# Recent Advances in Design and Decision Support Systems in Architecture and Urban Planning

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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 1-4020-2408-8 (HB)
ISBN 1-4020-2409-6 (e-Book)

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.

*Printed on acid-free paper*

Cover design by Jos van Leeuwen.
Front image adapted from page 355, courtesy of Masahiro Murakami et al.
Back image adapted from page 225, taken from the ARTHUR project,
courtesy of Alan Penn et al.



Printed in the Netherlands.

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# PREFACE

As editors of this volume we would like to express our gratitude to the contributing authors who have delivered these highly relevant and inspiring chapters and to the international scientific committee for their help in the review and editing. Special thanks go to our colleagues Mandy van de Sande, Marlyn Aretz, and Leo van Veghel, who were great in organising the conference and took care of everything that made it a pleasant and comfortable event.

*Eindhoven, July 2004*

Jos van Leeuwen and Harry Timmermans
Conference Chairs

## INTERNATIONAL SCIENTIFIC COMMITTEE

# INTRODUCTION

The International Conference on Design & Decision Support Systems in Architecture and Urban Planning is organised bi-annually by the Eindhoven University of Technology. This volume contains a selection of papers from the seventh conference that was held at De Ruwenberg Castle in Sint-Michielsgestel, The Netherlands, from 2 to 5 July, 2004.

Traditionally, the DDSS conferences aim to be a platform for both starting and experienced researchers who focus on the development and application of computer support in the areas of urban planning and architectural design. This results in an interesting mix of well-established research projects and first explorations. It also leads to a very valuable cross-over of theories, methods, and technologies for support systems in the two different areas, architecture and urban planning. This volume contains 22 peer reviewed papers from this year's conference.

The chapters in this volume are organised into 5 sections. The first section, on artificial intelligence, deals with three applications of neural networks. The second section is about the role of visualisation in design and decision support. This section includes three chapters on how visualisation can improve public participation in governmental decision-making processes and two chapters on the potential of visualisation and design support systems in architectural design.

The third section deals with simulation technology. Simulation is implemented using agent technology in three chapters, while two other chapters implement micro-simulation techniques and cellular automata respectively. Section four contains six chapters on design research and the development of systems for design support. Finally, the fifth section includes three papers in the area of geographical information systems.

The following paragraphs provide an overview of these five sections.

## Applications of Artificial Intelligence

Being able to predict the risks related to soil and rock behaviour is of vital importance in many parts of the world. Statistical methods are generally used but are not sufficient to deal with the complex nature of phenomena such as landslides. *Yesilnacar and Hunter* present a method that utilises a neural network for enhanced predictions of landslide susceptibility. They have been able to demonstrate that their neural network model can deal with the multivariable problem of landslide susceptibility and that it is capable of pointing out the key factors for the risk of landslides.

Optimal planning of facilities, such as schools, is essential when resources are scarce. It requires careful prediction of urban and social development and activities. *Akamine and Rodrigues da Silva* evaluated an application of Artificial Neural Networks in the form of a neural spatial interaction model to address this problem. They discuss the possible reasons why this model behaves differently from the gravity models that are traditionally used in this context.

The chapter written by *Diappi, Bolchi, and Buscema* is about spatial distribution and evolution. They use neural networks (self-organising maps) to simulate the evolution of land use patterns in Milan at two different temporal thresholds between 1980 and 1994 to 2008. The use of neural networks implies that the model can learn trends in spatial evolution.

## Visualisation for Design and Decision Support

Governmental organisations are often confronted with the problem of how to make use of a large variety of information resources and how to make this information available to the public. Large scale participation of civilians in governmental decision-making processes regarding the built environment is becoming more feasible with the application of online technologies.

*Pettit, Nelson, and Cartwright* describe an Australian case study of community participation in land use planning. The case study implemented a host of digital media to allow for well-informed collaborative decision-making. *Barton, Parolin, and Weiley* developed a platform that supports integration and interoperability of many data sources concerning social, financial, and physical aspects of the urban environment. Their Spatial Decision Support Systems proposes a variety of visual interfaces to allow access to this data by both experts and non-experts.

Another interesting chapter about visualization is the one by *Shen and Kawakami*. They discuss the development of an on-line planning support system using WEBGIS in the context of public participation. Especially of interest is the expansion of the possibilities of WEBGIS to 3D *visualization*.

The ongoing development of VR technology has prompted *Göttig, Newton, and Kaufmann* to evaluate and compare a range of contemporary systems in the context of architectural models and abstract data. Aspects such as the quality of display, the quality of the spatial impression, the ease of navigation, and the effect on creativity in design are compared for four different systems. The final conclusion is not overall positive with respect to the capabilities of these systems to support early design tasks.

An interesting approach to design support is offered by *Lee and Qian*. They describe a colour coordinate system that supports the design process by

matching designers' feelings, described using adjective words, with colours taken from an indexed colour database. One function of the system is to analyse colour images and match them with adjectives and vice versa, while a second function of the system deals with various kinds of colour harmonies. The latter function supports designers in selecting a complete colour scheme that matches their aesthetic intentions.

