C. M. Herr, N. Gu, S. Roudavski, M. A. Schnabel, *Circuit Bending, Breaking and Mending: Proceedings of the 16th International Conference on Computer-Aided Architectural Design Research in Asia,* 199-208.

A CONTEXT IMMERSION OF MIXED REALITY AT A NEW STAGE

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Abstract. This paper presents a novel approach to the potential of mixed reality embodied in smart phones and ubiquitous environments. We analyzed the related works to the concept of context and mobile computing and then investigated into leading companies by interviewing senior manages of the mixed reality (MR) projects in Korea. As a result, the concept of context immersion is proposed for describing the various context relationships among the real locations, objects and persons. By considering the MR environments as a converged world, this paper characterizes the context immersion as the combination of the time and location-based, object-based and user-based contexts. Through the context immersion, users can be connected to the real life, not limited to the imagery world, thus experiencing strong immersion in the MR environments. At the end, we present the development direction for the future with a focus on the MR contents rather than the technical aspects.

Keywords. Context Immersion; Mixed Reality; Augmented Reality; Ubiquitous Computing; Mobile Computing.

1. Introduction

As new devices in ubiquitous computing such as smart phones and appliances have been much developed, the mixed reality (MR) has become one of emerging issues in all areas of our daily life. Mixed reality (MR) commonly overlaps computer-generated images and real images in the physical world. Recently, research on MR has adopted a new approach focusing on humanities and social sciences, where the MR combines real environment with geometric information as well as user and social network information. From the point of view, this study will propose the concept of context immersion at a

new stage for explaining the new paradigm driven by the smart phones and ubiquitous computing in MR. Instead of a head-mounted display (HMD) that Sutherland (1968) presented as a see-through display, MR has become to adopt ultra mobile smart phones and PDAs (Wagner and Schmalstieg, 2009). Our research starts from the potential of the smart phones that allow powerful networking and mobility. Smart phones realized the seamless MR as a personal media hub.

2. Background

2.1. MIXED REALITY AND SMART PHONE

Many works on MR have discussed the combination of the real and virtual as well as real time interaction and registration in 3D since Asuma's survey (Azuma, 1997). However, not only text and 2D information but also various media beyond 3D images have used in the domain of the MR. Miligram (1994) illustrated MR as a virtuality continuum that consists of augmented reality (AR) and augmented virtuality (AV). Since our work starts at the context in the real environment, we focus on the AR more than AV considering the concept of immersion in virtual reality (VR).

For the common usage of the AR, Azuma et al (2001) presented nine areas as fundamental elements to be developed: Ubiquitous tracking and system portability, Ease of setup and use, Broader sensing capabilities, Interface and visualization paradigms, Proven applications, User studies and perception issues, Photorealistic and advanced rendering, AR in all senses, and Social acceptance. The MR domain has dealt with smart phones and ubiquitous computing, thus smart phones become an ideal platform for MR (Henrysson et al, 2005).

2.2. CONTEXT AWARE

Ishii and Ullmer (1997) coined the term 'tangible bit' that represents interactive surfaces, coupling of bits and atoms, and ambient media. The concept of mixing the real and virtual can be found in the ubiquitous computing environments, where the real is an electronic world that responds to the cyber space. The MR visual interaction can be one of the ubiquitous computing environments. Many works have dealt with the context to understand the ubiquitous computing environments.

Schilit (1994) explained that the context is to consider the endless changing environment. Liberman (2000) defined that context is everything except the explicit input and output. Gellersen et al (2002) described that the context

is captured through sensors and defined by analyzing sensor data. Dey (2000) suggested the context to be any information which characterizes the situation of an entity. For the context types, location, identity, time, and activity are considered. The context can be used for context aware mobile devices such as smart phones and PDAs. To understand our environment effectively, context awareness adopts the reasoning method of 5W1H (Schilit, 1994; Dey, 2000; Ha et al, 2006).

The related AR works (Pyssysalo et al, 2000; Priyantha et al, 2001; Herrysson and Ollila, 2004) considering mainly ubiquitous computing and context awareness deal with location-based systems. Location is the most basic context in the ubiquitous environments. Smart phones detect the location using a GPS receiver, compass and accelerometer. Of course, they have a sensitive camera and a bright display like AMOLED. Abowd et al (2005) argued that the smart phone is the most powerful platform for pervasive computing.

