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Vision-based Eye-controlled Interface for Human-Machine Interaction

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Abstract: In this proposed work, a research work implementing hands-free interfaces between human and computer is carried out. The purpose of this work is to compensate the people, especially who have disabilities in their body which prevent them from using the mouse. This work is focused on the computer accessibility where computer is very much essential in human life. The system is developed to make the people interact with the computer to operate all real life operations such as internet browsing, audio and video player, GPS, surgical operations etc. The proposed interface allows people to move cursor and perform mouse click operations using eye gestures without any special hardware. Hence this work leads to the implementation of low cost human-interface system. Face and Eye detection are carried out with cascade of boosted classifiers using haar-like features, Haar-cascade is an object detection algorithm used to detect faces, objects and facial expressions in an image. The work has been implemented on openCV, python programming environment with operating system as windows 10 and the system performs better than the existing systems.

Keywords: Face Detection, Eye Detection, Cursor movement, mouse click operations, Haar Cascade Classifier.

I. INTRODUCTION

The main objective of the proposed work is to implement a hands-free mouse control system to interact without any special hardware with the computer. The proposed system is designed to interact with a computer using human facial gesture for carrying out operations like window open and close, navigation between tabs, zooming etc.., The Haar cascade classifier is used to detect the face and eye position in the captured video sequences.

A. HUMAN-COMPUTER INTERACTION(HCI)

HCI is the interaction between users and computers using new modalities for computer interaction like speech, input by gestures or by tangible objects with sensors. A further input modality is eye gaze which nowadays finds its application in accessibility systems. Therefore, eye gaze could serve as an interaction method beyond the field of accessibility.

B. EYE TRACKING FOR HCI

Human computer interfaces utilize eye-movement measures that allow users to explicitly control the interface though the use of eye movements. These systems usually use the eye movements to control the cursor position and use eye blinks to trigger mouse clicks or other events. The aim of this work is to find new forms of interactions utilizing eye gestures suitable for users. The Haar cascade algorithm is an object detection algorithm used to locate faces, pedestrians.

C. HAAR CASCADE ALGORITHM

The Haar cascade algorithm is an object detection algorithm used to locate faces, pedestrians, It is a machine learning based approach where a cascade function is trained from a lot of positive and negative images.

D. EYE DETECTION

A new rectangle features are drawn using the eye detection, Once the face is detected a region of interest (ROI) is selected from the face region based on face geometry. Now in this ROI Haar cascade classifier eyes detection is applied if the array values of eyes are zero then it will be a eye closed state If closed eye are not detected Haar classifier for open eyes are checked. After it complete it takes the next frame from camera and processes it.

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Fig.1. Eye Centroid

The eye centre location starts with ROI of face obtained from web camera. After capturing there is calibration block where eye gaze is initialized for pointer position on screen. The eyes are detected using Right eye splits and Left eye splits classifier.

E. APPLICATIONS OF THE PROPOSED SYSTEM

The proposed system can be applied to the following **Hands-Free Interfaces** for**:**

•Multimedia Operations
•Printer Operations
•Internet Browsing
•Web Application for Smart Home Environment
• ATM Operations
• Computer Games
• Mobile Operations
•GPS Operations

II. LITERATURE SURVEY

Marco Porta, Alessia Ravelli, [1] The proposed work WeyeB, is a browsing system which allows the two basic Web surfing operations, namely page scrolling and link selection, to be easily performed without using the hands. For eye-controlled scrolling the screen have four eye-sensible regions placed at the top, bottom, left and right sides. Each region is subdivided into four sub-areas. When the user looks at the central area of the screen, no scrolling occurs, while the content is scrolled up, down, left or right once the user looks anywhere outside the rectangle for more than certain time (2 seconds), it disappears

Disha H. Nagpure,Shubhangi T. Patil,Snehal P. Bujadkar, [2] Proposed a work that describes eye motion detection using a five stage algorithm to estimate the direction of eye movements to control computer system. The viola-Jones object detection algorithm is mainly used for head detection. The mouse is controlled by using the movement of cursor with respect to the proportional movement of the eye.

Kunhui Lin, Jiyong Huang Jiawei Chen Changle Zhou [3] Introduced a fast eye detection scheme for use in video streams rather than still images The temporal coherence of sequential frames was used to greatly improve the detection speed. First, the eye detector trained by AdaBoost algorithm is used to obtain the rough eye positions. Then these candidate positions are filtered by geometrical patterns of human eyes.

