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Skin based real time air writing using web camera

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ABSTRACT

Skin detection is one of the most essential and primary stages in image processing applications such as face detection, hand detection and hand tracking. In proposed system, hand segmentation using color models is introduced for detecting user's hand by skin based segmentation technique for writing alphabets according to the movement of hand. The proposed system lets the user to write alphabets using hand detection based on skin and works efficiently in faster, robust, accurate and real-time applications.

Keywords: Hand Segmentation; Color Spaces; Hand detection; Morphological operations; Contour; Convex Hull

1. INTRODUCTION

In today's high-tech era, numerous technologies are progressing day by day. One such encouraging concept is Human- Machine Interface. One of the most essential considerations to make system efficient, accurate and reliable is Human Computer Interaction (HCI). There are several systems dealing with simple techniques for HCI, these techniques ensure the use of mouse; keyboard etc. for input to the systems. Most commonly used techniques are physically in contact with the system recently new techniques have been developed to make Human Computer Communication is more efficient. One of the supreme gifts of nature to the mankind is the capability to express him by reacting to the actions occurring in his surroundings. Motions are considered as the extreme natural expressive way for interaction between human and computers in virtual system. The task of hand movement recognition is one of the important problems in computer vision. With recent development in information technology, human interactions systems are build which involve tasks related to hand processing like hand detection, hand recognition and hand tracking.

We wish to make a Window-based application for live skin based hand detection and recognition using webcam input in C#. This project is a combination of live hand movement detection and face identification. This application uses the webcam to detect the hand and face made by the user and perform mapping of alphabet according to hand motion. The user has to perform a particular movement of hand in order to form a single alphabet. The webcam captures this and identifies the alphabet, recognizes it (against a set of known alphabets) and performs the action corresponding to it. An alphabet could be written even while sitting afar from the computer screen. This paper presents an interactive technique for Human Machine Interaction using the hand detection based on skin.

The organization of the paper is as follows. In section 2, Literature review has presented. In section 3, Technologies used in proposed system are described. The description of proposed system is described in section 4. Implementation phase in which techniques used for Segmentation of hand and hand detection are introduced and discussed in section 5. Experimental Results and conclusion is discussed in section 6. In section 7, future work has been discussed.

2. LITERATURE REVIEW

Lots of works have been done on hand movement recognition using different techniques. This section presents a quick review on some of the previous work done. Many researchers have invented techniques to deal with the various hand movement and features for getting more accuracy and more recognition rate. The Kalman filter is used for hand tracking to obtain motion of hand region. To recognize real time hand movements in unconstrained environments, Kalman filter offered a hand gesture recognition system [1]. Meenakshi Panwar [2] proposed approach that uses some pre-processing steps for removal of background noise. Mohan Pradhana [3] invented a very simple and efficient approach for recognizing the hand movements that represents numbers from zero to nine. The design of above discussed system is divided into two phase namely, preprocessing and classification phase. But the negative side of using this approach is that the planned system is able to organize only the static images.

In reference [7], Amardip et al have used a web camera, hand glove and image subtraction algorithm to map mouse inputs with hand movement. Different fingers of hand glove have different colors that make system faster and easier. Gowrishankar. R [8], have used web camera and different techniques such as image recognition, color

recognition process and Sixth Sense Technology (is a set of wearable devices that acts as a gestural interface) to control the mouse movement with finger. Our project is inspired by work of Lianwen Jin [9], where he used FVCR system, to write character with hand movement without use of any additional device. A robust fingertip detection algorithm, image segmentation techniques and recognition of fingertip algorithm used to write the character. [10] Akash. S used sixed sense technology to command to computer using hand gesture. He also used pendant like wearable device to virtually paint and write without using any pen or physical equipment and web camera to detect or capture hand movement. Kamran Niyazi [11] et al used Web camera and color tapes. Camera detects color tapes for cursor movement. Distance between two colored tapes in the fingers can be calculated to perform clicking actions. Our work inspires by these technologies that kid can interact with the system to write the alphabet without using any glove or sensor our system work with normal web camera in real time. The previously researchers works in this area by using gloves and sensor based cameras to perform the activities our system is independent with reference to sensor and gloves.

3. TECHNOLOGIES USED

a) Emgu CV

Emgu CV is a cross platform .Net wrapper to the OpenCV image processing library. It allows OpenCV functions to be called from .NET compatible languages such as C#. The wrapper can be compiled by Visual Studio. It runs on Windows, Linux, Mac OS X, iOS, Android and Windows Phone.

b) C#

C# (pronounced as see sharp) is a general-purpose, object oriented, interoperability, scalable, updateable, efficient and easy to use programming language based according to the current. We have used the C# interface of EmguCV for the implementation. C# permits programmers to quickly and easily build solutions for the Microsoft .NET platform. It also supports Data Encapsulation, interfaces and encourage the programmer to build robust applications.

