Enhancing Robustness to lighting and Immersiveness in the AR based Product Design

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***Abstract*—Recently, various AR-based product design methodologies have been introduced. In this paper, we propose technologies for enhancing robust augmentation and immersive realization of virtual objects. A robust augmentation technology is developed for various lighting conditions and a partial solution is proposed for the hand occlusion problem that occurs when the virtual objects overlay the user's hands. It provides more immersive or natural images to the users. Finally, multimodal interaction is enabled to provide more immersive experience to users. An immersive game-phone model is selected to demonstrate that the users can play the game the racing game by grasping a tangible object with effective sounds. The proposed methodologies will be contributed to the immersive realization of the conventional AR system.**

***Index Terms*— AR-based Product Design, Hands Segmentation, Tangible Object, Multimodal Interaction**

I. Introduction

In the conventional desktop based product design environment, users have been inspected virtual objects through a monitor in fixed position. Also they have been used a mouse or a keyboard to interact with virtual objects in front of the monitor. However, in the wearable AR environment, users are wearing a HMD and can interact intuitively with a tangible object by grasping with hands. Namely, it reduces gabs between modeling spaces and user (interaction) spaces. However, several problems exist in applying AR technology to product.

In the typical AR application using ARToolKit [1], the shade under hands or spot-like lighting can cause unstable augmentation. In order to reduce these problems, our method makes binary images through "Adaptive threshold" [2] and detects rectangles from these images. Also, augmented virtual object can occlude with users' hands when users interact with the augmented virtual objects. It may cause visually awkward the augmented image results and it also can reduce immersion or naturalness. To overcome this problem, our method estimates "Gaussian Mixture Models" [3] which is composed of hand and marker color distributions in the HSV color space. By comparing likelihoods of each distribution based on the Bayes decision theory, we can segment hands object and overlay it on the augmented virtual object again. Lastly we allow users have interesting experience by enabling multimodal interaction. In our application, the users grasping the augmented game-phone which is a tangible object, they can control the game by tilting the tangible object in the direction of x, z axis. It is same way to control the game in real game-phone. In racing game, if player collides with wall, vibration effect is generated. Also, explosion sound is played.

The section 2 will present related research; explanation of the detailed algorithm will be followed in section 3. In section 4, we address implementation and show the experiment results of the proposed method. Finally we present conclusion and future works in section 5

II. Methodologies for Enhancing Robustness and Immersiveness

A. Robust Marker Detection under Various Lighting Conditions

In this paper, we apply "Local adaptive threshold" to obtain the binary image. Each pixel set the threshold value to the mean value of each block unit so that the threshold value depends on a local block unit. It is possible to detect the marker in the relatively bright lighting condition or dark lighting condition. That is, some significant features in homogenous color surfaces can be detected in the some various lighting condition. The size of a neighbourhood block is adaptively decided with respected to the size of detected marker.

B. Reduction of Hand Occlusion

In order to reduce the hands occlusion phenomenon, we propose a method. This is composed of three steps as follows.

In the first step, by only processing the hands area on the tangible object, we can reduce the redundant time to process an entire image and improve processing speed. In the second step, we apply the statistical approach to segment hand objects from the area of tangible object. By estimating "Gaussian Mixture Models" which are composed of marker's colour distribution and hand object's colour distribution, hand object's pixels are decided based on the Bayes decision theory. Finally, overlay segmented hand object on augmented virtual object again. H

This research is supported by the Ubiquitous Computing and Network (UCN) Project, the Ministry of Information and Communication (MIC) 21st Century Frontier R&D Program in Korea and Immersive Contents Research Center (ICRC) at at Gwangju Institute of Science and Technology (GIST)

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colour component in the HSV colour space is used to minimizing the sensitivity of lighting.

