AN OVERVIEW ON COLLABORATIVE AUGMENTED REALITY ENVIRONMENT POTENTIALS IN URBAN PLANNING

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ABSTRACT

This paper describes an augmented reality (AR) environment that allows multiple participants or multi-user to interact with 2D and 3D data. AR simply can provide a collaborative interactive AR environment for urban planning, where users can interact naturally and intuitively. In addition, the collaborative AR makes participants in urban planning to share simultaneously a real world and virtual world. The fusion between real and virtual world, existed in AR environment, achieves higher interactivity as a key features of collaborative AR. In real-time, precise registration between both worlds and multi-user are crucial for the collaborations. Common problems in AR environment will be discussed and major issues in collaborative AR will be explained details in this survey. The features of collaboration in AR environment are will be identified and the requirements of collaborative AR will be defined. This paper will give an overview on collaborative AR approach potentials in urban studies and planning. The work will also cover numerous systems of collaborative AR environments for multi-user.

Keywords: Augmented Reality, Multi-User, Collaborative, Urban Planning.

1 INTRODUCTION

In 1965, Ivan Sutherland developed a technology that made it possible to overlay virtual images on the real world [1]. Attaching two head worn miniature Cathode Ray Tubes (CRT) to a mechanical tracker he created the first display known as Head-Mounted Display (HMD). With this technology of display users could see a simple virtual wireframe cube layover in our real world, as the first AR interface born. The term AR is often used to refer to interfaces in which two and three-dimensional computer graphics are superimposed over real objects, typically viewed through head-mounted or handheld displays [2]. In 1994, the context of AR, often the term “Mixed Reality” (MR) is used. It is a superset of AR and covers the reality-virtuality continuum between completely real environments and completely virtual environments, a concept introduced by Milgram and Kishino [3], which encompasses both AR and Augmented Virtuality (AV). The degree of how much both elements between virtual and real objects, are within an MR application, define its classification as either AR or AV. Azuma and friends [4] provide an in-depth review of current and past AR technology and applications in their research.

Based on review related literature on urban planning, the Digital Urban Planning was first come up with the development of Digital City in later 2000. Professor Lai Ming, who is one of the officials of the Ministry of China Construction, pointed out that Digital City supplied totally new way to solve the issues of urban planning, managing, constructing, and controlling [5]. At the same time, Professor Ding Lie Yun said that the concept and method of urban planning require to be changed along with the development of digital city [6]. Two months later, Professor Jian Fengmin [7] published a paper titled "from digital earth to digital urban planning. The fact is that the concept has been built-up during the past five years, from 2000 to 2005. In 2001, Professor Wu Shuxia [8] claims that digital urban planning was the combination of theory and method of traditional urban planning with new technology in the new digital city period. The concept of digital urban planning is not only the technology, but also the quantitative theory and method of urban planning [9]. Later, technologies AR are expanding for urban planning. An Augmented Reality Workbench called “Luminous Table” that attempts to deal with this issue by integrating multiple forms of physical and digital representations. In order to support the urban design process, 2D drawings, 3D physical models, and digital simulation are overlaid into a single
information space [10]. Schmalstieg et. al. [11] describes how AR technology is applied in the urban reconstruction process and can be used to share the sense of place and presence. It introduces Urban Sketcher, an AR prototype application designed to support the urban renewal process near or on the urban reconstruction site.

This paper describes collaborative AR environment potentials to be applied in urban planning that employs collaborative AR as a medium of collaboration. This paper will explain a collaborative AR system for real-time involves interaction operations. AR enables us to enhance real world with virtual world. Section 2 will describe AR environment for urban planning and common problems encountered in order to propose AR environment. Their subsection will explain about collaborative AR environment including their features of collaborative AR, and requirements of collaborative AR environments. In the next section will summarize the previous collaborative AR environments that have already developed and proposed by group of AR researcher that focusing on AR collaboration for collaborative AR environment. Finally, this paper will discuss the comparative studies on previous works of AR projects, focusing on collaborative AR environment for urban planning. Conclusion and future directions are discussed in Section 6.

2 AR ENVIRONMENT FOR URBAN PLANNING

Traditionally urban design is perceived, communicated and created using physical and digital media. However, these realms are handled as separate entities, which hinder collaboration, understanding and communication. Collaborative AR systems can integrate these tasks into one media type and allow a different conversation with complex issues. Human Computer Interfaces (HCI) and Tangible User Interfaces play a key role in AR. They allow the combination with both the real and virtual component of an urban design project.

