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Context-aware Augmented Reality Authoring Tool in Digital Ecosystem

Jonghee Park, Changgu Kang, Sejin Oh, Hyeongmook Lee, and Woontack Woo
GIST U-VR Lab.
Gwangju, 500-712, S. Korea
{jpark, ckang, sjoh, hmooklee, wwoo}@gist.ac.kr

***Abstract*—In this paper, we propose a context-aware authoring tool which users make virtual contents in-situ. In order to realize, three essential components are defined and some technical challenges are reviewed. We expect that the contents will be adaptive and responsible to dynamic environment. It will be applicable for many industries such as book publication, in-situ simulation and so on.**

***Keywords*-augmented reality; authoring; tangible user interface;**

I. INTRODUCTION

As ubiquitous computing technology extends, *Metaverse*[1] which can overcome temporal and spatial limitation is emerging recently. *Metaverse* is an virtual world which users do social, economic, cultural activities using their own avatar. Therefore, users should have an ability to generate virtual models corresponding to real objects in order to implement *Metaverse*. The main function of users in digital ecosystem of *Metaverse* is to produce, consume, reuse and share digital contents frequently [1]. Under the situation, an authoring tool which users can use easily performs important role in producing digital contents.

In this paper, we propose a context-aware authoring tool which has features on dynamic environment. The users can produce virtual models of real objects and track them in real-time based on sensor and image information. In addition, the users can register several virtual contents based on the generated 3D coordinate system. In addition, users can assign intelligence to the virtual characters which enable dynamic response according to external environment changes using tangible user interface.

Chapter II will introduce some related works. Then, chapter III and IV explain essential components and technical challenges for context-aware authoring tool. Finally, scenario in possible application will be discussed in chapter V.

II. RELATED WORKS

Many researchers propose several authoring tools. All of them can be categorized into two levels: low and high level. ARToolkit [2] and OSGART [3] are representative low level authoring tools which provides robust tracking module. Users extend their program based on provided API. AMIRE [4] proposed component based objected-oriented approach which has features on reusability and maintenance. APRIL [5] is the augmented reality presentation and interaction language based on XML. Even though early works are designed and organized well, it is still hard for users who do not know programming to author AR application. Therefore, it will be great work if tangible interfaces are included in those framework. ARTalet [6] shows tangible interface and manipulation techniques in order for users to manipulate virtual objects easily.

In addition, it is more helpful for users in authoring process if intelligent contents are given. Monkey Bridge [7] generated behavior automatically according to height of AR content. AR LEGO and Mr.Virtuoso showed representative guidance system using AR agent. However, previous works have limitations on external changes in AR space such as abrupt appearance of real objects. Therefore, virtual content should respond adaptively as unexpected surroundings change. Finally, users do not need to assign the contents' behavior manually in external changes.

Moreover, early authoring frameworks are usually based on marker based tracking. Marker based tracking is still very robust and stable in fixed environment, but it is unpleasant to users' eye. SIFT [8] and SURF [9] are remarkable recognition and tracking methods based on natural features of target objects. However, there is a limitation on time performance and robustness under severe environmental changes such as illumination changes. Therefore, adaptive and robust tracking methods are necessary to environment changes.

III. CONTEXT-AWARE AR AUTHORING TOOL

The goal of this paper is to define essential components for context-aware authoring and context-aware computer vision, intelligent AR (augmented reality) agent and in-situ tangible user manipulation for making intelligent AR contents possible. To achieve our goal, multiple 3D objects should be tracked in real-time using object features and environmental context (gathered from various sensors). Then, real world and virtual world (Metaverse) are coordinated and registrated in real-time. In the mixed reality, in-situ 3D tangible user manipulation skills are immediately and intuitively applied to author AR contents which reacts to

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[1] http://en.wikipedia.org/wiki/Metaverse

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environmental changes dynamically. Ultimately, based on these technologies, context-aware AR authoring will be completed.

We define three essential components as context-aware computer vision, AR intelligent agent and in-situ tangible manipulation in order to implement context aware authoring. Figure 1 denotes relation between those components. Firstly, sensor manager is responsible for gathering various sensor data. Sensor manager synchronizes multi-sensor data and fuse them. The sensor information is sent to context-aware computer vision module and intelligent AR agent. Then, context-aware computer vision module reconstructs and tracks 3D objects using the sensor data. The output of this module is 3D coordinate system of each tracked object. Next, intelligent AR agent generates five senses (vision, auditory, tactile, olfactory and palate sense) of virtual contents based on tracked coordination system and sensor information. Therefore, it can respond dynamically according to change of real objects. Finally, users can make responsible AR contents with in-situ TUI (tangible user interface). They are able to manipulate virtual contents and make 3D animation using tangible objects intuitively. In addition, adaptive 3D menus are provided according to the change of environment.

