A Proposal of Virtual Piano by Using Horizon View Camera

Ayami IWATA, Kunihito KATO, Kazuhiko YAMAMOTO
Yamamoto Lab, Dept. of Information Science, Faculty of Engineering, Gifu Univ.,
1-1 Yanagido, Gifu, Gifu, Japan

Abstract. We have proposed Horizon View Camera (HVC), which is a unique system of the object detection by a single camera and has some unique characteristics. HVC is to put a single camera on the ground, and the optical axis of the camera is directed toward the horizon by using a mirror. HVC can obtain two kinds of images. One is the image including only the object on the ground. Therefore, it is possible to detect objects easily. We have shown its effectiveness by measuring distances to objects using the obtained images from HVC with straight motions. Moreover, we proposed HVC-90 that is more effective system than the original HVC for object detection. HVC-90 can detect objects in various motions. In these camera systems, we used characteristics obtained from moving HVC mainly. In this paper, moreover, we develop a unique input interface by using characteristics from standing HVC. We made a potable piano as an example of this interface, and show its effectiveness.

1. Introduction

Now a day, many kinds of input interfaces have been developed by physical sensors [1][2]. With the developments of them, input interfaces by using a camera are researched actively [3][4][5]. In the case of using the camera, there are a lot of advantages. It is possible to have various effective functions because the camera is a general-purpose sensor. Therefore, input interfaces with the camera have been proposed by various methods in a lot of fields. However, most of these methods measure only the position because the camera is usually set on the upper side. When we try to make the input interface as substitutes for a keyboard and a mouse, it is necessary to measure the position and detect the touch to the surface at the same time. In order to solve these problems, it is necessary to use some cameras generally.

We have proposed Horizon View Camera, we call it HVC [6]. This is a unique camera system by using a camera and a mirror. It is possible to direct the optical axis of the camera to the horizon by reflection the mirror. Therefore, HVC has some characteristics that the object detection is easy and correct and so on.

In this paper, we had second thoughts about these characteristics, consequently we obtained new characteristics. In the case of the input interface by using a camera, it is important to solve two considerations, the position measurement and the touch detection to the surface, as above. By using new characteristics of HVC, however, these considerations can be solved.

Therefore, we propose a unique input interface by using characteristics of HVC. We have used images obtained by moving HVC to detect object. By focusing attention on images obtained by standing HVC, however, it is possible to realize a unique input interface with the position measurement and the touch detection. Moreover, we made Virtual Piano as one example of this, and we show the effectiveness of this proposal system.

2. Object Detection by Horizon View Camera

Horizon View Camera (HVC) is a unique camera system for the object detection. It is constructed by using a mirror and a single camera. It is possible to direct the optical axis of the camera to the horizon by reflecting the mirror. Figure 1 shows HVC system. It is possible to obtain two kinds of images: the direct image and the reflected image at the same time as shown in figure 2. The reflected image includes only objects on the ground without the ground. The direct image includes the ground and objects which are the same as the reflected image. The border line between two images is horizon. The image from the HVC has various characteristics. By using them, we have proposed the method of the objects detection, and we confirmed that the HVC could detect objects with high accuracy by moving forward. Moreover, we have proposed Horizon View Camera-90 (HVC-90). It is possible to detect objects in various motions [7].

In this way, we have researched about HVC and HVC-90 for the purpose of the object detection. In these camera system, we used characteristics of images obtained from miving HVC. We have never used characteristics of images obtained from standing HVC. In this paper, therefore, we develop a unique input interface by using characteristics of images obtained from standing HVC.

