state of repair, one can define a list of priorities and a study of maintenance requirements for a given piece of real estate, and so on. (Kooijman & Straub, 1991[8]). These particular characteristics underline the potential of the logical model of an advanced GIS, in regard to the representation of urban studies but also make clear the essential importance of the conceptual model of the data. This must be conceived after a careful analysis of the needs of the user of the system and the final goals of the project. Naturally this does not exclude eventual modifications of the system or demands for additional applications since the technology, flexible as it is, can adapt. In any case extra attention in the design phase pays off in optimal results especially in the more burdensome phase of the direct acquisition of data.

Methodological Aspects in the Planning of the Conceptual Model

The conceptual planning of an informational system is like a suit made to order: it cannot be done without the person who will use it. It often happens however that this user substitutes the complete personalization which these technologies provide for a conceptual model defined on the basis of a correct methodological process. The planning methodolgy of a GIS presents several specific aspects in respect to the classical

planning methodology of informational systems. A recent direct survey carried out on operating methodologies within the sector reveals a primary procedure defining, at the macro level, a rough data model with the following four phases: (AA.VV., 1991[9])

a-analysis of feasibility
b-design details
c-realization

The analysis of feasibility is subdivided in turn in two phases: a study of strategic feasibility, which defines the factors which influence the realization and functionality of the system; a study of technical feasibility specific to the architecture of the system. Phase b) can be executed in different ways, with differentiated levels of definition, going from the traditional detailed design and consequent realization to the acquisition and modification of a commercial package, or else the development of prototypes in an iterative process. This phase presents the major differences in respect to a philosophy of work requiring a different interpretation of the methodology of defining the conceptual model of the data. This is often too limited even in cases where a more accurate elaboration would produce remarkable functional advantages. Generally, it is possible to define the following phases of the conceptual project of a system geared to objects:

I-analysis of the needs of the user:
a)-definition of the requirements of the project
b)-individualization of the informational models (information and
standard analysis) to be generated

II-definition of the data base:
a)-analysis of the entities (individualization and classification,
subclasses)
b)-analysis of the relationships (individualization of the typology
and the cardinality)
c)-feed-back generated from the verification of the relationships
between objects (point II/b)

III-definition of the data archive:
a)-analysis of geographic data (individualization of coordinates,
shape, dimensions, attributes of the entities)
b)-analysis of the attributes (names relative to the various
classes of entities, domain, function, cardinality)
c)-verification of appurtenance of the attributes and relationships (13)

IV-formalization of the conceptual model.

Phase c) of realization of the system very often utilizes the articulated iterative method in: logical definitions of the details (with the planning of fundamentals such as input/output, batch programs referring to the data base); realizations (the writing down of the program, testing, and predisposition of the manual/user). Phase d) consists in the verification and functional and organizational expansion options of the system.

Conclusion

The interdisciplinary vision typical of these systems, the expandibility, the flexibility and the common geographic base of many problems linked to territory make them always more useful, especially in public administration. This paper points out the innovative elements with which the GIS can analyze specific applied areas such as the management of urban quality and assets, represented by a system of objects localized geographically. These objects constitute a particular environment and represent the level of satisfaction with the community's explicit and implicit requirements. They can be correlated in detail through a continuous data system to the maintenance management of specific real estate sectors (residential, public, schools, hospitals, etc.). The role of research on conceptual models of data in the sector of urban quality and assets management is underlined as an important factor which ideally should precede the phase of development and logical personalization as well as the definition of the physical architecture of the system.

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SECTION 7: Integration Approaches

'An Agent-Based Approach for Integrated Design Environments'
T.Khedro, M.Genesereth and P.Teicholz; Stanford University, USA.

'On Structuring Primitives and Communication Primitives for Design Environments'
N.Ritter, B.Mitschang, M.Gesmann, A.Grasnickel, T.Harder, C.Huff, C.Hubel, W.Kafer, H.Schoning and B.Sutter; University Kaiserslautern, Germany.