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Review Paper

# Implementation of Virtual Mouse Using Pupil Detection for Physically Disabled

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**Abstract:** Current technology often uses the computer mouse or finger to move the cursor along the screen. A mouse or finger movement is detected by the system and mapped to the cursor movement. HCI (Human-Computer Interface) involves the use of computer technology to provide a human-computer interface. Communication between humans and computers needs to be made more effective through appropriate technology. Interaction between humans and computers is crucial. It is therefore important to find a method for enabling individuals with disabilities to communicate with computers and be part of the Information Society in an equal way. In this project, a virtual mouse is built that works based upon the movement of the pupil of an eye, where the detection takes place with the help of a webcam. Here, the system detects the face of the user using facial landmark detectors. Then using the Canny Edge detection algorithm, the pupil of the eye is detected. Then the mouse is calibrated to the pupil. Left click and right click are implemented by detecting left blink and right blink of eye using Eye Aspect Ratio algorithm. The system is expected to be easy to use, take fast input, and work as an alternative to a physical mouse.

**Keywords:** Pupil control system, Pupil tracking systems, Mouse cursor, Webcam, Eye movement, Virtual mouse.

## 1. Introduction

Numerous individuals these days have been getting infections that impede them physically, due to which the individual is not capable of utilizing their body from the neck to toes. Their eyes can be helpful to make significant positive changes to their daily activities. A significant group of individuals affected by paralysis are not able to utilize computers to perform daily activities. Right now, people with disabilities interact with the computer console by gripping long sticks inside of their mouths. The procedure that is being implemented will offer assistance to the disabled to be self-dependent in their lives. It'll provide them with an opportunity to involve, interact and work more than before. New ways of performing human computer interaction are evolving recently. Many specialists are bringing remarkable results in this challenging field[12]. Human’s eyes contain data that can be retrieved, extracted and utilized in different kinds of applications. Eye signals appear as an individual’s fascination. It is the following of points on the face to keep track of movements detected from a human’s eye. By capturing the changes in the eye and utilizing them as control variables to empower, and coordinate interaction without needing any input. Mouse, console, and other sorts of input devices have been utilized for taking input from users. People having disabilities cannot use these input devices[13]. This project will physically support them and help to make them contributing individuals to society. The reason for this is to investigate and move forward upon existing roads within the eye signal following framework. Especially those ranges which can offer assistance to physically debilitated people, empowering the disabled people to utilize computers and many of the programmable controlled frameworks. In this way, these people appear to fulfill their commitments, enhance the quality of their lives, and carry out ordinary daily tasks. We have employed the same method, and advanced and moved forward upon them creating a more strong and more precise framework. We utilized the webcam that's connected to the computer.

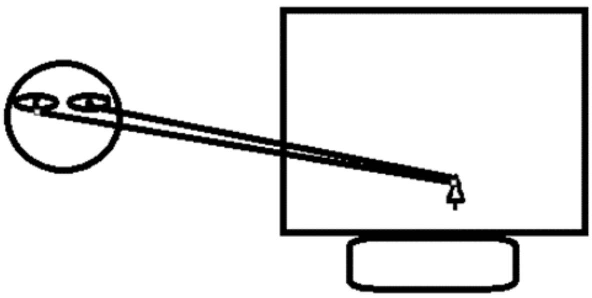

**Figure.1** Idea of pupil cursor movement

## 2. Literature Survey

The following literature has been examined in order to meet the objectives, comprehend the study field, concentrate on responding to the research questions, formulate data collecting techniques, clarify the usage and meaning of the current language, and correctly identify the project framework in the particular situation at hand. The fundamental challenge was comprehending the study field that includes both pupil recognition and mouse cursor movement.

Following a review of the literature, the major goal was to create a system that was simple to use for people with physical disabilities[12]. The "The Sixth Sense" technology from MIT, which makes use of hand and eye motions to improve human-computer interaction, has limits when it comes to helping people with disabilities and interacting with other technologies. Although Drewes and Heiko offered a thorough study, the algorithms needed to be further improved because of laborious calibration methods[2]. Schmidt and Jochen created a quick method of using the structure from motion algorithm for HCI, which Kassner, Moritz Philipp, and William Rhoades Patera improved and expanded for effective pupil monitoring through their PUPIL framework.
In 2018, a Hough transform-based eye-tracking algorithm was created, although it had problems with real-time tracking and needed a powerful computer system[6].
In 2017, the authors introduced an improved system for paralyzed patients using a camera and the pupil to control the mouse cursor, but the system took a long time to identify the pupil using various algorithms and methodologies[3].

In 2016, a wearable eye-gaze tracking system that operates using vision was introduced, which utilizes a high-infrared camera to detect a person's eyes. However, the system's slowness and high cost pose limitations[11].

In 2015, a technique for determining the pupil center coordinates using the circular Hough transform approach was given . This method makes use of a camera to determine the pupil. This method, however, is not real-time and takes a while since it first takes a picture of the torso, then the face, then the eyes, and last the pupil[4].
In 2014, a face and eye-controlled system was developed using MATLAB to control the mouse via a camera with eye and face movements. However, this system's range is limited to a few centimeter radii[14].

A technique was developed in 2013 that utilizes eye-tracking technology to select pictograms. The method incorporates different eye-tracking techniques to ensure the system's reliability. However, the technique is not effective when there is any liquid in the both eyes, such as when women apply beauty products to eyes, which can cause the mechanism to malfunction.

