13

Augmented Reality for Multi-disciplinary Collaboration

Rui(Irene) Chen and Xiangyu Wang
The University of Sydney
Australia

1. Introduction

During the past few years, people have started to consider using digital technologies to assist the multi-disciplinary work (Sonnenwald, 2007; Mentzas & Bafoutsou, 2004; Bos & Zimmerman, 2007). Many design activities involve participants from different disciplines. Cross-disciplines require information sharing. Comprehension also becomes more complicated. Therefore the need of understanding the other disciplines has become more important. However, as the number of specialty areas increases, the languages that define each separate knowledge base become increasingly complicating. Hence, concepts and viewpoints that were once considered as part of a whole become detached. This phenomenon is typical of the development of tertiary education, especially within professional oriented courses, where disciplines and sub-disciplines have grown further away from each other and the ability to communicate with different disciplines has become increasingly scrappy.

Although the combination of different discipline bases within the same school or department has been considered to some extent, many of them do not take the full advantages of the hybrid opportunities that are related to the work within cross-disciplines. Most time institutes or schools educate different disciplines' students separately, therefore, students only can be taught to seek for single-source solutions. Hence, there is a need to establish the knowledge of cross-discipline in education. For example, in a typical construction project, there involves knowledge from several different domains. Architects design the building and coordinate the input of other specialists in the team. Land surveyors survey the property and structural engineers design and specify the structural components of a building including foundations, footings, posts, beams, wall systems, etc. Electrical engineers design the power, lighting and communication requirements of the building. Mechanical engineers design the heating, cooling and ventilation of the building. Hydraulics engineers are in charge of designing the water and sewerage requirements. Quantity surveyors are responsible for the cost estimation of the design. It is apparent that different disciplines need to have a common platform to communicate and collaborate together.

2. Needs

It is essential to coordinate a team of specialist consultants, the possible solution to help design and coordinate the cross-discipline work no matter whether it is a small or large

Source: Augmented Reality, Book edited by: Soha Maad,
ISBN 978-953-7619-69-5, pp. 230, January 2010, INTECH, Croatia, downloaded from SCIYO.COM

project. Same level of attentions should be paid to each discipline in details. Although usually architects play a valuable mediation role in the built environment, working closely with user groups and clients, builders, trades-people, government bodies, councillors and consultants, balancing their needs and requirements. This mediating role requires architects to have coordination, negotiation and resolution skills (Holm, 2006).

Architects usually need to establish the client's needs, expectations, project requirements and budgets. This usually should be collected to prepare the design brief.

Architects analyses the design brief, the site conditions, features and constraints and then determines the best location and orientation. Architects begin to develop ideas through rough plans, sketches and models. These ideas are brought together into concept design drawings. The most common communication method is to use two-dimensional drawings produced by computer-aided design (CAD) systems to convey design information by means of representing three dimensional buildings and surrounding elements (road, pool, landscape, infrastructure, etc.) and depict their relationship in the project site (Holm, 2006). In addition, the development team need communicate their planning information regarding costs, management hierarchy and feasibility studies in forms of tables and diagrams generated by some spreadsheet software. However, this is often not easily transferred into designs and drawings. It causes the difficulties for each specified discipline to comprehend each other's information due to the fact that their information may be incoherent or are typically viewed in separate working environments. Therefore, there is a need to offer the work platform for knowledge gaining and express the analytical thinking from multi-discipline.

3. Collaboration

Hara (2003) summarises collaboration as people working together for a common goal and sharing of knowledge. Similarly, Weiseith, Munkvold, Tvedte, and Larsen (2006) suggest that collaboration takes place when two or more people communicate and cooperate to reach a goal. Effective collaboration requires all involved appropriately and actively working together. There have been studies to identify the factors involved in combining peers. There are certain phases involved in collaboration in design as shown in Fig. 1.

Most time, the first step is to identify information needs no matter which design they are required to implement. Then it moves to the initiation phase which prepares a clear guide about what information to be collected. Then the design phases engage in many different tasks, however, all the disciplines need to actively develop their ideas, through rough plans, sketches and models. Design ideas should be brought together in a later stage and processed to generate proper data for analysis. Since the collaborative work generally involves different specialized knowledge, when they are processed together, there is always a need to be revised. Finally, it can be collated to see if it meets the requirements.

