Facial-Expression Based Mouse Cursor Control for Physically Challenged Individuals: A Human Computer Interaction (HCI) Approach.

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1. Abstract:

The Human-Computer Interaction application i.e., cursor control using facial movements works with just regular webcam. The system targets on using user's facial movements. Its free of hands, avoidance of wearable hardware or sensors. The application deeply centered around facial landmarks prediction for face from eye-blinks and mouth movements detection in a video. Actions like mouth open to activate or deactivate mouse control, Wink of Right-side eye to right click, Wink of Left side eye for function of left click, squinting a person's Eye for activate or deactivate scrolling, Head Movements (Pitch and Yaw) –scrolling or cursor movement. With the help of these landmarks of the face make use of building corresponding features for further allowance to detect certain actions, for detection of winking and blinking of eye using eye-aspect-ratio and yawn and pout of mouth using mouth-aspect-ratio. The actions act as triggers for the mouse control. The model mainly looks into two main factors while analyzing, they are Eye Aspect-Ratio (EAR) that helps for detecting winks and blinks etc. and MAR which is known as Mouth-Aspect-Ratio to get to know the status of mouth either closed or opened.

2. Introduction:

In the modern era, computing systems have taken the most integral role of our daily life. With the evolution of technology, computer systems have been developed to perform various tasks, both simple and specialized. However, for individuals with physical disabilities, many input devices such as keyboards and mice can be difficult or impossible to use. This challenge can be solved through the development of assistive technologies, such as HCI which is known as Human-Computer Interaction applications.

Current research paper concentrates on the development of a robust HCI application for disabled persons using directed cursor control and facial expression tracking technology. With just a regular webcam, users can control the cursor using their facial expressions, without the need for wearable hardware or sensors. This application is compatible with both laptops and desktops and enables operations such as cursor movement in all directions, click events, and scroll events. The system is deeply centered around facial landmarks prediction for the face from eye- blinks and mouth movements detection in a video. This research paper delves into the technologies used in the development of this HCI application, including face detection models, landmark detection models, head pose estimation models, and gaze estimation models. This study major objective focuses on an effective & accessible HCI application for individuals with disabilities, making computer usage an easier and more inclusive experience.

3. Literature survey:

The advancement of technology has led to the development of various human-computer interaction (HCI) systems, including those based on facial and ocular movements for cursor control. In one proposed system, the mouse cursor can be controlled using facial movements, with a suggested algorithm for a multimodal HCI system that efficiently controls all mouse actions, including clicks and scrolling. The system also offers the possibility to add functions to cover practical situations, and the use of HCI techniques can control other computer-generated biases [1]. Another system employs the Raspberry Pi and OpenCV for cursor control using eyeball movement based on the Eye Aspect Ratio (EAR) method, which can be expanded to cover all mouse tasks [2]. A third system also employs Dlib and the Haar Cascade algorithm for cursor control based on eyes and facial movements, which can be improved through additional techniques such as clicking events and interfaces using eye movement and blinking [3]. Another facial expression-based system uses the Viola & Jones algorithm and a standard web camera to record the subject's emotion and send data, enabling physically disabled individuals to use the mouse cursor independently [4,10]. In a system based on eye movement, the mouse cursor is controlled using limbus tracking, pupil tracking, electrooculography, and saccade, which has some limitations related to head movement and squinting [5]. Another system enhances cursor control using eye mouse with Haar- like object detectors, Hough man Circle Detection, OpenCV, and separate techniques for detecting the iris, but it lacks scrolling and red-eye effect detection [6,11]. A system that utilizes the Raspberry Pi and specialized hardware for controlling the movement of eye and co-ordinate with the cursor movement and function employs the center of the pupil for the same purpose. These systems offer various benefits for HCI, including enabling physically disabled individuals to use the computer independently, providing new ways to interact with the computer, and advancing the field of HCI through the application of IoT [7]. This paper describes a real-time approach for detecting eye blinks and winks using video and MATLAB software. The approach involves eyes and facial pair localization, optical flow classification, & analysis. The methodology which is introduced in this study has been verified & tested under various environments & has shown high accuracy in detecting blinks and winks, and performing mouse analogous functions [8]. This research proposes an algorithm that operates the movements of mouse in computer using the movements of iris tracking. It can benefit physically handicapped individuals to communicate and perform computer tasks. Iris movement can move the cursor, while blinking the eyes can perform mouse clicks and scrolling functions [9]. A face detection methodology is introduced using support vector machines & spectral histograms. The method groups face images together and achieves higher efficiency on Datasets which were used commonly and provides robust classification of non-facial & facial outlines under diverse situations [14]. It represents new facial detection system using neural network methodology and logics that carefully inspects even smaller aspects of a Recognized image data and adjudicates amongst numerous networks for achieving higher performance. Data that consists of face examples of positive attribute are aligned for purpose of training, and similarly the negative attributed data/examples are collected using a bootstrap algorithm. [15].

