SIXTH SENSE – An Air Mouse

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Abstract: The Sixth Sense is a wearable gestural interface that augments the physical world with digital information and lets us use natural hand gestures to interact with that information. The sixth sense technology was introduced to bridge the gap between physical world and the digital world. This paper provides an analytical approach towards the Sixth Sense technology wherein the cursor movements and click events of the mouse are controlled by simple hand gestures. A Web Cam is used as a sensing element to detect the gestures. The gestures sensed by the camera are converted into digital form using image processing to develop a virtual human computer interaction (HCI).

Keywords: Sixth Sense technology, human computer interaction (HCI), image processing, hand gestures.

I. INTRODUCTION

The Sixth Sense is a wearable gestural interface that augments the physical world with digital information and lets us use natural hand gestures to interact with that information. The Sixth Sense technology bridges the gap between the physical world and the world of data. Sixth Sense aims to integrate online information and technologies into everyday life. So it can help the human to make decision effectively[4].

There are many inventions in controlling computer applications with gestures by various technologies such as data glove, vision based and touch screen The main objective of this paper is to create a virtual Human Computer Interaction system using Web camera to interact with the computer in a more user friendly manner. The new generation computer technology in user-interface has become more natural and realistic to gesture interface, capturing the motion of our hands and controlling the devices. Hand gesture may include multi-touch screen interface, MS Surface computing, or camera based gesture recognition.

This paper deals with the controlling all operations of mouse such as right click, left click and movement of cursor over the desktop, drag and drop, screenshot, zooming, scrolling, Air drawing and painting through hand gesture. Here a simple Web Cam is used to detect the gestures and hand movements. The camera senses the colour bands and gestures which are then converted into digital form by using algorithms. These algorithms are implemented using MATLAB (MATrixLABoratory) programming.

II. RELATED WORK

A. Sixth Sense

The Sixth Sense prototype, by Pranav Mistry is comprised of a pocket projector, a mirror and a camera as shown in Figure 1. The hardware components are coupled in a pendant like mobile wearable device. Both the projector and the camera are connected to the mobile computing device in the user's pocket [4][5][10]. The projector projects visual information enabling surfaces, walls and physical objects around us to be used as interfaces; while the camera recognizes and tracks user's hand gestures and physical objects using computer-vision based techniques.

The software program processes the video stream data captured. by the camera and tracks the locations of the coloured markers (visual tracking fiducials) at the tip of the user's fingers using simple computer-vision techniques. The movements and arrangements of these fiducials are interpreted into gestures that act as interaction instructions for the projected application interfaces. The maximum number of tracked fingers is only constrained by the number of unique fiducials, thus Sixth Sense also supports multi-touch and multi-user interaction [5].
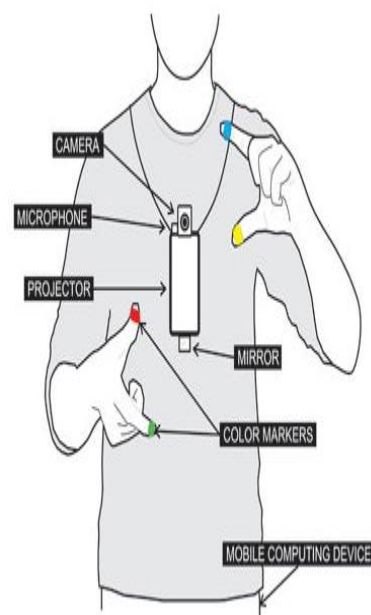

Fig. 1. Sixth Sense Prototype by Pranav Mistry

B. Mouse free

Many researchers in the human computer interaction and robotics fields have tried to controlmouse movement using video devices. However, all of them used different methods to make aclicking event. One approach, by Hojoon Park [1] used index finger for cursor movement and angle between index finger and thumb for clicking

events. Also, Erdem et al [2], used fingertip tracking to control the motion of the mouse. A click of the mouse button was implemented by defining a screen such that a click occurred when a user's hand passed over the region. Another approach was developed by Chu-Feng Lien [3]. He used only the finger-tips to control the mouse cursor and click. His clicking method was based on image density, and required the user to hold the mouse cursor on the desired spot for a short period of time. Paul et al [5], used another method to click. They used the motion of the thumb to mark a clicking event. S Malik developed a real-time system that can track the 3D position and 2D orientation of the thumb and index finger of each hand without the use of special markers or gloves. His system could be used for single pointing and pinching gestures.