Creamer and Lattuca (Creamer & Lattuca, 2005) underscored the social inquiry aspect of collaboration, suggesting that collaboration promotes people understanding and learning from each other. In describing collaboration as social practice, they emphasise the role of interaction and building relationships. In the context of learning, Oliver, Herrington, and Reeves (Oliver et al., 2007) described collaboration as "interactions that are interdependent and actually promote the kinds of joint contributions of different domain knowledge that enable outcomes to exceed what might normally be achieved by individual activity. Therefore, it is apparent that the lack of mutual understanding of cross-discipline could cause inefficient work, cease the learning esteem and even delay the work progress.

Fig. 1. Phases for collaboration in design

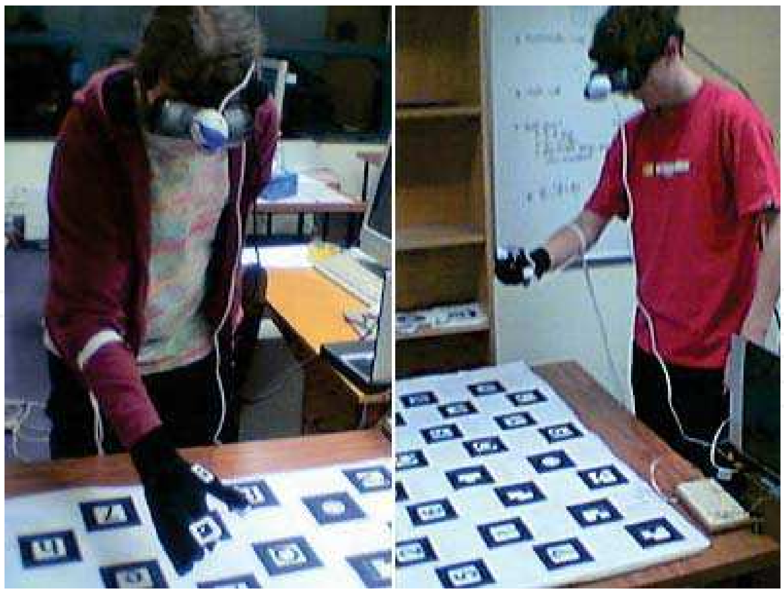
4. Related work

The problem of information transfer between different disciplines may result it certain delays of decision-making and also lack in the practicability of the design. Several attempts have been made to eliminate the problems by integrating knowledge from different fields with digital environments that allow multiple disciplines to input their information and also interact with digital information seamlessly and intuitively during the design processes.

The project of FingARtips used Augmented Reality technology that requires users to wear heads-up displays or virtual glasses (Buchmann et al., 2004) (see Fig. 2.(a) (b)) to be able to view digital information that is overlaid onto physical objects in the real world (see Fig.3.(a) (b)). So the setup of urban planning workspace allows the users to see the immersive view of a model.

