Recent Trends in Ubiquitous Virtual Reality[1]

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Abstract

Computing technology is radically changing the manner in which we work and communicate with computers. Ubiquitous Virtual Reality (U-VR) has been researched in order to apply the concept of virtual reality and its technology into ubiquitous computing. In this paper, we analyze past research on ubiquitous virtual reality and find future research direction.

1. Introduction

Computing technology is radically changing the manner in which we interact with computers. The field of future computing is highly interdisciplinary and the major areas of research will be diverse, ranging from highly theoretical to practical system, mathematical to intuitive.

In 1991, Mark Weiser discussed ubiquitous computing that computing resources that are embedded into our daily life [1]. In 1990s, wearable computing had been researched actively with augmented reality at MIT and CMU [2,3]. Ishii proposed 'Tangible Bit' at 1994 and Tangible User Interface has been appeared [4]. In 1997, Azuma published a survey on augmented reality (AR) [5]. Steve Mann described his wearComp (Wearable Computer) invention as a tool for "Mediated Reality" [6]. After that, various computing paradigms such as pervasive computing (Novel, Bob Frankenberg), Invisible computing (Donald Norman), proactive computing (Intel, David Tenenhouse), disappearing computing (EU project) discussed.

With this historical background, Ubiquitous Virtual Reality (U-VR) has been researched in order to apply the concept of virtual reality and its technology into ubiquitous computing environments [7-9]. The idea comes that the limitations of virtual reality could be improved through the new computing paradigm, on the other hands, the problems when we realize ubiquitous computing could be solved by conventional virtual reality. Over the last few years, we have studied the future computing paradigm, Ubiquitous Virtual Reality that supports seamless Human-Contents-Environment Interaction. At this moment, we need to review these research activities to find future research direction.

In this paper, we analyze past research on ubiquitous virtual reality and find a future research direction. First, we find proper U-VR definition on today from the definitions of U-VR on past papers. Second, we select several representative researches which present the concept of U-VR. Finally, we derive the characters of U-VR and find future research direction.

The discussion is illustrated with research activities in this research area. Based on research results, we discuss successes and limitations of state of art technologies. Four characteristics are discussed to analyze research results until now.

This paper is organized as follows: In Section 2, we discuss the definition of ubiquitous virtual reality. The representative research results and features are explained in Section 3. The conclusion and future works are discussed in Section 4.

2. What is Ubiquitous Virtual Reality (U-VR) ?

In 2005, Jang wrote that *"U-VR is a new paradigm combining virtual reality with ubiquitous computing. This can provide user with various applications according to the context of users or environments"[10]*. This was the first paper which introduced U-VR. In this description, 'context' is key factor to combine virtual reality and ubiquitous computing. However, it was conceptual without concrete characteristics. Kim proposed more clear definition at 2006 [8]. In his paper,

[1] This research was supported in part by the CTI development project, MCT and KOCCA, and in part by the Foundation of UCN Projects, the MKE, and the 21C Frontier R&D Program in Korea as a result of subproject UCN 08B3-O1-20S

978-0-7695-3259-2/08 $25.00 © 2008 IEEE
DOI 10.1109/ISUVR.2008.27

U-VR was defined as *"A concept of creating ubiquitous VR environments which make VR pervasive into our daily lives and ubiquitous by allowing VR to meet a new infrastructure, i.e. ubiquitous computing"*.

However, we still had a question about '*U-VR environments'*. So, he wrote *'collaborative wearable mediated attentive reality'* to demonstrate this idea. Y.Suh explained these terms in a slightly different way from S.Kim's paper [9]. The next paragraph explains what 'collaborative wearable context-aware mediated reality' is.

The 'Collaborative Mediated Reality' means that U-VR enables collaborators to share necessary contents and devices to carry out tasks. The contents mean realistic multimedia contents stimulating five senses of a human being. The devices mean smart objects which are pervasive in a real environment, and include wireless devices as well as wired devices. In U-VR environments, multiple users do not need to collaborate within a VE using conventional VR user interfaces. Instead, they collaborate with each other by sharing realistic multimedia contents in a real space. Thus, users share their goal through collaborative environments. To share their goal, they also share time and space. By extending the concept, collaborators can generate a special environment where they share even their feelings. They work together by using the realistic multimedia sharing and multi-modal interaction.

