Embedded Virtual Mouse System by Using Hand Gesture Recognition

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***Abstract*-- In the digital information time, daily life is inseparable with human-computer interface (HCI). Human computer interaction has a long history to become more intuitive. For human being, hand gesture of different kind is one of the most intuitive and common communication. However, vision-based hand gesture recognition is still a challenging problem. In this paper, an embedded virtual mouse system by using hand gesture recognition is proposed. There are several techniques involved in the proposed system. Skin detection and motion detection method are used to capture the region-of-interest and distinguish the foreground/background area. Connected component labeling algorithm is used to identify the centroid of an object. The removal on arm and the convex hull algorithm are used to recognize hand area as well as the related gesture. The result shows that our system can operate well even in some harsh environment.**

I. INTRODUCTION

In recent years, the applications such as human-computer interface (HCI) and robot vision have been activated in research areas. As in virtual environment (VE) applications, they offer the opportunity to integrate various latest technologies to provide a more immersive user experience [2]. A virtual mouse with HCI arises much attention and it could substitutes the function of traditional mouse and touch panel. To realize this device, the techniques based on computer vision are involved. Some algorithms are even used with hand segmentation based on skin color [3]. A vision-based HCI system with hand gesture analysis is introduced in [4].

Our design on this work explores the low cost and high performance virtual mouse. All the functions on computer mouse are considered. We capture the hand gesture by a single web camera for natural and intuitive human-computer interaction. With this common environment, the system can provide high recognition result even in some harsh background environment.

II. PROPOSED METHORD

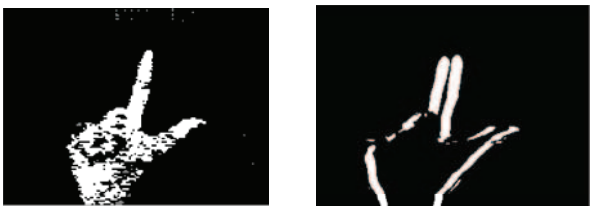
A. Skin Segmentation and Motion Detection

We use the skin detection algorithm to detect and separate the hand from background. We define the range of skin color is as follows:

$$0 < Y < 210$$
$$70 < U < 128$$
$$130 < V < 180$$

The skin color detection can be obtained by determining the range of Y, U, and V values, which is the value of the user skin color. This is used as a threshold to determine whether the value is belonged to a white pixel (hand image) or black (background). The results are shown in Fig. 1(a).

The motion detection is calculated with two continuous



(a) (b)

Fig. 1. (a) Skin color segmentation. (b) The result of motion detection.

frames. It is processed as follows:

$$m(x,y) = \begin{cases} 1, if\ (|\ Y_{x,y,i} - Y_{x,y,i-1}\ | > threshold) \\ 0, else \end{cases}$$

Where x and y represents the coordinate, and i represents the number of frame. As $m(x,y)$ equals to one, it means the motion is detected. The result of motion detection is shown in Fig. 1(b).

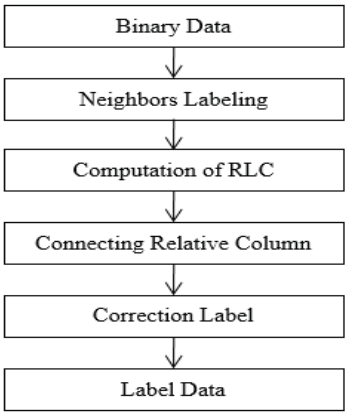


Fig. 2. Flowchart of the proposed labelling algorithm.

B. Labeling

The purpose of labeling is to search for an adjacent segment in order to find out the connectivity. It usually encounters two problems. One is that some connected points are not marked with the same values. The other issue is that labeling could have the property on low throughput due to its non-efficient algorithm. We apply the algorithm based on [1] and enhance the performance. The proposed method can not only generate a complete labeling result, but also increase the throughput. The flowchart of proposed labeling algorithm is shown in Fig. 2. First we apply raster scan in every pixel and record it for the

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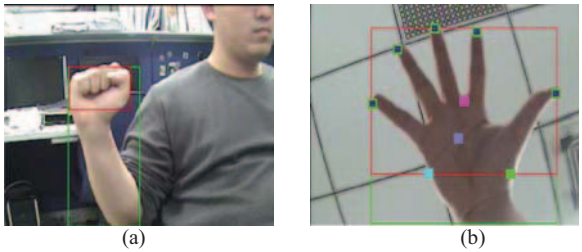
following usage with run length coding (RLC) and encoding label (EL). As in a group of connected pixels, the positions of the first and last pixel are recorded in RLC and the label value is recorded in EL. The calculation on centroid and area of an object is performed.