AR environments are defined by Milgram and Kishino [3] as those in which real world and virtual world objects are presented together on a single display. The AR applications have shown that AR interfaces can enable a person to interact with the real world in ways never before possible [2]. A comprehensive survey of AR is found in [4]. These AR researches, however, have been made mainly on single-user applications so far. New application fields will appear if multi-user able to share a physical space and if we can seamlessly offer a virtual space into the shared physical space [12]. For example, it becomes possible for multiple people to collaborate to design something while exchanging their ideas through virtual objects [13].

Common to all roundtable meetings is that the multi-user are sitting together, facing each other, and communicating verbally and through hand gestures and facial expressions [14]. Multi-user is often starting with simple sketches by their hand drawings, improving over several stages of 2D plans and 3D models, gradually getting more complex and finally leading to very complex CAD models and highly real 3D models [14]. It is a highly iterative process, which is often very slow. Architects consider the possibility of interactively varying and touching the sketches, plans, and models as an essential part of motivation during design review meetings. AR collaboration and multi-user for urban planning are reflected by the use of intuitive interaction mechanisms, which allow even untrained users to benefit from the enhancements provided by the AR environment.

3 COLLABORATIVE AR ENVIRONMENT

In collaboration, people use speech, gesture, gaze and non-verbal cues to attempt to communicate in the clearest possible fashion. Interactions can be characterized into two groups: user-object interactions and user-user interactions. User-user interactions deal with communication between users, such as chat. Once we got a few users interact among them in AR environment with user-object interaction and user-user interaction, we referred this kind of environment as collaborative AR environment. The framework for collaborative AR environment is setting up as illustrated in figure 3. Marker in augmented reality is assigned as base marker and also can be used as interaction tools which we can assign action for each single marker. The base marker is a set of marker used to station the virtual object. Interaction markers are used to manipulate object projected on this base marker set. Both markers must work together to make the
whole environment works. We may treat each of these markers as a single marker. Each of these markers can be assigned with an action. Marker can be used as interaction tools. The pattern for these markers must be unique. Sample of pattern of marker is shown in figure 4.

3.1 Collaborative AR interfaces

In face-to-face collaboration, people use speech, gesture, gaze and non-verbal cues to attempt to communicate in the clearest possible fashion. Real objects are also more than just a source of information, they are also the constituents of the collaborative activity, create reference frames for communication and alter the dynamics of interaction, especially in multi-user settings [15]. The collaborative AR environment developed allows users to share a virtual space projected into their common working environment [13].

A seam is a spatial, temporal or functional constraint that forces the user to shift among a variety of spaces or modes of operation [19]. People looking at a projection screen or crowded around a desktop monitor are less able to refer to real objects or use natural communication behaviors [20]. Tangible User Interfaces (TUI) can be used to support collaboration and develop the theme of how real world objects can be used as computer input and output devices [10]. Tangible interfaces are extremely intuitive to use because physical object manipulations are mapped one-to-one to virtual object operations. However, information display can be a challenge. It is difficult to dynamically change an object’s physical properties, so most information display is confined to image projection on objects or augmented surfaces.

![Figure 3. Framework of collaborative AR environment for urban planning](image)

![Figure 4. Sample of marker pattern](image)

**Table 1. Comparison of collaborative AR interfaces and example has given for each collaborative interfaces and technologies.**

<table>
<thead>
<tr>
<th>Collaborative AR</th>
<th>AR Condition</th>
<th>Example</th>
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<tbody>
<tr>
<td>Face-To-Face</td>
<td>Conversation, speech, gesture, body language and other non-verbal cues combine to show attention and interest, [9]</td>
<td>Studierstube (as shown in Figure 9)</td>
</tr>
<tr>
<td>Remote Collaboration</td>
<td>The roles of audio and visual cues in teleconferencing have produced mixed results, [21]</td>
<td>WearCom</td>
</tr>
<tr>
<td>Transitional</td>
<td>Physicality, AR and immersive VR are traditionally separate realms that people cannot seamlessly move between. [22]</td>
<td>MagicBook (Figure 7 illustrates a MagicBook)</td>
</tr>
<tr>
<td>Hybrid</td>
<td>Integrate AR technology with other collaborative technologies, [23]</td>
<td>AR PRISM, EMMIE</td>
</tr>
</tbody>
</table>

For co-located collaboration AR can blend the physical and virtual worlds so that real objects can be used to interact with 3D digital content and increase shared understanding. Tangible interaction techniques can be combined with AR display techniques to develop interfaces in which physical objects and interactions are equally as important as the virtual imagery and provide a very intuitive interaction metaphor, defined as Tangible Augmented Reality (Tangible AR).
Most technology for remote collaboration also affects communication. Audio interfaces remove the visual cues vital for conversational turn taking, leading to enlarged interruptions and overlap, difficulty in disambiguating between speakers, and in determining other’s willingness to interact [22]. With conventional video conferencing subtle user movements or gestures cannot be captured, there are no spatial cues between multi-users, the number of multi-user is limited by monitor resolution and multi-user cannot easily make eye contact. Speakers cannot know when people are paying attention to them or are able to hold side conversations. The main effect on communication is the presence of mediating technology rather than the type of technology used [24].