System	Multimodal	Device Control Support	Supported Device Functions
Proposed Multimodal HCI	Yes	Yes	Cursor Movement of Mouse (Left, Right, Up, Down). Mouse Scroll (Up, Down), Mouse Click (Right and Left)
Vision-Based Multimodal HCI	Yes	Yes	Cursor Movement of Mouse (Left, Right, Up, Down). Mouse Click (Right and Left)
EYE-GAZE TRACKING	No	No	No
Eye-Blink Monitoring	No	No	No

Table 3.1: Above Table [1] is the comparison analysis of existing systems to the proposed system with all the device functions that can be supported.

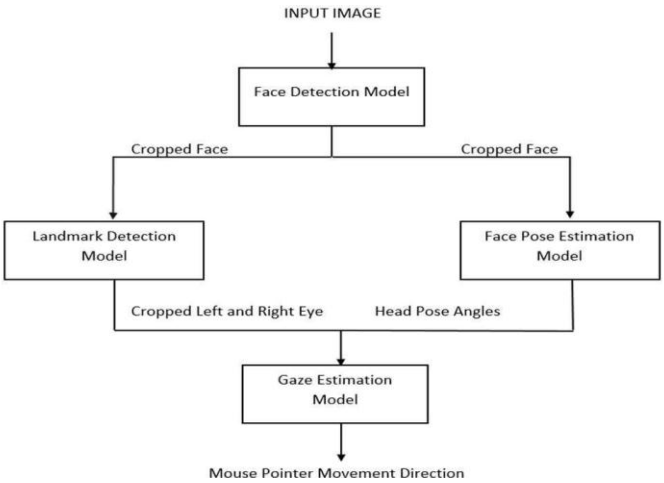
4) PROBLEM IDENTIFICATION AND OBJECTIVES

Computing devices have become a ubiquitous aspect of our everyday existence, used for everything from work to entertainment. Unfortunately, for people with physical disabilities, operating a computer can be a significant challenge. To promote greater accessibility, researchers have developed assistive devices that enable individuals to control a cursor using facial movements. This technology has the potential to greatly benefit handicapped and disabled individuals who may not be able to use traditional input methods. While there are already systems available for hand gestured cursor control [12] and Eye pupil-based cursor control [13], they have limitations and cannot perform basic mouse operations such as minimize, drag, scroll up, scroll down, left-click, and right-click.

The main and target objective of our proposed methodology in this system will offer a mechanism for controlling the computer mouse cursor without the need for manual manipulation, through the use of facial gestures. This approach necessitates neither wearable hardware nor sensors, as the system can be operated using a standard webcam or the built-in camera on a laptop. The actions that the user can perform include activating applications by opening their mouth, activating, and deactivating scroll mode by squinting their eyes, and clicking events using a wink of either eye. In addition, the user can also control the cursor movement in our desired direction just by altering the direction and movements of you face.

5.System Methodology.

Based on the diagram, the process involves using a Face Detection Model to obtain an image of the face through a video stream from a camera or webcam. Subsequently, the Landmark Detection Model is employed to detect various features like the mouth, left and right eyes, and other facial attributes from the acquired face image. The Head Pose Estimation Model is then utilized to determine the head's movements, which correspond to the motion of the computer mouse cursor.



The accurate orientation of the computer mouse cursor relies on the collaborative outcomes of both the Landmark Detection Model and the Head Pose Estimation Model, which are integrated by the Gaze Estimation Model. The Gaze Estimation Model plays a vital role in deciphering facial expressions to ensure precise positioning of the mouse pointer.

