

Real Time Hand Gesture Movements Tracking and Recognizing System

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Abstract— Human computer interaction has a long history to become more intuitive. For human being, gesture of different kind is one of the most intuitive and common communication. However, vision-based hand gesture recognition is a challenging problem, which is involved complex computation, due to high degree of freedom in human hand.

In this paper, we use hand gesture captured by web-cam instead of mice, for natural and intuitive human-computer interaction. Skin detections method is used to create a segmented hand image and to differentiate with the background. A contours and convex hull algorithm is used to recognize hand area as well as the number of fingertip of hand gesture image to be mapped with button. Moreover, for detection of hand gesture motion, we use Lucas-Kanade pyramidal algorithm.

The result shows that this system can operate well so we can interact with computer using our hand gesture instead using a mouse.

Keywords - hand gesture, human computer interaction, contours, convex hull, Lukas-Kanade Algorithm.

I. INTRODUCTION

The development of user interfaces has increased rapidly, especially in consumer devices. The use of the touch interface (e.g. touch screen) has commonly in today devices such as computer tablets, Smart Phones, and other control interface on an electronic device. The development of user interface are tends to the use of human body gesture, especially human hand as the main interface, which is more natural and intuitive. However, so far the user interface is still limited to movement on the two dimensions surface, such as the use of the mouse and touch screen.

Many researches explore various mechanisms of interaction with the computer in a more practical, efficient, and comfortable. Starting from the use of devices like ergonomic keyboard interaction based on gesture hands [1], to the effort to seek mechanisms of interaction without having to get in touch directly with the computer input devices.

The use of pointing device with tactile feedback as a mechanism of interaction with the computer have been examined by [2] in 2008. In the same year, Juan P. Wachs developed a method of vision-based system that capable to interpret the user's hand gesture to manipulate objects on

medical data visualization environment [3]. Tao Ni [4] developed the technique called rap Menu (roll-and-pinch menu) interactions to select a specific menu remotely by using hand gesture input.

[5] had developed a framework interface for immersive projection system CAVE in the field of virtual reality by using hand gestures. Hand gesture recognition is performed with the use of blob detection. This recognition model allowing the implementation of an effective interface. Other research on the recognition and tracking of a hand gesture motion done by [6]. Tracking and recognition of hand gestures motion, which is captured by web cameras, are used to control the computer cursor as a replacement of the mouse. [7] conduct research to develop a system using vision-based interface webcam cameras and computer vision technology that allows users to use their hand to interact with the computer. In this research, the user can interact with a computer using their hand movements without the use of a marker. [8] use hand segmentation and color model to track the movement of the hand. Segmentation and tracking process is done by using a color model to extract or identify the gestures hand to implement real-time applications that are better, faster and more accurate.

II. THE PROPOSED METHOD

A. Research Objectives

The objective of this research is making a system prototype that can track the movement of the hand as well as to recognize the meaning of simple hand gestures command as a replacement of the mouse device. We propose a new approach and algorithms for hand gesture recognition that consist of two-step. The first step is hand gesture pose recognition process. Beginning with the identification process and separation of hand gestures image captured by ordinary webcam from their background images including the body and the head of the user. The segmentation and elimination of background from hand image is obtained using skin color segmentation algorithm combined with reduction of the background image. We use YCrCb color space instead of

RGB color space to eliminate the variation of room illumination. The convexity hull algorithm is applied to recognize hand gesture contour area as well as the number of fingertips to map with the mouse button.

The second step is tracking and recognizing the moving of user hand that recorded by webcam using Lukas-Kanade pyramidal algorithm. The tracking of hand gesture motion will be used to move the cursor according to the hand movement. Fig. 1 show the system proposed, starting by capture the user hand image, removing the background and segmented process. The detection of hand image is accomplished by detecting the hand contour and determines the hand center point. The fingertips detection is obtained with convexity defect and convex hull algorithm, and will be used as the replacement of mouse buttons click. The motion detection will track the hand motions to move the cursor as a replacement of the mouse function.