2.3. IMMERSION

Slater and Wilbur (1997) defined immersion as a description of display technology that can be objectively assessed in terms of stimuli from reality, sensory modalities, a field of view and a display resolution. However, Witmer and Singer (1998) described the concept of immersion as a psychological state of being enveloped by and interacting with an environment that allows users a continuous stream of experiences. The former emphasize the technology itself that delivers the immersion to users whereas the latter deals with the users' feelings immersed in the system. This research adopts the latter definition of immersion for introducing a context immersion of MR for smart phones since our focus is on the users' experience in MR environments implemented by mobile and ubiquitous computing.

Until now, research on immersion mainly has dealt with immersive virtual environments (VE) where the users are surrounded by sensory interfaces and then perceptually feeling of being in the virtual worlds (Carrozzino, 2010). The conventional immersive VEs have been achieved by developing wearable devices and large displays that isolate the users completely from the real context. One of the wearable devices to embody the immersive VE is head mounted displays (HMDs) that confine the user's view in the simulated environment. Kuchelmeister et al (2009) proposed an immersive AR system, 'iDome', that provides panoramic and spherical representations for visualization. The immersive VE called NICE was implemented in a highly graphical immersive VR system called the CAVE (Cruz-Neir et al, 1993). Smart phones do not provide such large scale of displays or surrounding interfaces, but enables seamless interaction between the real and virtual domains in MR.

3. Exploratory research

3.1. LITERATURE STUDIES

The related works on 'mixed reality' were searched through the article titles, abstracts, and keywords in SCOPUS online database. The total number of articles including journals conference proceedings is 1975. Most of the articles belong to the subject area of Computer Science and Engineer (50.5%). The result of our studies that categorized the articles by keywords is coincided with that of the survey made by Zhou et al (2008). Zhou and his colleges presented research trends in AR with a focus on tracking, interaction and display. They classified the papers of ISMAR proceedings into two groups. The first group includes five main research topics associated with technical issues: Tracking techniques, Interaction techniques, Calibration and registration, AR applications, and Display techniques. The second group is composed of more emerging research topics: Evaluation/testing, Mobile/wearable AR, AR authoring, Visualization, Multimodal AR, and Rendering. These issues would be more related to our research topic since mobile AR and human immersion will be discussed in this paper.

When the articles are classified by the source title, the proceeding of International Symposium on Symposium on Mixed and Augmented Reality (ISMAR) is dominant. Since 2009, ISMAR has included the section of an art, media, and humanities (AM&H) in the science and technology (S&T) part. The articles in the AM&H proceedings have given us the inspiration of context immersion in smart phones. Many of workshops, exhibitions, and installations in the conference have dealt with smart phones. ISMAR 2010 was in the same situation. Stapleton and Rolland (2010) expected that the exploration of the AM&H would be a dominant scope for the future since MR is based on more ubiquitous and mobile computing.

In the AM&H proceedings of ISMAR 2009, the augmented view of Dashuifa (Yetao et al, 2009) described 3D images that were restored through a telescope at the historic sites. Mission Dolores situated simulation (Liestol, 2009) showed a customized education and tourism contents using smart phones. Loosely coupled mixed reality (Myungho and Kim, 2009) used the environment metaphorically to combine the virtual and real using smart phones. EYEPLY (Hurwitz and Jeffs, 2009) in a smart phone provided the marketing and promotion as commercial services for users at the stadiums, parks, conventions and shopping malls. SLARiPS (Second Life Augmented Reality in Physical Space) Project (Stadon, 2009) showed avatars, 3D online platform and the process of MR considering cultural aspects. Koh et al (2010) suggested

a mobile AR cooking game with a focus on user interfaces and interaction from 2D to 3D spaces. Hertz et al (2010) developed an AR arcade driving game using GPS navigation and MR seamlessness. These articles present a variety of views on MR but all of them deal with a seamless context in the real environment. Also, according to the point of view, each paper focused on specific contexts among the various contexts such as location, identity, time, user, and object.

3.2. MIXED REALITY PROJECTS IN KOREA

We investigated leading MR companies in Korea and interviewed managers who plan their MR projects. Many of them have developed MR applications with smart phones. The MR applications are classified into three groups in terms of immersion. The one is to overlay virtual images over the real camera screen. The others are location-based applications such as Wikitude and Layar. The third is identified as social network service (SNS).