4. PROPOSED SYSTEM DESCRIPTION

The proposed system has three phases. In real time, input image has captured using a web camera is done in the first phase. The hand region based on skin color is detected using color space models and morphological operations are performed in the second phase of the proposed system. In the feature extraction phase, contours and the convex hull method is used to detect the border line of the segmented binary hand image. Finally system starts writing the alphabets keeping the (x,y) coordinates value according to the hand movement. The experimental setup of writing alphabets using skin based hand detection requires a low cost web cam and prefers a plain background with black screen to get accurate results. It does not require any special equipment such as colour data gloves.

Following are the steps in our approach:

i. Capture the image frames from web camera.
ii. Segment the hand portion from Image frames.
iii. Apply dilation and erosion operations to eliminate noise from the output obtained from hand segmentation.
iv. Find Contours.
v. Detect the convex hull of a contour and calculating centroid of the hand.
vi. Tracking the pointer using the coordinates obtained from the centroid to perform writing actions according to the hand movement to write the alphabets.

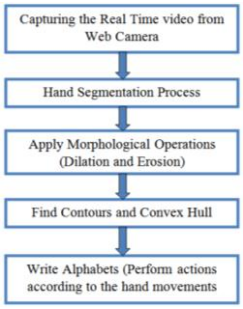

Figure. 1 Block diagram of the system

5. IMPLEMENTATION

a. Webcam

A webcam is a video camera that streams its image in real time through a computer. Sensitivity of mouse is related to resolution of camera. An enhanced user experience is guaranteed only when the camera resolution is good. The webcam serves the purpose of taking real time images whenever the computer starts. System will take input from the webcam and converting it into a form that can be processed easily. Our system will decide the respective action on the basis of hand movement. After that system will map the movement of hand on templates of alphabets from the input of the webcam.

b. Hand Segmentation

Hand segmentation is done by separating the user's hand from the background in the image. Segmentation can be done using several methods. An important step in hand segmentation is thresholding which is used to separate the hand from the background. Various methods are used to select the appropriate threshold value to obtain better result explained in [4]. On the input image, thresholding is done according to a threshold value. 0 is set to those Pixels that are having intensity less than the threshold value and 1 is set to those Pixels that are having intensity more than the threshold value. Thus a binary image where pixels 0 represent the background and pixels 1 represent the hand is the output of thresholding. Therefore, pixels having value 1 is the user's hand. There are some constraints on the background to extract hand in order to avoid much noise.

Figure. 2 Blob of user's hand

The detected white blob can also be some other object instead of user's hand so whether the detected object is a hand or not is decided by the hand detection part explained further. User's hand is segmented according to the intensity of the pixels used. Usually intensity of hand is much higher, so the hand will easily be segmented by keeping the background dark.

Incremental Thresholding Value is one of the segmentation methods which can automatically select the threshold value. In this method, the function used in Static Thresholding is used. But in case of Incremental Thresholding Value the thresholding value keeps on incrementing, that is the variable thresh is incremented by value '1' in a range from 20 to 160, till we detect only one contour in the input image. It also ensures that the whole hand is detected as a blob without any internal fragmentation. One important factor that should be considered for color is the choice of a right color space. This paper proposes a hand segmentation method based on RGB, HSV, and YCbCr color space.

c. Color Spaces

There are different color spaces depending on different color expression ways [5, 6]. There are different hand skin color ranges in different color spaces. Selecting appropriate color space is the key stage for hand segmentation process.

d. RGB Color Space Model

RGB color space is a kind of mixed color space. It describes color space using primary colors.

- Red
- Green
- Blue

It can also represent many colors. RGB color space is not used in most experiments because it is difficult to digitize the information and mixes hue, luminance and saturation together.

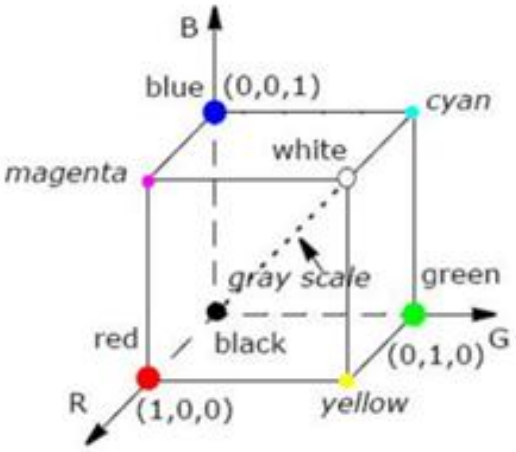

Figure. 3 RGB color model

e. HSV Color Space Model

HSV is often called HSB (B for brightness). The HSV color space model describes colors in terms of following:

