Computer Aided Architectural Design Futures 2001

Proceedings of the Ninth International Conference
held at the Eindhoven University of Technology,
Eindhoven, The Netherlands, on July 8–11, 2001

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KLUWER ACADEMIC PUBLISHERS
DORDRECHT / BOSTON / LONDON

A C.I.P. Catalogue record for this book is available from the Library of Congress.

ISBN 0-7923-7023-6

Published by Kluwer Academic Publishers,
P.O. Box 17, 3300 AA Dordrecht, The Netherlands.

Sold and distributed in North, Central and South America
by Kluwer Academic Publishers,
101 Philip Drive, Norwell, MA 02061, U.S.A.

In all other countries, sold and distributed
by Kluwer Academic Publishers,
P.O. Box 322, 3300 AH Dordrecht, The Netherlands.

Cover designed by Jac de Kok,
Rendered images of the new faculty-building of Architecture designed by Bert Dirrix,
Photographs of the conference venue at Eindhoven University of Technology
by Jos van Leeuwen

Printed on acid-free paper

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Printed in the Netherlands.

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PREFACE

Computer Aided Architectural Design has become a main factor in everyday processes in the architectural office. New developments in visualisation techniques, Internet, organisational forms, and programming languages push the boundary what is technologically possible in CAAD software. Academic and industrial researchers alike are looking for new and unanticipated ways to use CAAD in a productive and creative manner. The CAAD Futures conference is a venue in which state-of-the-art work is presented and views for the future are discussed. Since its start in 1985, the bi-annual conference has been instrumental in charting the development of CAAD and use in architectural and engineering design. The series of conferences started in 1985 in Delft, and has since travelled through Eindhoven, Boston, Zurich, Pittsburgh, Singapore, Munich, and Atlanta.

The current proceedings provide the papers submitted for the CAAD Futures 2001 conference, which was held in Eindhoven. It counts over fifty papers, with contributions from many areas of research in Computer Aided Architectural Design. The breadth of the submissions is reflected by the sixteen categories that organise the proceedings. Most of these categories constitute well-defined areas of research, such as Case Based Reasoning, Virtual Reality, Hyper Media, Collaboration, and so forth. Others have proven more elusive: the category of Form Programming reintroduces the issues of description and generation of form by means of programming. Simulation appears in two categories: Simulation and Architectural Analysis. Papers in these categories differ mainly in the basic stance that is taken about the use of simulation results. XML is beginning to break through, but since it is so much integrated in the research work it did not stand out as a separate category.

The following paragraphs provide an overview of the papers per category.

Capturing Design

Capturing design is about the techniques and methods that support the designer in creating a digital representation of his/her mental image. For design recording, Gross, Do and Johnson propose to use speech recognition to create a searchable multimedia document, which includes the graphics as well as the designers' comments. Design creation and manipulation requires a more intuitive interface than the well-known WIMP interface. One approach is to interpret gestures [Kemp, Gross], another approach is to interpret digital sketches [Leclercq]. In the first case video is used to capture

hand positions and translate them into modelling commands, in the latter case pixels are converted into lines and relationships in the architects' sketch.

Information Modelling

Information modelling discusses methods for representing design information which captures architectural design features such as representational flexibility and temporal data. Sorts [Stouffs, Krishnamuri] specifies a common syntax, allowing for different vocabularies and languages to be created, and providing the means to develop translation facilities between these. Using such an information modelling method, Ekholm argues that user activities in a building should be taken into consideration by introducing an activity space with specific properties such as time schedule. With this information 3D models can be created which illustrate how these activities are accommodated in the building. Integration of spatial and temporal information is not only important in the design process but also in the construction process. Shih and Huang developed a system that supports presentation of changes in time as well as cross-analysis of spatial relationships between construction activities.