C. Mouse less

Mouse less is another such technology in which an invisible computer mouse provides the familiarity of interaction of a physical mouse without actually needing a real hardware mouse. The Mouse less invention removes the requirement of having a physical mouse altogether but still provides the intuitive interaction of a physical mouse that we are familiar with. Mouse less consists of an Infrared (IR) laser beam (withline cap) and an Infrared camera. Both IR laser and IR camera are embedded in the computer. Thelaser beam module is modified with a line cap and placed such that it creates a plane of IR laserjust above the surface the computer sits on. The user cups their hand, as if a physical mouse waspresent underneath, and the laser beam lights up the hand which is in contact with the surface.The IR camera detects those bright IR blobs using computer vision. The change in the positionand arrangements of these blobs are interpreted as mouse cursor movement and mouse clicks. Asthe user moves their hand the cursor on screen moves accordingly. When the user taps their indexfinger, the size of the blob changes and the camera recognizes the intended mouse click.

III.IMPLEMENTATION

The Sixth Sense is any wearable device which allows us to interact with the digital world easily; it connects the physical world and digital world. The Sixth Sense wearable device introduced here consists of Webcam which senses the colour bands and gestures which are then converted into digital form using algorithms written in MATLAB.

A. MATLAB (MATrixLABoratory)

MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment and fourth generation programming language. A proprietary programming language developed by Math Works, MATLAB allows matrix manipulations plotting of function and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, Fortran and Python. Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing capabilities. An additional package, Simulink, adds graphical multi-domain simulation and Model-Based Design for dynamic and embedded systems.

MATLAB version 2013a is used for making this project. Image Acquisition toolbox and Image processing toolbox is necessary for developing the firmware. Along with this, an updated version of Java is required.

B. Webcam

A webcam is a video camera that feeds or streams its image in real time to or through a computer to computer network.

Webcam is a necessary component for detecting the image. Sensitivity of mouse is directly proportional to resolution of camera. If the resolution of camera is good enough, an enhanced user experience is guaranteed. The webcam serves the purpose of taking real time images whenever the computer starts. On the basis of gestures and motion of fingers, system will decide the respective action. The webcam used here has a video resolution of 1280x720=0.9Megapixels

C. Image Processing

Processing the image include various steps, capturing the image from video, converting it into grayscale image, filtering the image and then converting the image into binary that is digital form.

1. Colour Detection

MATLAB captures image in RGB format, which contains three layers of Red, Green and Blue. The image in MATLAB appears in the form of a matrix. Each element of matrix shows the sum of all three layers of Red, Green and Blue colours. To detect a Red colour, we take the Red layer containing values of Red colour. The process flow chart is shown below. To get red components, the red layer of that image is taken and this layer is then subtracted from the gray version of original image, to convert into a grayscale image. The Noises are then filter out, this image is then converted into binary image, which has 1s at red components and 0s elsewhere. The unnecessary components are then removed; the obtained image then have only red object components'. These components are then counted and bounded with boxes[6][12][15].
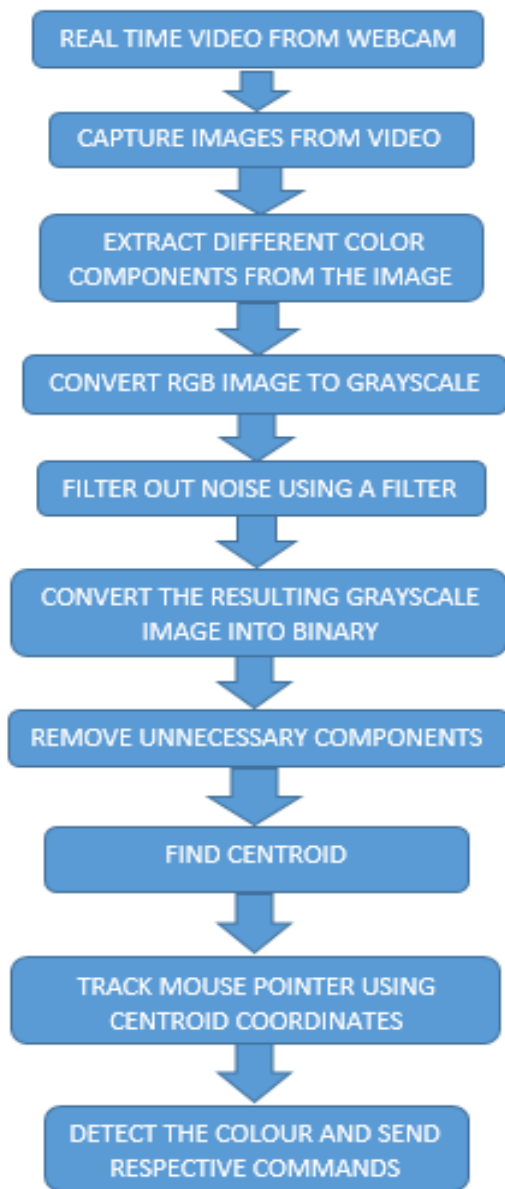

Fig. 1. Input Image

Fig. 3. Process FlowChart

In this project, there are uses of red, blue, green, yellow, magenta, cyan and black planes. In order to identify the colours of the hand, MATLAB's built in function "imsubstract" can be used.