S.S.Deepika and G.Murugesan, [4] In this proposed work, image based eye tracking technique used for interaction. It is based on controlling cursor movements on the screen using only the eyes. The system proposed in this work uses a low resolution webcam which is attached to a wearable glass frame, for eye tracking. The images obtained from the webcam are processed to locate the iris center. This is used to estimate the eye gaze. The cursor is moved in the desired direction on the screen based on the estimated eye gaze. The selection of the tabs is also carried out by blinking.

Jilin Tu, Thomas Huang, Hai Tao [5] Implemented a system for The human facial movement such as rigid movement, e.g. rotation and translation, and non-rigid movement, such as the open/close of mouth, eyes, and facial expressions, etc. This work introduce visual face tracking system that can robustly and accurately retrieve these motion parameters from video at real-time. After calibration, the retrieved head orientation and translation are employed to navigate the mouse cursor.

Kaushik Parmar,Bhavin Mehta,Prof. Rupali Sawant, [6] Presented a vision & feature-based system for detection of long voluntary eye blinks and interpretation of blink patterns for communication between man and machine. Supplemented by the mechanism for detecting multiple eye blinks, this work provides a complete solution for building intelligent hands-free input devices.

Pravin R Futane, Dr. R. V. Dharaskar and Dr. V. M. Thakare[7], In this work have identified an alternative to mouse command especially with reference to cursor controlling applications. The two application case scenario; one by hand gestures and another by hands-free interface i.e. Face gesture is discussed with algorithms used such as convex hull, Support vector machine and basic mathematical computation. They have been applied to give command and perform the activities like open any note pad, office tools software not by using mouse but by using gestures.

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Yo-Jen Tu, Chung-Chieh Kao, Huei-Yung Lin and Chin-Chen Change[8], In this work, a face and gesture based human computer interaction (HCI) system is developed to control the system. The positions of the eyes and mouth, and use the face center to estimate the pose of the head can be identified. The experimental results show that the proposed approach is accurate with gesture recognition rate of 93.6%.

III. PROPOSED SYSTEM

In the proposed project work, the system is developed to interact with a computer using human facial gesture without any hardware. All computer operations are carried out using vision-based interfaces such as eye, lip and tongue movements.

The workflow of the proposed work is shown in Fig 2.

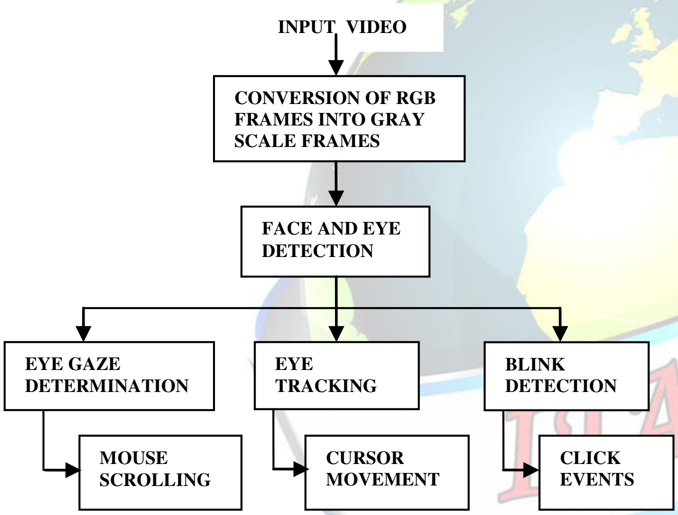

Fig.2. Work Flow of the Proposed Methodology

A. FACE DETECTION

The Haar Cascade classifier algorithm is used to detect faces. The classifier is configured with a minimum size of 150 x 150 pixels and a scaling factor of 1.1, The biggest face in the image is chosen as a region of interest.

i) HAAR CASCADE FACE DETECTION

For the detection of the face, Haar features are the main part of the Haar cascade classifier. Each features results in a single value which is calculated by subtracting the sum of pixels under white rectangle from the sum of pixels under black rectangle as shown in Fig.3 Haar like features are the rectangle features for rapid face detection are used.

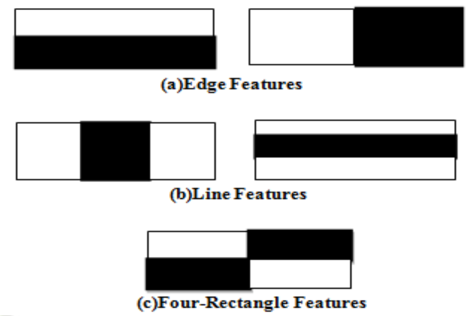

Fig.3. Haar Features

P(x) = Sum black rectangle – Sum White rectangle

Each feature is a single value obtained by subtracting sum of pixels under white rectangle from sum of pixels under black rectangle. The face is detected from top left corner and ends the face detection process at bottom right corner of the image, The rectangle features are computed using integral image concept. It takes four values at the corners of the rectangle for the calculation of sum of all pixels inside any given rectangle. In an integral image the value at pixel (x,y) is the sum of pixels above and to the left of (x,y). Sum of all pixels value in rectangle D is shown in Fig 4 The integral image is calculated as below.

