Character Visualization in Miniature Environments with an Optical See-through Head-Mounted Display

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Abstract. In this paper, we present a visualization method of virtual characters to provide augmented reality (AR) experiences for a user wearing an optical see-through head-mounted display (HMD). First of all, we execute plane detection to find position of a user's real desk. Second, we perform position update of virtual characters to connect real-time location information for reflecting the height of miniature objects on the desk. Finally, we visualize virtual characters that is involved in environmental properties with the optical based see-through HMD. Our method can be applied to AR contents with respect to contexts of environmental information surrounding the user such as miniature elements.

Keywords: Augmented reality, virtual character, see-through HMD.

1 Introduction

Recently, augmented reality (AR) systems to overlay virtual objects on the real world have been widely used for the purposes of location based service, and many researchers have many efforts to study interaction design of AR objects to support an intuitive sense of the user [3]. In particular, realistic operation about the virtual character with context-aware interfaces of real-world environments are also introduced with a view to offering a seamless environment beyond the barrier between virtual space and real one [4]. In recent years, markerless-based tracking with a depth sensor such as Microsoft Kinect have extensively increased, which allowed user interaction to manipulate the virtual character with detection of the users motion in real-time [2]. Sam et al. proposed an augmented reality system to visualize virtual spiders that were controlled behavior and interactivity using a depth camera [5]. Ha et al. presented a miniature AR system to help exhibition visitors and to provide DigiLog experience by interactive storytelling. Here, position of virtual objects was determined by 3D reconstructed models, and AR objects were visualized with devices such as a phone and an e-book [7].

In this paper, we present a visualization method of virtual characters in relation to real situations such as miniature environments with wearing an optical see-through HMD. Our method is capable of executing updated location of the virtual character through real-time height information of the miniature topography estimated by a depth camera. Specially, we combine the sensors among

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an optical-based see-through HMD, a depth camera, and a optical based tracker to provide real-time visualization and tracking. We also develop activity animation of the virtual character to apply with various contexts of the composed miniature environments such as the miniature element involving position of the virtual character.

2 Character Visualization System

2.1 Position Detection to Visualize Virtual Characters

First of all, we execute plane detection to identify an active desk in real environments and execute height estimation of the desk with the basis of the installed depth camera. The virtual character for visualization can be updated continuously with correct position based on a height map to consider not only the desk but also miniature elements.

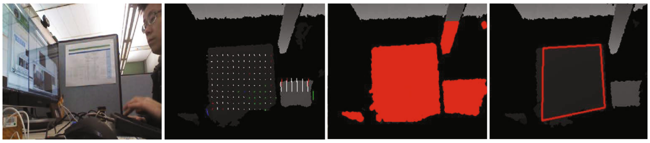


Fig. 1. Active plane detection to find the real desk as an interaction space: (a) real environments of the desk; (b) normal map to extract using depth information; (c) candidates among plane areas; and (d) the result to detect an active plane

Figure 1 shows the overall procedure of the active plane detection to find an interaction space on the real desk using a depth camera. First, we calculate the normal vectors of all pixels in a depth image by doing cross product of three neighboring 3D point [1]. Second, we divide all depth pixels into spatially several neighboring components which can be easily classified by gathering same normal directions. In order to reduce the depth noise, we simply smooth each depth value by meaning of around nine pixels before the division. Third, we select our active plane as a component in the middle of the image as an interaction space. Fourth, we take the 3D plane equation using randomly selected three points among given N points obtained from the interaction space. Let P1=(X_1, Y_1, Z_1), P2=(X_2, Y_2, Z_2), and P3=(X_3, Y_3, Z_3) be the three points. Three typical plane equations can be described using P1, P2, and P3 as follows. Here, k represents the number of a selected point.

$$aX_k + bY_k + cZ_k + d = 0 \quad (1)$$

We solve these equations using Cramers rule. Last, we convert the xyz coordinate for the active plane into the criteria coordinate by calculating the transformation matrix T and multiplying all 3D pixel values P by the matrix.

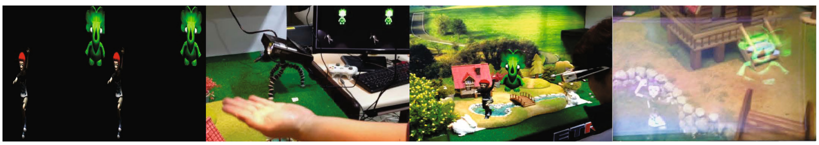
$$Pc = T * P \quad (2)$$

2.2 Visualization of Virtual Characters with the See-through HMD

We install our miniature environments including an optical see-through HMD, a MS Kinect depth camera, and an optical-based tracker. In particular, the depth camera for real-time height calculation is installed over the top of miniature. As a precise tracking to obtain the data of head position, we use NatualPoint OptiTrack rigid-body markers and an object-tracking toolkit that can calibrate and track 6DOF (six degrees of freedom) objects related to head motion of the user. To visualize virtual images, we also use Silicon Micro Display ST1080 HMD to support see-through visualization [6].

To adjust position of the virtual character with height information, we use the method by the extraction of height values with real-time depth information since this is able to reflect positional movement of dynamically movable objects. Figure 2 shows real-time character visualization to apply height information of movable elements in miniature such as a pond and a bridge. Unlike visual tracking with pose estimation of traditional augmented reality, we combine virtual objects with 3-axis location based on the coordinate system of the optical tracker and the value coverted real-time depth information into tracker coordinate. Additionally, we also develop generation of automatic animation to consider local position of the character on the miniature. For example, when the virtual dinosaur falls out the pond which is a part of miniature, it plays the animation to paw the air to get out of the water automatically.

As a software development platform, we use the Unity 3D tool to render the virtual content, and C# language to integrate the movement and animation of virtual characters with the depth camera on a Microsoft Windows 7 operating system. The quantitative evaluation of the distance about average errors to compose 3D virtual objects had less than 0.3mm in tracking accuracy that was considered with the combination of the optical tracker and the depth camera. Moreover, our estimated results of achieved accuracy about the height position with the AR characters had less than 1cm, and online detection speed for interaction to apply the height of the users hand had more than 20 frame per



(a) (b) (c) (d)

Fig. 2. Character visualization with the see-through HMD in relation to real-world height of the miniature: (a) virtual characters generated by computer and reflected stereoscopic visualization. The virtual dinosaur was transformed with position to consider hill height of our miniature system; (b) The virtual dinosaur to reflect height position of the userś hand; (c) a concept of character visualization to overlay virtual objects on the optical see-through HMD under miniature environments; (d) the result of character visualization to capture inner images of the HMD using a webcam.

second (FPS). Our system is built on a PC with a 3.07GHz Intel Core i7 CPU, 12 gigabytes of main memory, and a NVIDIA GeForce GTX 260 graphics chip.

3 Conclusion and Future Work

An augmented reality system using an eyewear based device such as a see-through HMD needs to reflect visualization involving real environments for the purposes of providing realistic experience. In this paper, we proposed a constructed system including the see-through HMD to visualize virtual characters on the miniature with coordinate correspondence. We also presented visualization methods of virtual characters living real worlds to consider positional information such as the height of real objects, and the dominant plane. In our future work, we need to work towards the expansion of improving an algorithm for a depth camera which can locate random position away from regular position on the top of the miniature to support wearable technology. we will also develop interaction methods of virtual characters with finger gesture.

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