Desktop and immersive collaborative virtual environments (CVEs) can provide spatial cues to support group interactions. These interfaces restore some of the spatial cues common in face-to-face conversation, but they require the user to enter a virtual world separate from their physical environment. According to Raskar et. al. [25], in case multiple cameras are used to capture and reconstruct a virtual geometric model and live video avatar of a remote user.

Removing the seams in a collaborative interface is not enough. CSCW interfaces may not be used if they provide the same experience as face-to-face communication; they must enable users to go “beyond being there” and enhance the collaborative experience [26, 27]. Considering face-to-face interaction as a specific type of communications medium, it becomes apparent that this approach requires one medium to adapt to another, pitting the strengths of face-to-face collaboration against other interfaces [26]. In fact, because of the nature of the medium, it may be impossible for mediated collaborations to provide the same experience as face-to-face collaboration [26, 28].

3.2 Features of collaborative AR environment

In collaborative AR environment, there a few features are required to include. The features as follows:

- **Virtuality.** The potential of objects can be viewed and examined, either are not reachable or do not exist in the physical spaces can be carried out in AR environment [28, 29].
- **Augmentation.** Real objects that do exist in real world can be augmented by virtual annotations. As a result, it allows a smooth fusion between real objects and virtual properties in propose processes. [29].

- **Multi-user.** The situations where multi-user gather together perform other types of cooperative work or collaboration. Higher interactivity among multi-user effectively interacts with themselves using normal sense of human interactions, like verbal and gestures are now simply possible in an augmented reality setup [30].

- **Independence.** Each user has the option to move freely and independently of the other users. Each user may freely control his own independent viewpoint. However, not only is observation independent, interaction can also be performed independently without interrupting any action that performed by other users [29, 30].

- **Individuality.** In general models and objects are shared among users means all users can observe the same coherent model, consistent in sense of visibility. The displayed objects can also be different for each observer, as required by the application’s needs and the individual’s option [29].

<table>
<thead>
<tr>
<th>Collaborative AR System</th>
<th>System Overview</th>
</tr>
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<tbody>
<tr>
<td><strong>Studierstube</strong>: An Environment for Collaboration AR.</td>
<td>Developed at the Technical University of Vienna uses light-weight HMD displays to project artificial 3D displays into the real world. [9]</td>
</tr>
<tr>
<td><strong>MARE</strong>: Multiuser AR Environment on table setup.</td>
<td>Decomposed the table surroundings in two parts: first, the personal area where the user puts his private real and virtual objects. The second part is the shared area, communication and common interactive space. [31]</td>
</tr>
<tr>
<td><strong>Virtual Round Table</strong>: A Collaborative Augmented Multi-User Environment.</td>
<td>Designed to support location-independent mixed reality applications, overcome the limitations for collaboration and interaction of existing approaches. It extends preserving verbal and non-verbal communication and cooperation mechanisms. [32]</td>
</tr>
<tr>
<td><strong>Construct3D</strong>: Collaborative AR in Education.</td>
<td>Designed for mathematics and geometry education. It describes efforts in developing a system for the enhancement of spatial abilities and maximization of transfer of learning. [33, 34]</td>
</tr>
</tbody>
</table>
4 PREVIOUS COLLABORATIVE AR SYSTEM

The features stated in previous section have been discussed. Then in this section will summarize the previous collaborative AR environments that have already developed and proposed by group of AR researcher that focusing on AR collaboration for collaborative AR environment. The several systems as summarized in Table 2.

5 COLLABORATIVE AR ENVIRONMENT FOR URBAN PLANNING

Section before we have discussed about collaborative AR environment and their features that have a force on overcoming major issues with collaborative AR. This section summarizes previous collaborative AR systems for designing and planning as shown in Table 3. A survey and an empirical study several AR systems that employ collaborative AR environment potentials for urban planning is represented in Table 4.