The simple overlay applications are divided into the two types, marker-less application (Figure 1-a) and marker-based application (Figure 1-a). The virtual game overlaps a real scene in the Sky Siege without markers but the AR Defender needs markers in order to draw the same context. The marker-less and marker-based types seem to be very simple but utilize real seamless environments for the background of the games, thus allowing new user experiences in their usual environments such as homes and offices.

(a) Sky Siege (b) AR Defender (c) iNeedCoffee (d) Ovjet

Figure 1. Mobile AR projects.

Location-based applications depend on the location-aware technologies such as GPS and WPS in order to overcome the limitation of time and place for providing a variety of contents. The Wikitude world browser, introduced in 2008, projects the local information and landmarks onto the camera's screen. In addition, the Wikitude Drive provides the AR navigation based on the wiki structure. In Korea, the Location-based service (LBS) has become popular. The iNeedCoffee (Figure 1-c) informs us of the location of our favourite brand coffee shops and instruct us on how to go the nearest coffee shop. Espe-

cially, as a platform for AR, the Architecture Walk provides the content of the tourism with the augmented acoustic feature. These applications adopt various spatial and historic contexts which were considered importantly in mobile computing.

SNS applications consider multi-users and more relationships based on the LBS. The Ovjet (Figure 1-d) provides the AR contents with a focus on the relationships among users, objects, and places. It can actualize the personalization of contents, interactivity, sharing, and collaboration.

4. Context immersion in the MR environments

4.1. THE CHARACTERISTICS OF THE CONTEXT IMMERSION

This paper suggests the context immersion to understand new phenomena of having a small display but allowing relatively strong immersion in smart phones. Since smart phones produce the active relationships among the real persons, objects and locations through the social interaction, they could arouse much powerful immersive context which connects users to the real life, not limit them to the imagery world. Rather than adopting confined displays, smart phone can utilize the strength of mobile and ubiquitous computing, thus ambient media can be opened and activated within the boundary of the smart phones.

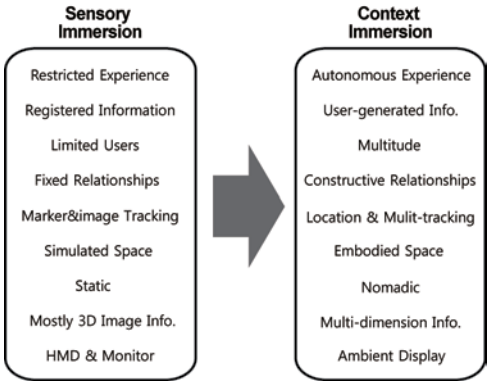

Figure 2. The characteristics of the context immersion.

To sum up, the immersion cannot be fully achieved by the technologies or devices. The important factors that affect the users' immersion are the relationships based on the person, objects and locations in real context. Through the literature review and investigation, we identified the characteristics of the context immersion as shown in Figure 2. The mobile AR applications that

provide LBS or SNS interact on the experience and user-generated information made by multitude. Then, the context immersion generates constructive relationships using location and object tracking. To express various contexts, it uses 3D images as well as texts, 2D images, and other multimedia formats. Also, the context immersion starts at the ubiquitous computing with mobile devices.

4.2. THE CONTEXT IMMERSION IN THE MR ENVIRONMENTS

Compared to the immersion generated by the visual, acoustic, haptics, and motion characteristics (Carrozzino and Bergamasco, 2010), we propose three dimensions of the context immersion in MR environments as shown in Figure 3. The Time and location-based context immersion would be on the increase in the range of static to nomadic for coping with mobility. The Object-based context immersion basically depends on a hard object tracking but utilizes a sophisticate location-aware technology further, thus realizing the object relationships. The user-based context immersion leads to unlimited communications with users networking all of contexts. This type of context immersion evokes user's personalization, interactivity, sharing, collaboration, user making contents, and artistic contents. The immersion expands the SNS (social network services) as a blogging platform using all of contexts such as time, locations, objects, and users.

These dimensions should be applied to smart phone applications for developing an immersive MR, which might provide many possibilities in architecture and design domains. Compared to the traditional CAVE-type immersion, these context immersions could act more effectively to obtain and use physical information on construction management automatically and nomadically (Lee et al, 2009) rather than to visualize and design virtual objects on a tabletop (Dunston and Wang, 2005).

