In-air Typing Interface for Mobile Devices with Vibration Feedback

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1 Introduction

Recently the miniaturization of mobile devices has progressed and such devices are difficult to have input interface that has wide operation area on their surface. Conventional input interface on a cell phone, such as a touch panel or keypad, has limited operation area. There has been many approaches to handle this problem, but they require users to wear some physical devices[Harrison and Hudson 2009] or to use in some specific environments[Roeber et al. 2003].

We propose vision-based 3D input interface for mobile devices which does not require wide space on the device's surface, other physical devices or specific environments. Users can operate the device by the movement of a fingertip in the air. Since the fingertip near the camera moves fast in the image, we use a high-frame-rate camera for stable tracking. Applying a frequency filter to the scale change of the fingertip image, the system detects the small keystroke action in the air. To realize input interface in which we can type letters fast, we attached a vibration motor on device and vibration feedback is conveyed.

2 System Configuration

We constructed a system shown in Figure 1. A compact IEEE1394 high-frame-rate camera Firefly MV (Point Grey Research Inc.) with a lens having a focal length of 1.9 mm, four white LEDs, a vibration motor, a PC and a small USB display. We used the camera at a frame rate of 144 fps (frame per second) with an image size of 752 $\times$ 180 pixels.

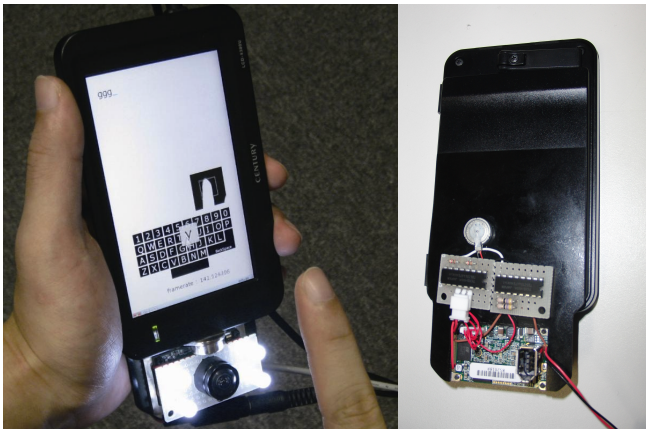

Figure 1: *Prototype System*

Image Capture and Preprocessing

Small operation area on the surface of mobile devices is a significant problem. We used a camera with a wide-angle lens so that we can operate it in a wide 3D space. Since the images obtained through a wide-angle lens is distorted, we applied distortion correction to the obtained images. As a result, the angle of view of 90 degrees is acquired. Since the fingertip near the camera moves fast in the image, a high-frame-rate camera is used for stable tracking. Using skin color extraction, the fingertip region image is extracted.

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3D Fingertip Tracking

In this interface, the 3D position of fingertip is estimated by tracking in order to gain high-accuracy position. When a fingertip moves in 3D space, the shape of the fingertip in the image is transformed in various ways. Four parameters are estimated to track the user's fingertip: translation along the plane perpendicular to the camera's optical axis, rotation around the optical axis and scale change. The Lucas-Kanade Algorithm is used to estimate these parameters[Baker and Matthews 2004]. Before tracking starts, users have to register their fingertip image as a template. Since the scale change of the fingertip is inversely proportional to the distance between finger and camera, the 3D position of the fingertip can be estimated.

Detection of Keystroke Action and Vibration Feedback

In desirable input interface, user can type letters quickly when user get accustomed to the system. We defined the following gesture as keystroke action. The gesture is slightly moving a fingertip back and forth in the direction of the camera's optical axis, like typing with a physical keyboard. In this system, we utilized the difference of the dominant frequency of the fingertip's scale in images so that a keystroke action can be detected.

To realize input interface in which we can type letters fast, tactile feedback is important. With tactile feedback, users can quickly recognize that the input action of the users is detected. From this respect, we attached a vibration motor on the back side of the display which vibrates for a short time when a keystroke action is detected.

3 Applications

In-air Typing Keyboard is an application in which user can type letters in the air. The pointer of software keyboard moves according to the position of the fingertip. If the pointer is located on the target key and a keystroke action is detected, the target character is input. By utilizing the depth information of the fingertip position, other application examples can also be constructed: Zooming Picture Viewer and 3D Painter. In Zooming Picture Viewer, the user can zoom and scroll the picture on the display with the 3D position of the fingertip. The user can draw lines in 3D space with fingertip using 3D position directly in 3D painter.

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