5.1 Facial Landmarks Prediction Model:

The system relies on facial recognition to identify and process specific areas on the face, including the mouth, right eye, left eye, nose, and jaw. These predicted marks are used to enable the system to detect and respond to different facial movements, such as mouth opening, squinting of the eyes, and winking.

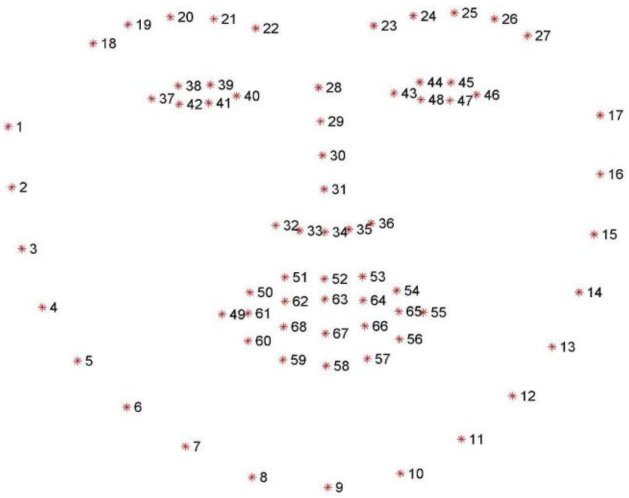


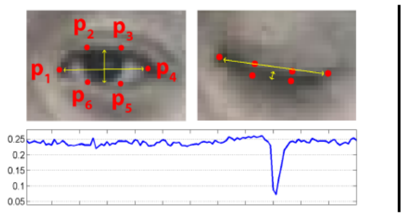
Fig 5.1.1 The pre-existing facial landmark detector contained in the dlib library is employed to approximate the placement of 68 coordinate pairs (x, y) that correspond to various facial features on the visage.

By performing expected facial expressions, specific features can be produced that enable us to detect blinks through Eye-Aspect-Ratio and yawns through Mouth-Aspect-Ratio. These actions are programmed using the PyAutoGUI module to manipulate the mouse cursor.

5.1.1 Eye Aspect Ratio [EAR]:

Eye aspect ratio (EAR) can be utilized to identify eye blinks and winks. When the eye is shut, the EAR value will decrease below a predetermined threshold, whereas an open eye will result in an EAR value above the threshold.

If EAR <=THRESHOLD:



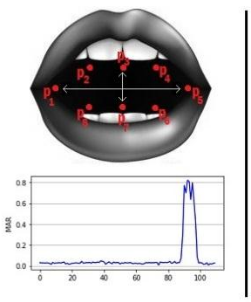
$$\text{EAR} = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_1 - p_4\|},$$

5.1.2 Mouth Aspects Ratio [MAR]:

The system is designed to identify the opening and closing of a person's mouth, with the mouth aspect ratio (MAR) value increasing when the mouth is open and decreasing when it's closed. The proposed system leverages multiple modalities by combining both MAR and eye aspect ratio (EAR) measurements.

if MAR <=THRESHOLD:

STATUS = 'CLOSE'.



$$\text{MAR} = \frac{\|p_2 - p_8\| + \|p_3 - p_7\| + \|p_4 - p_6\|}{2\,\|p_1 - p_5\|}$$

6. IMPLEMENTATION:

During the implementation process, the first step involves defining all the necessary threshold values and initializing counters of frame and frame length, which are used to drive mouse action. The next step is to obtain the facial corners from the HOG face sensor and gain the indicators of facial landmarks for the mouth, both eyes, and nose. Following this, the face in the image frame is converted into grayscale format, and the facial marks coordinates (x, y) are stored in a NumPy array. Subsequently, the Eye Aspect Ratio and Mouth Aspect Ratio are computed. Finally, a bounding box is drawn exactly from the center of the nose, and the necessary functions can be performed within that bounding box.