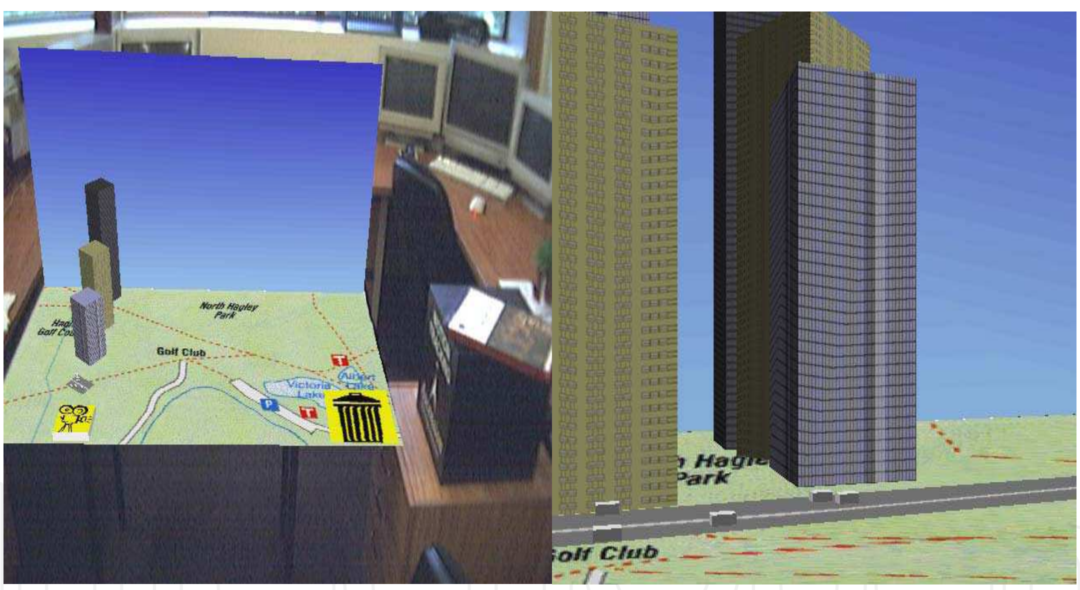
However, this feature is limited by the number of concurrent users the system can handle at a given time and the cost of equipment for single users may not be feasible for large size of users from different disciplines. Furthermore, another issue is tracking inaccuracy. Only when the glove is reliably tracked, can the system be thoroughly evaluated and put to use.

Another example is MetaDESK called "Tangible Geospace" (Ishii & Ullmer, 2006) which is one of Tangible User Interface system. It has been used in urban design and planning and has been developed for designers who need to collaborate with the other disciplines simultaneously in a single environment. Several physical objects and instruments for interacting with geographical space sit in a translucent holding tray on the metaDESK's surface (Ishii & Ullmer, 2006). Through placing a small physical model (phicon) of Great Dome onto the desk, a two-dimensional map appears underneath on the desk, bound to the Dome object at its location on the map. Simultaneously, the arm-mounted active lens (Ishii & Ullmer, 2006) (Fig. 4. (a)) displays a three-dimensional view of MIT with its buildings in perspective.



(a) (b)

Fig. 2. (a)(b). The urban planning demonstration setup.



(a) (b)

Fig. 3. (a). The urban planning workspace (b) Immersive view of a model (Buchmann et al., 2004)

As an alternative to the two phicon scaling/rotation interaction, a rotation constraint instrument made of two cylinders mechanically coupled by a sliding bar has been implemented (see Fig.4.(b)). This instrument allows scaling and rotation manipulation of the two geospace control points, while preventing the ambiguous two-phicon rotation by the intrinsic mechanical constraint.

However, this main function is to view existing design and it seems not enough to assist the users from multi-disciplines to make informative design decisions along with engineers and planners.

(a) (b)

Fig. 4. (a). Active lens in tangible Geospace (b). Rotation constraint instrument (Ishii & Ullmer, 2006)

5. Application framework

In order to ensure dynamic and interactive knowledge among different fields in building design which is an essential prerequisite for effective collaboration, a suitable knowledge base is required for gaining the different information. Therefore, the knowledge base collects from each individual workspace specific to each individual knowledge domain that corresponds to the number of specialists involved, as well as into the shared design workspace (see Fig. 6).

