Bare-Hand-Based Augmented Reality Interface on Mobile Phone

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ABSTRACT

This paper proposes an augmented reality interface that provides natural hand-based interaction with virtual objects on mobile phones. Assume that one holds a mobile phone in a hand and sees the other hand through mobile phone's camera. Then, a virtual object is rendered on his/her palm and reacts to hand and finger movements. Since the proposed interface does not require any additional sensors or markers, one freely interacts with the virtual object anytime and anywhere. The proposed interface worked at 5 fps on a mobile phone (Galaxy S2 having a dual-core processor).

KEYWORDS: Interaction techniques for MR/AR, MR/AR for entertainment, vision-based registration and tracking.

INDEX TERMS: D.2.2 [Software Engineering]: Design Tools and Techniques—User interfaces; H.5.2 [Information Interfaces and Presentation]: User Interfaces— Interaction styles

1 INTRODUCTION

With the recent advance in the performance of mobile phones, many effective interfaces for them have been proposed. Existing interfaces can be classified into two categories: hardware-based and vision-based. In general, the vision-based interfaces have received more attention since the hardware-based ones require additional equipment or physical sensors which are inconvenient and relatively inaccurate.

As an example of existing vision-based interfaces, Haro et al. proposed to use mobile phone's rigid movements as interaction input [1]. For estimating phone's movements, they measured the optical flow in the camera images. An and Hong proposed to use fingertip's movements as interaction input and they tracked the index finger of the hand holding a mobile phone [2]. Also, Gallo et al. proposed a pointing system that the pointer's position is obtained by estimating the bare hand positions using image gradients in a color space relevant to human skin [3]. However, most of existing vision-based interfaces can provide simple and limited interactions.

A few years ago, Lee and Höllerer proposed a hand-and-vision-based interface [4]. They assumed wearable computing scenarios, where a body-mounted camera sees the hand. The interface provides interaction with virtual objects augmented on his/her palm by estimating palm pose. However, users cannot move their fingers during interaction since it requires fingertip information to estimate palm pose.

Recently, Seo et al. proposed a more advanced vision-based interface on an ultra-mobile PC. They assumed a natural interaction scenario where one holds a mobile device in a hand and sees the other hand through the mobile device's camera. It can provide more various and sophisticated interaction with virtual objects augmented on his/her palm by recognizing not only the palm pose but also fingers' articular movements [5]. However, the interface estimates palm pose using the wrist location and the convexity defect point between the thumb and the index finger which are insufficient to estimate palm pose. So, they limited the scope of palm pose to only one direction of pitch and yaw rotation e.g. it can cover 0° to 60° of pitch rotation but cannot cover 0° to -60° of pitch rotation.

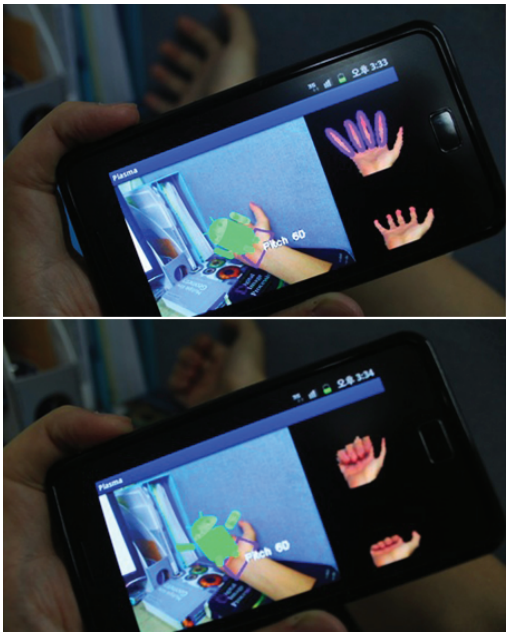

Figure 1. Bare-hand-based augmented reality interface on mobile phone. The android character is rendered on user's palm and dances when user closes his/her hand.

This paper proposes an improved vision-based interface on augmented reality environment. The proposed interface is similar to the one proposed by Seo et al. in the same scenario, but it can more accurately estimate all possible palm poses (covering pitch of -60° to 60°, yaw of -45° to 60°, and roll of -180° to 180°). While Lee and Höllerer paid less attention on providing finger-based interaction with an augmented virtual object and Seo et al. offered simple interaction such as opening or closing the hand, our interface offers finger-based complicated interaction, e.g. menu selection using fingers, by adopting the shape-decomposition-based finger detection method. For implementing the interface on a mobile phone, our hand shape recognition method [6] is substantially modified, which is a time-consuming process. Finally we obtained a plausible interface working at an interactive frame rate. Figure 1 shows a demonstration on a mobile phone using the proposed interface. To the best of our knowledge, this is the first work that presents a bare-hand-based AR interface using palm pose and finger gesture on a mobile phone.