6.1 Process:

- This project code is a program that uses facial landmarks detection to perform mouse actions such as left and right clicks, scrolling, and moving the cursor. It uses OpenCV, Dlib, and PyAutoGUI libraries.
- The program first defines some helper functions to calculate the eye aspect ratio, mouth aspect ratio, and direction between two points. It then initializes some variables such as the thresholds for triggering mouse actions and the counters for each action.
- Subsequently, the software sets up Dlib's facial detector and predictor and obtains the indices of the facial landmarks corresponding to the left and right eyes, nose, and mouth.
- Within the primary sequence of instructions, the software captures a video frame from the webcam, alters its dimensions, and converts it into a grayscale format.
- Following this, it proceeds to detect any facial features present within the grayscale image and determines their exact spatial position. Specifically, it retrieves the coordinates for the left and right eyes, mouth, and nose landmarks of the detected face region.
- The software computes the aspect ratios for the eyes and mouth and uses them to trigger mouse actions such as left and right clicks and scrolling. It also uses the direction function to move the cursor when the mouth is open. Finally, the program displays the webcam frame and waits for a key press to exit.

7. Results:

The primary objective of this project was to enhance the way machines interact with and respond to human behavior. The article focused on creating a technology that is portable, inexpensive, and compatible with any normal operating system. The proposed system aims to control the mouse pointer by capturing the human face and calculating the positions of the eyes and nose. The movement of the pointer will be in the same direction as the head movement. The mechanism will control basic mouse actions such as moving in all directions, left-clicking, right-clicking, and scrolling. The system activates the cursor by opening the mouth, and the movement of the pointer can be controlled by gazing at the head. The clicking events are performed by making winks with the eyes. For left-clicking, a wink with the left eye is used, and for right-clicking, a wink with the right eye is used. By squinting the eyes, scrolling can be activated, and the same action deactivates it.

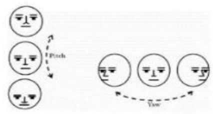
Action	Function
 Opening Mouth	Activate / Deactivate Mouse Control
 Right Eye Wink	Right Click
 Left Eye Wink	Left Click
 Squinting Eyes	Activate / Deactivate Scrolling
 Head Movements (Pitch and Yaw)	Scrolling / Cursor Movement

Fig7.1 A suggested collection of tasks and their respective purposes.

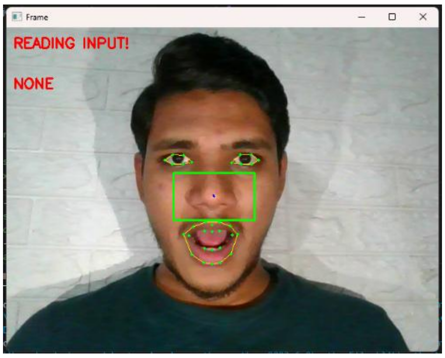


Fig 7.2 Illustrates the action for the initiation of mouse control.

Fig 7.3 Illustrates the action of Up, Down, Left, Right movements of the mouse cursor.

Fig 7.4 Illustrates the action of Squinting of eyes to turn on the scrolling mode on and down, up scroll movements of cursor.

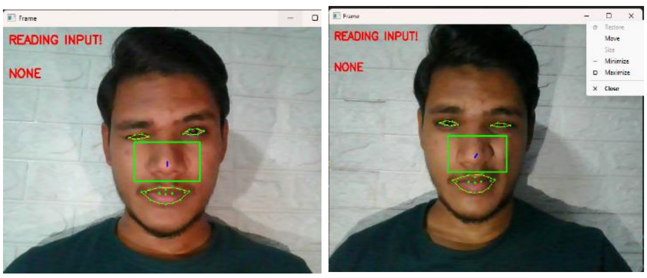


Fig 7.5 Illustrates the action of each eye winking for the corresponding Left and Right click of mouse.

8. CONCLUSION AND FUTURE SCOPE

The objective of our research is to enhance the functionality of our software, with a focus on tracking head movement as the primary event for cursor movement. The goal is to achieve faster response times for pointer movement to fully replace traditional mouse operations. Additionally, we aim to incorporate advanced features such as voice recognition and text extraction for typing, as well as dragging, zooming in, and zooming out. This plan includes designing an interface that can be implemented in real-life applications, specifically to assist physically handicapped users in operating a PC or laptop using their movements and facial expressions, without requiring the assistance of others. This Paper work aims to empower individuals with disabilities to achieve their technology goals and alleviate their dependence on others for computer operation.

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