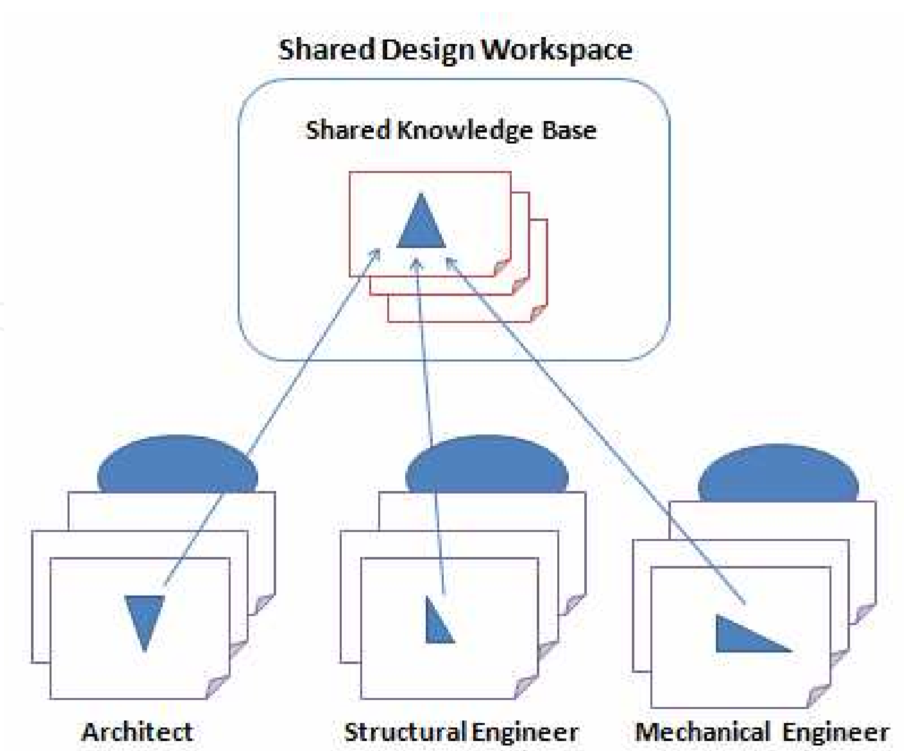


Fig. 6. Private and shared knowledge base

This model presents a distributed structure of independent Design Workspace, each referring to one of the numerous disciplines in design domain. The benefit of this structure is that each of the individual parts are linked directly to a centralized knowledge base so that they can all visualize the integration of the partial solutions.
During the design process individuals are able to create or modify their own personal design with their own specific knowledge and describe it with their own personal or professional languages. This process is none other than merging the knowledge from all the different disciplines into shared workspace.
The database should be developed based on the model of the structure described above. Hence, during the design process each sector can verify their own personal design case using their own specialist knowledge until they have deemed it to be satisfactory. Meanwhile, the updating information will be transferred to the top of knowledge base so updating and combining can be instantly and spontaneously made.
The main application of this framework lies in the interpretation between different disciplines and provides users with immediate feedback with relevant results through an intuitive interface. The process starts when the users from different disciplines enter their primary design with essential data. In some specific part, if users do not know or understand the design from other disciplines, they can directly contact with the other users from those disciplines. Users have their own workspaces which enable them to interact with the physical objects as if they would like to do so with an actual physical of a design project. Information can then be calculated and combined and the outcome can be immediately projected in the corresponding discipline. The Fig.7 has demonstrated the relationships between the different elements in the framework.