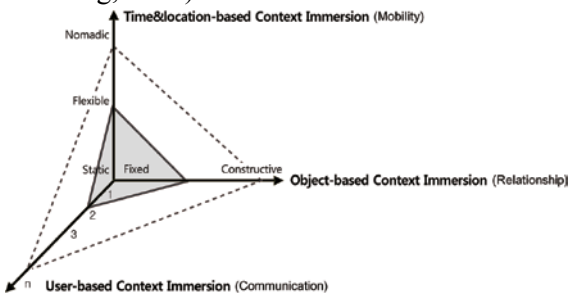

Figure 3. Dimensions of the context immersion in the MR environments.

The time and location-based context immersion pursues mobile relations

using location-based tracking such as GPS and WPS. The immersion would be derived from the degrees of how to overcome constraint of time and space, and what to interact with the context of time and location. The context immersion would promote the MR by taking advantage of unlimited spaces, mobile access, multi-dimensional information, and various displays. Figure 4 shows the mobility of time and location-based context immersion. As seen in LBSs such as the Architecture Walk (Figure 1-c) and the Wikitude world browser, this context immersion has been used to provide the historic building simulation and history as well as the site information using GIS in various applications. This immersion should be considered basically for collaboration in ubiquity beyond the mobility.

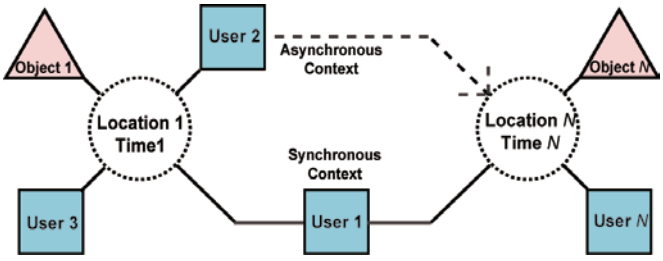

Figure 4. Mobility of time and location-based context immersion.

The object-based context immersion seeks to make the various relationships among objects and to combine a virtual image and a real image by tracking the target object's coordinates based on the marker. This immersion uses a new object recognition and information technology in the ubiquitous computing environments. Especially, our architectural design domain that deals with space can obtain many benefits in the range of loosely coupled objects (Myungho and Kim, 2009) to carefully managed construction objects.

The User-based context immersion could involve various types of user such as normal users, power users, content providers, developers, and service providers (Belimpasakis et al, 2010). Since the users have the goal of communication, MR is a platform as opened Application Programming Interface (API) for the communication. Therefore, power users generate and share their content. As shown in Figure 3, the number of users can be ranged from one user to multiple users. The important aspect of user-based context in the MR environments is how many users communicate with each other. It could be a more immersive environment with many users than one user in MR since we would like to interact and share our experiences with the others. A smart phone has a small-sized display, but affords the context immersion. Therefore, they provide more potentials and challenges for the built environment than the AR in architecture and design (Wang, 2009) since the context

immersion is based on mobility, relationships, and communication. When the mobile applications for architecture and design are developed, these dimensions should be considered to optimize the applications and improve the functions.

5. Discussion and Conclusion

This research introduced the concept of context immersion as a novel approach to the embodiment of MR in ubiquitous and mobile computing based on the results of the literature studies and investigation. To cope with the limitation of location and time in the conventional devices, the mobility and networking of the smart phones are considered for achieving more immersive MR environments that build the interactive relations among persons, objects and locations. Based on the characteristics of the context immersion, three dimensions of the context immersion were presented. The time and location-based context immersion strives for mobility using location-based tracking such as GPS and WPS, enabling unlimited spaces, mobile access and multi-dimensional information. The object-based context immersion is related to the object recognition, making the various relationships among objects. The user-based context immersion allows unlimited communication with users on the network, evoking user's personalization, interactivity, sharing, collaboration, user making contents. The results of this research reveal that the context immersion in mobile MR is different from the sensory immersion in VE achieved by the conventional technologies such as visual and acoustic features. Through the context immersion implemented by mobile and ubiquitous computing, users can be connected to the real life. The understanding of a context immersion of MR can lay the ground for evolving knowledge on the development of immersive MR environments to affect the users' experiences and relationships in real context. This research needs to be thoroughly examined in an experimental study in order to prove the arguments practically for the future by focusing on the MR contents.

Acknowledgements

This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2010-327-G00141).

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