The 'Wearable Mediate Reality' means that users are provided with services through wearable devices anywhere in a U-VR environment. That is, a user can be provided with services without the constraints of time, place and device, with respect to personal information. For the services to be supplied through the wearable devices, mobility should be guaranteed. Furthermore, the intimacy of a user interface must be maintained so that users can exploit wearable devices conveniently. Ideally, the user interface should be transparent to users so that they can concentrate on their tasks without the necessity of being conscious of the user interface.

The term `Context-aware Mediated Reality' means that a user accesses and interacts intelligently with realistic multimedia contents, which the user pays attention to, through the user interface. For this purpose, virtual objects should be integrated seamlessly into a RE to provide seamless presence, which preserves five senses, to users. Through context-aware augmentation techniques, virtual objects are augmented based on the extracted context for user as well as environment. Furthermore, augmented realistic contents are required to be responsive to respond intelligently to the user's interests.

3. Representative U-VR Applications

Many researchers have tried to explain their research activities in terms of ubiquitous virtual reality [11]. Tobias Hollerer presented his version of U-VR with four key terms; mobility, collaboration, interactive visualization, and immersion. Adrian David Cheok mentioned ubiquitous media as research issues related to ubiquitous VR. Asa MacWilliams proposed ubiquitous augmented reality as a middleware for decentralized service management [12]. Finally, Thies Pfeiffer presented video conferencing when he discussed about ubiquitous virtual reality [13]. These researches presented different aspects about ubiquitous virtual reality.

A wide range of U-VR applications has been developed. A testbed for applying U-VR-enabling technologies to home environments is ubiHome [14-17]. Various kinds of pervasive sensors and services have been embedded in ubiHome (in Figure 1). Those sensors and services form the foundation of an integrated smart home for multiple residents. For instance, ubiTV is a context-based TV application providing personalized services to multiple users. Additionally, it controls display devices by adapting to a user's attention based on the user's direction [18].

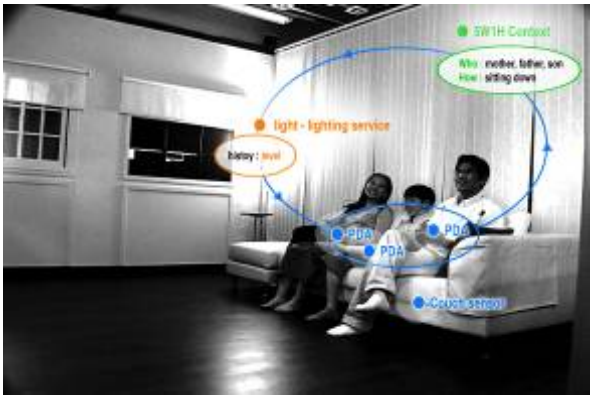

Figure 1. ubiHome test-bed

Wearable Computing Platform is composed of physiological sensing devices (Figure 2), Wearable Personal Station (WPS), comfortable clothes, application programs. Based on this platform, various technologies for personal information management have been developed, such as emotion extraction and user profile analysis [19,21]. It is also combined with mobile or head-mounted camera for wearable augmented reality applications. Natural view user interface (NVUI) and smart controller, AR PushPush [20,24].

Figure 2. wrist-type sensing device.

Finally, there has been research to achieve Context-aware Mediated Reality, such as responsive contents, seamless integration, and personalized multi-modal interaction. We are developing display devices, tangible interfaces and intelligent contents. In particular, the Responsive Multimedia System (RMS) for personalized virtual storytelling was established to provide users with a cultural, creative personalized experience by adapting the overall concepts of U-VR [18]. Socially Interactive Agents was also good example for context-aware mediated reality [23].

Figure 3. Responsive Multimedia System (RMS)

4. Conclusion and Future works

In this paper, we reviewed the definition of U-VR. In this paper, we analyze past research activities on ubiquitous virtual reality and find future research direction. The discussion was illustrated with research activities in this research area. Recent research activities of U-VR are collaborative wearable context-aware mediated reality. However, there are still lots of challenges on the future scenario and application developments.

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