CBR Techniques

Case Based Reasoning has attracted many researchers as a method for architectural design knowledge encapsulation. On the urban level, Peng, Chang, Blundell Jones and Lawson implemented a system that can generate on user request, VRML models of city plans with its contextual information. On the building level, Chien and Shih developed a system that supports browsing the design space by filtering components and assemblies from the database. Heylighen and Neuckermans tested their web-based design assistant whether it really engaged students into in-depth explorations of designs from the case base.

Virtual Reality

VR technology has initiated a range of new developments in architectural design. The most wide spread application is the architectural walkthrough. Stappers, Saake and Adriaanse analysed CAVE experiments and conclude that narrative enhancements can substantially improve the level of engagement. VR requires special input devices for navigation. A very special device is the human muscle as used by Knight and Brown to activate signals. Maver, Harrison and Grant argue that the possibility to navigate

through virtual buildings is even more relevant for people with mobility or visual impairment. VR technology is taken one step further by Do into the direction of a design tool named VR sketchpad. This supports the recognition of simple shapes while sketching, translates them into building elements and displays the scene in VRML. An additional feature is the transparent window to quickly trace and extract any image from other application software.

CAAD Education

In CAAD education the Virtual Design Studio has received much attention. Clark, Maher and also Russell extend this idea into a Virtual Learning Environment. They argue that more important than form and space are the enhancements to give it a sense of place. Therefore special platforms are developed and used in architectural education. Architectonic learning and revealing new ideas is possible through digital narrative scenarios within a 3D space as presented by Strehlke and Engeli. Hyperstructures allow multi-threaded, multi faceted representations. Woodbury, Shanon and Radford introduce play to stimulate collaborative design. It builds confidence to continue and competence to perform. QaQish developed a method to evaluate the effectiveness and productivity of CAAD courses between and within students. Its purpose is to work as a framework to augment interactivity and positive learning.

(Hyper) Media

The medium through which architects work while designing, has undergone many changes and developments in the past years. The environment in which to communicate with others and oneself has become more responsive, intelligent, and geared to a natural interface. Cheng investigates the effectiveness and bias that several media induce when users are making surveys. This work gives indications how media such as photographs, video, sketching, etc. influence the recording process. Jung presents ongoing work on annotation of online geometric models by multiple participants to share design ideas. A fluent interface that is quick to use is required to make online-discussions easier to attend. Jung demonstrates how a pen-interface can work in such a system. Do shows a prototype of a system that can relate different design drawings by understanding the geometry of the drawings. It helps as an explorative tool to organise many drawings. Another way to look at drawings is presented by McCall, Vlahos, and Zabel. They show how the hand-made trace can provide a useful organising structure for hyperstructuring design drawings, in particular when based on

traces on drawings. In this way, the ease of hand sketching can be combined with automated organisation. Mishima and Szalapaj present a multi-media system for conveying architectural concepts to architects and architectural students. The content of the system focuses in particularly on analysis and design concepts.

Design Evaluation

Evaluation is a crucial step in the design process to assess the performance and impact of the building (component) design, and whether it lives up to the expectations of the designer, national codes, the client, etc. Automated code checking for example, has received some attention in the past. Yang and Li show how an Object Oriented approach for both representing codes and building designs can aid in automated code checking. The two other papers in this category deal with lighting evaluation. Moeck shows how a top-down approach, using evaluation criteria such as visibility, material appearance, and location of shadows and highlights can lead to a fast lighting proposition. This strategy reverses simulation techniques where first all sources need to be placed and then the lighting can be simulated and evaluated. Eissa, Mahdavi, Klatzky and Siegel test the hypothesis that lighting tools that use numeric simulation and scientific visualisation can provide adequate material for designer to evaluate the lighting design. Such research work is valuable to better understand and use visualisation tools in evaluation of designs.

