Augmented Reality-based Exhibit Information Personalized Service Architecture through Spectator's Context Analysis

Sungmo Jung[1], Soou Kim[2] and Seoksoo Kim[3]

[1,3]Department of Multimedia, Hannam University, 306-791 Daejeon, Korea
[2] Morning Entercom, Inc., 302-837 Daejeon, Korea

sungmoj@gmail.com, top1@morningenter.com, sskim0123@naver.com

Abstract

This paper suggests a personalized service system offering effective exhibition information by collecting, analyzing, and managing spectator environment information in exhibitions based on a ubiquitous environment. To that end, we use AR technologies that can provide intuitive and supportive information for displaying exhibition information. The previous AR is considered quite static, for virtual information is provided by pattern matching (e.g., markers, features of an object, etc.). Therefore, the system in this paper offers dynamic personalized services in that virtual information is displayed according to spectator's situations and carries out context inference by grouping context information into metadata and by measuring similarity.

Keywords: *Context Analysis, Augmented Reality, Personalized Service, Exhibit Information*

1. Introduction

The term, 'ubiquitous', originates from a Latin root meaning 'being everywhere at the same time' and has become widely known by Mark Weiser [1]. Recently, combination of various IT technologies has enabled dynamically personalized context-aware services in smart and active environments.

Such a change is being applied to exhibitions as well [2-3]. Exhibitions based on the ubiquitous environment make an attempt to offer exhibition information with various services but the contents are still not sufficient and quite simple, failing to satisfy spectators. Therefore, an interface technology, which can increase satisfaction for the services and express multimedia information in a natural way, is required at this point. This is why AR (augmented reality) is attracting attention, for the technology can realize such an interface by offering intuitive and cooperative information.

AR is being applied to various areas including surgery practice, repair of a complicated machine, product marketing, game service, a war simulation for the military, and so on, as depicted in Figure 1. However, current AR technologies are not sufficient to offer dynamic personalized services, for virtual information is sent in a mechanical manner whenever a specific condition is met. Hence, this paper suggests a personalized service system which can offer various types of dynamic exhibition information by combining advanced AR interface technologies with context-aware technologies (which can collect the context information of individual spectators).

[3] Corresponding Author

Figure 1. AR Applications – (Top) Surgery Practice, Marketing, (Bottom) Game, War Simulation

2. Related Works

2.1. Augmented Reality

Augmented reality is a technology that involves showing virtual information such as text or image onto image of real world in a real-time basis [4]. Compared to virtual reality, AR allows users to have virtual experiences with various sensors, display devices expressing the sense of hearing, sight, and touch, and simulations combining both real and fictional phenomena.

Initially, the AR system had been developed by Ivan Sutherland in 1968 using Head Mounted Displays (HMDs) [5], which could only display some very simple wire frames in real time, due to the limitations of the computer performance at the time. After that, in 1992, Tom Caudell developed display technology using HMDs in earnest and began to use the term, AR, and since then, consistent research has been conducted. In modern times, as the performance of easy-to-carry computing terminals and display environments has been developed, AR technology has been rapidly developed, and is being used in many areas is being actively conducted with consistently increasing demands. For the realization of AR is real life, what point of the object image captured by camera should be augmented needs to be decided and augmentation methods are classified into marker recognition methods and markerless recognition methods. Since markerless recognition methods require feature points which are extracted from the image captured by camera, much time and labor are needed for image processing [6]. Besides much research is required to increase extraction rates and the research on this topic are in active progress. Marker recognition methods are a method of augmenting an object in a point where the computer recognizes the tag interface serving as a pointer connecting the real world and the virtual world, which is called a marker. This method, due to its high recognition rates and easy use, is widely used in the realization of AR.

Core technologies to establish AR systems include marker detection to locate an object, matching, tracking, camera calibration to synthesize virtual objects into actual images and calculate camera variables, display, and 3D modeling technology. That is, it is a technology field that provides the image with information such as characters and graphic objects in real life to enhance users' understanding of the situation of moving objects in 3D space.

