Dynamic Projection Mapping

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Figure 1: *Dynamic dress-up simulator in the real-world. The color and patterns of user's clothes (leftmost image) are overwritten with projected images, and changed into an new looking. The new clothes are fitted with user's active motions. This effect can be seen with our own eyes, through no additional displays. Moreover, this system can achieve entertainment effects like a see-through human.*

1 Introduction

A projection mapping is the latest and effective application of image projection technologies. It changes physical appearance of real objects, and provides extreme reality of projected images. Thus this technique is thought to be a true augmented reality without any additional displays in front of our eyes.

However, it has a large limitation of its targets to be static. This technique is heavily rely on geometrical and photometric information of target surfaces, for providing precise overlapping of projected images as a new appearance on physical objects. So, as the first step, we have to precisely measure the geometric and photometric characteristics of the targets over time, and that is an obviously bottleneck of wide and accessible applications. In order to break down this situation, we strongly request arbitrary image projection on dynamic targets. Although some of previous researches [Fujii et al. 2005] have tried to solve this problem, their results are only for limited situations as a moving solid body with constant lighting.

Therefore, in this research, we propose a projection mapping with dynamic compensation of geometric and photometric changes. This technique can overwrite the appearance of active objects including humans, and provide a new appearance, just like a transformation or a display-less augmented reality. We demonstrate this technique as a dynamic dress-up simulator with active models (Figure 1).

2 Geometrical Compensation

Our proposal provides two technical factors for achieving the interactive projection mapping that changes our appearance with image projection. First is a dynamic geometrical compensation with a commodity depth sensor as real-time surface capturing. Generally, physical objects including target humans change geometrically at any time, according with their movements. The changed geometry is usually captured and used for geometrical correction of projecting images by using computer vision techniques. However, they are generally slow and not capable of being used for the interactive projection mapping. So we use the commodity depth sensor, like Kinect, for capturing the target surface, and use it for precise image projection on arbitrary-shaped targets in real-time. Furthermore, for compensating potential delay of a camera and a projector, we introduce a precise motion prediction with a recent CCD camera with 200Hz update rate, which commonly has high speed capturing spec, faster than the update rate of a projector.

3 Photometric Compensation

Second factor is a dynamic photometric compensation for adapting changes of target surfaces, including a reflectance property and environmental light (Figure 2). We estimate a simple response function of the pair of a projector and a target in real-time, and use it for canceling physical color of the target and provide a new appearance. Because general projectors are based on gamma characteristic, differences of the surfaces are represented as a scaling factor of the gamma characteristic, previously and precisely captured[Majumder and Gopi 2005]. In addition, we estimate a change of per-pixel lighting condition. When we project images in our accessible environment, not a special studio, we have to consider the effect of indirect-reflected light between neighboring pixels. Then, we can precisely control projected light, and overwrite original color of real object freely. For stable estimation of these different parameters, we use a recursive least square (RLS) algorithm. Most of this estimation including geometrical compensation is processed with GPUs (dual GeForce GTX 295) at 25fps.

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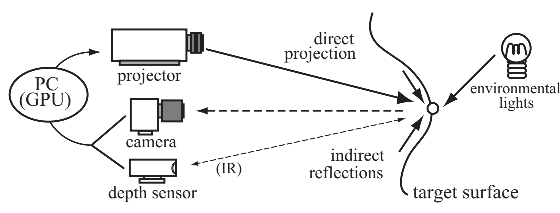

Figure 2: *Projector-Camera system and Lighting environment.*

References

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