Table 3. Collaborative AR systems for designing and planning

<table>
<thead>
<tr>
<th>AR System</th>
<th>Exhibit contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>MagicMeeting</td>
<td>Supports product review meetings by augmenting a real meeting location. Instead of real mock-ups, virtual 3D models are used, which may be loaded into the environment from usual desktop applications or from PDAs. [35]</td>
</tr>
<tr>
<td>AR-Planning Tool Designing Flexible Manufacturing Systems with Augmented Reality</td>
<td>Supports the collaborative planning of production lines. Machines are modeled as virtual building blocks and can be positioned by the user with a visually tracked paddle. [36]</td>
</tr>
<tr>
<td>URP is an application for urban planning and design</td>
<td>Physical architectural models placed on an ordinary table surface to cast shadows accurate for arbitrary times of day; to throw reflections off glass facade surfaces; and so on. [37]</td>
</tr>
<tr>
<td>The Urban Sketcher Mixing Realities in the Urban Planning and Design</td>
<td>Supports a range of devices for collaborative multi-modal interaction. Interaction view space modification, painting, sketching, and simple which possible in real-time. [38]</td>
</tr>
</tbody>
</table>

Table 4. Collaborative AR systems for urban planning

<table>
<thead>
<tr>
<th>AR System</th>
<th>Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARThur A Collaborative Augmented Environment for Architectural Design and Urban Planning. (As shown in figure 12)</td>
<td>Arthur uses for presentation. It allows designers a direct access to geometrical data and provides a tabletop immersive environment. By using optical augmentation and wireless computer- vision based trackers to allow for a natural 3D collaboration. Virtual objects are displayed using stereoscopic visualization to seamlessly mix them into the real world. However, it attempts to integrate manipulation techniques of CAD directly through spatial 2D menus and does not provide an estimate of this approach. [14]</td>
</tr>
<tr>
<td>The Luminous Table Augmented Urban Planning Workbench: Overlaying Drawings, Physical Models and Digital Simulation. (As shown in figure 13)</td>
<td>It attempts to tackle this issue by integrating multiple forms of physical and digital representations. 2D drawings, 3D physical models, and digital simulation are overlaid into a single information space in order to support the urban design process. The physical objects are tracked with cameras. It was conceived as a platform for multi-layered physical and digital representations. [39]</td>
</tr>
<tr>
<td>The Augmented Round Table A new Interface to Urban Planning and Architectural Design</td>
<td>Augmented Round Table is providing a new interface for collaborative design and review for architecture and urban planning. The interface relies on unobtrusive input mechanisms and natural and intuitive user interactions. Focus on providing an intuitive environment, which supports natural interaction with virtual objects while sustaining accessible collaboration and interaction mechanisms. [13]</td>
</tr>
</tbody>
</table>

Users experience with collaborative AR environment besides sharing the 3D data simultaneously, have shown that they facilitate collaboration in a natural manner, enabling people to use normal gestures and non-verbal behavior in face-to-face collaboration, and to have access to their conventional tools and workplace in urban planning naturally and intuitively. Here the comparative studies on collaborative AR system that applied in urban planning. This paper proposed a survey and empirical study shows that collaborative AR nowadays very potentials approach to be employed in urban planning.
6 CONCLUSION

AR interfaces enable the development of innovative CSCW applications that are seamless and enhance face-to-face and remote collaboration. They are seamlessness achieved because they allow the multi-user to use conventional tools and workplace practices while superimposing the virtual images onto the real world. Thus AR interfaces enhance the real world rather than replacing it entirely as do immersive VR environments. These AR improvements can be used to support face-to-face and remote collaboration in ways otherwise impracticable, enabling users to go “beyond being there”.

In this paper we performed our survey on collaborative AR for urban planning. On the first section we identified the collaborative AR environment. We found several common problems that can be encountered by AR collaborative environment. In this paper we described the major issues in AR collaboration system. We also have identified the features of AR collaborative that required for collaboration AR environment. Users experience with these interfaces have shown that they facilitate collaboration in a natural manner, enabling people to use normal gestures and non-verbal behavior in face-to-face collaboration, and to have access to their conventional tools and workplace by both face-to-face and remote collaboration.

AR techniques can be effectively used to develop fundamentally different interfaces for face-to-face and remote collaboration. This is because AR provides seamless interaction between real and virtual environments, the ability to enhance reality, the presence of spatial cues for face-to-face and remote collaboration, support of a tangible interface metaphor, the ability to transition smoothly between reality and virtuality. In this paper we have provided several examples of collaborative AR environment and previous works of collaborative AR environment for urban planning. Finally we have stated comparative studies the highlighted on collaborative AR environment for urban planning. This survey and an empirical study shows that collaborative AR nowadays very potentials approach to be employed in urban planning. The challenge of this survey is to bring collaborative AR environment that potential for urban studies and planning in order to provide new effective approach in urban studies and to enhance collaboration shared physical urban workspace. As conclusion, we hope that this research is useful for AR urban planning and also brings benefit to the computer graphics community especially in AR emerging technologies.

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