Especially, AR needs tracking technologies in order to augment virtual information and, as seen in Figure 2, marker-based or markerless methods are mainly used for data processing. In this paper, we have designed an exhibition information system with a marker-based AR technology which has high recognition rate in an indoor environment and augmented virtual information according to behavior patterns analyzed by context information of the spectators.

Figure 2. AR Processing Method – (Left) Location, (Middle) Marker, (Right) Markerless

2.2. Context-Aware and Personalization Service

Dey defines context as "any information that can be used to characterize the situation of an entity, and the entity refers to a person, a place, or an object related with interaction between a user and an application while including the user and application themselves" [7]. Context-aware is a situation that context information is used for offering services to a user by being subject to the user's work or provides suitable information [8]. Here, the system is aware of the context.

In this paper, we manage context information (needed for dynamic services) as groups of metadata and include all types of information which can be used or have the potential for being used for characterizing context entities so as to provide the most suitable services to spectators in constantly changing environments. For example, the suggested system uses profiles of an exhibition/spectators and information of surrounding environments as context information, compares previous cases (similarity analysis), and provides personalized exhibition services.

3. Suggested AR Exhibit Information Service

3.1. Service Architecture

The architecture of the AR exhibition information service suggested by this paper consists of a web server (so that all data are processed on the web), a context grouping module, a case comparison module, and an AR process module as depicted in Figure 3. Spectators receive services by logging into the web through their smartphones, and virtual information appears according to their context information.

The context grouping module collects context information from physical sensors, virtual sensors, video input, *etc.*, and groups the information into XML metadata file so as to compare previous cases.

The case comparison module compares the grouped metadata files with previous cases in order to measure similarities. The analyzed similarity servers as the basis for augmenting virtual information in the AR process module.

The AR process module selects and augments exhibition information by referring to similarity analysis and patterns of detected markers.

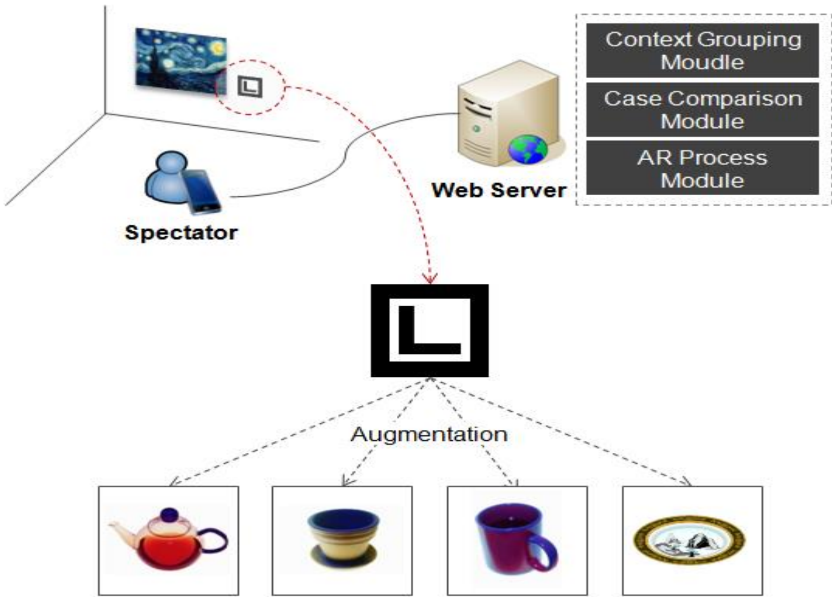

Figure 3. Architecture of AR Exhibit Information Service

3.2. Context Grouping Module

In general, the context information is divided into spectator profiles, exhibition profiles, and spectator environment information while Table 1 shows elements that belong to each category. The profiles are managed by explicit input of spectators and participants in the exhibition through a webpage or a specific service, and the spectator environment information is collected from physical/virtual sensors of a smartphone.

Table 1. Classification and Type of Context

Classification	Type
Spectator Profile	Spectator ID, Password, Name, Age, Sex, Job, Hobby, Address
Exhibit Center Profile	Exhibit Booth ID, Password, Exhibit Name, Booth Location
Spectator Environment Information	Spectator Location, Time, Weather, Date, Marker Pattern

3.3. Case Comparison Module

In this paper, metadata are created in a set form, as depicted in Figure 4 based on the context information collected from various routes, so as to measure similarities.