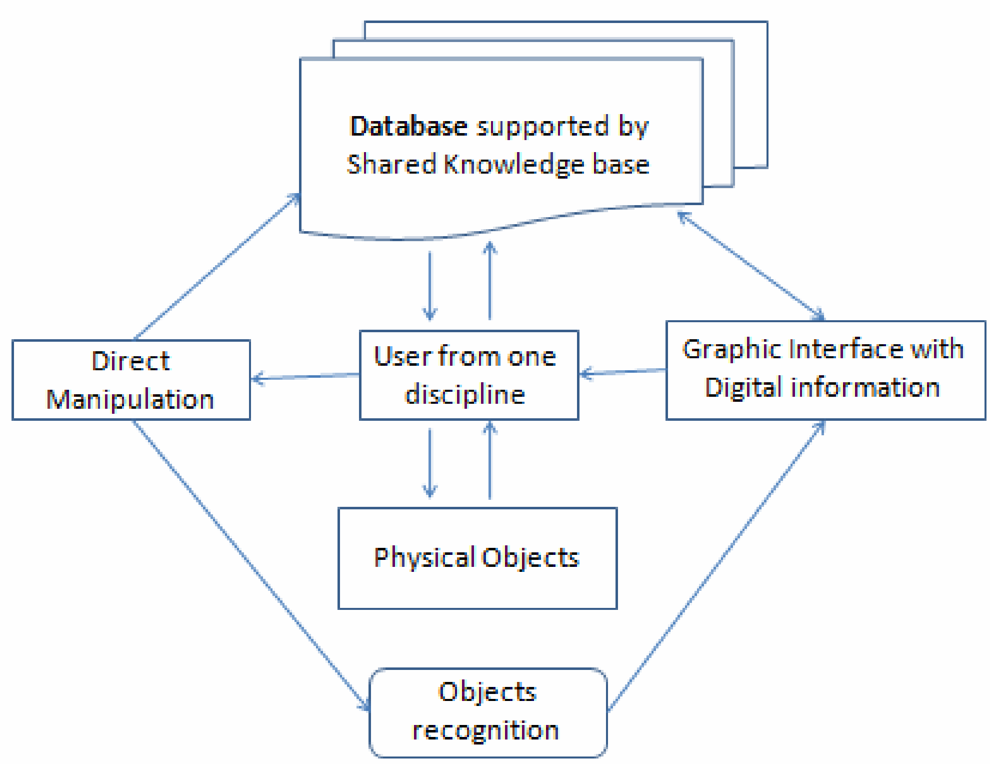


Fig. 7. The relationship between the elements

6. Scenario

The scenario based on the framework provides visual aids for interpreting and communicating drawings from architects to engineers. Superintendents/project managers on site usually refer to design drawings and specifications to examine if the work is performed as designed because chances are that workers on site cannot fully understand the design (Dunston & Shin, 2009). Although the architects can be requested to staff on site and check the correctness, it is still unavoidable that miscommunication or misinterpretation can appear quite often. For instance, one architect may try to convey some instructions about a specific task, however, he/she may find it hard to describe in words or 2D sketch. This often fails since during this process, an individual refers to their own mental image of forming and the result of forming an image is different depending on the different tasks and resources. The 2D drawing usually does not contain sufficient information for workers on site to imagine the actual design in actual scale, accurate position and orientation. Some research (Cooper & Podgorny, 1976; Shepard, 1992) indicated that it involves a large amount of time to mentally match a rotated object with an original object as angular difference results in different orientation and also it may require extra mental load to depict the specific position in real world location. Apparently, the mental load experienced in inferring 3D design from 2D drawings increases as a design becomes more complicated. These factors underline the importance of using proposed framework into the design. Since Tangible Augmented Reality systems could help different disciplines of the co-workers to understand