$$G1=A,\ G2=A+B,\ G3=A+C,\ G4=A+B+C+D$$
$$G1+G4-G2-G3=A+A+B+C+D-A-B-A-C=D \quad (1)$$

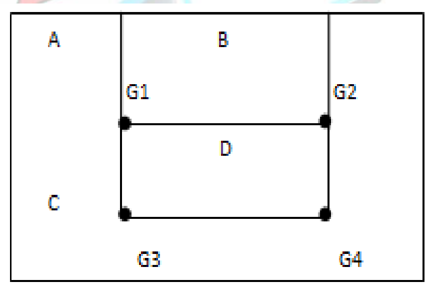

Fig.4. Calculation Of Integral Image

ii) INTEGRAL IMAGE

The integral image is an array containing the sums of the pixels' intensity values located directly to the left of a pixel and directly above the pixel at location (x,y) inclusive. So if A[x,y] is the original image and AI[x,y] is the integral image then the ntegral image is computed as shown in Eqn. 2.

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$$AI[x,y] = \sum_{x' \le x, y' \le y} A(x',y') \quad ....(2)$$

The rotated integral image is calculated by finding the sum of the pixels intensity values that are located at a forty five degree angle to the left and above for the x value and below for the y value.

So if A[x,y] is the original image and AR[x,y] is the rotated integral image then the integral image is computed as shown in Eqn. 3.

$$AR[x,y] = \sum_{x' \le x, x' \le x-|y-y'|} A(x',y') \quad ....(3)$$

It only takes two passes to compute both integral image arrays, one for each array. Using the appropriate integral image and taking the difference between six to eight array elements forming two or three connected rectangles, a feature of any scale can be computed. Thus calculating a feature is extremely fast and efficient. It also means calculating features of various sizes requires the same effort as a feature of only two or three pixels. The detection of various sizes of the same object requires the same amount of effort and time as objects of similar sizes since scaling requires no additional.

iii) CASCADE CLASSIFIER

The face detection can be performed by cascade using haar like features as shown in fig 3. In training phase the classifier is trained with a number of positive and negative samples to get a cascaded classifier. It consists of cascaded stages of weak classifiers . The optimal set of cascaded features and corresponding thresholds are obtained from the AdaBoost algorithm.

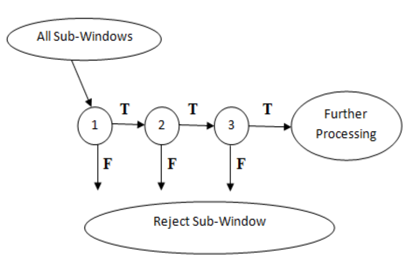

Fig.5. Haar Classifier

A series of classifiers are applied to every sub-window. The cascaded structure is shown in Fig.5. The first classifier eliminates a large number of negative images and passes almost all the positive sub-windows (high false positive rate). The subsequent stages of the cascaded detectors reject the negative sub-windows passed by the first stage weak classifier. After several stages of processing the number of negative windows will be reduced greatly.

B. EYE DETECTION

When the rough face region is detected an efficient classifier method will be sequentially applied to locate the rough regions of both eyes which will be used to the following eyes detection. The portion of the image is divided corresponding to the face in 6x5 equal regions. The first step is to calculate the eyes from the rough face region image. The eyes are located in the upper part of the face, eyes are in the third top to bottom row, the left eye is in the second column and the right one is in the fourth column.

C. MOVING THE CURSOR

Cursor movement is calculated based on the relative displacement between face images acquired consecutively. Once the first rectangle is drawn as the detected face, the algorithm continues detecting faces for one more second subsequently the average of the centroid of each detected face rectangle is calculated. This point is used as a reference to calculate the cursor's displacement to the middle of the screen, the limit of relative displacement between $(x,)$ and $(x,)$, is experimentally assumed to be 20 pixels.

The relative displacement is calculated using the formula below

$$M(x,y) = P(x,y)/2 + (R(x,y) - C(x,y)) \cdot (P(x,y))/L \quad ...(4)$$

The above process is repeated while a face is detected in the image. If a face is not detected, the cursor stays in last position. When a new face is detected, the cursor is located in the middle of the screen, the average of the centroid is calculated for one second and the user takes back control of the cursor.

i) ALGORITHM FOR CURSOR MOVEMENT

- Eyes within the rectangular search region are specified by ROI. The ROI must be specified as a 4-element vector, [*x y width height*], that defines a rectangular region of interest within image.

