ASIAGRAPH Forum 2012 PROCEEDINGS

# 이미지 기반의 가상 현실 연구

# Research on Image-based Virtual Reality

이하섭, 立山義祐, 小木哲朗 /慶應義塾大学 システムデザイン・マネジメント研究科

Hasup Lee[1], Yoshisuke Tateyama[2], Tetsuro Ogi[3] / Graduate School of System Design and Management, Keio University

*[1]hasups@sdm.keio.ac.jp, *[2]tateyama@sdm.keio.ac.jp, *[3]ogi@sdm.keio.ac.jp

Abstract: We defined components of virtual world as dynamic objects, static objects and background. We developed video avatar as image-based system for dynamic objects and proposed 3D object level-of-detail modeling of mesh from range image. As image-base approach for background, panorama background modeling is studied. User interface for this whole system was also developed using computer vision technique.

Keywords: Virtual Reality, CAVE, Video Avatar, Tiled Display, Range Image, Level-of-detail, Panorama, Computer Vision, Gesture Recognition

## 1. Introduction

The research for virtual reality has a wide spectrum. The continuum between real and virtual reality is proposed in [1]. The items of continuum depend on which is the base part and which is added to. This continuum was extended by new axis ‘mediality’ in [2]. The categorization of VR system is determined by its realness. Photographs can give more reality than paintings if you are not an artist. We thought a real image based approach can build more realistic system because we are not graphic designers. We defined components of virtual world as dynamic objects, static objects and background as shown in (Figure 1). Dynamic objects can be deformed but static objects and background cannot. Dynamic and static objects interact with user but background does not.

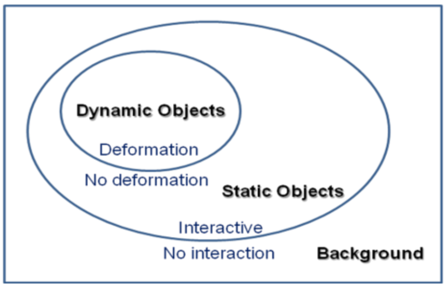


**Figure 1: Components of virtual world**

We developed video avatar as image-based system for dynamic objects and proposed 3D object level-of-detail modeling of mesh from range image. As image-base approach for background, panorama background modeling is studied. User interface for this whole system was also developed using computer vision technique.

## 2. Video Avatar

Video avatar technology made users can share a virtual space between remote sites. Users can point out the 3D data more precisely using video avatar with stereoscopic devices. The example of video avatar is shown in (left of Figure 2). We applied this video avatar technology to the display of the digital museum [3]. We extract background image from recorded video stream using chroma key and send the stream to remote host. We use very high resolution projector and huge screen for viewers to feel the mood of the environment when and where the exhibits existed (right of Figure 2). Also we applied video avatar to tiled display communication [4]. We capture and send/receive the user’s image using fish-eye camera. Using multiple fish-eye camera, eye to eye directional communication is possible and finger tip can be detected.

**Figure 2: Video avatar in CAVE and huge screen**

## 3. 3D Object LOD Modeling

In 3D graphic systems, the system performance is changed continuously because the number of objects or the complexity of the background scene changed. If we can control the LOD (level-of-detail) of the object, we can construct an effective computer graphics system. LOD modeling consists of the representation of the mesh and the algorithm to generate a certain LOD. We proposed a wavelet-based LOD modeling [5] and a new data structure called marching cube octree [6], which is based on the data structure of a Marching Cube algorithm used to generate mesh from range data. We used this data structure to make the new LOD model. Using the sampling paradigm, our algorithm turned out to be faster than previous methods. Our model can support adaptive simplification, progressive transmission, view dependency rendering and collision detection. By using the marching cubes, our LOD mesh generation algorithm becomes efficient without floating point operations. The example meshes of our model are shown in (Figure 3). (Dataset source: Cyberware™)

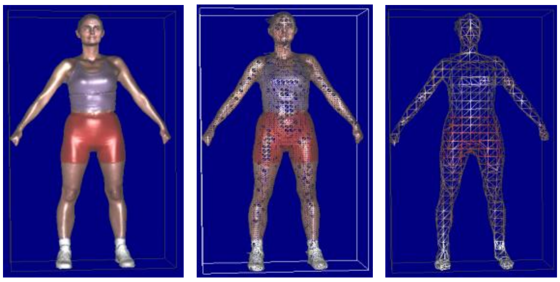

**Figure 3: Level-of-detail modeling of 3D mesh**

## 4. Panorama Background Modeling

We make the panoramic images from the real environment using a digital camera and a panoramic tripod head and apply them to the CAVE system to increase user's immersion. We take photos for panoramic image representation efficiently by formulating the calculation of panoramic image photographing. A virtual sphere surrounding CAVE was defined in graphic system. We took the panorama photos as texture and mapped into inside of the sphere. Only one panoramic image is constructed using a digital camera and panoramic tripod head in [7] and the stereo background modeling is made by two panoramic images for left and right eye in [8]. The more efficient method for take picture of environment is improved with 3D panorama sweep function in [9]. The CAVE system with real image-based background modeling is shown in (Figure 4). As an application, we used panorama background modeling to present the Great East Japan Earthquake to users effectively [10].

