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Eyeball Movement-Based Cursor Using Deep Learning

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Abstract: **The paper proposes a hand free human-machine interaction (HMI) system to give a better way for communication between humans and computers. It is mostly seen that long hours in front of the pc and using the mouse puts the user's hand for too long in a bad posture that increases inflammation in the wrist and hand, leading to some major issues. Additionally, the main focus is on the usage of the modern technology by the handicapped people who tend to get a lot of boost, since it is a hindrance to them to use the mouse. The following paper develops a modern way for differently abled people to use the mouse with just their eyes. The proposed system carries the human eyes to perform the movement of the mouse cursor. This paper also carries out the design of a machine learning and deep learning approach with some inbuilt dataset to classify the individual eyes of both human eyes with quite a high accuracy that ensures the control over the movement. The use of filters which is provided by the libraries which are used to remove the noise to obtain smooth and accurate operation the details along with the performance evaluation shows that the proposed HMI system has extensive control over its performance for differently abled people.**

Index Terms **- Webcam, Eye cursor, Deep learning, Machine learning .**

I. INTRODUCTION

Our existing laptop and computer user interface cannot be used by all people, in other words the differently abled , they often face difficulty while using these devices. They always need to seek out help from others which makes them dependent on someone. To connect them with the modern world and so as to make them feel independent, the following project will give a boost in their day to day life. Also this project is useful for all types of people who would use their systems efficiently and with greater speed. This project is not only for the sole purpose of the differently abled but also for those who spend hours using their pc and the mouse , it is observed that excessive use of the mouse can put their wrist in danger of getting some serious inflammation which could lead to some major issues of internal tissue damage .Through this project it can be said that how an electronic device can be used to simplify things without any excessive usage of hands , by simply using the vision one can control the mouse without any hindrance, ,relatively improving speed of the user. The paper will mainly focus on how to reduce hardware in our system by implementing new technology just by using software and a simple webcam, to move and to click. The remainder of this paper is organized as follows: Literature Survey in Section II, Face and Eye Detection in Section III that is in Methodology also with the systems Block Diagram, Section IV contains the Implementation and Result of the systems with Real time Output snaps ,including Blink Detection and Cursor Movement ,in Section V Discussion about the project is done with observation and how the system is better and what are the future scope . Section VI shows the Conclusion of the project and Section VII is the Reference with citation.

II. LITERATURE SURVEY

The system proposed by G. Norris and E. Wilson[1] focuses on eye movement with Electroencephalogram(EEG) which is set up consisting of an instrumentation amplifier and an inverting op amp and the system is set up by wearing it on your head and attaching the EEG specifically to the required points on the head . The EYE Mouse detects the change in EOG from looking up,right ,down, left since there is a variation of potential and this is captured accordingly w.r.t the eye movement and it is recorded.This in turn is able to click .

The system proposed by Bullying, J. A. Ward [2], contains the eye mouse,and how the EEG system is used with the cursor movement by the simulation of the brain signal and then mapped accordingly to the cursor.

The work proposed by V. Khare, Et.al [3], focuses on tracking the eye movement by capturing the real time video using a microprocessor .The experiment include the use of a webcam which tracks the live video which in turn is broken into frames and a certain threshold is predefined for some certain movement of eyes ,with the help of comparison of the predefined threshold, the cursor will move accordingly with the movement of the eyes.

In a paper by Mohamed Nasor Et.al [4] focuses on how the Iris detection system is functioned using MATLAB. With the help of a webcam , the face is detected first and then iris is detected and extracted using the library of MATLAB which leads in tracking of the eyes and then iris shift is calculated ,the shift is then mapped with the help of Graphical user interface and the eye is detected and it is mapped with the cursor and the mouse cursor moves accordingly .

