AN INTERACTIVE COMPUTER SYSTEM WITH A GESTURE-BASED MOUSE AND KEYBOARD

PrakashKumar.C[1],AjaiKumar.D[2],Paramasakthi.G[3],Preethiha.D[4], Raguram.S[5]

[1]Assistant professor, Department of Computer Science and Engineering

[2,3,4,5] UG Scholar, Department of Computer Science and Engineering,

Angel College of Engineering and Technology, Tiruppur-641665.

Abstract: In this world, researchers are now focused on making our devices more interactive and operational with minimal physical contact. In this research, we have submitted a real-time computer system that can operate without any physical hardware specifically a keyboard and mouse. This system can be beneficial toeveryone, especially to paralyzed people who face difficulties to operate a physicalkeyboard and mouse. We used computer vision so that the user can type on a virtual keyboard using a yellow-colored cap on his fingertip, and can also navigate to the mouse-controlling system. Once the user is in mouse-controlling mode, the user can perform all the mouse operations only by showing a different number of fingers. We validated both modules of our system by a 52 years old paralyzed person and achieved around 80% accuracy on average.

Keywords**:** Human-computer interaction, Colour Detection, Hand gestures, Virtual keyboard, Virtual Mouse.

1. INTRODUCTION

The purpose of computers has become an integral part of our way of life and the human-computer interaction is more appropriate every day.

These facilities are granted by the majority of the people. The physical impairments, people face many difficulties in using these devices. In specific, physical impairments with severe movement disabilities, people may have limited ability to control fine motor. Therefore, they may not be able totype and connect with a normal keyboard and mouse. It is important to use effective technologies to ensure accessibility for such people. The eye-tracking devices are available on the market, it has many functionalities, accuracy level, and price range. Many research studies require eye-tracking devices of high precision to test a range of eye characteristics, but they are very expensive such as infrared[14].

In this work, a multi-modalinteractive keyboard and mouse system are proposed by us. Where we determine and track a color (yellow in this research) to replace the use of a traditional keyboard and mouse using the device's camera. Without any additional hardware requirements by using vision-based color recognition techniques and hand-gesture recognition techniques are achieved by taking inputs from a camera.

Our system will allow the user to operate their computer's keyboard and mouse using only their hand bearing a yellow color cap on their fingertip. The main goal of this research is to build an interactive keyboard and mouse system so that motion-impaired people can communicate with the computer through its webcam using one hand only. In this aim, secondary the objectives are:

- to detect a yellow-colored cap
- the cap is placed to recognize the key

- to track the mouse movement by using the movement of colored cap and
- to detect the number of fingers shown to determinet he left-button or right-button click of the mouse

The article is integrated as follows: section II on a virtual keyboard and virtual mouse system presents a few works, section III illustrates methodology, section IV discusses the results of our study, and finally, section V concludes our work and discusses future work.

1 LITERATURE REVIEW

There are traditional approaches for virtual keyboards and mice systems which are usually based on eye gestures. Our literature review focuses on the research works on virtual keyboards and virtual mice which were published in Elsevier, Springer, ACM Digital Library, IEEE Digital Library, etc. We discussed a few related works on virtual keyboards and virtual mice in the following two subsections.