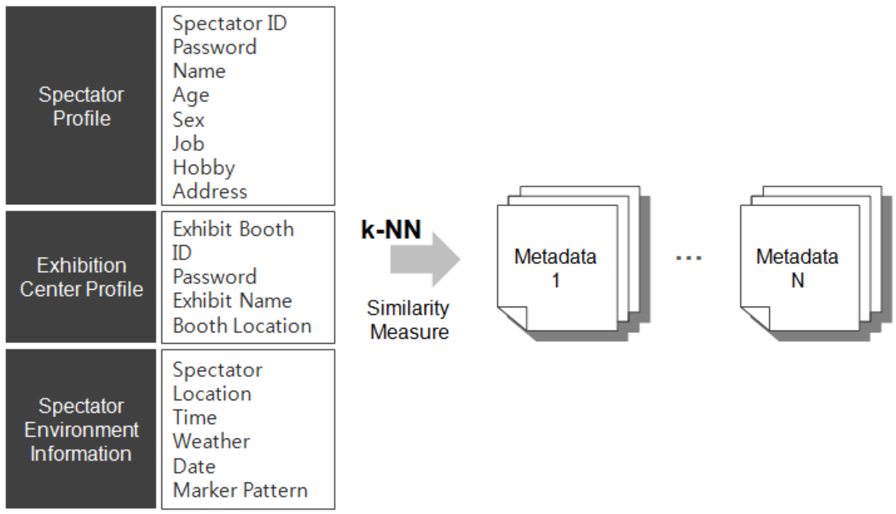

Figure 4. Metadata Set of Context

The created metadata are a new case, and it is compared with previous cases in order to measure similarities. In this paper, we used k-NN(k-Nearest Neighbors), the most commonly used method to measure similarity. The method searches for k number of past cases which are most similar to the new case. And the following formula is used to calculate similarity, applying weight of context information.

$$Similarity(NI, CI) = \sum_{i=1}^{n} f(NI_i, CI_i) \times W_i \Big/ \sum_{i=1}^{n} W_i \qquad (1)$$

NI: New case

CI: Past case saved in the case database

n: Number of attributes held by a case

NI_i: *i* th attribute of the new case

CI_i: *i* th attribute of the past case

$F(NI_i, CI_i)$: Function measuring the distance between NI_i and CI_i

WI_i: Weight of *i* th attribute

In general, the calculated similarity value falls between 0 and 1 (normalized actual number) while a value closer to 0 means low similarity and a value closer to 1 means high similarity.

3.4. AR Process Module

The AR process module in the suggested system is based on markers and has the following flow, including context grouping and comparison modules.