S. Mathew et.al[5] in their proposed paper provides an idea to control home appliances for disabled people . The method here uses an eye tracking method for eye movement for individuals, further following a simple circuitry. In this system , HOG is used to find

the Histogram of the image and with the addition of SVM, detection of face takes place and the iris portion is cropped and then there are some points in eye which are targeted and the movements of those points maps the cursor movements ,this is a non training based algorithm and it uses Image processing for all the functions .
In a paper proposed by S. R. Fahim, et al[6], it focus on the uses HOG system and motion vector with python programming and Haar Cascade Algorithm which is a training based algorithm, and it is used mainly with programming in machine learning , eye dataset is given in this, by having multiple dataset of eyes, then the eye data is collected and the following system works accordingly to the eye movement and clicking is done with the help of the eye blinking.

III. METHODOLOGY

In our proposed work the cursor is controlled by eye movement using only the webcam. By using a webcam or external camera we designed a system where people can move the cursor and perform left and right clicks using eye winks.

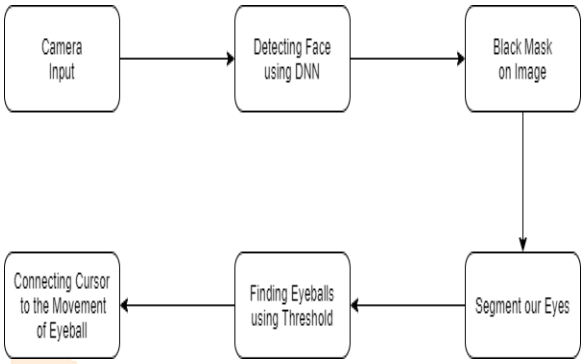
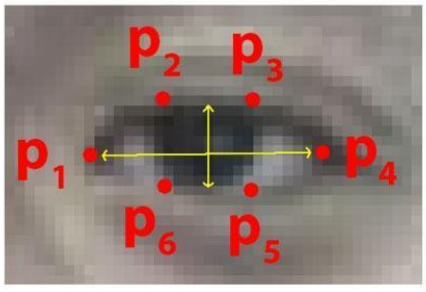


Fig 1: block diagram of the proposed system

The features such as face and eyes detected should be accurate and real time.. We are working with the live feed obtained through a webcam. In this system face and eye features are detected using Facial Landmark detection. Facial landmark detection estimates the location of coordinates (x, y) that map the facial points on a person's face. After capturing the live images, we use the Facial Landmark Detector to map the facial points. We make a black mask of the same size as our webcam frame. We store the coordinates of the facial marks on the left and right eyes respectively and draw them on the mask. After detecting the eyes, we draw the eyes on the black mask that we created. Now we have a mask where the area across the eye is drawn in white, wherein the mask is black. This white area is expanded and morpholized a little using a morphological operation. We now segment out the eyes. Now we convert all the white pixels to black that are 255 values so that only the eyeball area is the dark part left across the white eyes area. We need to create a binary mask by thresholding. For thresholding, we convert the resultant image to grayscale. So now we find an appropriate value of threshold against which we segment out the eyeballs from the eye. Now the eyeballs are segmented out. We now find the two largest contours from the mask which should be our eyeballs. This leaves out some errors such as not being able to detect eyes accurately, but it can be measured by taking the midpoints between the eye area and dividing the image accordingly. Then we find the value of contours[7] which is maximum in those frames and those should be our eyeballs. For the detection of movement of the eyeball , we calculate the ratio of eye landmark points to get the position of eyeball and then connect the movement of eyeball to cursor using a script that controls the mouse to automate interaction with other applications. Now the cursor will move according to the movement of our eyeballs.
We now move on to the clicking part where the blinking of eyes is used for clicking events. Firstly, we calculate the eye aspect ratio (EAR). The Eye Aspect Ratio is a constant value when one's eye is open, but rapidly falls to 0 when one's eye is closed.



$$\mathrm{EAR} = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_1 - p_4\|}$$

Fig 2: calculation of ear

We then take the average EAR[8]of both eyes respectively and calculate the absolute difference between both the EAR's. Now we compare the difference EAR and value of threshold that we have set for the blink. If the difference is greater than the blinking value of threshold, we move further and compare the EAR of right and left eyes respectively. So if the EAR of the right eye is greater than the EAR of the left eye, it implies that the right eye is open but we cannot be sure of the left eye; or the other way round. To check whether the left eye is open or not, we compare the EAR of the left eye and the value of the threshold for the eyes that we had set previously. So if the value of threshold is greater than the EAR value, it implies that the left eye is closed. Now we link this to the left click of the mouse and therefore, left mouse click is performed. We now use the same procedure for right click using the right eye wink. Now we can move the cursor using our eyes and also perform right click and left click by winking the right eye and left eye respectively. The basic explanation of the above process is given in the following block diagram, the webcam of the pc or laptop will take the input as an image of the eye [9].