1.1 VIRTUAL KEYBOARD

In 2010, Y. Adajania et. al developed a *Virtual Keyboard Using Shadow Analysis*[2]. This system recognizes the Keyboard, hands shadow, and fingertips using color segmentation and the Sobel technique. Ambient lighting conditions are required for this system. This system can analyze 3 frames per second. In 2011, S. Hernando et al. built a method for a virtual keyboard using a webcam [10]. In this method, two functions are used for finger detection and location detection. It is used two different webcams which are used to detect skin and location separately. The median time per character of this virtual keyboard is 2.92 milliseconds and the average accuracy of this system is 88.61%.
In 2013, M. H. Yousuf et al. introduced a keystroke detection and recognition model using fingertip tracking [25]. They successfully recognized 28 keys by capturing real-time movements of finger joints.
In 2015, I. Patil et al. constructed a virtual keyboard interaction system using eye gaze and eye blinking [16]. First detects the face and then detects the eye and nose region to recognize an eye blink by the system. The Open CV Java framework is used in this approach. In 160X120 frame size, this approach achieves 48% accuracy, and in 1280X960 frame size, 98% accuracy is achieved.
In 2016, Hubert Cecotti developed a system for disabled people named *a multi-modal gaze-controlled virtual keyboard* [6]. To spell 30 different characters and a delete button to recover from errors for menu selection has 8 main commands in the virtual keyboard. They evaluated the performance of the system using the speed and information transfer rate at both the command and application levels.
V. Saraswasti et al. introduced a system for disabled people entitled *Eye Gaze System to Operate Virtual Keyboard* [18]. First, it captures the user's face and gets the position of eye gaze which is used as a reference point in the later stages. The Haar Cascade method was used to extract features of a face, and the Integral Projection method was used to get the position of the eye movement. Based on their experiment, the ratio between the duration of normal writing and the duration of typing using their system for two words is 1:13.
In 2017, S. Bhuvana et al. constructed a virtual keyboard interaction system using a webcam [5]. This system can detect the hand position over the virtual keyboard. This system provides a white paper virtual keyboard image and detects which character is pointed. This approach used the built-in function of the Image Processing Toolbox in MATLAB.
In 2018, Jagannathan MJ et al. presented a fingerrecognition and gesture-based augmented keyboard system [13]. The system was developed using OpenCV libraries and Python. Palm detection is used for typing on the augmented keyboard. Virtual Keyboard performs based on the movement of the finger.

1.2 VIRTUAL MOUSE

In 2016, S. Shetty et al. constructed a virtual mouse system using color detection [19]. They used a webcam for detecting mouse cursor movement and click events using OpenCV built-in functions. A mouse driver, written in Java, is required as well. This system fails to perform well in a rough background.
P. C. Shindhe et al. expanded a method for mouse-free cursor control where mouse cursor operations are controlled by using hand fingers [21]. They collected hand gestures via webcam using color detection principles. The built-in function of the Image Processing Toolbox in MATLAB and a mouse driver, written in Java, are used in this approach. The pointer was not too efficient in the air as the cursor was very sensitive to the motion.
G. Sahu et al. built a system for controlling mouse pointers using a webcam [17] which controls the volume of the media player, and PowerPoint slides and can make or end a call. Theyused RGB color tapes to recognize the user's finger.
In 2019, K. Hassan et al. presented a system to design and develop a hand gesture-based virtual mouse [20]. They captured different gestures via webcam and performed mouse functions according to the gestures. This system

achieved 78%-90% accuracy. The system does not work efficiently in a complex or rough background.

As we can see from the reviewed literature, previous systems include either a virtual keyboard or a virtual mouse. Those systems can't fully eliminate the need for a mouse and a keyboard. This work aims to build an interactive computer system that can be operated without any physical mouse or keyboard.

2 METHODOLOGY

2.1 PROBLEM DESCRIPTION

This paper aims to implement a computer application that uses alternative methods to control the keyboard and mouse cursor. People who suffered from a stroke can recover from the side effects. Therefore, we propose a new keyboard and mouse cursor control system based on vision and color recognition techniques, utilizing hand gestures recorded from a webcam.

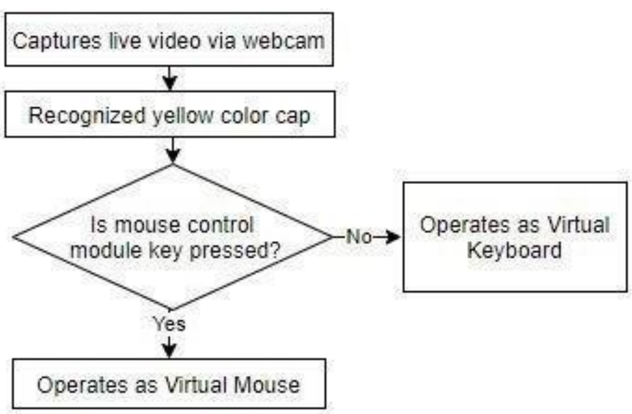

Fig.1. Overview of the proposed interactive computer system

It shows the overview of the process of interactive keyboard and mouse controlling systems. This work aims at creating a system that recognizes the colors.