Fig. 4. Colour plane detected and converted to Grayscale Image

2.   Image Filtering

As soon as the colour in the real time image is detected, the next step is to go for filtering of this single frame. Care has to be taken about the processing speed of every frame since every camera has different frames per second, median filter is used here to filter the images and remove the noise.

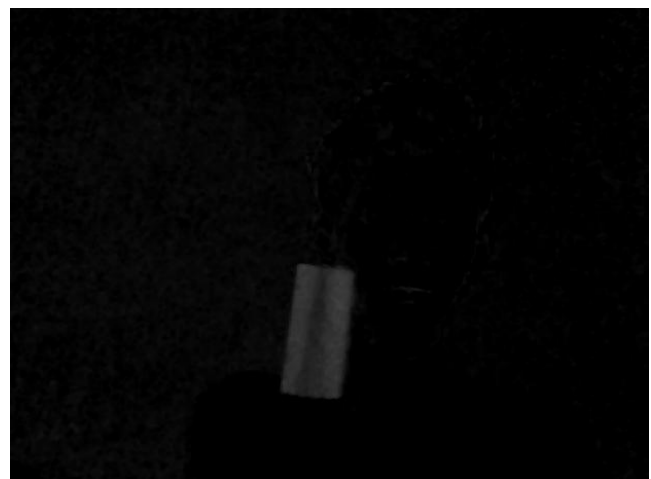Fig. 5. (a) Image before Filtering

Fig. 5. (b) Image after Filtering

The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing. Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise. [8]

The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighbouring entries. The pattern of neighbours is called the "window", which slides, entry by entry, over the entire signal. For 1D signals, the most obvious window is just the first few preceding and following entries, whereas for 2D (or higher-dimensional) signals such as images, more complex window patterns are possible. [14] Median filtering gives optimum results. Result of the filtering looks like as mentioned in Figure 5.(b)

3. Conversion of Image to Binary

As soon as filtering is done over a frame, next step is to convert the image to binary. For conversion of image built in function "im2bw" is used.

The BW image replaces all pixels in the input image with some threshold greater than the Value 1 (white), and replaces all other pixels with the value 0 (black).

Fig. 6. Image converted to BW

4. Removing small unnecessary components

All the areas other than the pointer need to be removed in order to get the best accurate number of the object detected in the image. To do this, MATLAB's "bwareaopen" function is used.
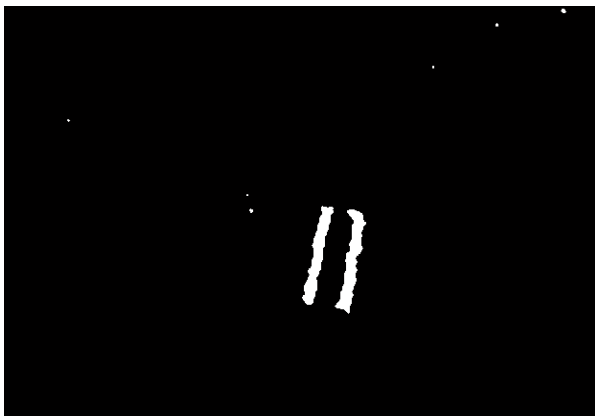

Fig. 7. (a) Image before removing unnecessary components

Fig. 7. (b) Image after removing unnecessary components

It removes from a binary image all connected components that have fewer pixels than the binary image, producing another binary image.

5. Finding Centre

For the user to control the mouse pointer it is necessary to determine a point whose coordinates can be sent to the cursor. With these coordinates, the system can control the cursor movement. An inbuilt function in MATLAB is used to find the centroid of the detected region.

The output of function is a matrix consisting of the X (horizontal) and Y (vertical) coordinates of the centroid. These coordinates change with time as the object moves across the screen. Once the coordinates are determined, the mouse driver is accessed and the coordinates are sent to the cursor. With these coordinates, the cursor places itself in the required position. It is assumed that the object moves continuously, each time a new centroid is determined and for each frame the cursor obtains a new position, thus creating an effect of tracking. So as the user moves his hands across the field of view of the camera, the mouse moves proportionally across the screen. [12]