IV. RESULTS AND IMPLEMENTATION

First step in the proposed system is to detect faces in a given input image, for this we use deep learning based face detectors. This deep learning based face detector is based on the single shot detector (SSD) framework with a ResNet based network.[10]. The shape predictor algorithm and facial landmark detector [11] This deep learning -method uses a training set of facial landmarks on a labeled image. These images are labeled manually. More specifically it works on the distance between pairs of input which is pixelated.

Providing training to the data, an ensemble of regression graphs are trained to estimate landmarks position from pixel intensities. So, this pre-trained network in the dlib library can detect 68[12] (X,Y) co-ordinates that map facial structure on the face. These annotations are part of a 68 point IBUG 300-W dataset on which dlib shape predictor was trained.[13]

Fig 3: dlib 68 landmark

Accuracy of the system practically should have been 100 percent ,but due to external impact such as intensity of light , an average camera etc were the reason to get the accuracy little low , the accuracy of the system is about 70-85 percent after all the trial and error , in which the maximum average being 85 at broad daylight , whereas at night time the average accuracy decreases to about 75 percent. These are the output which are determined using this experiment , how the cursor moves in that specific direction , as one can see in the fig 4,5,6, the cursor moves down , left and right respectively , the threshold is determined earlier and then the cursor is moved, the result where taken as follows

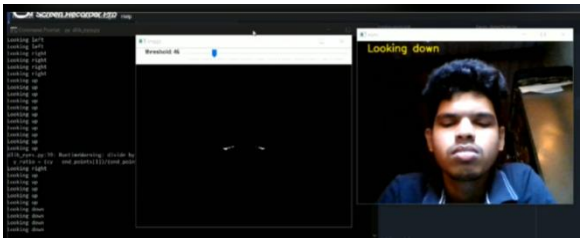


Fig 4: moving down

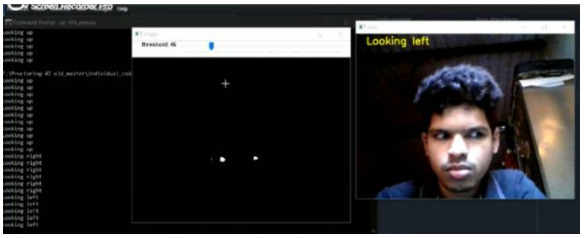


Fig 5: moving left

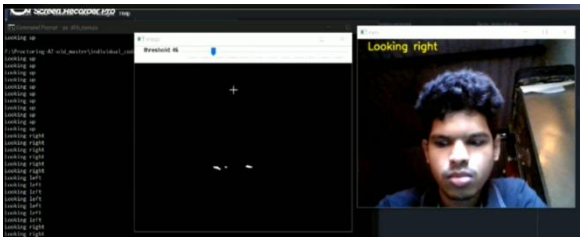


Fig 6: moving right

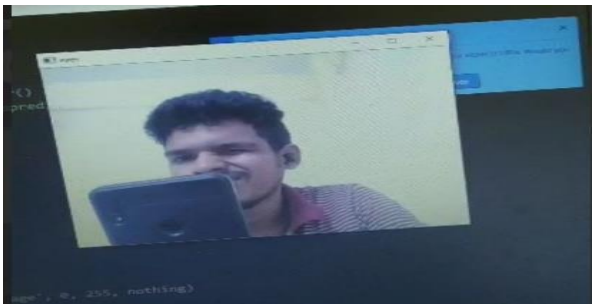


Fig 7: clicking

Next is the clicking event in fig 7 which is recorded using the EAR ratio. when the ratio is very less it is calculated and simultaneously executed with somewhat good accuracy. The output of the code can be seen roughly with the help of these following graphs,fig.8. shows the Accuracy of the system in different lighting conditions, whereas fig.9. is the estimated value of the threshold value for different light intensity The following graph shows that when there is natural light and we have a good light quantity then the accuracy of the system is much higher than when there is less light. Also the effect of a good webcam is must for a much better result.For optimum accuracy a good camera should be used and if possible use it in ample amount of light for the best result.

