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## FINGER TRACKING AND RECOGNITION USING OPENCV RASPBERRY PI 3

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**Abstract** - Raspberry Pi 3 as an embedded system platform supporting the OpenCV library so that it can be used in performing object recognition and detection. Hand movements as innovative and interactive a way of communication can be used to interact with computer by digital image processing and computer vision. This study aimed to track and recognize fingers. Algorithms in this study was divided into three-pre-processing, segmentation and feature extraction. In testing using the Raspberry Pi that remotely accessed, detection and estimation of the number of fingers could be done with an accuracy of 75% and the computing time of 9:20 seconds.

**Keywords:** pre-processing, image segmentation, feature extraction, contours, convex hull, convexity defects

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### I. INTRODUCTION

Raspberry Pi as one of the ARM architecture-based platform used in performing object recognition using OpenCV library. OpenCV is freeopen source computer vision library for public. OpenCV library has developed for Raspberry Pi platform.

Hand gestures is a natural, innovative, and non-verbal communication way to communicate. Some systems provide technique to interact to a computer. One of them is controlling the computer by using a mouse, keyboard, and others. Several years ago, technique in recognition of hand gestures have been widely introduced, for example, hand gesture recognition techniques using instrumented gloves and Optical Marker, etc. Instrumented gloves used many sensors in it, so that the instrumented gloves was expensive to produce and required cable in the operation, thus making instrumented gloves were not effective. Optical Marker worked by using infrared light and complicated process. The systems used complex configuration. Therefore, the present study was intended to track and recognize fingers. Algorithms used in the present study was divided into three-pre-processing, segmentation and feature extraction.

Then the color channel changesto grayscale channel. Then, it is the thersholding method, a part of the

image segmentation, and followed by feature extraction. In feature extraction, a system detects the movement of the hand, and estimate the number of fingers. The authors used the method of contours, convex hull, as well as convexity defects to find hand gestures and estimate the number of fingers.

### II. RELATED RESEARCH

A lot of related research on recognition of hand gestures and human computer interaction (Human Computer Interaction) among others are:

In the study [1], tracking and recognition of hand movements using camera. Image transformation was by changing the RGB channel into a channel YCbCr. The image in YCbCr channel then converted into binary image by applying the method of Edge Detection, matching the orientation of the hand. It found features of centeroid, peaks detection, Eucladian distance and thumb. In this study, the success rate was 92% with a computation time of 2.76 seconds. The algorithm implemented was MATLAB.

In the study [2], the author used algoritmas K-means clustering to divide the input image to further segmentation. The author used a bounding box to find the orientation. Features like centeroid, Euclidean distance was calculated for detection. Here hand represented to seven bits. The first bit represented the orientation of the hand.

The second bit detected the presence of the thumb in the image. The next three bits used to represent the number of fingers. And the last two bits were for comparing the appropriate hand movements or equal to the number of fingers. This algorithm success rate was 94% with a computation time of 0.60 seconds. This implemented algorithm was MATLAB.

### III. THEORITICAL FRAMEWORK

In order to get more comprehensive result, it is necessary to understand about the digital image, image processing and image segmentation in finger tracking and recognition as follows:

#### A. Digital Image

In general, digital image processing refers to the processing of two-dimensional images using a computer. The main purpose of image processing is for making the image easily interpretable by humans or machines. With image processing, an image is transformed into another image.

Digital image is defined as function  $f(x, y)$  sized  $M$  rows and  $N$  columns, with  $x$  and  $y$  are the spatial coordinates and amplitude of  $f$  at the point of coordinates  $(x, y)$  is the intensity or gray image level at that point. The value of  $f(x, y)$  is the product of the amount of light on the object (illumination) and the degree of the object's ability to reflect light (reflection).

The value of wedge between the rows and columns of the matrix (at position  $x, y$ ) is called the picture element, image elements or pixels. A pixel represents not just a single point in an image but a section in square form which is the smallest part of the image. A pixel has a value within specific range from the minimum value to the maximum value. The range varies depending on the type of color. But in general, the range is 0-255.

Based on the pixel values, digital images can be grouped into two types of images, namely:

##### 1. Image color

Color images are often called RGB image or true color image because it can represent the color of the object resembles the original color by combining the three basic colors, namely red (R), green (G) and blue (B). Each pixel has three channels that represent the value of each component of image base color.

##### 2. Greyscale

Grayscale image has only one color channel value per color, red = green = blue. These value is for indicating the level of intensity. Colors are black, grayish and white. Gray level here is gray with various levels of black to nearly white.