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- The centre points of the eyes are detected using by the eye region of right and the left region of eyes and mentioned as l_c and r_c.
- A line is drawn using the two centre point of the eyes which will be taken as a reference for cursor movement.
- The midpoint of the line is defined using the array values of r_c[0] , r_c[1] and l_c[0] , l_c[1].
- Using the midpoint array the relative displacement between the two eyes are calculated which is used for moving the cursor over the computer screen.
- A centre mid point is taken as M(x,y) the centre point of right and left eye movement taken as reference and used to move the cursor over the computer screen.

D. MOUSE CLICK EVENTS

The activation of the mouse buttons use the changes that occurs in the eye image when the eye is open or close. If the user closes the left/right eye for more than one second, the system will activate the corresponding click of the eye closed, classifier is applied on each eye region to reduce changes in lighting and shadows production.

The modules of the proposed work are implemented on OpenCV and PYTHON. The implementation details are given below.

IV. IMPLEMENTATION

A. FACE DETECTION

The Haar Cascade Classifier is loaded for detecting face from input video sequence and the faces are detected using ROI by drawing a rectangle over the detected regions. The face is detected as shown in Fig 6.

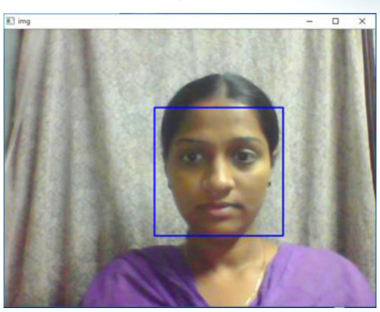

Fig.6. Face Detection

B. EYE DETECTION

The Haar cascade classifier is loaded to detect the eye regions using ROI and a rectangle is drawn over the detected eye regions.

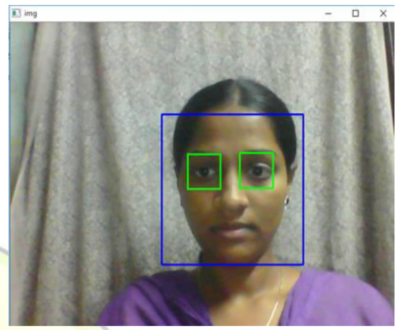

Fig.7. Eye Detection

C. MOVING THE CURSOR

The movement of the cursor using the centre position as reference from eyes, the average of centroid and relative displacement are calculated.

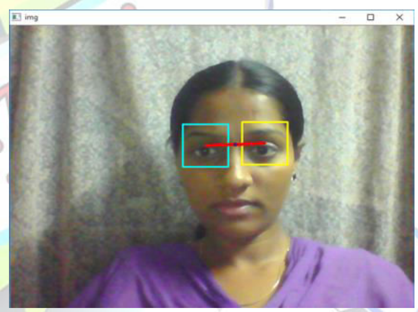

Fig.8. Cursor Movement Using Eyes

D. MOUSE CLICK EVENTS

The mouse operations are implemented by closing eyes. The ROI of the eyes are stored as array values and length of the values are obtained. If eyes are closed the array values will be lesser than the eye open values and by calculating these values and mouse click actions are performed.

The Output screenshots are show below

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OUTPUT SCREENSHOTS

Left Click

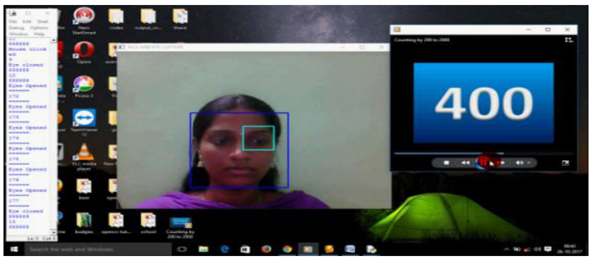

Fig.9. Accessing Windows Media Player- pausing the video by closing eyes, left click operation is invoked by closing the eyes

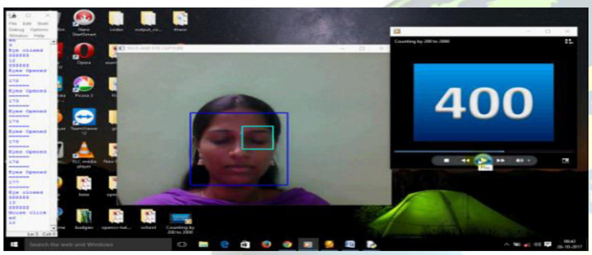

Fig.10. Windows Media Player- video is paused after performing left click by closing the eyes