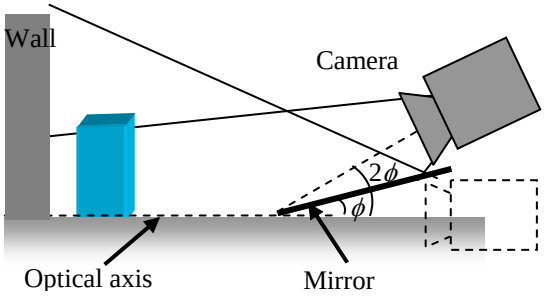


Figure 1. HVC system

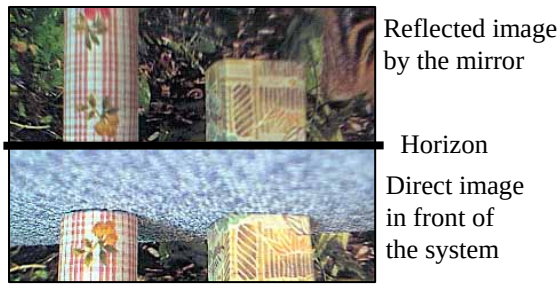


Figure 2. Image from the HVC

3. Input Interface by Using Horizon View Camera

Images obtained from standing HVC have two kinds of characteristics. (1): The object detection becomes easy as above. (2): The ground region extraction becomes easy. Because the reflected image includes only objects, and the direct image includes the same objects and the ground. Therefore, the ground region is extracted by deleting the objects in the reflected image from the direct image.

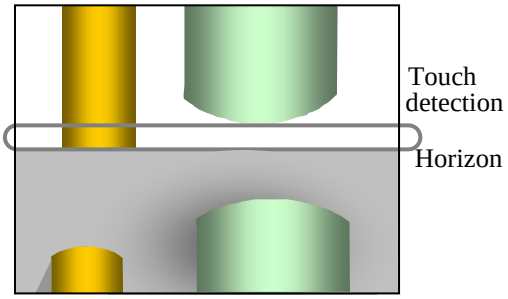


Figure 3. Touch detection

We have second thought about these characteristics of HVC. (1): The reflected image includes the grounding point of objects. When an object is grounded on the ground, the it is touching to the horizon in the reflected image. When an object is floating in midair, it is separating from the horizon. By watching the horizon in the reflected image, therefore, it is possible to detect the touch of the object to the ground shown in figure 3. We obtained a unique characteristics that it is the same as touch sensor. (2): It is possible to detect the grounding point of objects in the direct image. We have known the

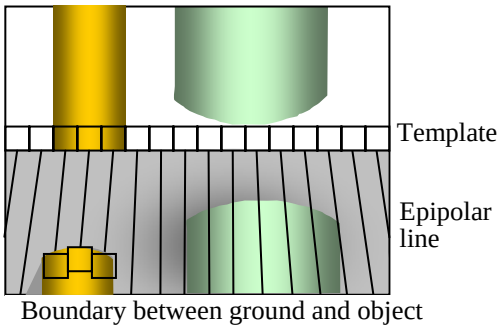


Figure 4. Epipolar lines of HVC

camera parameters, and we obtain the foot region of objects in the reflected image. Therefore, we detect it by searching the matching point of the foot image in the direct image by using the epipolar line shown in figure 4. Moreover, it is possible to measure the object position by using the coordinate in the image and the camera parameters. We are summarized as follow: it is possible to realize a unique input interface by using these characteristics. This system has the touch sensor to the surface by using the reflected image and the position measurement of the touch point by using the direct image.

4. Virtual Piano

There are some applications as the input interface of HVC. In this paper, we made “Virtual Piano” as an example. Figure 5 shows “Virtual Piano”.

In order to realize an input interface by HVC, methods are develop as follow: we detect a object in the direct image, and we estimate the touch of it to the digital in the reflected image. In the direct image, the image is fixed because HVC is fixed to the board. Therefore, it is possible to detect the finger region by background-subtraction when the finger appears on the board. Next, it is necessary to estimate the touch of the finger to the board. However, it is easy because it is equal to touch the finger to the horizon in the reflected image. Therefore, we just watch near one point on the horizon which is searched on the epipolar line. In the case of touching to the board, the position from the camera is measured by using the coordinate of the finger region by triangulation. This method has some advantages. The background image is usually fixed and it is easy to detect the touch of the finger because the searching area is small. Therefore, we have the high expectation that it is possible to work with high accuracy in various situations.

