# Study of the Finger Detection Technology in the One Camera Touch Panel

Hiroki Goto[a,*], Lifeng Zhang[a]

[a]1-1sensui-cho Tobataku, Kitakyushu city, Fukuoka Japan 804-8550
Kyushu Institute of Technology

*Corresponding Author: goto.hiroki348@mail.kyutech.jp

## Abstract

As the finger detection method of the touch panel, there are resistance film method, capacitance method, optical method, and ultrasonic method. The touch panels that we use on a daily basis include smart phones, car navigation systems. They mainly use resistance film method and capacitance method.

However, the touch panel of the image processing method has begun to be studied in recent years. This method, by recognizing the fingertip coordinates in three dimensions by using multiple cameras, it is determined whether a fingertip is in any position of the panel.

The purpose of this study is to perform finger detection by image information obtained using one camera.

**Keywords**: touch panel, finger detection, one camera.

## 1. Introduction

### 1.1 Background

The touch panel is that the device can perform the operation of the computer by touching directly on the screen. By integrating sensors for touch operation detection and the like on the display unit, it is possible to sense the position of the finger or the pen touching the screen and give an instruction to the computer. Since you can touch by directly touching the icons and buttons displayed on the screen, the operation method is easy to understand, and it is easy to use even for those unfamiliar with computer operation. By integrating display and input into one device, it is possible to downsize or simplify the whole device. Moreover, since there are no hardware buttons, there is a feature that operability can be flexibly changed by software.

In recent years, the touch panel of the image processing system has begun to be studied. This method, by recognizing the fingertip coordinates in three dimensions by using multiple cameras, it is determined whether a fingertip is in any position of the panel. However, the touch panel of the conventional image processing method has identified the position of the fingertip on the principle of stereo vision. Since stereo vision requires two or more cameras, the setting conditions of the camera are severe, and the burden of image processing is larger than when one camera is used. Therefore, the touch panel recognition system by one camera have been important.

### 1.2 Purpose

The purpose of this study is to consider the finger detection technology in the touch panel of the image processing system using one camera. It performs finger detection using a detection technique of the template matching and optical flow.

## 2. Principle

### 2.1 One camera touch panel

One camera touch panel is a touch panel that performs detection using one camera and one panel. A camera is attached to the top of the panel, and fingers of real images and fingers of reflected images appearing on the panel are detected using image information obtained from the camera. Fig. 1 shows overview of one camera touch panel.

There are three merits by using one camera touch panel.

1, Simplification of equipment
2, Loss reduction in failure
3, Huge panel area

Fig. 1. Overview of one camera touch panel

### 2.2 Template matching

One of image processing applications is object detection. Template matching is often used to find a specific pattern from images. In this method, the position of the template present in the image is found by comparing the region of interest while moving the template on the image.

(a)Input image (b)Template image

Fig. 2. Template matching

### 2.3 Optical flow

The optical flow is a technique for predicting to which pixel each pixel has moved between adjacent frames in a moving image. Since the optical flow varies with the movement of the object, information on speed can be obtained. Optical flow is mainly used for detection of moving objects and analysis of their movements.
Fig. 3 shows overview of optical flow.

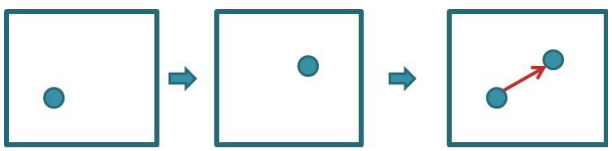


Fig. 3. Overview of optical flow

### 2.4 Coordinate transformation

In the case of the 1 camera touch panel used in this research, it is necessary to attach the camera to the top of the panel. Therefore, when viewed from the camera, the panel appears like a trapezoid, and the actual coordinates on the panel and the coordinates on the camera are different. In order to correct this state, a coordinate transformation algorithm is used.

## 3. Method

### 3.1 Experiment environment

This study used raspberry pie 3. Similarly, this study used a raspberry pie camera module for the camera.
Fig. 4 shows one camera touch panel used in this study.