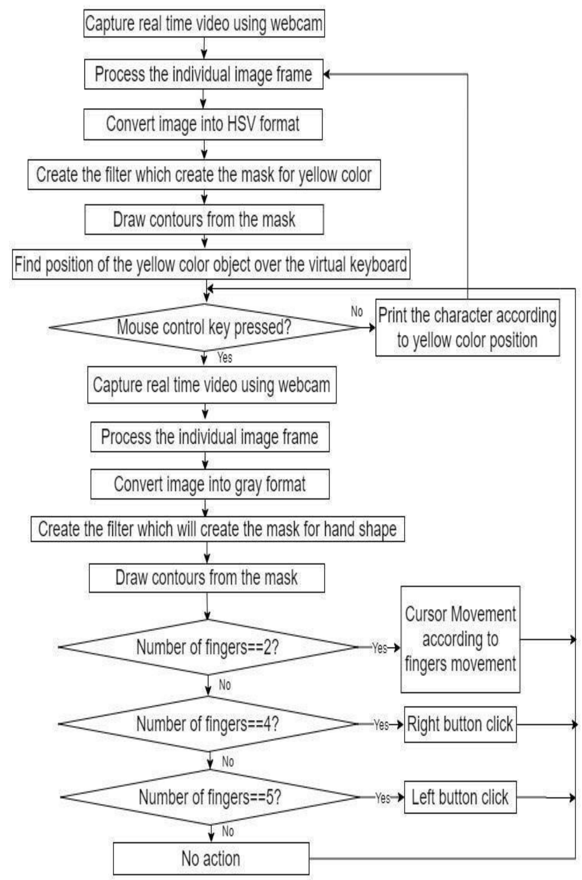

Fig.2. The Procedure of gesture-based mouse and keyboard and hand gestures, and controls the computer's keyboard and mouse according to those gestures using color detection technique.

Our system will use a computer's webcam and will display an onscreen keyboard layout. Users will be able to type through the keyword using a yellow color cap on their fingertips. Users can also turn on the mouse controlling system by pressing the *Mouse Control Module* button using that yellow color cap. After that, another live video frame willbe shown for tracking the hand movements to recognize mouse functions. It represents the system architecture for the virtual communication system.

2.2 VIRTUAL KEYBOARD

We used the procedure to type on a virtual keyboard using our fingertips:

Step 1: It Capturing real-time video using the computer's webcam

Step 2: It Processing individual image frames from the captured video

Step 3: It converts image frames into HSV format
Step 4: It creates a filter that can create the mask for the yellow color
Step 5: It draws contours from the mask. Loop through all the contours and put a rectangle over it for object tracking by us.
Step 6: It finds the position of a yellow color object over the virtual keyboard
Step 7: It prints the character which is pointed by a yellow colored cap

This figure displays a live demonstration of typing *j* using

a fingertip and Figure 4 shows how to navigate into the mouse-controlling system.

2.3 VIRTUAL MOUSE

We used an infinite loop to catch the frames in each instance by webcam which will be available throughout the program. We capture the stream from the live feed, frame by frame, and then convert RGB images to grayscale images. We create a mask here that recognizes the hand's shape and counts the number of fingers in the shape. We have used the law of cosine as expressed in equation (1) to find the angle in the shape of the hand.

$$c^2 = a^2 + b^2 - 2ab\cos(C) \quad (1)$$

The mask creates some specific region of the image according to certain rules. Instead of that, we can draw contours from the mask. In object tracking, we loop through all the contours. The convex hull of a set X of points in any space is explained as the smallest convex set that contains X. Any deviation of this object from the convex hull can be considered as the convexity defect. The convex hull of a finite point set S can be defined as the set of all convex combinations of its points.
To find the contours in the image, we have used the *cvFindContours()* function of Open CV which uses an order-finding method to detect edges. We are interested in extracting the hand gesture in the contour extraction process so that shape analysis can be done to determine the hand gestures. The hand contour convexity defects were measured using OpenCV's *cvConvexityDefects()* function. The convex hull of an object can be defined using the convex combination of all its points. Convexity defects are identified when there is any deviation of the object from the convex hull [9]. After that convexity defects are acquired,

The two major tasks are considered to determine the mouse control functions:

- To identify fingertips and
- To count the number of fingers from the number of convexity defects

We convert the detected coordinate from the camera resolution to the actual resolution of the screen. The mouse-controlling module will be performed in the following manner:

- if it detects two fingers, it will move the mouse cursor in four directions there are left, right, up, and down according to the movement of the fingers.

- if it detects four fingers and five fingers, then right button click and left button click actions will be performed, respectively

Figures 5, 6, and 7 demonstrate mouse cursor movement, left button click, and right button click operations, respectively.