C. Removal Arm and Convex Hull

According to the result on skin segmentation, the area with skin color is not exactly equal a palm area. Usually the arm area is included and marked. Here we need to remove it causes only the palm area is helpful to high recognition result. As illustrated in Fig. 3(a), the area with full arm is with green rectangle, and the palm part is marked with red rectangle respectively. This is accomplished by the length determination method. The result is illustrated in Fig. 3(a).



(a) (b)

Fig. 3. (a) Removal on arm and interception on palm. (b) The result of convex hall algorithm.

We use Jarvis March algorithm to find the convex hull points. As shown in Fig. 3(b), the black dots indicate the noticeable convex hull points. We only take the top of the convex hull point and ignore the other lower points. Then the orientation of the convex hull point and the center of gravity is acquired as the purple dot. With the length and width of the palm, we can determine several types of gestures.

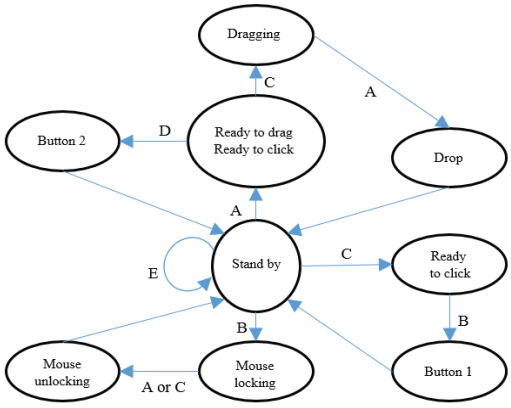


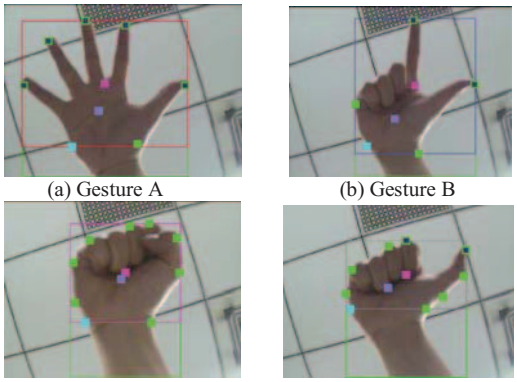
Fig. 4. Finite state machine of virtual mouse.

D. Mouse Function Implementation

In this application, the hand gesture motion detection and recognition will be implemented to replace the mouse function. We use four kinds of hand gesture, sequentially as a gesture A to gesture D. The virtual mouse is operated with the finite state machine as shown in Fig. 4. In particular, to emulate the situation of mouse dragging, user performs gesture A to C intuitively without prior training.

III. EXPERIMENT RESULTS

We provide several types of hand gesture in Fig. 5. In each gesture, we test 500 times for each gesture and measure the accuracy of hand gesture recognition. The corresponding recognition rate is shown in Table I.



(a) Gesture A (b) Gesture B

(c) Gesture C (d) Gesture D

Fig. 5. Four kinds of hand gesture.

TABLE I
ACCURACY OF HAND GESTURE RECOGNITION

	Gesture A	Gesture B	Gesture C	Gesture D
Gesture A	**462**	0	0	4
Gesture B	4	**411**	0	0
Gesture C	0	4	**438**	0
Gesture D	1	0	0	**476**
Miss	33	85	62	20
Accuracy	**92%**	**82%**	**87%**	**95%**

IV. CONCLUSION

In this paper, we proposed the system to recognize hand gesture and replace the mouse function, which includes the movement on mouse cursor, the drag and click. We utilize skin segmentation to separate the hand image with its background. Remove arm method effectively solves the situation of whole body into the camera. The convex hall algorithm is performed well in the detection on the number of fingers. In general, the proposed algorithm can detect and recognize hand gesture so that it can operate a new user interface in real world.

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