MIXED REALITY IN ARCHITECTURE, DESIGN AND CONSTRUCTION

Mixed Reality in Architecture, Design and Construction

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PREFACE

Xiangyu Wang and Marc Aurel Schnabel

PREFACE

With the advancement of digital technologies, Architecture, Design and Construction are constantly endeavouring to reach new horizons: Mixed Reality (MR) enriches their processes to these new destinies. In this book, we introduce MR technologies, research and their applications in architecture, design and construction arenas. The chapters address fundamental issues of MR and present impacts they have on these fields. As more researchers progressively employ MR as their base of enquiry, we see a need for a reference guide bringing the existing status of MR into awareness and expanding on recent research.

We include in this book, a range of invited chapters from leading researchers in the field of Mixed Reality in architecture, design and construction. All authors are experts and/or top researchers in their respective areas and each of the chapters has been rigorously reviewed for intellectual content by the editorial team to ensure a high quality. Predominantly, the chapters introduce most recent research projects on theories, applications and solutions of environments that employ MR and its technologies. More specifically, the central focus of the volume is on the manner in which they can be applied to influence practices in architecture, design collaboration, construction and education.

Introduction

To begin, we introduce, define and describe the various realms of Mixed Reality in the chapter *Framing Mixed Realities*. This overview of MR sets the context and frames the scope of the book. We describe the various realms of the Reality-Virtuality continuum and highlight their applications with key research works that are undertaken in the respective areas. This chapter is then followed by four sections in which there are chapters relating to architecture, design collaboration, construction and education.

Mixed Reality in Design Collaboration

Mixed Reality opens new avenues of communication and collaboration between architects, designers and engineers. Hence, researchers have been fascinated by the possibility of MR-mediated design. The four chapters in the second section present current research in this area.

Augmented Virtuality (AV) is explored much less than is AR. As a first trial in using AV in architecture, Xiangyu Wang and Rui Chen present in *Approaches to Augmenting Virtual Design Environments with Reality* an AV-based virtual space for remote design collaboration. Integrated into the AV environment are real-images mapped onto the surface of virtual counterparts, live video streams of participants, and 3D geometries within the environment. He describes the general concept, application scenarios, prototypical implementation, and the use of the AV system in its current state.

The second chapter by Hartmut Seichter *Communication in Augmented Reality Aided Architectural Design* explores the connection between collaborative urban design, Human Computer Interfaces (HCIs) and communication in MR applications. This chapter sheds light on aspects of communication that are particularly interesting in MR applications.

Jin Won Choi wrote the third chapter, *A Technological Review to Develop an AR-Based Design Supporting System.* It reviews the latest in AR technology and shows the manner which it can support various aspects of the construction industry. The author posits the way in which AR can support design and develops a design support system using realistic AR techniques.

The last chapter in this selection is by Xiangyu Wang and Mi Jeong Kim, *Exploring Presence and Performance in Mixed Reality-Based Design Space*, which presents an exploratory study on measuring the extent of presence in an MR-based design space through a comparative study using a tabletop system with two different types of displays: head-mounted displays and 2D screens. This study explores the link between object presence and design performance in immersive MR-based design space while manipulating 3D blocks representing virtual furniture.

As is evident, this chapter envisions a shift of paradigm to AR with the potential for an economic ripple effect, similar to that caused by the appearance of CAD/CAM techniques.

Mixed Reality in Architecture

The third section contains chapters addressing the issues and application of the Mixed Reality concept and technology in architecture. That four chapters address this specific topic in this section, attests to the rising importance with which this issue is regarded in the computer-aided architectural design (CAAD) community.

As Augmented Reality (AR) technology is migrating to mobile phones, it is critical to investigate how this class of technology/devices can be used to support architectural applications. The first chapter by Mark Billinghurst and Anders Henrysson, *Mobile Architectural Augmented Reality*, reviews previous work in the area of mobile AR in architecture, suggests how it could be applied in an architectural setting, and describes promising future research directions.