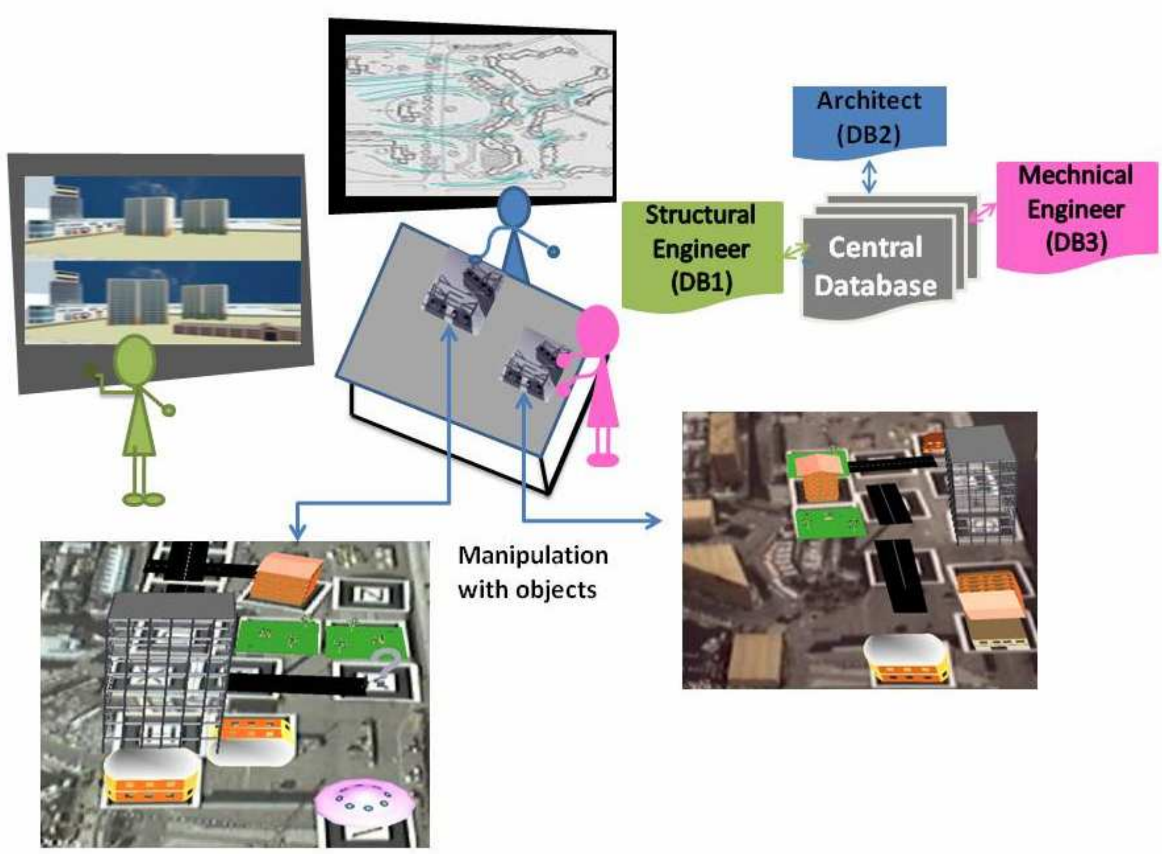


Fig. 8. Scenario demonstration

each other better. Firstly, the Tangible Augmented Reality system could render spatially from the selected portion to display the 3D design model in a real scale. Particularly, the intuitive interfaces are used to couple physical objects with digital information by means of physical input from the users as the demonstration you can see from the Fig.8. The information from different disciplines can be stored in different databases and finally exchanged the information in the central database. The Tangible Augmented Reality systems allow them to get instant feedback from the information being re-updated after the manipulation from the users. Therefore the reflection of the communication from the multi disciplines will not get lost or confused because of the correction or change from various aspects.

With the additional Tangible User Interfaces, the input and output sources can be integrated into the system. The digital information is displayed by overlaying the projector beneath the physical objects (Fisher & Flohr, 2008).

In addition, the database is built based on the structure of a shared knowledge base. Any instant modification or change can be detected and updated to the other user from different disciplines. The re-calculated and updated data can be informed immediately without delay. A conceptual image with calculated 3D design and contextual data can be displayed by Augmented Reality systems (see Fig. 9).

Fig. 9. A conceptual image of AR overlay of 3D design and contextual data (Dunston & Shin, 2009).

During these tasks, all users from different disciplines need to exchange information back and forth until the final compromise is met leading towards an agreeable and premier design. In this way, a common workspace is offered to solve these differences with visual and tactile aids.

7. Summary

This chapter presents a framework for multi-disciplinary collaboration. Tangible Augmented Reality has been raised as one of suitable systems for design collaboration. Furthermore, it emphasizes the advantages of Tangible Augmented Reality to illustrate the needs for integrating the Tangible User Interfaces and Augmented Reality Systems.

8. References

Bos, N. & Zimmerman, A. (2007). From shared databases to communities of practice: A taxonomy of collaboratories. *Journal of Computer-Mediated Communication, 12*(2), pp. 652–672.

Buchmann, V.; Violich, S.; Billinghurst, M. & Cockburn, A. (2004). FingARtips: gesture – based direct manipulation in Augmented Reality, *Proceedings of the 2nd international conference on Computer graphics and interactive techniques*, 15-18th June, ACM Press, New York, pp. 212-221.

Cooper, L.A. & Podgorny, P. (1976). Mental transformations and visual comparison process: Effects of complexity and similiarity, *Journal of Experimental Psychology: Human Perception and Performance*, 2(4), pp503-514.

Creamer, E. G. & Lattuca, L.R. (Eds.) (2005). *Advancing Faculty Learning Through Interdisciplinary Collaboration: New Directions for Teaching and Learning, No. 102.* New York: Wiley Periodicals.