- Hue
- Saturation
- lightness (luminance)

HSV is the most common cylindrical-coordinate representations of points in an RGB color model. HSV model is used in computer vision and analysing the image for segmentation. The diagram below shows a HSV Model

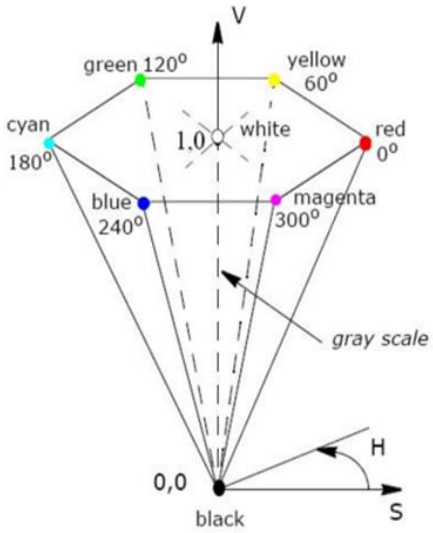

Figure. 4 HSV model

f. YCbCr Color Space Model

Information about luminance is stored as a single component (Y), and Information about chrominance is stored as two color-difference components (Cb and Cr) where Cb represents the difference between the blue component and a reference value. Cr represents the difference between the red component and a reference value. In short, Y′ is the luma component and CB and CR are the blue-difference and red-difference chroma components.

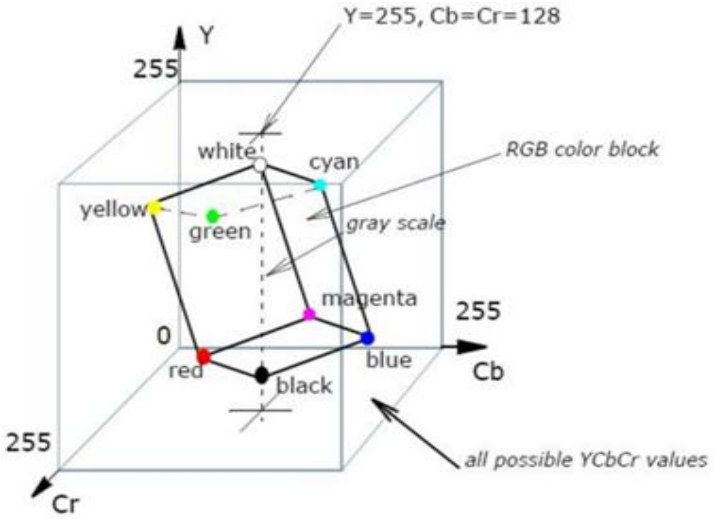

Figure. 5 RGB Colors cube in the YCbCr space

6. HAND SKIN DETECTION

a. Morphology Operations

The binary image formed in the previous section may contain white pixels at background (non-skin region). It may happen due to the background color resemble the skin color at hand region. Bad lighting conditions or existing pixels similar to skin pixels in those regions may cause these noises. Further implementation of morphological operations is required to fill up the black pixels on the segmented hand and white pixels on background so that hand can be clearly detected. Two morphological operations are encompassed namely dilation and erosion.

Firstly, dilation operation is done which adds pixels to fill up missing pixels in hand region. Secondly, erosion operation is performed to remove white pixels which do not belong to the hand region. These morphological operations are performed to improve the result obtained from hand segmentation.

b. Contours

A contour is the curve for a two variables function along which the function has a constant value. It joins points above a given level and of equal height. A contour map illustrates the contour using contour lines. The contour lines show the steepness of slopes and hills. Contours are curves describing the intersection of one or more horizontal planes with a real or hypothetical surface with. Contour lines are curved, describing straight or a mixture of lines describing the intersection of a real or hypothetical surface with one or more horizontal planes. The contour is tired around the hand that is formed by thresholding the input image. White blob is found out after pre-processing of the image frame. Contour is drawn around the hand (white blob).

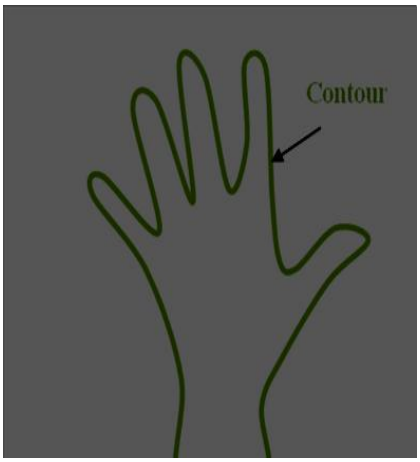

Figure. 6 Contouring of hand

The following function is used for finding contours in EmguCV using C# language:

Public
<Point>FindContours(CHAIN_APPROX_METHOD method, RETR_TYPE type, MemStoragestor)
method- contour approximation method is capable of compressing vertical, horizontal and diagonal segments and stores only their end points.
type- contour retrieval mode
stor- the memory storage used by the sequences.

c. Convex Hull

The convex hull of a set of points in the Euclidean space (a set of points satisfy certain relationships, expressible in terms of distance and angle) is the smallest set of convex that contains all the set of given points. For example, the convex hull is visualized as the shape made by a rubber band stretched around this set of points, when this set of points is a bounded subset of the plane. Convex hull is drawn around the contour of the hand; it can be visualized as contour points are within the convex hull. This makes a wrapper around the hand contour.