Here "bwlabel" MATLAB function crops the required area. To get the properties of the region such as centre point or bounding box, etc., MATLAB's built in function "regionprops" is used which measures a set of properties for each connected component in the binary image, BW. The image BW is a logical array, it can have any dimension, so for the application finding the centre is necessary for accurate movements.
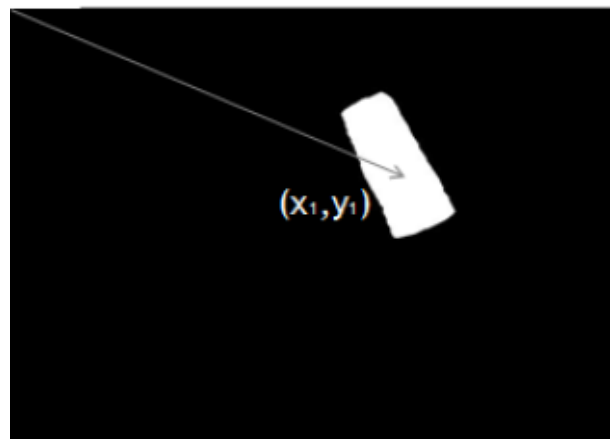

Fig. 8. Movement as per coordinates

D. Mouse cursor movements and Click events

There is no inbuilt function in MATLAB which can directly access the mouse drivers of the computer. But MATLAB code supports integration with other languages like C, C++, and JAVA. Since java is a machine independent language so it is preferred over the others. As java is object oriented an object is created and it is linked with the mouse drivers. Based on the detection of other colours the system performs the clicking events of the mouse. These colour codes can be customized based on the requirements. To move the mouse and to simulate the mouse click event "Java class java.awt.Robot" can be used. [10]

The Table below shows the different colours, their positions and various mouse operations respectively.

TABLE I
DIFFERENT COLOURS, THEIR POSITIONS AND FUNCTION

VARIOUS COLOURS AND THEIR POSITIONS			FUNCTION
LEFT	CENTRE	RIGHT	
	RED		Cursor move
BLUE	RED		Left click
	RED	BLUE	Right click
	GREEN		Air Drawing/ writing, continuous selection
	MAGENTA		Scrolling
	CYAN	MAGENTA	Zoom in
MAGENTA	CYAN		Zoom out
	YELLOW		screenshot
	BLACK		stop

The control actions of the mouse are performed by controlling the flags linked with the mouse buttons. JAVA is used to access these flags. The user has to perform hand gestures in order to create the control actions. Due to the use of colour pointers, the computation time required is reduced.

Furthermore, the system becomes resistant to background noise and low illumination conditions.

The Figure 9 shows the detection of different colours and their BW image.
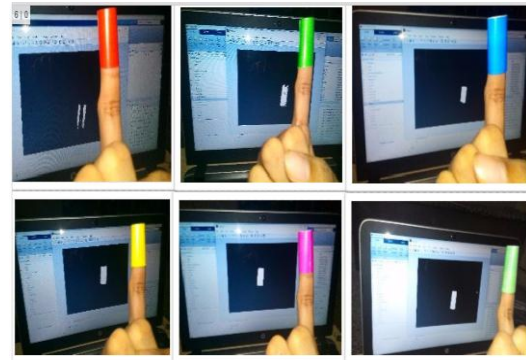

Fig. 9. Detection of Different Colours

The Figures 10 and 11 show the different gestures for controlling. For right click and left click blue colour should be on right and left side of red colour respectively. Similarly, for zoom in and zoom out magenta colour should be on right and left side of cyan colour respectively as shown in above table.
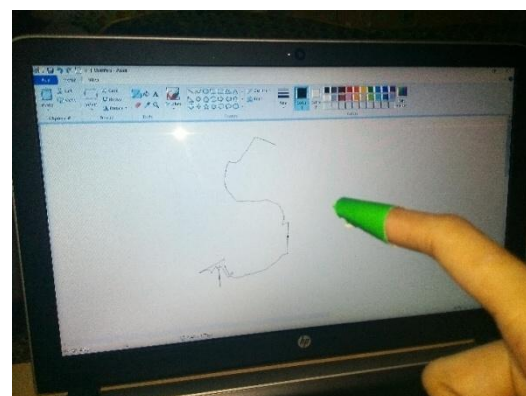

Fig. 10. Right click of Mouse

Fig. 11. Air Drawing/ Painting

IV. FUTURE SCOPE

The system can be further extended to, by adding more gestures for better control to perform more operations. In future by using more colours and gestures, keyboard can also be replaced by Air writing. A projector can be used as in the original Sixth Sense prototype by Pranav Mistry to extend the control anywhere in future and any digital system can be controlled.

V. CONCLUSION

In this project a simple approach towards Sixth Sense technology has been introduced. The Sixth Sense can be considered as the future of Augmented Reality. The system can be used to reduce workspace and naturally interact with computers. Sixth sense is developed to seamlessly integrate information into reality. The future may depend upon this sixth sense. The proliferation and the use of this technology is immense. The advantage of this technology is portable, its cost effectiveness and data can be accessed from the machine directly in real time.

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BIOGRAPHY

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