The process to change color image to grayscale in the equations (1) and (2).

$$(x, y, f(x, y)) \rightarrow (x, y, I(x, y)) \dots\dots\dots (1)$$

$$I(i, j) = \frac{R(i, j) + G(i, j) + B(i, j)}{3} \dots\dots\dots (2)$$

##### 3. ThersholdingImage

Thersholding image is an image that has been applied thesholding method. The image can usually be used in making binary image. Thersholding is most simple method in image segmentation. Thersholding is simple method to replace an image with the image of a black pixel if the image intensity  $I_{i,j}$  is less than fixed constants  $T$  ( $I_{i,j} \leq T$ ), or a white pixel if the intensity of the image is larger than the constant  $T$ .

#### B. ImageProcessing

Image processing aimed at improving the image quality of the display image for human viewing or to convert an image to have a better format so that the image is more easily processed by computers. Image processing can be done for example by using image filtering.

##### 1. Image Screening

In digital image processing, image filtering is used for suppressing high frequency in the image as a method of smoothing, or suppress low frequency as in clear or detect edges in the image. The purpose is to make the image seem better or to make the image appear more clearly for better information in the analysis / recognition and can also reduce noise

##### 2. Gaussian Blur

In the image processing, Gaussian Blur is the result of the blurring process an image by using a Gaussian function. Usually it is used in image processing, especially noise and detail reduction on the image. Gaussian smoothing is usually used in the pre-stage process in computer vision algorithms intended to improve the structure of the image on a different scale.

The equation of the one-dimensional Gaussian function as shown in equation (4).

$$G(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{x^2}{2\sigma^2}} \dots\dots\dots (4)$$

Meanwhile, the equation of the two-dimensional Gaussian function as shown in equation (5)

$$G(x, y) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{x^2+y^2}{2\sigma^2}} \dots\dots\dots (5)$$

$X$  is the distance from the origin in the horizontal axis,  $y$  is the distance from the origin in the vertical axis, and  $\sigma$  is the standard deviation of Gaussian distribution.

#### C. Image Segmentation

Image segmentation is a process of dividing digital image into multiple segment (number of pixels or commonly known as super pixels). The purpose of segmentation is to simplify and / or change the representation of an image into an meaningful and easy to analyzed image. Image segmentation is usually used in finding the location and area (line, curve, etc.) of an image. In other words, it is a process to determine a label for each pixel with the same label from the specified characteristics.

D. *Active Contour Model*

Active Contour Models or *snakes* is a framework in computer vision for perimeter line on a possibility of the object in a 2D image having noise. *Snakes* is very popular in applications for object tracking, shape recognition, segmentation, edge detection, and stereo matching.

E. *Convex Hull*

In mathematics, convex hull or convex envelope of a set X of points in the Euclidean plane or Euclidean space is the smallest convex that has set X. For example, when X is bounded subset of a plane, convex hull can be visualized as closed form of rubber bands drawn around the convex hull of X. the equation is:

$$\text{Conv}(S) = \left\{ \sum_{i=1}^{|S|} \alpha_i x_i \mid (\forall i : \alpha_i \geq 0) \wedge \sum_{i=1}^{|S|} \alpha_i = 1 \right\}$$

F. *Convexity Defects*

Convexity defect is a cavity or spheres in an object (such as a lump, or contours) outside an image in other words areas not covered by the object, but located within the outer area of the determined convex hull.

IV. RESULTS AND DISCUSSION

A. *IMPLEMENTATION*

1. Pre-processing

The first process was to change the color image (RGB) grayscale. After that the image of the gray was blurred to reduce details, and then thresholding image method was applied so that the image can be analyzed for the next process.

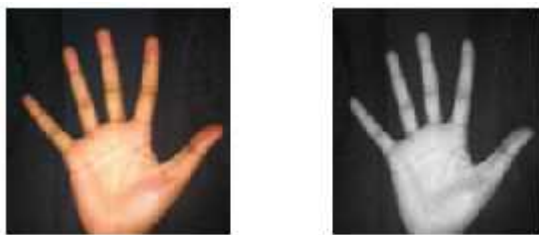


Figure 1. The color image was changed into grayscale



Figure 2. The blurred greyscale and thresholding image

2. Hand Segmentation

In this process, hand image segmentation in pre-process was extracted to hand image background. There are several methods in the segmentation process. An important step in segmentation is transformation and thresholding. Segmentation of an image into several areas that each pixel has the same attributes. To be meaningful and useful in performing image analysis and interpretation, these areas

must be highly related to describe objects or features of interest.