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2 METHOD

The proposed method consists of three steps: hand detection, palm pose estimation, and finger gesture recognition. First, a hand is segmented from an input image through thresholding in YCrCb color space and distance transform. Second, a palm pose is estimated by comparing the detected hand with a database that includes PCA and gradient histogram of all palm poses. Since the comparison with a database requires repetitive and time-consuming computations, the palm pose estimation is run in parallel in the background. Finally, it recognizes finger gestures using shape decomposition and context-based decision. Here, for accurately recognizing the finger gestures, hand's frontal view is obtained using the palm pose information before the finger gesture recognition as shown in Fig. 2-(a).

Through various optimizations such as reduction of floating point operation, parallel processing, and so on, the interface, which the proposed method is ported on a mobile phone, works more than three times faster than the one that the previous method is directly ported on mobile phone. Also, our method had a recognition rate of 83% on average in the experiment with 800 images including 5 finger gestures and 16 palm poses as shown in Fig. 2-(b) (covering pitch of -60° to 60°, yaw of -45° to 60°, and roll of -180° to 180°).

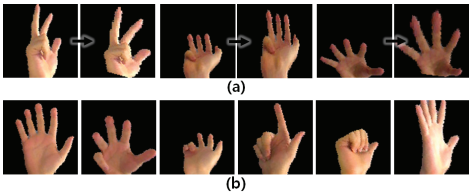

Figure 2. Results of hand's frontal view obtainment (a) and hand images used in experiments (b).

3 APPLICATIONS USING THE PROPOSED INTERFACE

Using the proposed interface, we implemented augmented reality applications where a virtual object is rendered on user's palm and reacts to the changes of fingers, hand positions, and palm poses. As a target platform, we used a commercial mobile phone (SAMSUNG Galaxy S2 having 1.2 GHz dual core processer, 1GB RAM, and Android 2.3 OS). The proposed interface worked at 5 fps on average. Figure 3, 4, and 5 show examples of the applications using the proposed interface. Figure 3 shows an application where the virtual object reacts to the change of palm pose. The virtual object on palm was slipped out of the palm when user tilted his/her palm. Figure 4 shows an application where the virtual object reacts to the hand shake. When user shook his/her hand, the virtual object jumped. Also, since the proposed interface can individually recognize the gestures of each finger and their lengths, more detailed interaction could be provided such as selecting menu as shown in Fig. 5.

4 CONCLUSION

A novel bare-hand-based augmented reality interface which provides natural interaction with a virtual object on one's palm on mobile phone was proposed. Detailed interactions also could be provided since it could accurately recognize various palm poses and finer gestures. We are currently more optimizing the method for further increasing the working speed.

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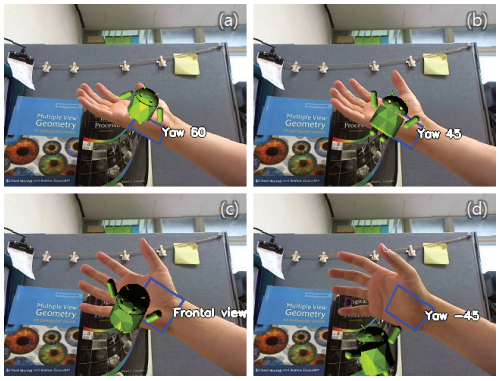

Figure 3. Slide interaction with the android character when the hand is tilting (the procedure is from (a) to (d)).

Figure 4. Jump interaction with the android character when the hand is shaking (the procedure is from (a) to (d)).

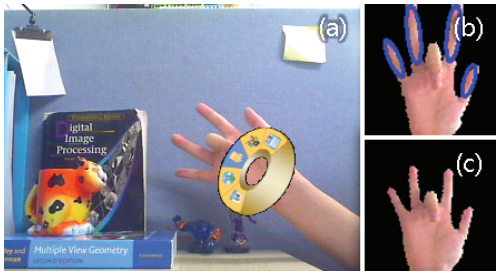

Figure 5. Menu selection using fingers. (a) Menu selection, (b) hand's frontal view and finger gesture recognition, (c) detected hand.