The second chapter by Bruce Hunter Thomas, *Augmented Reality Visualisation Facilitating the Architectural Process*, examines how a wearable AR computer system can facilitate the architectural design process for the user. He presents an overview of wearable computer technologies and AR and then introduces his AR 'Tinmith' Backpack System computer system.

As a means to digitally archive historical building information, the chapter by Atsuko Kaga, *Simulation of an Historic Building Using a Tablet Mixed Reality System*, proposes the use of 'Tablet MR,' which can overlay on-the-spot photographic images and Virtual Reality (VR) images to realise a simulation for education of a historical building site. Construction of an experimental model, evaluation of accuracy, and suggestion of a system application possibility are also performed.

This section concludes with the chapter by Jules Moloney – *Temporal Context and Concurrent Evaluation*. He explores the question of how MR might be integrated with current practice to enable more considered decision making at the early stages of design. Two ideas are introduced, temporal visualisation and concurrent evaluation, as the conceptual underpinnings of the implementation of MR technology. This chapter also reviews the taxonomy of MR, and clarifies the requirements for a decision support visualisation environment.

Mixed Reality in Construction

The fourth section looks at three applications that stand as exemplars of Mixed Reality in a construction context. They discuss both static and mobile MR-interactions that allow for a new mode of engagement and way-finding in the process of building, construction and related fields.

Phillip S. Dunston and Do Hyoung Shin set out to explore *Key Areas and Issues for Augmented Reality Applications on Construction Sites*. They present potential applications for MR to support construction activities. They study three key areas whereby MR aids the process: inspection coordination and communication.

In his chapter *Tracking Technologies for Outdoor Mixed Reality Applications*, Amin Hammad proposes novel techniques for the way in which virtual models of construction equipment can be operated and viewed by several operators to interactively simulate construction activities on a construction site. He presents a real scenario and discusses a framework for general use.

Finally, Marcus Tönnis and Gudrun Klinker conclude this section with their chapter *Augmented 3D Arrows Reach their Limits in Automotive Environments*. They describe their research in interface and navigation within a 3D MR realm. Based on automotive MR-information support, the research discusses MR as an aid for navigation without distracting the operator. This research has a

variety of potential applications in the construction industries, and therefore stands as a sample of one way in which to explore the new possibilities that MR offers to the field.

Mixed Reality in Education and Learning

In the last section, the role of Mixed Reality in learning and education is discussed. Students and educators are not only challenged with teaching and learning to use tools and instruments, they also have to understand the essence of designing. In this capacity, MR can be a medium that allows the exploration and integration of ideas into the domain of the real.

Firstly, Remo Burkhard and Gerhard Schmitt present in their chapter *Visualising Future Cities in the ETH Value Lab: New Methods for Education and Learning* how MR allows not only students, but also urban planners and decision-makers, to engage in research from the very beginning of a design process. They describe how their MR-lab fits into an educational framework and how the facilities are used in city planning and research.

In the following chapter, *Interplay of Domains: New Dimensions of Design Learning in Mixed Realities*, Marc Aurel Schnabel argues that the distance between the idea in the imagination of a design and its representation, communication and realisation can be bridged by employing MR. Especially in an educational context, the reinterpretations of the design ideas in different realms allows students to understand their actions and reflect on their design as a deep learning experience.

In the final chapter, Thomas Kvan discusses in *Debating Opportunities: Learning Design through Different Structures* the role of representation and simulation in the design process. He specifically focuses on the role of the model in MR and as a medium to support learning in design studios. He concludes with a postulation of the contribution MR makes on design learning.

Postscript

To provide the reader with easy access to all content of the book and to provide an overview and guide of relevant literature in the field, we include a Glossary and References from all chapters in the Postscript. Here too, we reflect critically on the investigations presented and propose ways in which the field may evolve in near future. The contributions made in this book are a snapshot of the current research in Mixed Reality that is evolving rapidly opening new horizons to the fields of architecture, design, and construction. The use of MR in these industries will soon become standard like CAAD or Building Information Modelling (BIM). It is exciting to be able to take part in the development of these new possibilities.

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