Virtual Reality in Ubiquitous Computing Environment

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***Abstract*—In this paper, we propose a novel concept of Ubiquitous Virtual Reality (U-VR) and examine technical challenges to be required for realizing it. It is difficult to realize Virtual Reality (VR) in our daily life although a lot of hardware and software have been developed. In addition, there is no chance for people to experience VR systems except for a special exhibition since there is no attractive application. On the other hand, there is extensive research regarding the possible applications that support the user's interaction, utilizing various aspects of context of the user and the ubiquitous computing environment which will be equipped with many pervasive but invisible computing resources. Thus, we present a concept of U-VR that is realized through the feature of Collaborative Wearable Attentive MR (Mediated Reality). Also, we investigate three challenges that are significant in realizing U-VR in holistic u-Space.**

Index Terms—Virtual Reality, Ubiquitous Computing, Ubiquitous Virtual Reality, u-Contents

I. Introduction

Until now, VR systems have put the value on constructing Virtual Environment (VE) generated from a computer to encourage users to feel as if they exists in Virtual Environment (VE) by stimulating five senses. Especially, Collaborative Virtual Environments (CVEs) are experienced by users with the advances of computer graphics, multimedia, distributed computing, and high-band networking technologies [1]. Participants in CVEs can collaboratively interact with one another by utilizing speech, video image, and graphics although they exist in different places [2][3]. Nevertheless, VR is far from users in RE with a logical gap between VE and RE. Moreover, people do not make the most out of VR systems as there are few applications which are relevant and feasible in a real life. Recently, people have a growing interest in ubiquitous computing paradigm which enables them to access computing resources in daily life anywhere and at any time [4]. In the ubiquitous computing environment, users are supplied with personalized service that is enabled by various aspects of context of the users and the environment [5][6]. The ubiquitous computing environment equipped with these features is possibly used as an infrastructure in implementing VR into daily life. In this paper, we present a novel concept of U-VR and useful approaches to overcome the limitations which VR has to face if it is to be realized in ubiquitous computing environments. VR focuses on the activities of a user in a VE that is completely separated from a RE. On the other hand, ubiquitous computing focuses on the activities of a user in a RE. Although VR and ubiquitous computing reside in different realms, they have the same purpose, i.e. to maximize the human ability. Therefore, by supplementing the weaknesses of VR with the help of ubiquitous computing, we look for ways to evolve VR in ubiquitous computing environments. In this paper, we present a concept of U-VR and investigate methods for realizing it.

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II. Ubiquitous Virtual Reality

A. Holistic u-Space

There exists a physical or logical gap between 'virtual space' in VE and 'real space' in RE. For VR to be realized in ubiquitous computing environments, this gap is to be minimized, in order to link the two spaces seamlessly. For this to result, we need to define a new type of 'space'. Firstly, Personal Space (PS), which is similar with '3rd skin', is a space in which an individual is supplied with personalized service by his or her private information. In the PS, an individual has a complete control of data/info flow, i.e., incoming, filtering, selecting, outgoing using a user profile. Then, Community Space (CS) is one in which multiple persons who have goals in common establish a logical group and communicate with one another to achieve their goals. In the CS, a group partly controls and has ownership based on common interests of the group. Lastly, General Space (GS) is one in which anyone accesses and enjoys services and contents in a public space. In the GS, everyone has a temporary and free access, but regulated by a public social contract. Likewise, U-VR is the concept to enable 'Human-aware' or 'Contents-aware' technologies for supporting experience and expression of personalized, selectively shared, and seamlessly interactive u-Contents[7] under the infrastructure where the PS, CS, and GS are dynamically constructed and released.

B. Concept of Ubiquitous Virtual Reality

VR has been a means for extending the capability of human beings by letting things unable to work have its power to do unless it is definitely impossible in a virtual environment. We define Ubiquitous Virtual Reality (U-VR) by extending the capability of human beings into a Real Environment (RE), not confining it within a simulated space. In other words, we

combine VE and RE seamlessly instead of only focusing on the generation of an ideal VE. Furthermore, contents are interactable within RE as well as VE so that they can be systemically associated with services in a RE. Consequently, U-VR is 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'*. U-VR is demonstrated as Collaborative Wearable Attentive MR (Mediated Reality).

C. Feature of U-VR

1) Collaborative: One of the features of U-VR environment, "Collaborative", is to use multiple information and resources in a difficult situation to achieve users' complex intention through just one service. Hence in the U-VR environment, it creates high quality information from mixing specific services or information through a "collaborative" feature. It enables a mutual cooperation with widespread devices or contents as well as existing properties cooperating with multiple users. In other word, the "Collaborative" feature of U-VR means a smart and cooperative space, in which users, services, and contents interact.

2) Wearable Attentive: In one sense, users in U-VR environment are supplied with personalized services with the help of wearable device in which personal information is collected and managed anywhere and at any time. In another sense, a user interacts with smart objects or intelligent and realistic contents, which the user pays attention to, through a transparent user interface. For this to be realized, objects to which a user pays attention are augmented with virtual contents.

3) Mediated: U-VR has the 'Mediation' feature that selectively mediates contents in real environment according to the user's and the environment's contexts. The feature helps to realize the real Mediated Reality mentioned by S.Mann and R.Azuma. The realization is accelerated by combining the conventional AR technologies with context-awareness. Here, the three prominent features are introduced from the viewpoint of vision-based AR.

D. Technical Challenges

1) Resource & Contents Sharing: To use distributed resources and share contents, the following technical elements have to be solved. For configuring Community Space, we need to obtain information of objects existing in the space. In order to do this, context-aware technology and resource discovery technology are needed. Also, understanding user's intention and configuring community technology for achieving user's intention are parts that have to be solved. For this kind of technology, social networks among users, services, and contents are required, and a middleware has to be constructed. In case of sharing distributed resources, information releasing problems are important to be solved. U-VR grid, real-time VR processing technology from sharing distributed resource, controlling virtual objects with ubiquitous computing technology, and synchronizing data which are used by these technologies are also considered as important technical challenges.

2) User attention-based personal information and interface provision: In U-VR environment, 'mobility' should be ensured to let users enjoy personalized service through the wearable device. Furthermore, the familiarity of a user interface must be maintained and users should be able to utilize wearable devices conveniently. Ideally, the user interface is transparent to users so that they can concentrate on their tasks without the necessity of being conscious of the user interface. To realize "Attentive" in U-VR environment, we have to consider user interface that supports easy access to, and convenient use of services which the user pays attention to. For this purpose, context-aware augmentation techniques make it possible to augment intelligent and realistic contents into a RE based on contextual information of environments and users. It is important that intelligent and realistic virtual contents should be integrated seamlessly into a RE to provide seamless presence to users.

3) Mediation-supported Infrastructure: The proposed MR is considered as the invisible bridge between contents and users. To build up the bridge, ubiquitous computing and AR infrastructures are required. Let us consider the dominant three features described earlier. Firstly, the fast recovery of precise 3D geometry of u-Space is one of the challenges in MR. The research on reconstruction has been widely studied in computer vision. However, it is not suitable to use the results in collaborate dynamic environment directly. The hybrid method using the users' context should be developed. Secondly, the physical sensor information for MR should be specified for the realistic rendering. Each sensor parameters should be defined in a certain unified way. Then, the unified model including vision parameters and physical parameters is suggested. Thirdly, the AR services should change its format depending on the users' context such as individual profile. From the users' context, different interactive scenarios can be generated. For that, both users' and services' infrastructure should be matched.

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