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Context-aware Mobile AR system for Personalization, Selective Sharing, and Interaction of u-Contents in u-Space

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***Abstract*—Researchers in mobile augmented reality (m-AR) technologies have so far emphasized the technical challenges such as the accurate augmentation, natural interaction, realistic rendering. However, this is not enough for the m-AR technologies to be well exploited in the ubiquitous computing environment. Thus, we propose a context-aware mobile Augmented Reality (m-AR) system that supports enabling u-Contents to be not only personalized but also shared selectively and interactively among user communities. For this to result, it manages mobile user's profile and various kinds of context in Ubiquitous Smart Space (USS). The proposed system can be widely applied for m-AR-enabling applications in which mobile users' activity, preference, and intention can be analyzed in order to provide personalized services through m-AR technology-enabled interface.**

***Index Terms*—Context-aware Mobile AR, Personalization, Smart Object Control**

I. INTRODUCTION

Until now, augmented reality (AR) systems have been developed to faithfully realize the basic concept that they supplement the real world with virtual objects to enhance the user's perception of and interaction with the real world [1]. Researchers in AR technologies have so put the value on the technical problems such as accurate augmentation, natural interaction, realistic rendering. With advances in tracking and increased computing power, mobile AR systems are developing. Studies on mobile AR technologies also try to technically improve challenges [4].

MARS (Mobile Augmented Reality Systems) project performed at Columbia University [1] aimed to compound a novel user-interface by mixing two emerging research fields; AR and mobile computing. Studierstube was developed as a software framework suitable for developing AR applications with the concepts of mobile, collaboration, and ubiquitous [2]. Recently, 'Invisible Train' by Daniel Wagner et al., demonstrated real-time and multi-user AR game [3]. There was a conceptual framework which tried to bridge the real and virtual world with the notion of ubiquitous computing and mobile AR [4].

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The concept of context-awareness is used to support object recognition in large-scale museum guidance by Bruns, E. et al.[5]. However, these approaches to researches on provision of context-aware services exploiting m-AR technologies have some limitations in that they just focus on solving the technical challenges of m-AR rather than providing users with personalized services. Additionally, they do not support the personalized context annotation in which the details such as service properties or contents can be adaptively changed according to user's preferences exploiting m-AR. These approaches are not enough for the m-AR technologies to be well exploited in the ubiquitous computing environment.

Thus, we propose context-aware mobile Augmented Reality (m-AR) system that supports enabling u-Contents to be not only personalized but also shared selectively and interactively among user communities based on mobile user's profile and context in USS. Applicable areas of the proposed system could be m-AR-enabling applications, such as a meeting system that supports information augmentation to real environment and collaboration, a universal remote controller for controlling various kinds of smart objects, a mobile service agent that utilize user's location and activity to diversify and expand its use for mobile augmented reality based services.

This paper is organized as follows. In section 2, overview of the context-aware m-AR system is given. We describe the proposed approaches in section 3. Finally, we conclude our work and briefly outline a remaining work in Section 4.

II. CONTEXT-AWARE MOBILE AR

A. Concept of Context-aware Mobile AR

We define several keywords before presenting the concept of context-aware m-AR system. At first, *Ubiquitous Smart Space* (USS) is defined as community computing based intelligent dynamic collaborative space through the seamless flowing of information among environment (device, resource), user (individual/group) and u-Contents (service). *u-Contents* is defined as AR contents which are provided to users, supporting to enable for users to interact/collaborate with each other as well as producing personalized intelligent response to users' interaction in USS. *Mobile AR* is defined as technologies to support information exchange and control between u-Contents and USS through mobile AR devices. Fig 1 shows a concept

diagram of a context-aware m-AR system in USS.

Fig. 1. Context-aware Mobile AR in USS

B. *Key Features of Context-aware Mobile AR*

Context-aware m-AR will support

· Personalization: it lets AR systems provide intuitive and transparent user interface such that lets a user concentrate on the original task, presents private information to individuals without fearing that others will see it, and augments personalized responsive content.

· Selective sharing: it lets AR systems construct group or community space based on common interests among users in USS.

· Interaction and collaboration: lets the AR systems selectively distribute common knowledge/experience on u-Contents interactively/collaboratively among user communities.

III. . PROPOSED APPROACHES

We addressed the meaning of Context-aware m-AR system. In the following, we present the proposed approaches for realizing it. Thus, five approaches, which are significant factors in realizing context-aware m-AR systems, are investigated.

A. *USS Application Scenario Design and Implementation*

Firstly, in this paper, we design and implement USS for smart object control, personalized u-Contents and selective sharing of them. For this to result, we perform the scenario-based USS design and user modeling. We develop a simulation system, USS Player, to simulate in virtual environment.

B. *Development of Mobile Application Model for Personalization in USS*

Second, we develop researches on a unified context modeling and management technology for mobile users that support application development by seamlessly interoperating context among user community (personal and group information space), USS (public information space), and u-Content (services). Thus, we develop application software platform to exploit and represent user context (location, movement within information space, users' preference/attention/intention) for smart object control and application development.

C. *USS Management for selective u-Contents sharing and collaboration*

Third, we build USS with harmonizing media services among user communities. We classify context generated from various sensors around the environment into 5W1H and integrate each item semantically and structurally. And we generate and manage group context by extracting common preferences by analyzing user's integrated context and its relationship. Then we manage collaboration-oriented information space using integrated context and group context of users within the space.

D. *Mobile AR technology in USS*

Fourth, we develop collaboration-oriented m-AR technology for smart object control, service personalization by user profile filtering and selective sharing of u-Contents. We develop mobile AR framework compatible to middlewares in USS. Also, we develop real-time invisible marker tracking method using a camera on mobile AR devices, so that smart object control technology is realized using mobile AR devices. Moreover, the proposed method supports the fine-grained interaction with the augmented u-Contents by tracking user's hand.

E. *Development of u-Contents Personalization Responsive Technology for Interaction*

Lastly, we develop personalized responsive engine for u-Contents to enable personalized interaction with mobile users. We are developing intelligent u-Contents reacting to mobile users' interaction. And we develop tangible interfaces for personalized interaction of mobile users.

IV. CONCLUSIONS AND FUTURE WORK

In this paper, we introduce a novel concept to design and implement USS for personalized smart object control and u-contents provision as well as selective sharing of u-contents based on user's common interests. For this, we exploit user preferences managed in a mobile device to provide personalized services using m-AR technologies. Remaining work is to elaborate the proposed mechanism of each component in context-aware m-AR system. Furthermore, we should implement and evaluate the proposed approaches.

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