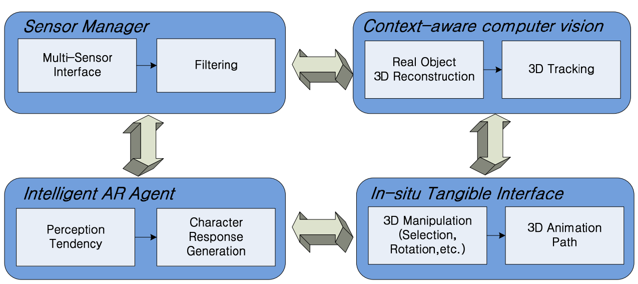

Figure 1. Essential components for context-aware authoring

A. Context-aware Computer Vision

Context-aware computer vision is a technology which exploits environmental and user context(e.g., light, sound, motion, proximity, occlusion, etc,.) gathered from various sensors to make algorithm more efficient. So, context-aware computer vision utilizes both camera image and sensor information to overcome lots of computer vision problems. Figure 2 denotes a general tracking procedure using object feature. From camera captured image, feature points are extracted and its descriptors are generated in order to match them. From the matching set, camera pose is estimated after optimization processes. We divide sensor data into two categories. One is from sensors attached on cameras and the other information is from sensors distributed in environment. Basically, sensors attached on cameras provide additional information such as rotation, motion, etc,. [10] [11] and environmental sensors can generate illumination [12]. In figure 2, sensor information can be utilized in many ways. For example, search range can be reduced by accelerometer in feature extraction and camera rotation can be estimated from gyroscope sensor. Sensor data should be gathered in real-time in order to reflect changes of environment.

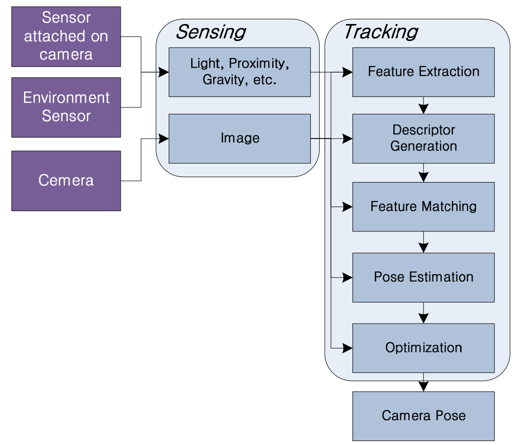

Figure 2. General process of context-aware tracking

B. Intelligent AR Agent

Intelligent AR agents autonomously perceive and react to real objects as well as virtual objects in dual spaces. Figure 3 describes the overall procedure of intelligent AR agents through three key components: sensing, perception, and reaction. First, by utilizing heterogeneous physical and virtual sensor, the agents detect surrounded objects and any changes of them in their environment *(Sensing)*. They understand the sensed information, i.e., unknown object perception by using perception history, and generate the set of available responses suitable for their context *(Perception)*. Finally, the intelligent AR agents determine the suitable response suitable for the context according to their goals and show the selected response adaptable to the dual spaces *(Reaction)*. Finally, our AR agents focus on generation of adaptive response according to real and virtual objects. Therefore we should provide more realistic agent than previous works.

C. In-Situ Tangible Manipulation

In-Situ Tangible Manipulation allows that the user controls a virtual object using physical manipulator in the real place. Thus, according to egocentric viewpoint by real-time camera input, the user interacts with virtual objects using tangible user interface without going to another window or application. Base on the Bowman's classification of interaction [13], we are targeting to develop three context-aware 3D interaction techniques: adaptive 3D menu placement (system control), responsive 3D object selection (selection), and 3D object trajectory setting with effective representation (manipulation). In detail, first, the adaptive 3D menu