## Simulation and Agent Technology

This volume contains two chapters about progress in developing the Masque system, a multi-agent framework for generating alternative plans in local land-use planning. It is based on a set of models, formalised expert knowledge, and a different set of decision support tools. In this framework the agents represent land-use experts and initiate the development of plan proposals and request each other to express their claims in order to incrementally draw up these proposals. Thus, some agents take care of the actual planning process, while others are used to represent existing knowledge or simulate likelihood outcomes of plan decisions. *Ma et al* outline how Bayesian belief networks are used to represent expert knowledge as part of this system. This approach is of interest in that it allows the consideration of uncertainty. *Devisch et al* discuss the use of agents to simulate housing choice. The model, still under development, focuses on the process of decision-making as opposed to observed outcomes.

Another development of a multi-agent system is presented by *Bandini, Manzoni, and Vizzari*. Their system takes advantage of elements of cellular automata and defines a model of situated cellular agents. Through this combination, the autonomous agents can operate and interact in a geometrical representation of either a physical or abstract reality. The agents' behaviour can be influenced by their spatial position and relation to adjacent as well as distant agents. The area of application is crowd modelling, where individuals are represented by interacting agents that behave according to their position and signals from elements in their environment. The multi-agent system is tied to a 3D modelling tool to allow for 3D visualisation of the environment and the agents behaviour.

The approach to simulation by *Ballas, Kingston, and Stillwell* is not based on multi-agents, but rather they support the use of general spatial micro-simulation techniques, such as simulated annealing. The chapter discusses and illustrates the potential of their spatial micro simulation-based decision support system for policy analysis. In particular, the system can be used to describe current conditions and issues in neighbourhoods, predict future trends in the composition and health of neighbourhoods and conduct

modelling and predictive analysis to measure the likely impact of policy interventions at the local level.

Cellular automata models have recently gained a lot of interest in the urban planning literature. These models are especially relevant to modelling the evolution of some spatial phenomenon. *Ohgai et al* report a state-of-the-art application to the problem of fire spread, providing evidence to the potential of such models in disaster mitigation.

## Design Research and Design Support Systems

The ARTHUR project, described by *Penn et al.*, has developed a designers' meeting table that adds digital visualisation to conventional media. Collaborating designers use so-called optical see through augmented reality displays to look at a virtual environment that is blended into the real objects on the table, while still being able to see each other as well. This chapter not only provides a detailed discussion of the system's design and implementation, but also offers a thorough discussion on design theory and the possible impacts of innovative tools on the nature of the design process.

While the importance of images as a resource in architectural design is evident, finding relevant images is still a challenging task. The approach presented by *Kacher, Bignon, and Halin* devises a hierarchy of terms, with given weights, to index images and the architectural elements represented by them. The key for the correct indexing of images is a semantic and unambiguously structured thesaurus that the authors developed to describe the images. Five criteria are used to determine the weight of the relationships between an image and the terms from this thesaurus.

There are two chapters on the application of case-based reasoning. *Bi and Medjdoub* address the problem of how to plan building services in a given space configuration. Their approach offers an interesting combination of case-based reasoning and constraint-based adaptation. With an application for ceiling layout for fan coil systems, they demonstrate how adaptation of retrieved cases can quickly lead to a better design. A strong schematisation of space layouts and sequential constraint solving are instrumental to reducing the complexity of problems.

In his chapter of case-based design, *Lindekens* argues that reduction of context information is essential in design decision-making. Without the ability to reduce the abundance of information that is usually involved in design, designers would not be able to take design decisions. Likewise, the reduction of information makes it easier for others to understand the design rationale. Transformation of information between design steps is the key to understanding the process. Based on this theory, Lindekens proposes a case-based approach to support design and re-design.

One elemental aspect of architecture is the notion of *level*. The chapter by *Bax and Trum* on Domain Theory defines the notion of level in architecture in order to structure both architectural objects and architectural design processes simultaneously in a consistent way. They discuss a number of principles to identify levels and types of levels. This leads to a hierarchy of levels of control, complexity, and composition, which are oriented towards construct, product, and form respectively.

*Chang* explores the latest developments in the Web-based Architectural Learning Environment that now supports design learning using design puzzles. This development acknowledges the fact that design is not simply about solving design problems as a puzzle, but first of all about creating the puzzle itself. It therefore supports both making the puzzle and solving it. In the WALE environment, which is a multi-user role-playing environment, design students can, in an exploring manner, make and solve interactive design puzzles.

## Geographical Information Systems

The final section of this volume contains three chapters on geographical information systems. *Tisma* presents the development of a new tool, Rasterplan, which goes beyond visualisation. Her tool also supports the allocation of future land use. It allows the realization of a quantitative program for future spatial needs for various functions such as housing, green and water areas, working, and recreation. In addition to quantitative calculations, qualitative criteria for location choice can be also expressed in a form of suitability maps or buffers.

Another utilisation of GIS databases is presented by *Rodrigues, Souza, and Mendes* in an extension of the tool ArcView. This extension, called 3DSkyView, is developed to assess and visualise sky view factors of urban environments. The sky view factor, through its thermal and geometrical parameters, is an indication for urban heat islands and can be used to identify problems in the canyons of an urban landscape. With the current implementation of this tool, the authors are able to visualise this factor in the continuum of an entire urban area.

Finally, a detailed study of how geographical information can be used in the analysis of the impact of the urban environment on public safety is shown by *Murakami, Higuchi, and Shibayama*. Through in-depth analyses using a GIS database, they are able to relate criminal incidents to the local urban layout and road network. From these observed relationships, they intend to objectively predict unsafe locations in urban environments on the basis of GIS data.