

A Color Based Touchless Finger Mouse

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Abstract— People work with computers almost anytime, everywhere in the current trend. However, continuously controlling a computer with mouse for a long time might cause much strains to people's wrist. This work proposes a touchless finger mouse using webcam. A marker with different colours representing different actions is used. The webcam will capture the information on the marker and trigger the associated actions. This prototype is proven to be able to perform most of the actions a normal mouser can perform.

Keywords— Image processing; computer vision; finger mouse.

I. INTRODUCTION

Nowadays, computers have become an inherent part of human livings. People always deal with computers in their work, in their life, and even in their entertainment activities. In work, they use applications like word processing, spreadsheets, or some specialized software like Computer Aided Design (CAD), SPSS predictive analytics software, and so forth to solve their daily tasks. In life, people are shifting the trend to online transactions. Goods will be sent to their door by just a few clicks. Bills are paid by just a few clicks. Hang-outs with friends could be done via internet as well. Computers are just anytime, everywhere, everyone.

A mouse is typically used with a computer to control the motion of a cursor in a graphical user interface (GUI). There are some main operations that a mouse can perform. Firstly, pointing-and-clicking can select files, programs or actions from a list of menus, or through icons. It can also trigger the floating menu which will only appear by right clicking. More particularly in clicking, a user can right click, single click (left click), double click, triple click, and etc. Secondly, drag-and-drop can move the object by holding the mouse button down while moving the cursor to different location.

However, it is recently found that a mouse can cause repetitive strain injury (RSI) [1], [2] when users repetitively control a mouse to perform their tasks on the computer. In view of this, our work proposes a touchless finger mouse where the users are able to perform mouse operations simply by showing their finger in front of a webcam. The non-contact element makes this a good solution for outdoor installations because no contact with peripherals is needed.

Section 2.0 explains some issues related to mouse and how the prototype in this work overcomes the issues. Section 3.0 describes the technical aspects of the prototype and ultimately some conclusions are drawn in Section 4.0.

II. RELATED ISSUES

There are some ergonomically designed mice to help increasing the comfort when using a mouse, such as a roller mouse, vertical mouse, joystick, or switching from using a mouse to a stylus pen with graphic tablet [3]-[5], but in chronic RSI they may result only in shifting the problem to another area. Some of these devices are expensive, which might not be widely affordable to general users.

The proposed prototype is designed to address the above problems while preserving the main characteristics of a mouse. Firstly, it is simple to operate. Secondly, it is low cost device. Thirdly, it can select graphic object quickly. Lastly, it is used for quick positioning of cursor on an item. Besides that, the proposed work also has some strength over the existing devices to substitute mouse, as follows:

- a. For those existing free hand mouse control program, users may need to use some high cost unique devices [6]-[8] or high resolution cameras. As for the prototype, it just needs to use a low cost color marker which could be D.I.Y. and a webcam.
- b. Most of the existing free hand mouse control programs need some complex steps to perform a simple click operation. The prototype is able to perform click operations, drag operations, and some other simple actions.

III. PROPOSED SYSTEM DESIGN

The prototype involves a few processing steps as depicted in Fig. 1.

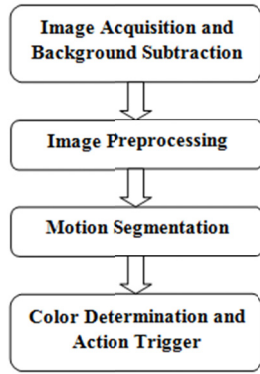


Fig. 1 System flow diagram

A. Image Acquisition and Background Subtraction

The proposed prototype is able to capture motion in real time. Firstly, image acquisition obtains image frames from the webcam. Then a background model is developed as the basis for motion detection. The background model will be updated frequently to adapt to changes in illumination.

Background subtraction approach is then deployed to identify moving objects from the portion of a video frame that differs significantly from the background model. This process aims to extract the region of interest from the images. The ultimate purpose of background subtraction is to allow the system to recognize the position of the marker accurately. In order to reduce the computational complexity of 3-dimensional RGB colour images, every image frame is converted to greyscale form which is 2-dimensional in intensity. After conversion, the area of the colour marker will be extracted and highlighted as a bright gray colour region. Fig. 2 is an example of the colour extraction result for red colour.