Design Systems Development

The development of design systems is a complex task, in which the insights from information modelling, user interface, design methods and tools, etc. are incorporated and have to be balanced out. Two papers in this category deal with general issues in design systems development: usability and inconsistency. Chien demonstrates how an Object-Oriented Software Engineering strategy combined with a usability analysis method can help to develop prototype software with a higher degree of usability for the user. Hoffmann, Stumptner and Chalabi discuss the issue of consistency of data models. During the design process, they argue, multiple and also single designers cannot maintain consistent models of the design, as they are switching from perspective, design approach, organisation of the computer model, etc. The authors therefore propose a system that can hold these various views up to the point where they need to be unified again. In their paper, they also discuss the mapping functions between the various perspectives.

Collaboration

CAD support for multiple partners has been researched for quite some time now. Papers in this category focus either on the environment in which design partners collaborate [Johnson], [Han and Turner], or on the technical support issues that arise when working with multiple partners [Jeng], [Cerulli, Peng and Lawson].

Johnson points out that not only support for focused interaction is required, but also for unfocused interaction, which concerns the peripheral awareness of the designer of his or her partners. This information is important to convey in a design environment. Johnson presents a prototype interface that incorporates unfocussed interaction and present the first informal evaluations of such a system. Han and Turner experiment with VRML-based environments of distributed systems that support geometry display and communication with avatars of other designers, and show how these systems can be evaluated.

Jeng presents a rule-driven system that coordinates what kind of activities when, how, and by whom need to be undertaken in a design process with multiple participants. This coordination model is implemented as a web-based application. Jeng discusses the system as well as its potential use. Cerulli, Peng and Lawson present a system that records design processes, and that can provide meta-knowledge about this process for evaluation during or after the process. In this way, the decision-making process becomes more transparent for all partners involved, which can enhance the quality of decision making.

Generation

Automated building and shape generation have always been in the focus of research attention. In the past years, attention has been mainly on shape grammars. In this research field there are contributions from Park and Vakaló, and Chase and Liew. Park and Vakaló present a form-generating grammar that is derived during the design process by recording the objects that are involved in transformation steps. In this way, a designer does not to construct the shape transformation rules that are applied, yet the steps are recorded. Chase and Liew take a look at the field of redesign, where existing designs are adapted to suit changing requirements or tastes. They provide a framework based on feature grammars for this. Changes in style and appearance of the redesign are captured by means of rule modifications, using the mechanism of Function-Behaviour Structures.

Medjdoub, Richens and Barnard present a full-fledged automated generation system for pipe-routing of Low Temperature Hot Water plant

rooms. The system progresses through a sequence of steps based on a few starting assumptions for the room and provides a layout for the piping. The result can be manipulated interactive, while the system tries to conform to the constraints that apply to the piping system.

Design Representation

Representation of design plays a very central role in the discipline of architecture. Not only is the representation of what is (being) designed an inherent part of the design and construction process, also in architectural history and theory design representation has a key-role. Augmenting the richness of design representations is the objective of Tunçer, Stouffs, and Sariyildiz. This objective is pursued by interpretation of design documents, decomposition of their content and integration of decomposed documents into a rich information structure. Two different implementation approaches are discussed that are used to represent this type of rich information structures.

Kulinski and Gero regard design representation as a triplet of function, behaviour, and structure. The transitions between these three states of a design can be represented in a graph. The authors concentrate on analogy as a strategy in the design process; the matching of domains that share common representational structures. A model of situated analogy for design is presented, involving the re-representation of the knowledge in a domain for the purpose of finding analogies.

Tang and Gero argue that current CAAD systems lack the ability to support the speed and vagueness of the conceptual designing process. Through empirical data they show that perceptual cognition and connections between sketches and higher level cognitive functions are as important as the explicit representations that are recorded by CAAD systems. This leads to the conclusion that design representation should not be fixed but allow for the emergence of a variety of unexpected forms and spatial relationships.

Knowledge Management

Closely related to the subject of Design Representation is the topic Knowledge Management. This area, in the context of design support, addresses the development of methods for storing, retrieving, interpreting, and structuring design knowledge. Ciftcioglu and Durmesevic describe an approach of information mining to handle the complex relationships among information components and the interdependencies in information structures.