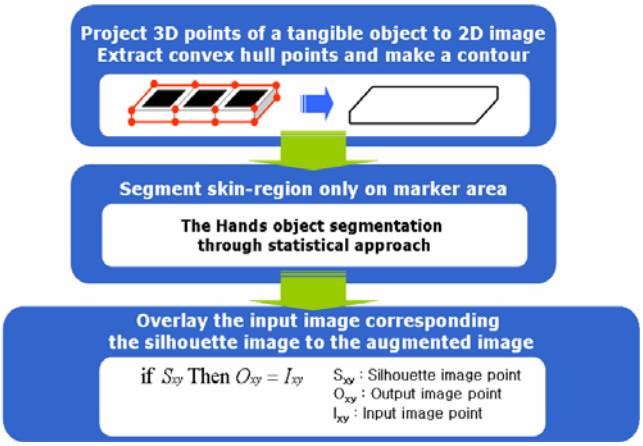

Figure 1. Three steps for reducing hands occlusion phenomenon

C. *Game Application Based on Multimodal Interaction*

The users can multimodal interaction with game-phone using the tangible object. For example, the users grasping the tangible object, they can control the game by tilting the tangible object in the direction of x, z axis. It is same way to control the game in real game-phone. In racing game, if player collides with wall, tactile information and vibration are generated. Also, explosion sound is played

III. Implementation and Experiment Result

We used a 3D video see-through HMD of VRmagic corporation [4] and Dell corp.'s workstation (e.g. 650MT). Input images was captured at 30 (f/s) and resolution was 640*480 pixels. We referenced the OpenCV version 5.0 beta [5] and ARToolKit version 2.70 beta [1] libraries.

The following figure 2 shows the results of "Local adaptive threshold". Robust augmentation is possible under various lighting conditions, the shade by hands or a table

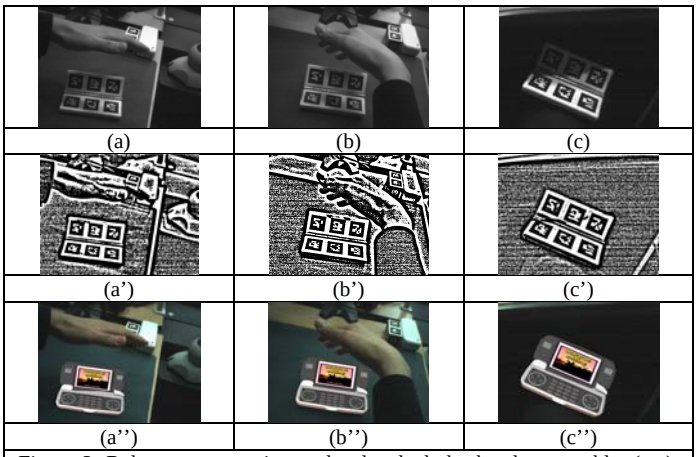

Figure 2. Robust augmentation under the shade by hands or a table. (a-c): Grayscale images. (a'-c'): Corresponding binary images. (a''-c''): Corresponding results images.

We've partially solved the hand occlusion problem. It provides more immersive or natural images to the users

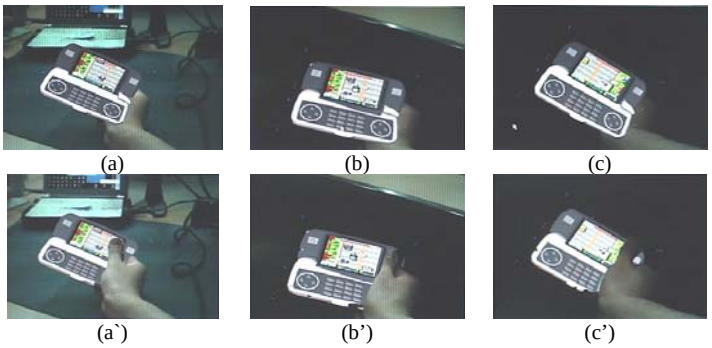

Figure 3. Hands object segmentation under various lighting condition.

IV. Conclusion and Future Work

In this paper, we proposed methodologies for more roust augmentation and interaction in AR-based product design. First, a robust augmentation under varying lighting condition is enabled by local adaptive thresholds. Second, we've partial solved the hand occlusion problem. It provides more immersive or natural images to the users. We assist the users to interact with a digital mock-up model much better by enabling multimodal interaction.

We realized the immersive model which is a game-phone with the proposed methods. The users can control the car in the racing game by tilting a tangible object. The proposed methodologies will be contributed to the immersive realization of the conventional AR system.

As future works, we will add other cues for more roust hands segmentation such as edge and geometry relations of hands model. Also we are considering the interaction with virtual objects using fingertips by exploiting 3D depth information and the augmentation by exploiting points tracking of a tangible object, even though all of markers are not detected.

References

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