

Applications of Mixed Reality

Article · January 2009

CITATIONS

2

READS

768

1 author:



Hannes Kaufmann

TU Wien

135 PUBLICATIONS 3,117 CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:



PLAYMANCER [View project](#)



D*STAR - Entwicklung eines 3D-Raumvorstellungs-Lerntests in Augmented Reality [View project](#)

Habilitationsschrift

Applications of Mixed Reality

ausgeführt zum Zwecke der Erlangung der venia docendi
im Habilitationsfach "Angewandte Informatik"

eingereicht im Mai 2009 an der
Technischen Universität Wien
Fakultät für Informatik

von

Mag.rer.nat. Dr.techn. Hannes Kaufmann
Ospelgasse 1-9/1/39, 1200 Wien
kaufmann@construct3d.org

Wien, am 27. Mai 2009

Contents

Introduction	1
1. Kaufmann H., Schmalstieg D. Mathematics and geometry education with collaborative augmented reality Computers & Graphics, Volume 27, Issue 3, pp. 339-345, June 2003.	20
2. Kaufmann H., Dünser A. Summary of Usability Evaluations of an Educational Augmented Reality Application R. Shumaker (Ed.): Virtual Reality, HCI International Conference (HCII 2007), Volume 14, LNCS 4563, ISBN: 978-3-540-73334-8, Springer-Verlag Berlin Heidelberg, pp. 660–669, July 2007.	27
3. Kaufmann H. Dynamic Differential Geometry in Education to appear in Journal for Geometry and Graphics, vol. 13, 1, 2009. (accepted for publication)	37
4. Kaufmann H., Csisinko M., Totter A. Long Distance Distribution of Educational Augmented Reality Applications Eurographics'06 (Educational Papers), pp. 23-33, Vienna, Austria, September 2006.	50
5. Kaufmann H., Csisinko M. Multiple Head Mounted Displays in Virtual and Augmented Reality Applications International Journal of Virtual Reality, vol. 6, no. 2, pp. 43-50, June 2007.	60
6. Kaufmann H., Meyer B. Simulating Educational Physical Experiments in Augmented Reality Proceedings of ACM SIGGRAPH ASIA 2008 Educators Program, Singapore, ACM Press, New York, NY, USA, December 2008.	68
7. Kaufmann H., Csisinko M., Strasser I., Strauss S., Koller I., Glück J. Design of a Virtual Reality Supported Test for Spatial Abilities in Proceedings of the 13 th International Conference on Geometry and Graphics (ICGG), Dresden, Germany, pp. 122-123, August 2008.	76
8. Csisinko M., Kaufmann H. Towards a Universal Implementation of 3D User Interaction Techniques in Mixed Reality User Interfaces: Specification, Authoring, Adaptation (MRUI07), Workshop Proceedings, Charlotte, North Carolina, USA, pp. 17-25, March 2007.	86

Introduction

This thesis gives an overview of the author’s scientific work in previous years. It reflects the author’s ambition to develop applications of mixed reality which are beneficial to society as a whole or to specific groups of people. Providing and deploying high-end mixed reality hardware and software applications to multiple users and larger target groups finally raises questions of scalability, robustness, design and affordability of the technology involved. They trigger scientific questions and developments in return. All of these aspects will be touched in this work.

The first part of the introduction defines the scientific domain and various problems therein followed by a discussion of the author’s contribution in this area. The individual publications that constitute the remainder of the thesis are briefly discussed and put in context.

Definitions

Since the area “Applications of Mixed Reality” – chosen as the title of this thesis – is very broad it is important to establish common terms in the beginning.

In order to classify virtual reality (VR) research Milgram and Kishino [1] published a taxonomy 15 years ago. Although the field widened and diversified over the years their work still provides a rough framework which helps to classify any work done in this area. We refer to the virtual continuum (Figure 1) as discussed in Milgram and Kishino’s paper. The virtual continuum represents a continuous set of (infinite) possibilities between real environments and fully virtual environments (VEs). All environments within that range (except the extremes of fully real and virtual environments) are considered mixed realities.

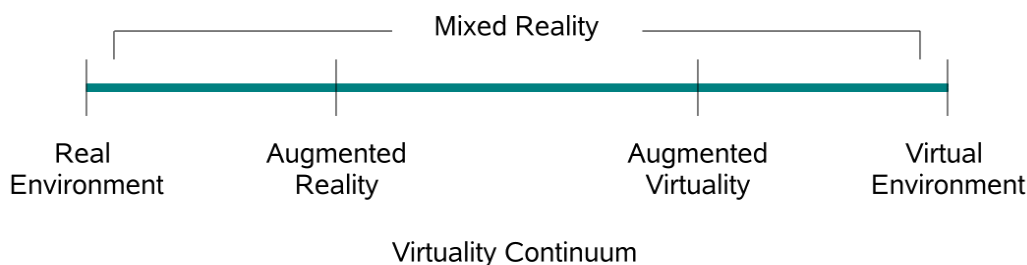


Figure 1: The Virtuality Continuum

Further on the authors specify and classify hardware and software environments within the virtual continuum and define six classes of “hybrid display environments”. In a second paper [2] they add a seventh class. Nevertheless given the broad range of

virtual reality hardware and setup variations available today it is neither always clear nor easy to identify into which category a specific setup falls.

Related to Milgram's taxonomy many applications presented in this thesis belong to class 6 (defined in [1]) which states

"6. Completely graphic but partially immersive environments (e.g. large screen displays) in which real physical objects in the user's environment play a role in (or interfere with) the computer generated scene, such as in reaching in and "grabbing" something with one's own hand [...]."

They mention further

"We note in addition that Class 6 displays go beyond Classes 1, 2, 4 and 5, in including directly viewed real-world objects also. As discussed below, the experience of viewing one's own *real* hand directly in front of one's self, for example, is quite distinct from viewing an image of the same real hand on a monitor, and the associated perceptual issues (not discussed in this paper) are also rather different. Finally, an interesting alternative solution to the terminology problem posed by Class 6 as well as composite Class 5 AR/AV displays might be the term "*Hybrid Reality*" (HR), as a way of encompassing the concept of blending many types of distinct display media."

Milgram and Kishino described three additional dimensions that distinguish different mixed reality systems: Extent of world knowledge (i.e. degree of knowledge of the real world by the application), reproduction fidelity (visual quality) and extent of Presence metaphor. Presence in short can be defined as a subjective phenomenon of the sensation of being in a virtual environment [3, 4]. It is the most researched dimension of the three and of high importance when designing new applications [5]. Different concepts and interpretations of presence have been discussed [5]. Whereas some applications require full presence of users others might require shared and equal awareness of the real and virtual e.g. in educational applications where teachers are outside the VE guiding students. With different Mixed Reality (MR) setups these variations can be achieved while maintaining a high level of presence in all cases. Appropriate and corresponding examples of application areas and target groups will be mentioned later.

Our work fulfills as well Azuma's definition of Augmented Reality (AR) [6], who defines AR as systems that have the following three characteristics:

- 1) Combine real and virtual
- 2) Interactive in real time
- 3) Registered in 3-D

The presented research covers a wide range of environments which are always interactive in real time but fulfill items 1 and 3 to varying degrees. The variety of systems is better encompassed by the term Mixed Reality or even Hybrid Reality – the latter term was not in use after Milgram and Kishino coined it.

System Architecture

A wide variety of MR hardware and software setups are imaginable and have been built in the past. However all share a common general system architecture. The five key elements of an MR system [7] comprise input and output devices whose spatial position and orientation might be tracked, a computing platform with a powerful

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.