Turk, Cerovsek, and Martens attempt to use machine learning and data mining techniques to cluster topics in the area of CAAD. This attempt has

the objective to provide an intelligent search interface to the CUMINCAD online database of CAAD publications. A number of algorithms for automatic analysis and grouping of publications are investigated, albeit with insufficient success.

Mann and Ó Catháin present how TRIZ, a systematic method for support of innovation and creativity, can be applied in the discipline of architectural design. Through a number of case studies, they demonstrate the potential of this method for re-using design knowledge in and outside the discipline of its original context.

Form Programming

Form programming comprises of a group of papers that focus on the generation of form by means of some algorithmic approach, other than shape generation. Gross presents a low level programming language with which one can quickly generate forms. As the author claims, advanced and complex shape modelling in CAD systems still is cumbersome, and some shapes cannot be made at all. A different approach to form programming is demonstrated by Choi, Kwon, and Lee. They have developed a design buffer which stores the rapid production of design ideas in the early design phase, and only later requires the architect to focus on a more rigid computer model, drawing from the many ideas and shapes in the design buffer. A Boolean set operator functions on the objects in this buffer, allowing the architect to quickly interact with the ideas. Mahalingam has developed a system in which effectors work on geometry (or other effectors) taking into account particular goals or constraints. By having effectors in particular for interior and exterior conditions of an envelope, shapes for example of an auditorium can be derived from this balance of forces. The work presented by Gavin, Keuppers, Mottram, and Penn, has a twofold target: one, to present a virtual working environment for multiple participants, and two, a mechanism to generate the environment in such a way that it reflects the design history and current status of the users in the environment. For this last purpose, the authors have developed a generative algorithm for the environment which gets feedback from analysis and user responses and behaviour.

Simulation

In the simulation section, four performance aspects are highlighted, namely: structural analysis, airflow analysis, HVAC analysis and life cycle analysis. Martini proposes a particle system approach for real-time, non-linear physical simulation. Koutamanis and den Hartog introduce surfaces to

define the interaction between the simulation of indoor climate and the representation of its spatial form. Mahdahvi, Brahma and Gupta tackle the problem of early design simulation by using a differential building representation in combination with agents that provide reference designs for technical subsystems. Ries and Mahdahvi developed an affordance impact assessment method for regional environmental simulation. All researches have in common that building performance simulation is integrated in a design evaluation tool.

Architectural Analysis

In contrast with the previous section, there are no computational models for architectural analysis that can be derived from the laws of nature. Yet there is a strong interest in design support on the architectural level. Analysis after the design process can bring forward new design knowledge. Koutamanis, van Leusen and Mitossi obtained new insights on activity allocation and compartmentalization by analysing pedestrian circulation. A very special method to enrich architectural investigation is introducing faking as part of scenario-building [Brown], currently well supported by digital techniques. Analysis as part of the design process may benefit from the curious agents proposed by Saunders and Gero that will support you in discovering interesting designs. Affordances of designs from the occupants' perspective is yet another typical architectural design consideration that is used by Tweed to analyse the use-value of a design for a variety of different occupants.

Urban Design

Urban plans can be reconstructed from the existing situation or newly designed using a design support tool. Chevier and Perrin developed an interactive tool for virtual 3D rough reconstruction of buildings using a scanned photograph and a cadastral plan. Having such a 3D model, people can participate in landscape design with a web-based tool developed by Alpha and Iki and Zhang, Tsou and Hall, thus creating design alternatives and evaluating the visual experience. Designing new urban plans is supported by the tools of Chitchian, Sauren, Sariyildiz and Heeling and of Canaparo and Robiglio. In the first case the tool is customized with specific objects and design scales. In the second case the suburbanization process is simulated using cellular automata and genetic programming.

To conclude, there are no clear revolutions going on in the field, although hindsight might prove us wrong in this respect. What we have here is an overview of a mature and well-established line of inquiry which boosts a rich development of tools to support architectural design with computers.

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