Fig. 4. One camera touch panel used in this study

### 3.2 Finger detection using template matching

As a method 1, we performed finger detection using template matching. In this method, the fingertip portion in the real image and the reflected image was taken as a template image. We made matching between these template images and the input images from the camera. When the frame of the real image part exceeds the frame of the reflection image part, we set it to judge as touch. We prepared fingertip parts of real images and reflected images as template images.

(a)Real image (b)Reflection image

Fig. 5. Template images

### 3.3 Finger detection using optical flow

As method 2, we performed finger detection using optical flow. Optical flow can obtain the motion of an object as a vector. In this method, fingertip detection is performed by using the motion vector of the finger in the input image from the camera. When the finger approaches the panel, the reflected image moves in the opposite direction. By using this fact, it is presumed that there is symmetry in the motion vector. We thought that fingertips could be detected by extracting the tip of the vector of each direction. Moreover, in this method, pixels with the largest vector size towards the panel were detected as the tip.

## 4. Results

### 4.1 Finger detection using template matching

Firstly, we verified "Method of comparing template and image area" prepared by OpenCV's template matching function. We decided to find an optimal method from the following three.

1, CV_TM_SQDIFF_NORMED
2, CV_TM_CCORR_NORMED
3, CV_TM_CCOEFF_NORMED

In each method, the relationship between the distance from the camera to the finger and the degree of matching is summarized in Table 1. SQDIFF_NORMED indicates that the value is closer to 0, and CCORR_NORMED and CCOEFF_NORMED indicate that the degree of matching is higher when the value is closer to 1.

Table 1. Distance from camera and matching degree

| distance | fingertip | SQDIFF | CCORR | CCOEFF |
|---|---|---|---|---|
| 10cm | real | 0.0391 | 0.9862 | 0.8039 |
| | reflection | 0.0744 | 0.9653 | 0.7306 |
| 15cm | real | 0.0313 | 0.9896 | 0.9599 |
| | reflection | 0.0808 | 0.9716 | 0.9099 |
| 30cm | real | 0.0575 | 0.9772 | 0.7707 |
| | reflection | 0.0943 | 0.9767 | 0.7354 |

In all three methods, the part other than the finger was often erroneously detected as a finger. Therefore, we set a threshold to judge whether it is a finger or not. In this method, we decided to use CCOEFF_NORMED with the greatest change. We set the threshold as 0.78 for both real image and reflected image. As a result, it was specified as a touch only in the 5 x 5 cm square area of the panel. From now on, we decided to conduct study under these conditions.

Fig. 6 shows the matching result when touching, and Fig. 7 shows the matching result before touch. Both of them can detect two fingertips of real image and reflected image.

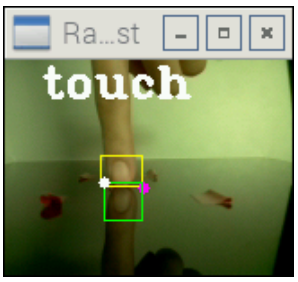



Fig. 6. Matching result when touching

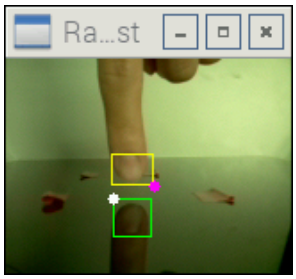
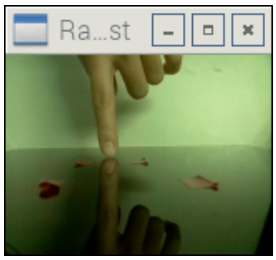



Fig. 7. Matching result before touch

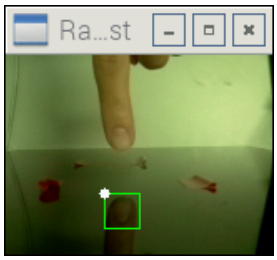
We obtain the coordinates at the time of the touch, and converted using a conversion algorithm from the coordinates on the camera to panel coordinates and outputs the result. Fig. 8 shows the output result of drawing a line at the touch.