3 Results and Discussions

3.1 Virtual Keyboard

We considered a stroke patient for our testing who has lost control of his left side. After doing some exercises, he was able to use our system and performed keyboard and mouse operations five times. We performed our experiment in a normal lighted room condition.
The summary of our experiment's parameters is given below:

- Considered text: A Brown Fox Jumps Over The Lazy Crocodile 1 2 3 4 5 6 7 8 9 0
- Number of characters(without space): 44
- Number of tests: 5
- Tested by: A 52 years old stroke patient who has very little control of his left side

Figure 8 shows the number of times each word and digit is correctly recognized by the system.

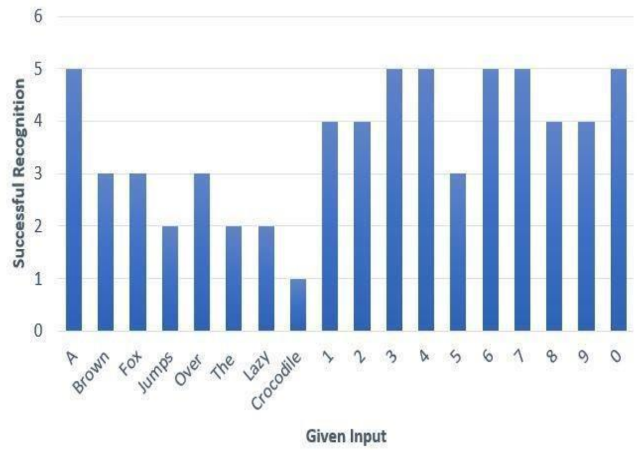

Fig.8. Experimental result of virtual keyboard

3.2 Virtual Mouse

In this system, recognizing the hand and counting the finger numbers by using a virtual mouse module can perform mouse functions. It performs six different functions: left-click, right-click, left movement, right movement, up movement, and down movement. We considered the same lighting and room condition which was used in the virtual keyboard experiment. The distance between the camera and the object is a maximum of 10 m and the objects are set in a fixed environment[24].

Fig.9. Experimental result of a virtual mouse

The virtual mouse experiment of this summary is given below:

- Number of mice functions:6
- Number of tests for each function: 5
- Total number of tests: 30
- Tested by: A 52 years old stroke patient who has very little control of his left side

Figure 9 shows the number of times each of the six mouse functions works accurately.
Figure 10 shows the confusion matrix for operations of the virtual keyboard and mouse. We performed each of our 24 tasks (eight words in the sentence, ten digits, and six mouse functions) five times. Our system successfully recognizes 95 operations out of 120 operations.
To evaluate system performance the accuracy of the system was measured using equation (2) [23].

Where D_F is the number of successfully recognized operations and T_F is the number of total operations. The accuracy of our system using equation (2) is 79.17%.
Since the system uses webcam-captured videos, the performance of the system may depend on illumination. Additionally, if there are other colored objects present in the background, the system may produce an incorrect response. Although this issue can be minimized by configuring the threshold values and other device parameters, it is still advisable that the operating background should be light and there should not be any bright-colored artifacts present in the background.
Additionally, on some low-computing computers, the device could run slower because it performs a large number of complex calculations in a very short time. However, for optimal system performance, a regular computer or laptop has the computational power needed. Another aspect is that the device will run slow if the camera's resolution is too high. This problem can be solved by reducing image resolution.

4 Conclusion & Future Work

The Keyboard and mouse form an integral part of the computer's system. Our system architecture can facilitate the use of computers for paralyzed people. We have developed a virtual system where people can communicate with a computer without using a physical keyboard and mouse. This led to a new age of Human-Computer Interaction in which physical contact with the computer would not be necessary at all. The use of object detection and image processing in Open CV for the implementation of our work has proved to be practically successful and the task of keyboard and mouse are achieved with good precision. The system can be beneficial to certain people who have no control over their limbs.

Most of the applications require additional hardware which is often very expensive. The motive of this work isto create this technology as cheaply as possible and to create it under a standardized operating system. Though our system can be used as an alternative to a physical keyboard and mouse, it still may perform less accurately in low-light conditions. This is a concern for further research. Moreover, the work can be extended fora wide variety of environments and can be tested using the sophisticated existing models [12] [1] [15] [3] [7] [11] [8]
[4] [22].

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