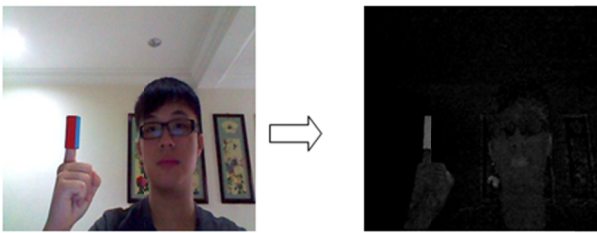


Fig. 2 Sample image before extraction (left), and after extraction (right)

B. Image Processing

After the colour extraction image was obtained, the next step is image preprocessing. Preprocessing is to refine the resulting image to remove unnecessary noise. Since the colour extraction image is in greyscale form, it is easy to change to binary form by thresholding. The advantage of changing to binary form is that it could increase the execution speed. Besides, it helps to save the storage space.

Thresholding is a labelling operation on a greyscale image that distinguishes pixels of a higher intensity from pixels

with a lower intensity value. Difference values close to zero are likely to have resulted from minor background fluctuations while large difference values indicate that an object is present in the foreground. Specifically, Eq. (1) is used to create a binary map $I_{bi}(x,y)$ where the presence of ones is used to denote moving objects. Fig. 3 shows the difference image before thresholding and after thresholding.

$$I_{bi}(x,y) = \begin{cases} 1 & \text{if } I_d(x,y) > \tau \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

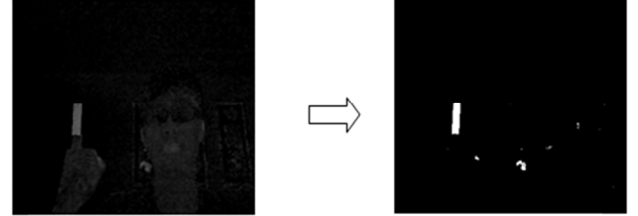


Fig. 3 Difference image before thresholding (left), and after thresholding (right)

There will still be some noise remaining in the difference images, though this is often imperceptible. Median filtering is used to remove the noise. Median filtering is a nonlinear operation often used in image processing to reduce "salt and pepper" noise. The particularity of the median filter permits it to smooth an image without the degree of blurring that a linear filter with similar smoothing characteristics can introduce. Median filter will replace the value of a pixel by the median of the gray levels in the neighbourhood of that pixel. This method is particularly effective when the noise pattern consists of strong, spikelike components and the characteristic to be preserved is edge sharpness.

Fig. 4 shows the images before median filtering and after median filtering. It could be clearly seen that the image before median filtering contains some salt and pepper noise which is represented by small white areas. Such noise had been greatly reduced in the resulting image of median filtering.

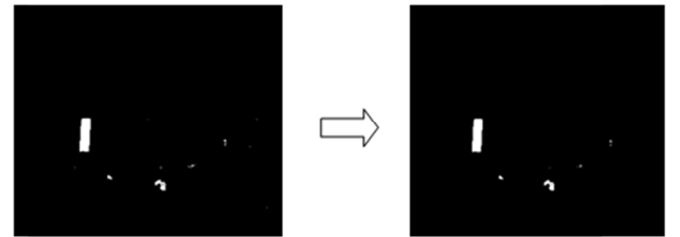


Fig. 4 Image before median filtering (left), and after median filtering (right)

After median filtering, the binary image will still contain some larger noise with different sizes. Hence, a size filtering is needed to re recognize the area of marker's colour accurately. In this work, the opening operation is adopted. The opening operation performs an erosion operation followed by a dilation operation using a predefined neighbourhood or structuring element. The erosion operation is to filter out the spurious noise of the objects. As for dilation operation, it will fill up the object holes. The

opening block uses flat structuring elements only and removes from a binary image all connected components (objects) that have fewer than P pixels to produce another binary image, where the P value is predetermined via several trial and error. The region of marker will be clearly stated out after labelling. Fig. 5 shows the image before and after opening operation.

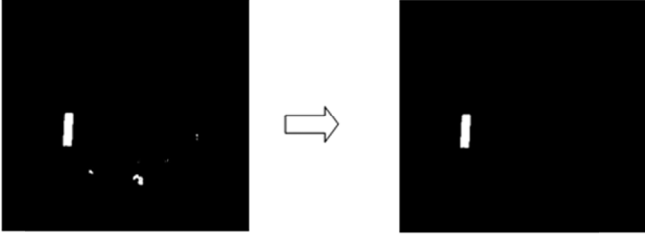


Fig. 5 Image before opening operation (left), and after opening operation (right)

C. Motion Segmentation

After the image preprocessing, the next step is to extract the region of interest for further processing using motion segmentation. By using edge detection technique, it will help to reduce the search area and detect boundary of the colour marker by tracing the outline or contour of the object. An edge may be able to be regarded as boundary between two dissimilar regions in an image.