Fig. 8. Drawing result

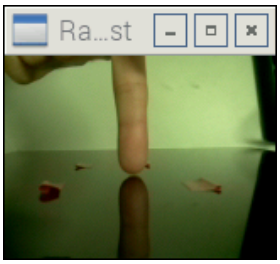
In the four patterns shown in Fig. 9, fingers could not be detected.




(a) Distant from camera




(b) Distant from panel




(c) Back of finger


(d) Side of finger

Fig. 9. Detection failure

### 4.2 Finger detection using optical flow

Fig. 10 shows the output result of the vector. White is a vector in the direction in which the finger of the real image moves toward the panel, and red is a vector in the direction of the finger of the reflected image toward the panel.

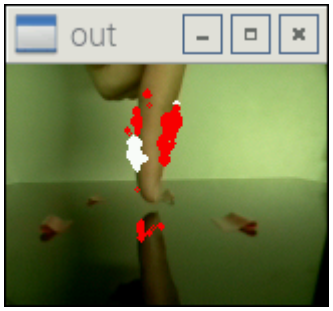



Fig. 10. Output result of the vector

We thought that the motion vector of the finger became symmetrical between the real image and the reflected image, but in reality, vectors in both directions were seen toward the real image. Therefore, we limited the detection range of the vector to the vicinity of the panel. Fig. 11 shows the results. As a result, only vectors near the fingertip can be detected.

Finally, we detected fingertip coordinates from this output vector. Fig. 12 shows the detection results.

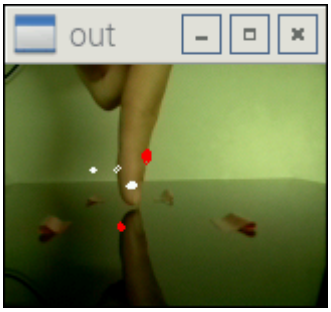
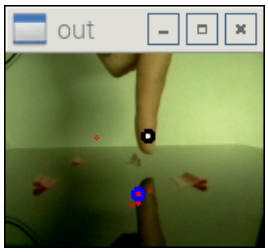
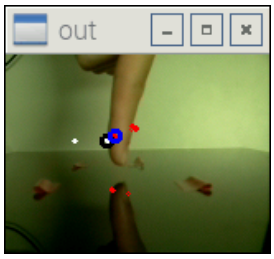



Fig. 11. Output result of the vector (limited range)




(a) Successful detection




(b) Detection failure

Fig. 12. Fingertip detection

## 5. Conclusions

In this study, we used template matching and optical flow as finger detection technology. Template matching was able to be detected stably under the condition of 5 x 5 cm square at the center of the panel. However, the detection range was limited by the finger size of the template image. In the optical flow, symmetric vectors could not be obtained between the real image and the reflected image. Moreover, it was not able to stably detect the fingertip area, and this time it was not possible to touch. Both of the methods are susceptible to the influence of light and need improvement in order to be practical. In the future, it is necessary to study optimal detection techniques using other methods such as object tracking.

## References

(1) Katsuto Nakajima : “Large screen system capable of interacting by touching the screen directly with a finger etc(Virtual touch screen)”, http://www.collabosgk.com/seedsconso/seeds/27/27-18.pdf, 2012

(2) Hironobu Fujiyoshi : “Motion picture understanding technology and its application”, http://www.vision.cs.chubu.ac.jp/vu/pdf/VU.pdf, 2009
(3) Manabu Hashimoto : “Attraction of template matching - Standard technology for object detection and positioning”, http://isl.sist.chukyo-u.ac.jp/islweb-pre/Archives/SSH2013TS-Hashimoto.pdf, 2013
(4) Yuki Kagawa : “Calculation of optical flow focusing on contour lines”, http://www.vision.cs.chubu.ac.jp/flabresearcharchive/bachelor/b03/paper/kagawa.pdf, 2004
(5) “OpenCV-1.0 Reference Manual(Japanese translation)”, http://opencv.jp/opencv-1.0.0/document/index.html