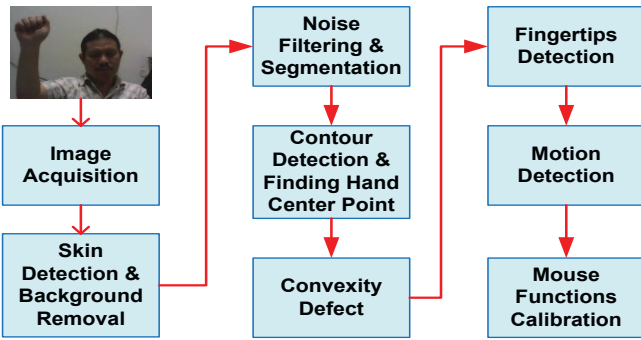


Fig. 1. The Proposed System.

B. Segmentation

The segmentation process is used to obtain the hand image to be processed further. We use skin detection algorithm to detect and separate hand skin color with the background due to its simple and fast detection. To improve the reliability from the variation of environment illumination, the RGB color space image will be converted to YCrCb. This conversion will separate the intensity component Y and chromaticity components Cr and Cb. The conversion obtained using (1)

$$\begin{aligned} Y &= 0.299*R + 0.587*G + 0.114*B \\ Cr &= (R - Y)*0.713 + 128 \\ Cb &= (B - Y)*0.564 + 128 \end{aligned} \quad (1)$$

The skin color detection can be obtained by determining the range of Y, Cr, and Cb values respectively, which is the value of the user's skin color to be used as a threshold to determine whether the value of a white pixel (hand image) or black (background). Equation (2) shows the algorithm of skin color detection and threshold process to convert to binary-segmented image.

$$w(x,y) = \begin{cases} 255, & \text{if } Cr1 < Cr < Cr2 \text{ and } Cb1 < Cb < Cb2 \\ 0, & \text{Otherwise} \end{cases} \quad (2)$$

with Cr1 and Cr2 as well as Cb1 and Cb2 are the range of hand skin color value. As we know that human skin color varies across human races or even between individuals of the same race. Additional variability may be introduced due to changing illumination conditions and/or camera characteristics. Therefore,

the range value of hand skin color should be adjust according to the user skin color as well as illumination conditions and/or camera characteristics.

C. Contour Detection and

The contour is a sequence of pixels with same value. Contour is found if there are differences in pixels with its neighbors. The contour can be obtain from binary image based on the results of skin detection between white pixels (the object that has the colors resemble hands) and black pixels (objects other than hands or background). This method however, has the possibility of a high error when an object in an image has a color that is almost the same. Therefore, need to be maintained so that there is only one object in the frame, which is the biggest contour (which in this case is the user's hand). Fig 2 shows the flow chart of contour detection.

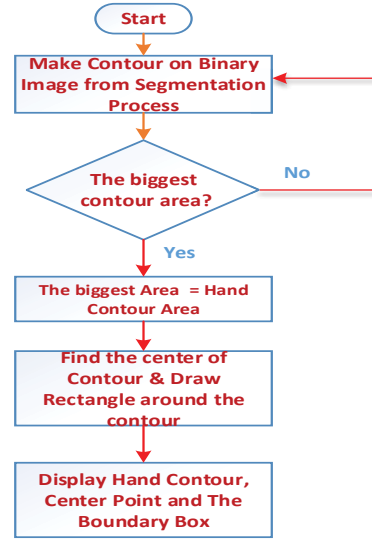


Fig. 2. Contour detection.

D. Convexity defect

This method is intended to detect the user's fingers captured by the camera. To extract hand features we use two-steps process. First step is construct a convex hull using Sklansky algorithm. Convex hull is a set of points that constitute a convex polygon covered this points set. Sklansky algorithm is a linear sequential algorithm to construct a convex hull from set of points or a simple polygon [9]. It is suitable for polygon with star shape and hand image as well. Sklansky algorithms perform scanning in counter clockwise direction in order to remove a vertex point p from a polygon P. Sklansky defines P as a collection of points that perform a polygon or as a closed region polygon-shaped. Fig. 3 shows the shape of a Sklansky square that illustrating the formation of hull using this algorithm.