**Figure 4: Panorama background modeling in CAVE**

## 5. User Interface

For our systems, we use game pad for manipulate the background but more unaffected interface is needed. To make such interface, a device held or attached to body like game pad, glove and hat is excluded. Because of seamless feature of screens of CAVE, standalone system like wireless network connected notebook, tablet pc is preferred for interface processing (left of Figure 5). So we developed an interface of gesture recognition using motion templates method [11] and blob detection [12]. The computer vision module recognizes predefined user's gestures and sends commands to master/render modules of CAVE system via internet. Using this method, we can add unaffected user interface to our system. The intermediate result of motion template method is shown in (center of Figure 5) and of blob detection is shown in (right of Figure 5).

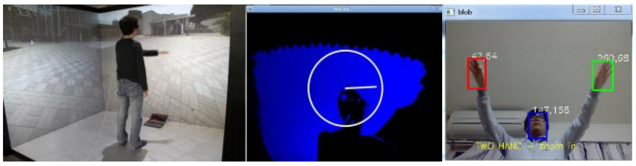

**Figure 5: User interface with gesture recognition**


## Acknowledgement

Most of these researches are supported by Keio University Global COE (Center of education and research of symbiotic, safe and secure system design) Program.


## References


[1] P. Milgram, H. Takemura, A. Utsumi and F. Kishino, "Augmented reality: a class of displays on the reality-virtuality continuum", Proc. SPIE 2351, 282, 1995.

[2] S. Mann, "Mediated Reality with implementations for everyday life", Presence Connect, the on line companion to the MIT Press journal PRESENCE: Teleoperators and Virtual Environments, MIT Press, 2002.

[3] H. Lee, Y. Tateyama and T. Ogi, T. Nishioka, T. Kayahara and K. Shinoda, "Interactive Exhibition with Ambience using Video Avatar and Animation on Huge Screen", The 14th International Conference on Human-Computer Interaction (HCII 2011), LNCS 6774, pp.253-259, July 2011.

[4] Y. Sakuma, H. Lee, Y. Tateyama, T. Ogi, N. Kukimoto and H. Kuzuoka, "Tiled display communication with space sensation using fish-eye camera", VRSJ the 16th Annual Conference, pp.89-90, September 2011.

[5] H. Lee and H. S. Yang, "Wavelet-Based Level-Of-Detail Representation of 3D Objects", Journal of KISS (Korea Information Science Society): Computer Systems and Theory, 29(3, 4), pp.185-191, 2002.

[6] H. Lee and H. S. Yang, "Marching-Cube-and-Octree-Based Level-of-Detail Modelling of 3D Objects", International Journal of Modelling and Simulation, Vol. 29, No. 2, pp.121-126, 2009.

[7] H. Lee, Y. Tateyama and T. Ogi, "Realistic Visual Environment for Immersive Projection Display System", The 16th International Conference on Virtual Systems and Multimedia, pp.128-132, October 2010.

[8] H. Lee, Y. Tateyama and T. Ogi, "Panoramic Stereo Representation for Immersive Projection Display System", The 9th International Conference on VRCAI (VR Continuum and Its Applications in Industry), pp.379-382, December 2010.

[9] H. Lee, Y. Tateyama and T. Ogi, "Image-based Stereo Background Modeling for CAVE System", International Symposium on VR innovation (ISVRI) 2011, March 2011.

[10] H. Lee, Y. Tateyama and T. Ogi, "Presentation of the Great East Japan Earthquake with Ambience using CAVE", ASIAGRAPH 2011 in Tokyo, pp.22-25, October 2011.

[11] H. Lee, Y. Tateyama and T. Ogi, "Unaffected User Interface for CAVE using Motion Templates Method", The 3rd International Conference on Advanced Science and Technology (AST 2011), September 2011.

[12] H. Lee, Y. Tateyama and T. Ogi, "Hand Gesture Recognition using Blob Detection for Immersive Projection Display System", ICECECE 2012 : International Conference on Electrical, Computer, Electronics and Communication Engineering, February, 2012.