Dunston, P.S. & Shin, D.H. (2009). "Key areas and issues for augmented reality applications on construction sites", in Wang, X. & Schnabel, M (eds.), Mixed Reality Applications in Architecture, Design, and Construction, Springer-Verlag, pp157-170.

Fischer, J. & Flohr, D. (2008). Selective Stylization for Visually Uniform Tangible AR, *in*B. Mohler and R. van Liere (ed), *EGVE Symposium08*, The Eurographics Association.

Hara, N. (2003). An emerging view of scientific collaboration: Scientists' perspectives on collaboration and factors that impact collaboration. *Journal of the American Society for Information Science and Technology, 54*(10), pp952–965.

Holm, I. (2006). *Ideas and Beliefs in Architecture and Industrial design: How Attitudes, Orientations, and Underlying Assumptions Shape the Built Environment*. Oslo School of Architecture and Design. ISBN 8254701741.

Ishii, H. & Ullmer, B. (2006). Tangible Bits: Towards Seamless Interfaces betweenPeople, Bits and Atoms, *CHI97*, March 22-27, ACM Press.

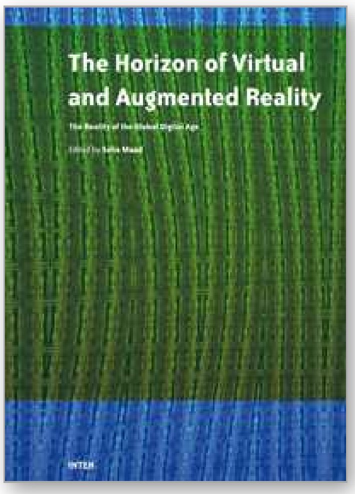
Mentzas, G. & Bafoutsou, G. (2004). Electronic collaboration, communication and cooperation: A taxonomy and a prototype. In E. Y. Li & T. C. Du (Eds.) *Advances in Electronic Business, Vol. 1, Theme: "Collaborative Commerce"*. (pp. 19-52). Idea Group Publishing.

Oliver, R. ; Herrington, J. & Reeves, T.C.(2007). Representing authentic learning designs: Supporting the development of online communities of learners. *Journal of Learning Design, 2*(2), pp1–21.

Shepard, R.N. (1992). Musing on telepresence and virtual presence, Presence; Telecoperators and Virtual Environments, 1(1), pp 120-126.

Sonnenwald, D. H. (2007). Scientific collaboration. In B. Cronin (Ed.). *Annual Review of Information Science and Technology, Vol 41* (pp. 643–681). Medford, New Jersey: Information Today.

Weiseth, P. E.; Munkvold, B. E.; Tvedte, B. & Larsen, S. (2006). The Wheel of Collaboration Tools: A typology for analysis within a holistic framework. *CSCW '06, Banff, Alberta, Canada.*



Augmented Reality
Edited by Soha Maad

ISBN 978-953-7619-69-5
Hard cover, 230 pages
Publisher InTech
Published online 01, January, 2010
Published in print edition January, 2010

Virtual Reality (VR) and Augmented Reality (AR) tools and techniques supply virtual environments that have key characteristics in common with our physical environment. Viewing and interacting with 3D objects is closer to reality than abstract mathematical and 2D approaches. Augmented Reality (AR) technology, a more expansive form of VR is emerging as a cutting-edge technology that integrates images of virtual objects into a real world. In that respect Virtual and Augmented reality can potentially serve two objectives: reflecting realism through a closer correspondence with real experience, and extending the power of computer-based technology to better reflect abstract experience. With the growing amount of digital data that can be stored and accessed there is a rising need to harness this data and transform it into an engine capable of developing our view and perception of the world and of boosting the economic activity across domain verticals. Graphs, pie charts and spreadsheet are not anymore the unique medium to convey the world. Advanced interactive patterns of visualization and representations are emerging as a viable alternative with the latest advances in emerging technologies such as AR and VR. And the potential and rewards are tremendous. This book discusses the opportunities and challenges facing the development of this technology.

INTECH
open science | open minds

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821