G. Mouse Function Implementation

In this research, the hand gesture motion detection and recognition will be implemented to replace the mouse function. The mouse function can be implemented using mouse event functions from API call to synthesize the mouse motion and button click, which found in user32.dll.

To implement mouse move, right and left click, double click and drag function, we use the following mouse event functions.

- Move; is implemented using `MOUSEEVENTF_MOVE`
- Left click; is implemented using `MOUSEEVENTF_LEFTDOWN` followed with `MOUSEEVENTF_LEFTUP`
- Right click, is implemented using `MOUSEEVENTF_RIGHTDOWN` followed with `MOUSEEVENTF_RIGHTUP`
- Drag, is implemented using `MOUSEEVENTF_LEFTDOWN` continuously while move to the intended directions.

The applied mouse function according to the number of fingers detected as shown in Fig. 7.

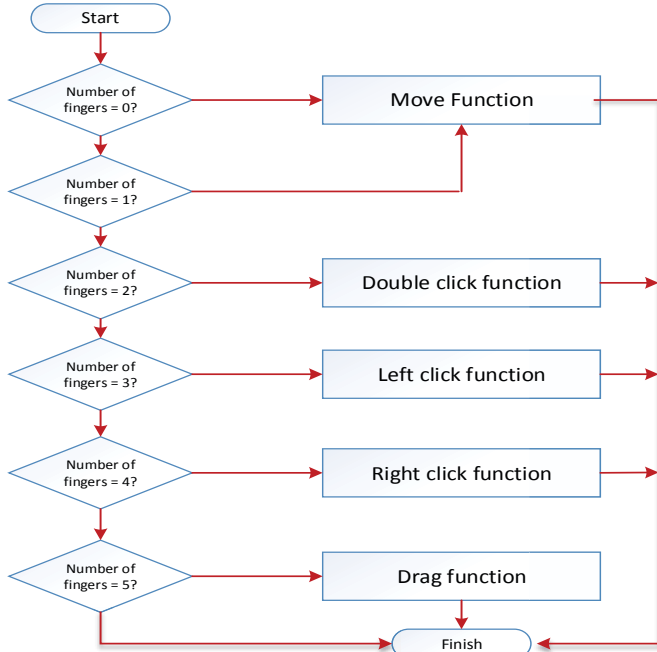


Fig. 7. Mouse function implementation.

III. EXPERIMENT RESULTS

To verify the effectiveness of the proposed approach, we done some testing using I7 1.7 GHz machine and the image sequences are captured at about 10 frames per second.

A. Segmentation using Skin Detection

The segmentation process is intended to get hand image and separate it with the image background. The RGB image captured from the camera will first converted to YCrCb color space to separate between the intensity component (Y) and color components (Cr and Cb). This conversion will reduce the pixels variation due to room illumination variation. Fig. 8 shows the original image in RGB space, image in YCrCb space and segmented image resulted using skin detection.

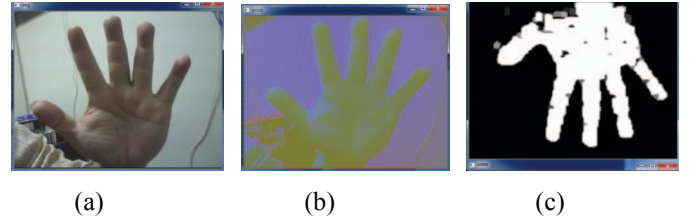


Fig. 8. (a) Original Image, (b) YCrCb image, (c) Segmented image.

B. Contours Detection

Binary image from segmentation results will then use to contour searching. The contour searching will produce more than one contour due to the imperfect segmentation, for example, there are other similar objects by hand but smaller. In order to ensure that only one contour, that is hand contour is processed, and then need to specified areas in which the largest contour. So only, the contour with the greatest area is to be formed, while the other will be ignored. This contour search results are shown in Figure 9.