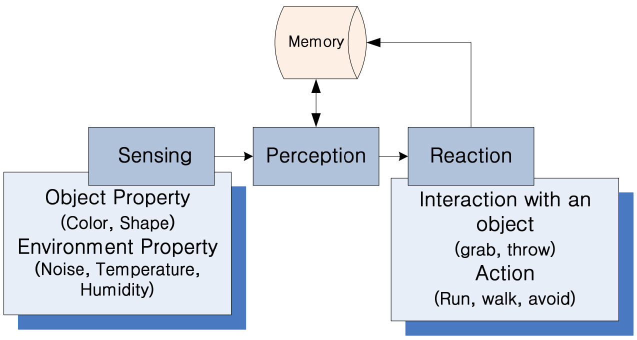

Figure 3. Overall procedure of intelligent AR agents in dual space

placement technique understands features of a target object with environmental context and then presents its 3D menu dynamically. The target object covers virtual objects, real objects, and the tangible manipulator. Second, the responsive 3D object selection considers environmental information and region of interest. Therefore, it helps reduce the selection space using contextual information and pick a small target object using tangible tool or device in a complex group directly. Finally, the 3D object trajectory setting is mostly close authoring context-aware augmented reality contents in terms of users' aspect. The user creates its own 3D trace of selected virtual or real object using tangible tool and we consider the effective algorithm representing trajectory data for resource performance. Also, it could extend to connect the relation among objects and generate the 3D animations for authoring AR contents with various stories.

IV. Technical Challenges

Real-time 3D reconstruction: Real-time 3D reconstruction is essential part in order to track and register 3D unknown objects. However, existing method takes lots of time to conduct bundle adjustment because the time is proportional to the number of features and viewpoints. Therefore, it is necessary to get accurate 3D reconstruction result with small number of images for real-time applications. If not, users have to wait long time to register unknown objects or possesses large amount of data.

Real-time multiple objects recognition and tracking: In order for users to author without any interrupts, real-time multiple objects recognition and tracking are very crucial. If not, users' satisfaction becomes low and nobody want to use it. Usually, tracking methods extract feature points from objects and recognize it. However, it takes long time to recognize multiple objects because of many reasons (feature extraction, descriptor generation, feature matching, etc,.). Therefore, it is very important to recognize and track multiple objects in real-time.

Fast and robust perception: Since Intelligent AR agents inhabit environments consisting of various virtual and physical objects, we need to consider how to enable the agents to perceive their surrounding objects and to interact with them autonomously. To enable the agents to perceive their surroundings, it is required to build the agent's own senses. Even though we aim at human-like agents in AR environments, it is too difficult to make the agents mimic the human's five sense in a realistic way. In addition, since the environments where the agents exist contains heterogeneous sensors, i.e. physical and/or virtual sensors, we require to enable the agents to perceive the sensory information from these sensors and consider how to match the sensed information to agents' senses in fast and robust ways.

Adaptation to unknown environments: When the user moves from the place to the place, the environment where AR agents exist is also changed. Even though the same place, the surrounded objects can be dynamically changed according to user interaction. Since the agents respond to the surrounded objects in a realistic way, it requires to make the agents adapt their behaviors according to changes of the surroundings in real-time.

Context management surrounding User/Object: Adaptive menu techniques allow that system present the virtual manipulators dynamically. According to the situation, they are superior to superimpose to the right menu-style with the right location (e.g. user around, object-referenced, or tangible device-referenced). The situation can be diverse by users viewpoint change, multiple object grouping, changeful background, etc. To make this menu placement technique more intelligent, we require considering how to manage and apply the obtained user and environmental context.

Depth enhancement in 3D selection and manipulation: Usually, contrary to the virtual space, we get the realistic experience and interest with In situ 3D object selection and manipulation. However, due to the lack of depth perception, it is easy to spoil the strength of In-situ Interaction. To supplement this drawback, it is required to provide subsidiary but effective hints or cues mechanism.

V. Possible Application

A. Miniature AR

Usually, objects in a miniature are fixed location on a surface and virtual contents can move there around freely. So, miniatures are very effective to show AR simulation and story. Figure 4 shows in-situ miniature AR authoring and interaction with users. All objects on the miniature are tracked in real-time and users wear HMD (head mounted display). Users are able to manipulate virtual contents in-situ and generates its 3D animation path on the miniature using tangible user interface. In addition, if users put real obstacles on the miniature, virtual contents response according to the object automatically.