Right click

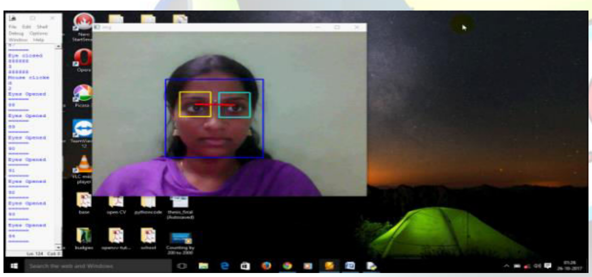

Fig.11. right click is done by closing eye to open function properties in the desktop

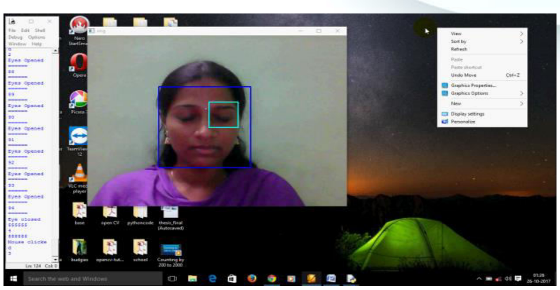

Fig.12. properties menu of the desktop opened on the screen after the right click done by closing eyes

V. EXPERIMENTAL RESULTS

In this section the experimental results obtained for the proposed approach is presented. The experiments are carried out in PYTHON SHELL in windows 10 operating system in a computer with Intel Celeron processor with 2.16 GHz with 2GB RAM.

A live video is captured using in-built Web Camera from 20 different subjects. To carry out mouse click events, the subjects are made to close their eyes 50 times /video for just 1 Sec during the capture of the images.

The performance of the proposed system is measuredbased on the accuracy as shown in Table 1.

Table 1: Accuracy of the proposed work

	SUBJECTS	No. Of Left Clicks	No. of Right Clicks	Accuracy	
				Left Click	Right Click
1	Subject 1	42	40	84	80
2	Subject 2	39	42	78	84
3	Subject 3	38	39	76	78
4	Subject 4	42	40	84	80
5	Subject 5	37	43	74	86
6	Subject 6	39	40	78	80
7	Subject 7	41	35	82	70
8	Subject 8	42	40	84	80
9	Subject 9	40	37	80	74
10	Subject 10	38	36	76	70
11	Subject 11	41	40	82	80
12	Subject 12	38	43	76	86
13	Subject 13	41	43	76	86
14	Subject 14	40	42	80	84
15	Subject 15	38	45	76	90
16	Subject 16	43	44	86	88
17	Subject 17	40	44	80	88
18	Subject 18	42	45	84	90
19	Subject 19	41	42	82	84
20	Subject 20	38	43	76	86
Overall Accuracy for Left and Right Clicks				82	85.7

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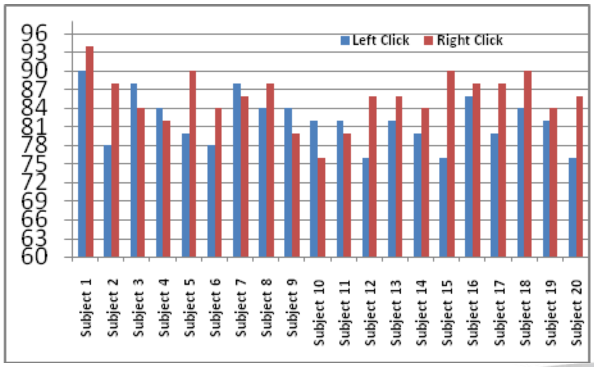

Fig 13. Accuracy values for different subjects

From the above experimental results, It is prove that the proposed system provides an overall accuracy of Left click 82 and Right click 85.7.

VI. CONCLUSION

This proposed system has been developed to enable people to interact with computer using eye gestures considering operations like window open and close, navigate between Tabs, zooming, etc. The algorithm has been implemented to detect the user's face in an office-type environment. On the other hand, the algorithm is developed to move the position of the cursor on the screen relative to camera from the real-time video captured. The left and right mouse click operations are performed by closing the eyes. This application has been tested with 20 subjects interacting with computer applications. This system performs better in a good lighting office-type environment.

VII. FUTURE ENHANCEMENT

As future work, this system will be developed with multiple gesture operations like lip and tongue movements. The proposed work can be extended for various other applications including mobile apps.

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BIOGRAPHY

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