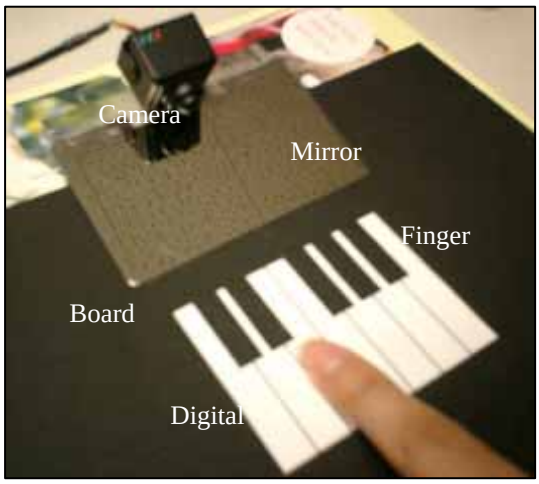


Figure 5. Virtual piano.

5. Image Processing of Virtual Piano

In order to realize “Virtual Piano”, it is necessary to detect the finger of a user, estimate the touch, measure the position and determine the sol-fa.

The finger is detected by background-subtraction in the direct image. By the influence of the light source and shadow of the finger, however, there is possibility of detecting the finger and something else. It is difficult to extract the finger region with high accuracy by using only background-subtraction. Therefore, we used the method of the ground region extraction in order to just detect the finger without something else [6]. In this method, templates are made on the horizon in the reflected image, and they are searching along the epipolar line in the direct image. When the finger touches to the horizon in the reflected, some templates include the finger and others are complex images without the finger. It is possible to detect the finger region by template matching in the direct image, because the direct image includes white, black and the finger. In theory, the finger is detected by this method only. However, it is difficult to detect it correctly with some misses of template matching. Therefore, we set out the correct detection by using both background-subtraction and the ground region extraction.

Next, we estimate the touch of the finger to the board. We make the template at the finger region in the direct image. We estimate the touch by the similarity of template matching on

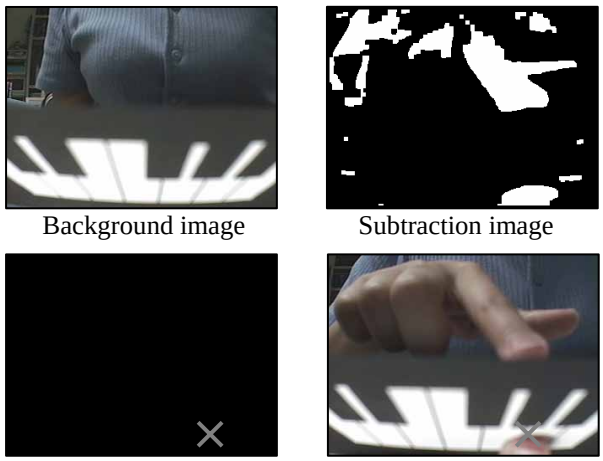
the horizon in the reflected image. Matching point is measured by the epipolar line. In the case of touching to the board, the finger position from the camera is measured to use the coordinate of the finger in the direct image by the triangulation. Figure 6 shows these image processing.

Obtained image from HVC

6. Conclusion

In this paper, we proposed a unique input interface by using HVC. Moreover, we made "Virtual Piano" as an example, and we develop an effective method with response to various situations. We have researched HVC to purpose the object detection until now. By the different perspective, we make possible to expand HVC to the input interface.

We proposed the method of the touch detection and the methods of the object detection in this paper. They are realized easily and correctly by using characteristics of HVC. Moreover, these methods became robust to changes in the environment by using both background-subtraction and the ground region extraction of HVC. Therefore, it is possible to realize this input interface with response to the background image including different colors such as white and black digitals.



Background image | Subtraction image

Finger region image | Finger position

Figure 6. Image processing.

In this paper, we made the input interface of HVC: "Virtual Piano" as an example. However, it is possible to make various input interfaces. In the case of other input interface, it is necessary to have high accuracy. In the future, we need to examine all parameters of HVC system and the image processing.

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