Interactive Projected Display on the Palm without Marker using Computer Vision Processing

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1. Introduction

Recent research introduced the interactive environment with non-device object using projected display technology [1]. In that environment, user can manipulate the system using physical object as they control physical object. This metaphor is expected to give user more natural interaction. Especially, one of the most promising features of the projected display is the accessibility. If the projected display with physical object does not require user to wear additional marker, it is possible to be accessed at anytime and anywhere user wants. By paying more attention to this feature, we developed the palm display which uses the palm as a display and the finger as an input device without attached marker. In this paper, first we show the example application and the interaction using the palm display, and we describe the implementation of the base technology.

2. The Television Controller

The advantage of the palm display is relatively clear. It is always accessible without further requirement. Most of people have experience to ransack the remote controller for the television or air conditioner. That is the reason why we developed the television controller as a first example application.

The Figure 1 shows the television controller on the palm. User can control the channel and volume of the television by generating *pause* event. To generate *pause* event, user pauses the movement of the fingertip on the control. Then, the system recognizes the *pause* event and event handler routine is executed. The reason why we select this method, called *pause*, will be explained at section 3.

In the Figure 1, the arrows for up and down directions are for controlling channel and the left-right directions are for the volume control. The button TV is for navigating applications. When there are several control applications for appliances, user can select the controller by selecting this button.

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Figure 1 Television controller on the palm

3. Development of Prototype

As shown in Figure 2, we used networked PTZ camera and common beam projector for the implementation of the prototype system. The networked camera allows us to control it by sending HTTP request message. By controlling its properties such as pan and zoom, we can focus on the user's hand. As a result, we can capture bigger-sized image of the hand. Moreover, in the future, we have a plan to cover whole range of the room. For this goal, the controllable PTZ camera is necessary.

The first step is to find the hand. In this step, the system processes image two times. The first process is to subtract background using cached background image. The second step is to find hand in extracted image. In this phase, we use the *hue* value in HSL color space. The *hue* property is excellent to extract human's skin color. The Figure 3 shows the result.

The second step is to extract the bright region from the result image from the first step. In this phase

Figure 2 Networked PTZ camera (left) and the beam projector (right)

Figure 3 Hand extraction, source (left) and result (right)

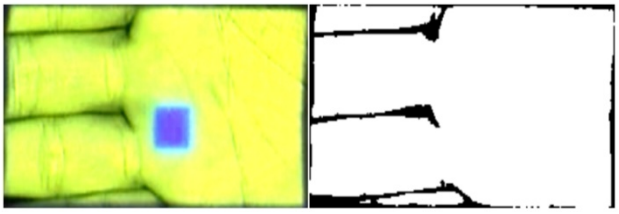

Figure 4 Extracted image of bright region

we employed *lightness* value in HSL color space. The *lightness* value describes its intensity of the light. Thus, it is good to extract bright region. The Figure 4 shows the result of this process.

The next step is to find the fingertip on the palm for detecting the event. The bottom side of the Figure 5 shows the shadows after noise reduction process. By analyzing shadow information we can keep track of the location of the fingertip. The research such as [2] also used shadow information, and they find that the better shadow image can be given if the angle between screen and projector is adjusted. However, this method is not appropriate to our configuration. We cannot expect where the hand is and it is difficult to request user to change the angle of his palm to the projector.

At initial phase, we tried to develop touch method using the shadow information. As shown in Figure 5, the touch event can be detected if the angle from the palm to the projector is suitable. However, when the angle is not appropriate, it is very difficult to find shadow information. The touch event is too dependent to external conditions such as the angle. However, we noticed that the location of finger can be tracked relatively well, if there is little gap between the finger and the palm. That is the reason why we use ***pause*** method for generating the event as explained at section 2.

4. Related Work

Lee et al. developed the prototype system of mobile interactive projected display [3]. Especially, the system recognizes the position in 3D by recognizing the attached infrared marker. Thus, the system can show the image in aligned manner. However, our system detaches the marker to guarantee the accessibility.

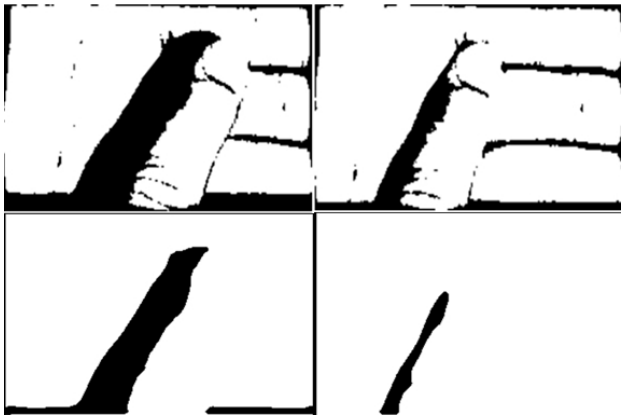

Figure 5 Not touched status (top-left), touched status (top-right), image after noise reduction (bottom)

Echtler et al. used also shadow but their system is equipped with infrared LED [4]. The acrylic glass is installed in their system and the LED is attached at the edge of the glass. When user pushes the glass, the more bright light, reflected from the LED, is emitted. Tracking that light shadow, their system can recognize the multi touch.

5. Conclusion and Future Work

In this paper, we introduced new interface called the palm display and described its implementation. We expect that the palm display is promising candidate interface for the controller in ubiquitous environment. However, there are two challenges we should address in the future. The first one is the higher recognition rates of the event. The current prototype shows about 80% exactness. We will raise the exactness. The other challenge is the development of more applications. We expect that the palm display can be good alternatives for personal display in the future. We will develop more applications for that future environment.

6. Reference

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