Fig. 9. The resulted contours search.

C. Convexity Defect and Number of Fingers Detection

The process begins with the formation of the convex hull, than followed by searching the defects areas, which can be used to detect fingers. Convex hull that is found will be marked by a small circle with blue color, as shown in Figure 10.



Fig.10. Convexity defect of hand fingerprints.

The convex hull that has been resulted will be used to determine the number of fingers. In the real world however, the illuminations are not perfect and always varies resulted that the number of circles that are detected not only in the fingertips only. In this case needs to be specified that circle use for counting only on the upper part of the image, and the maximum amount is five in accordance with the number of hand fingers, and then will be calculated and displayed on the screen. From the observations as shown on Figure 11, this

system is capable to detect the number of fingers shown by users from one finger to five fingers.

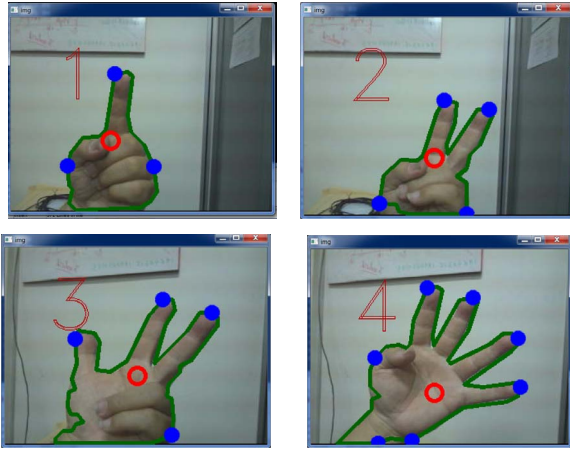


Fig. 11 The detection and number of fingers recognition.

D. Motion Detection

The detection of hand movement is required so that the mouse pointer can follow the user's hand gestures. In this process a bound box is formed that will enclose the contours of the hand, the upper left corner of the box is marked with pt1 and bottom right corner marked by pt2, and will be used as a parameter of the cvRectangle function, to display the box enclosing the contour of the hand, as shown in Figure 12.

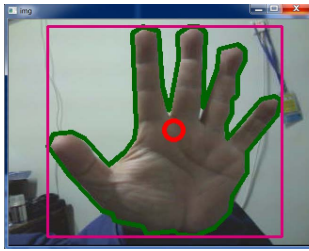


Fig. 12. The center point on hand contours.

To find a center point of the hand contours is done by searching for a center point of the box enclosing the hand contour, as shown in Fig. 12. Further, by using the box.center.x and box.center.y as the coordinates of the center point contours, mouse cursor can be arranged to follow the movement of the hand contour. The center point of the hand contour, represented as a small circle in red.

E. Discussion

To evaluate the performance of recognition proposed, we examine the system to operate the windows application that is MS Paint using hand gesture to replace mouse as user application interface. Testing is done under normal illumination, system can recognize, and track the movement of user hand. The center of hand gesture represented by a small circle had successfully follow the user's hand movement.

The segmentation process is capable in detecting the user's hand gestures and counting the contours. The system also can count the number of user fingers that associated with

a command button on a mouse. The hand motion can also been followed properly by the system, and the mouse click function represented by number of fingers detected have work.

However, there are some limitations of the program, i.e. the change of lighting environment is still influential in the process of segmentation, in particular on the process of the removal of the background.

IV. CONCLUSION

Based on the evaluation and discussion above, can be concluded that the system can recognize and track the hand movement and can replace the mouse function to move the mouse cursor and the mouse click function as well. The segmentation algorithm using skin color detection is good enough to separate the hand image with its background. The convexity defect algorithm can work well in detecting the number of user's hand, to replace the mouse click functions. In general, the system can detect and follow the hand movement so that can be used as user interface in real time.

The future work is to improve segmentation process in eliminating the effect of illumination changes. It is possible to use another color space such as HSV to minimize the effect of illumination changes.

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