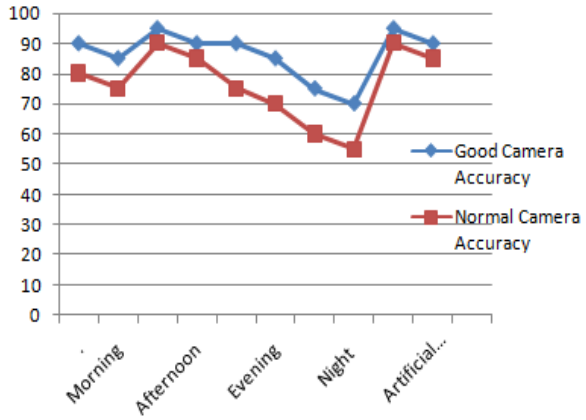


Fig 8: accuracy vs day time

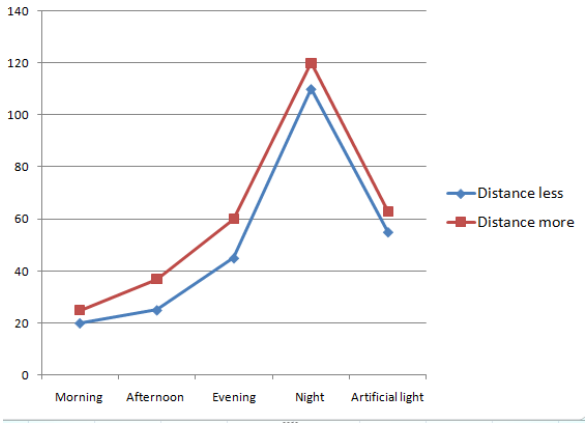


Fig 9: threshold difference vs day time

The following graph shows the adjusted threshold of the system on different lighting conditions ,it does not have such an effect on accuracy or precision in such but it will be easier to get the average threshold quicker if we know where the threshold is acquired on that specific time of the day.In the optimum threshold value one get the most efficient solution of the system.

V. DISCUSSION AND OBSERVATION

The setup reduces the burden of holding the mouse for its operation, decreases wrist pain and ensures reliable communication between the computer and differently abled people. Promising to perform better with a trained user and over the using time.
It can be extended ,which will be used for the implementation of a soft keyboard. By the control action using eye movements, video games can also be played using eye and eye gazing. It can also be used to detect if the user is sleepy or not, so that an alarm can be set for safe driving and improved safety. The system can be made in such a way to help the physically challenged to control appliances such as TV sets, tube lights etc. The system can also be used by individuals suffering from paralysis, to operate and control a wheelchair. The following principle can also be used to detect sleep and drowsiness of drivers in order to prevent vehicle accidents which can be . Eye gazing detection and tracking are also in gaming ,streaming and virtual reality.

VI. CONCLUSION

This project presents a novel HMI system for controlling a pointer on the computer screen based on eyes. The following proposed technique offers physically handicapped people another approach to cooperate with the real world in a better and efficient way. This particular system allows the user to mimic the actions of an ordinary computer mouse with the movements of their eyes and help them to scroll and click on the event ,greatly enhancing productivity for physically challenged people. It opens another age that is controlling mouse cursor developments using human eyes.Various problems were identified for the physically abled and existing business items that fell in a similar situation related to the mouse cursor and it manages to solve those problems. This is a user-friendly framework, specifically for its utilization in computer applications. Today, these data streams in the modules of eye tracking/following are being produced. These setups give more adaptability because they are easily accessible if you just know how to install these few libraries.

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