$$\text{If } \begin{cases} f(x, y) > T & \text{then } f(x, y) = 0 \\ \text{Else} & f(x, y) = 255 \end{cases}$$

Where, 1-20, 50 or 70 (Threshold value)

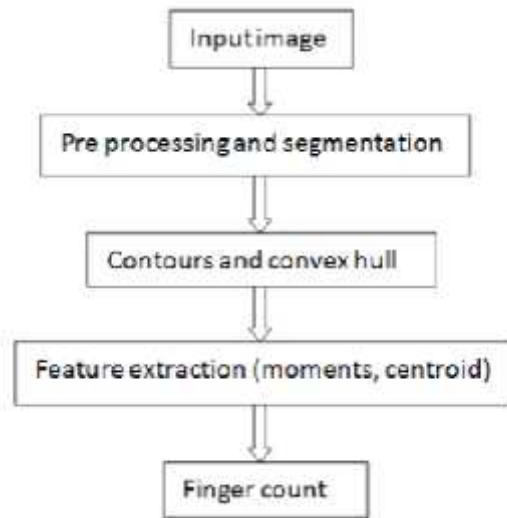


Figure 3. Flowchart of the algorithm equations and systems

3. Contours

Contours are the arch connected to all the points of continuous border, has the same color or intensity. Contours are useful function in computer vision in analyzing the shapes and object detection or object recognition. Contours are drawn simultaneously with the boundary area of the image of a hand that is usually found when an image has been applied thresholding method.



Figure 4. Contours of hand image

4. Convex Hull

Convex hull is a set of continuous points in Euclidean connected to the contours of the analyzed image. Convex hull is drawn around contours. Convex hull usually envelops the analyzed image contour.



Figure 5. Convex hull of hand image

5. Convexity Defects

Convexity defects around the contour image was analyzed. Usually it would match the set point of the contour associated with the convex hull of the image. Using the minimum point to make a circle that will be included in all contour points inside or outside of the convex hull.



Figure 6. Convexity defects of hand image

6. The Estimation of number of fingers

As the end result of the process, the system estimated number of fingers. The estimation of fingers used the results of the convexity defects in the form of point defects found in the image of the hand.

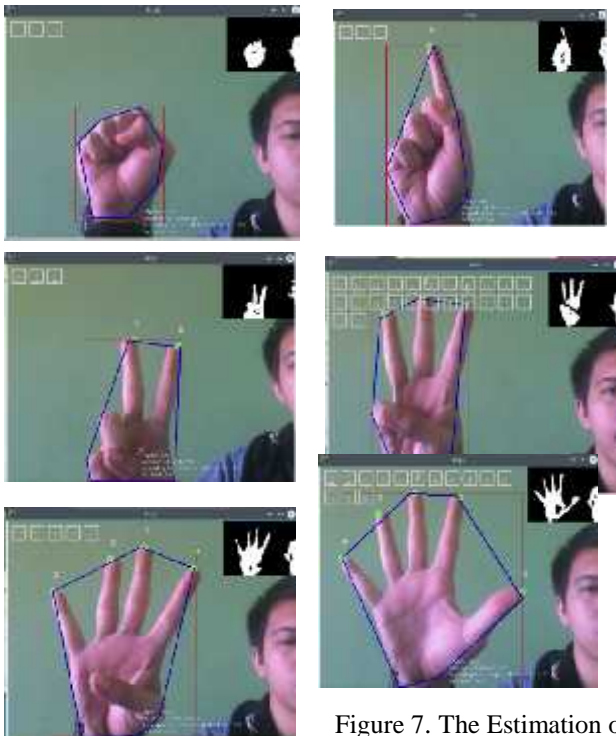


Figure 7. The Estimation of number of finger (s)

B. Experimental Result

Based on the results of experiments by using Raspberry Pi 3 accessed remotely, system can work well with a success percentage of 75% and the computing time of 9:20 seconds

C. System Application

- Human Interaction and computers for people with physical limitations
- Substituting the computer mouse
- Control application for music using hand gestures
- Control for electronic equipment using hand gestures

V. CONCLUSION

Based on the research of digital image processing and digital object recognition in the form of fingers estimation using Raspberry Pi 3 accessed remotely, the obtained accuracy was 75% and the computing time was 9.20 seconds.

VI. SUGGESTIONS

The limitation of computational of Raspberry Pi 3 that makes tracking and estimation of the number of fingers slower than the PC for that it should be reduction in the input image resolution and optimization of coding to obtain tracking and estimation fingers better.

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