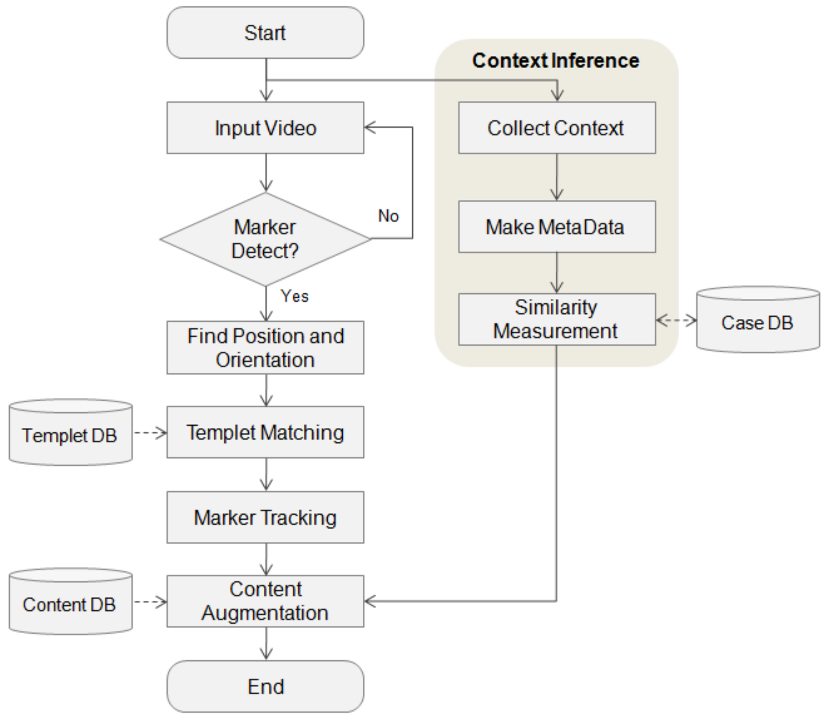

Figure 5. Flow of AR Processing Module

The processing flow mainly consists of marker detection, context aware, and context inference. Finally, the system provides dynamic services for exhibition information, which can be augmented by marker patterns based on similar cases[9] (determined by the similarity measurement).

4. Comparative Analysis

AR-based exhibit information personalized service architecture through spectator's context analysis suggested in this paper. The following table compares suggested service with existing service.

Table 1. Comparison of suggested Service with the Existing Service

Classification	Existing method	Suggested method
Number of marker for expression	1	1
Amount of Meta Data	80	240
Marker detection time	192ms	128ms
Number of database	1	3

5. Conclusion

Exhibitions based on the ubiquitous environment make an attempt to offer exhibition information with various services but the contents are still not sufficient and quite simple. Although AR technologies may be able to express such contents in various ways, virtual information is sent only in a mechanical manner whenever a specific condition is met. Hence, this paper suggests a personalized service system which can offer various types of dynamic exhibition information by grouping spectator/exhibition profiles as well as spectator environment information into metadata and by measuring similarity for context inference.

The system suggested in this paper applies marker-based AR technologies for more accurate recognition rates, but it was observed that the context information was less realistic and the speed of data processing slowed down when the types of context information increased. Therefore, AR technologies other than marker-based technologies should be applied and a method of optimizing similarity measurement should be found in the further study.

Based on this research, an application that enables real objects loading will be added to the future research. Besides, research on an algorithm which reduces more the marker detection time and a system that implements marker detection smoothly even in any environment must to be carried out. A plan to increase or decrease the number of markers printed in one screen should be prepared through the development of a technology of regulating the scale during marker copying. Because of the real time nature of AR, of the development of very fast and correct algorithms is required.

Acknowledgements

This work (Grants No.00044953-2) was supported by Business for Cooperative R&D between Industry, Academy, and Research Institute funded Korea Small and Medium Business Administration in 2011.

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Authors

Sungmo Jung received his B.S. degree in Department of Multimedia Engineering from Hannam University, Daejoen, Korea in 2008, and the M.S. degree in Department of Multimedia Engineering from Hannam University, Daejeon, Korea in 2010. Now, he completed in course of the Ph.D's degree in Multimedia Engineering from Hannam University. He is a member of IEEE and IEEE Communication Society. He has the international license CEH(Certified Ethical Hacker) for network penetration test. His research interests include Machine-to-Machine Architecture, Multimedia Communications, and Network Security.

Soou Kim received a B.S. degree in Chemical science Education from Chosun University, Korea, 1994 and M.S. degree in Public Information of Speech from Hannam University, Korea, 2005. In 1996, she established Morningentercom Company and she is a CEO till now. She was a part-time lecturer in Hyechon College, Korea from 2001 to 2012. And she is a chiefe of Daejeon and Chungnam Branch of KEA. Her research interests include Exhibit Information and Augmented Reality Services.

Seoksoo Kim received a B.S. degree in Computer Engineering from Kyungnam University, Korea, 1989 and M.S. degree in Information Engineering from Sungkyun-kwan University, Korea, 1991 and Ph.D. degree in Information Engineering from Sungkyun-kwan University, Korea, 2002. In 2003, he joined the faculty of Hannam University, Korea, where he is currently a professor in the Department of Multimedia Engineering. His research interests include multimedia communication systems, distance learning, multimedia authoring, telemedicine, multimedia programming, computer networking, and information security. He is a member of KCA, KICS, KIMICS, KIPS, KMS, and DCS. He is editor-in-chief of IJMUE.