In order to get the bounding box of the colour marker, the system will search through the rows from top to bottom and the columns from left to right. The bounding box is obtained by using Eq. (2). After finished searching, the bounding box of the colour area will be stored in memory for further processing. Fig. 6 shows the bounding box of the colour marker.

$$\begin{aligned} X &= \max(\text{column}) - \min(\text{column}) \\ Y &= \max(\text{row}) - \min(\text{row}) \end{aligned} \quad (2)$$

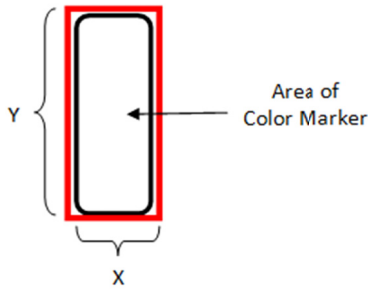


Fig. 6 Bounding box of the colour area

D. Colour Determination and Action Trigger

After getting the bounding box of the colour region, the system is able to determine the position of the cursor by mapping the centroid of the colour region to the corresponding coordinates on the computer screen. The centroid is given by the following equation.

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i, \quad \bar{y} = \frac{1}{n} \sum_{i=1}^n y_i \quad (3)$$

This centroid point is then mapped to the computer screen by calculating the ratio of the screen resolution to the webcam resolution. We need to subtract the coordinate of the centroid point in relative to the total resolution to overcome the mirror effects. As we are facing a webcam, it is just like we are facing a mirror. Hence, when we are moving to the right in our plane, the mirror is actually moving in the reverse direction in its own plane. The mapping calculation is given in Eq. 4.

$$X = (RC_x - \bar{x}) \times \frac{RS_x}{RC_x}, \quad Y = (RC_y - \bar{y}) \times \frac{RS_y}{RC_y} \quad (4)$$

where X and Y are the cursor point on computer screen, RC_x and RC_y are the resolution of webcam, RS_x and RS_y are the resolution of computer screen.

Different actions will be triggered according to the different types of colour. To avoid confusion in triggering action, the system will compare the number of pixels of different colours. The action associated to the colour with largest number of pixel will be triggered. For example, if the system gets the number of red colour pixel more than other colour pixel, it will trigger the red colour action.

The marker contains three sides of different colours and each side of colour will trigger different mouse action. Those three colours are red, green, and blue. For red colour, it will control mouse cursor to move according to the finger motion. As for green colour, the user can perform double click action. While blue colour will allow the mouse to perform drag action or perform right click action.

Hence, given a scenario where the user would like to start a program. The user could move the cursor by showing red colour side of marker to webcam. Once the cursor reached at the desired location, the user can turn the marker to green colour side so that the double click action can be triggered. Then the application will be initiated.

Let say the user would like to move a file from one location to another location. First, the user could choose the file by moving the red colour marker to the position of the file. Then turn the marker to blue colour side to right click and move the finger to destination location. Besides that, users can also draw on painting program using the finger mouse.

A combination of colour could be used to perform a task too. For example, the user would like to delete a file. The user could select the file by using the red colour marker, and then turn to blue colour side to right click on that file, so the floating menu will appear. From the menu, the user can choose the delete option by using the red colour marker again. All these could be done simply by moving the colour marker in front of the webcam. Fig. 7 illustrates the structure of the marker.

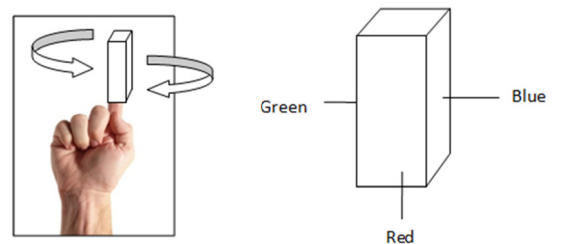


Fig. 7 The structure of colour marker

IV. RESULTS

After conducting a user acceptance survey targeting 20 students and 20 academicians in our university, it shows that 85% of them are satisfied with the overall performance of the system. 80% of them feel comfortable with changing the colour using finger marker. 72.5% of them are willing to substitute the mouse with the system instead.

V. CONCLUSION

The proposed prototype can control a lot of operations a normal mouse can perform. It has the advantages of zero contact to the pointing devices, which is particularly important when deployed in public places. This can reduce the risk of infection using keyboard, touch pad or touch screen. Besides that, it is affordable to almost everyone since it only requires a simple webcam and a D.I.Y. colour marker. It is believed that more enhancements could be done in the future to cater for stretching and rotation actions.

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