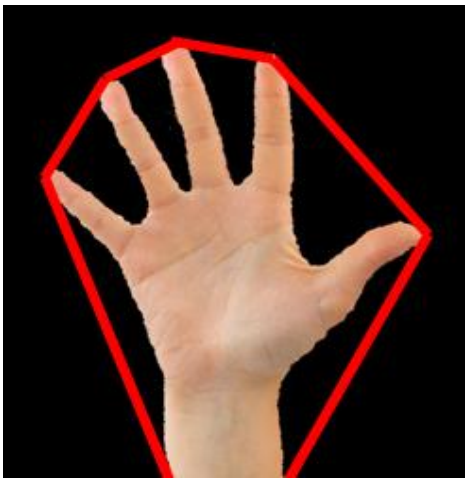

Figure. 7 Convex hull of hand

The following function is used for detecting the convex hull of a contour:

GetConvexHull(Emgu.CV.CvEnum.ORIENTATION.CV_CLOCKWISE);
Contours and convex hulls are collection of points needs to be connected with straight lines.

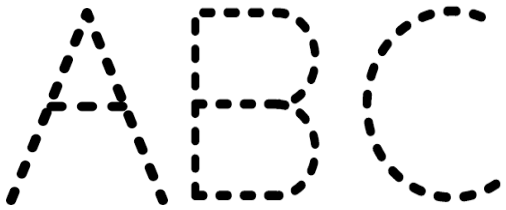

Figure. 8 Templates of alphabets

7. EXPERIMENTAL RESULTS

The proposed work is implemented in Microsoft Visual Studio 2015 with EmguCV libraries and skin based hand detection is tested with different people having different hand size under background constraints. Each person shows hand movements according to the alphabet in front of the camera. Experiments show that the response time of writing an alphabet through hand movements is comparable to the time for selecting a key from a keyboard for typing an alphabet as it does not require a database of training images.

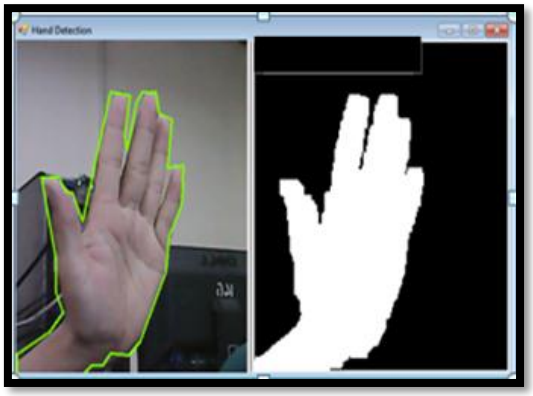

Figure. 9 Output of the test result contouring of hand

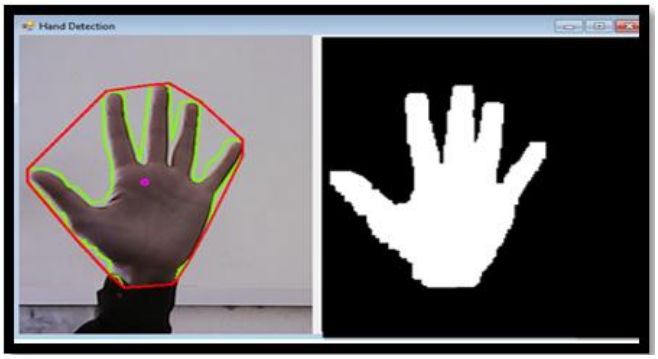

Figure. 10 Output of the convex hull showing middle point of hand

Figure. 11 The strokes direction in template

8. FUTURE WORK

The proposed system does not have a good background subtraction method which puts constraints on the user for successful working of the system. In future work, we wish to include those methods that assist to reduce these constraints so that the system is usable in any situation and produce better, precise and more accurate results.

9. CONCLUSION

This project completely eradicates the need of mouse. Also this would lead us to a new era of Human Computer Interaction (HCI) where no physical contact with the machine is required. The proposed system technology can be used to develop novel educational learning systems which assist children to learn handwriting in an interesting way.

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