B. Digilog Book

Digilog Book is an AR book which provides additional information by stimulating human's five senses with multi-

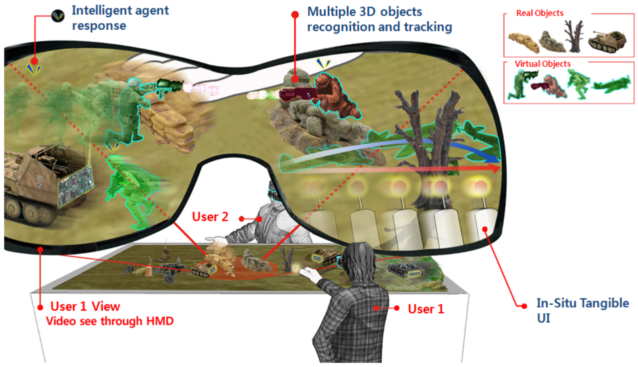

Figure 4. In-situ miniature AR authoring

media contents [14]. Digilog Book provides not only analog emotion of physical book, but also five senses experience of digital contents by combining advantages of paper books and multimedia content [15]. Therefore, users can acquire substantial information and experience realistic virtual contents from a book.

VI. Conclusion

In this paper, we propose a AR context-aware authoring tool which users can author responsible AR contents in-situ. In order to realize it, three essential components are defined and its technical challenges are reviewed. We expect this authoring tool can be utilized in many fields such as book publication, simulation and miniature industries.

References

[1] C. Shin, T. Ha, K. Kim, Y. Lee, and W. Woo, "Ubiquitous virtual reality framework and its application for fostering sustainable content ecosystem," *The Institute of Electronics Engineers of Korea*, vol. 47, pp. 1–11, 2010.

[2] H. Kato, M. Billinghurst, B. Blanding, and R. May, "ARToolKit," *Hiroshima City University*, 1999.

[3] OSGART. [Online]. Available: http://www.artoolworks.com/community/osgart/index.html

[4] R. Dorner, C. Geiger, M. Haller, and V. Paelke, "Authoring Mixed Reality–A Component and Framework-Based Approach," in *Entertainment computing: technologies and applications: IFIP First International Workshop on Entertainment Computing (IWEC 2002), May 14-17, 2002, Makuhari, Japan*. Springer, 2003, p. 405.

[5] F. Ledermann and D. Schmalstieg, "APRIL: A high-level framework for creating augmented reality presentations," *IEEE Virtual Reality, 2005. Proceedings. VR 2005*, pp. 187–194, 2005.

[6] T. Ha, Y. Lee, and W. Woo, "Artalet for digilog book authoring tool authoring 3d objects properties," in *Human Computer Interaction Korea*, vol. 1, 2008, pp. 314–318.

[7] I. Barakonyi, M. Weilguny, T. Psik, and D. Schmalstieg, "MonkeyBridge: autonomous agents in augmented reality games," in *Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology*. ACM, 2005, p. 175.

[8] D. Lowe, "Distinctive image features from scale-invariant keypoints," *International journal of computer vision*, vol. 60, no. 2, pp. 91–110, 2004.

[9] H. Bay, T. Tuytelaars, and L. Van Gool, "Surf: Speeded up robust features," *Lecture notes in computer science*, vol. 3951, p. 404, 2006.

[10] S. You, U. Neumann, and R. Azuma, "Hybrid inertial and vision tracking for augmented reality registration," in *Proceedings of the IEEE Virtual Reality*. IEEE Computer Society, 1999, p. 260.

[11] Y. Yokokohji, Y. Sugawara, and T. Yoshikawa, "Accurate image overlay on video see-through HMDs using vision and accelerometers," in *Proc. IEEE Virtual Reality 2000*, pp. 247–254.

[12] W. Lee and W. Woo, "Exploiting Context-Awareness in Augmented Reality Applications," in *International Symposium on Ubiquitous Virtual Reality, 2008. ISUVR 2008.*, 2008, pp. 51–54.

[13] D. Bowman, E. Kruijff, J. LaViola, and I. Poupyrev, *3D user interfaces: theory and practice*. Addison-Wesley Boston (MA), 2004.

[14] Y. Lee, T. Ha, H. Lee, K. Kim, and W. Woo, "Digilog book - convergence of analog book and digital content," in *Korea Information Processing Society*, vol. 14, 2007, pp. 186–189.

[15] J. Park and W. Woo, "Multi-layer Based Authoring Tool for Digilog Book," *Entertainment Computing–ICEC 2009*, pp. 234–239.