## 3. Proposed Work

1. The eye signal control framework is a simple and direct method that connects to the vision of the human eye and uses it to control a computer system. It operates by tracking the real-time motion of the user's eye gestures, which can be used in controlling the computer mouse pointer. The system requires at least one functioning eye with eye sight to operate effectively in a virtual mouse framework[1]. The eye signal control system can be utilized by adults and teenagers who have Ballerina Syndrome, injuries to spine, mental illness, paralysis, Midbrain infarct, and other similar conditions. Implementation of this technology can be done in daily life activities. Schools, hospitals, nursing homes can also use this virtual mouse. By viewing the system controls displayed on the screen, an individual can use a computer in the way a normal person uses it.
2. The eye blink is defined as a sudden opening and closing of the human eye. Each person has a unique pattern of blinks, which vary in terms of speed, degree of eye closure[8]. Blink duration is also different in different human beings. An eye is blinked within 100- 400 milliseconds. Our proposal is to use advanced facial feature detectors to identify the shapes of the eyes and eyelids. From the eyes, the pupil is detected by using Canny edge detection algorithm[6]. Based on the detected features, we calculate the eye aspect ratio (EAR) as an indicator of the level of eye opening. However, since the EAR value may not accurately detect eye blinks for each frame, we train a classifier that considers a larger temporal window of the frames to more accurately identify eye blinks[10].
3. Advantages of the proposed framework:
4. • Mouse cursor control system with no need for hands.
5. • Helping disabled people to utilize functionalities of computers.
6. • Mouse cursor controlling through eye development.
7. • Mimicking the mouse capabilities, such as cleared-out tap, and right press utilizing their eyes.

## 4. Implementation

A. Detection of face and eyes using facial landmarks detectors

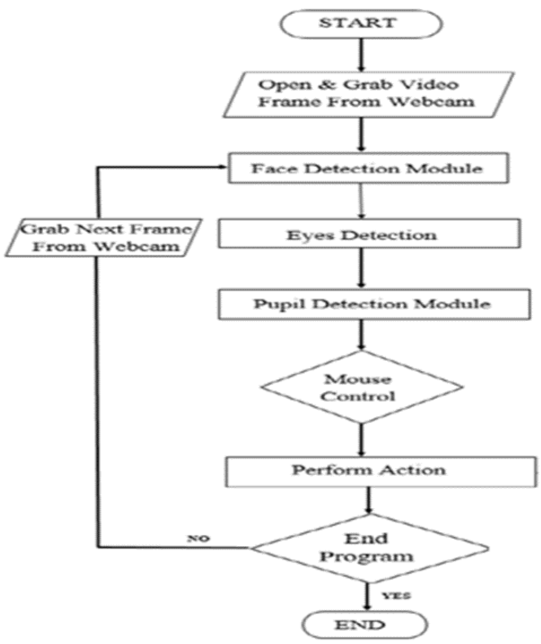


**Figure.2** Methodology

Facial points of interest: Confront (facial) points of interest are basic properties of a human confront that permit us to recognize between distinctive faces. Facial points of interest are utilized to distinguish and speak to key parts of a human face, such as a nose, eyebrow, mouth, or eye corners. A confront image's points of interest are ordinarily the 2D facilitates of their positions within the picture plane. These points of interest are broadly utilized for computer vision applications, like 3D confront morphing, head posture estimation, confront recreation, and extraction of facial districts of intrigued. A common representation of facial points of interest utilizing predefined 68 focuses is displayed in Figure 3.

**Figure 3**. Representation of facial landmarks using predefined 68 points

Examining the picture, we will see that facial locals can be obtained through straightforward ordering of Python:
- The mouth can be gotten to through focus [48, 68].
- The correct eyebrow through focuses [17, 22].
- The cleared-out eyebrow through focuses [22, 27].
- The correct eye utilizing [36, 42].
- The left eye with [42, 48].
- The nose using [27, 35].
- And the jaws by a means of [0, 17].

B. Detection of Pupil

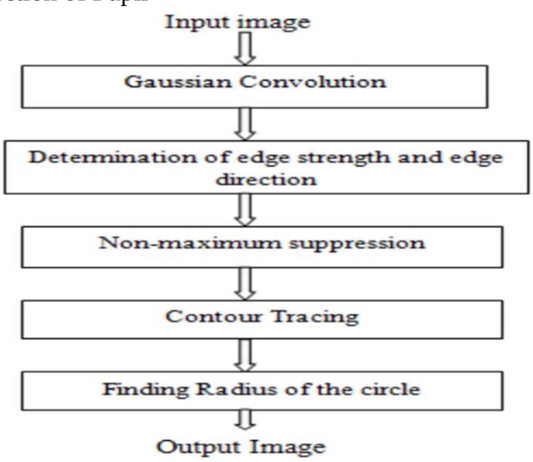


**Figure 3.** Flowchart for Canny edge detection algorithm

Detection of pupil from the given image can be done by detecting all circles in the particular image. So circles can be found by finding the edges in the images. This can be achieved by using Canny Edge Detection algorithm

The first step in the process is to eliminate noise from the image by applying the Gaussian filter. Next, the Sobel Operator is used to determine the edge quality and direction at each pixel. Non-maximum suppression is then performed, which involves setting the concentration of all pixels that are not maximal to zero within a specific local neighborhood. This neighborhood can be a linear window in different directions, such as those shown in Figure 3., which includes examples of windows at 0o, 45o, 90o, and 135o angles.

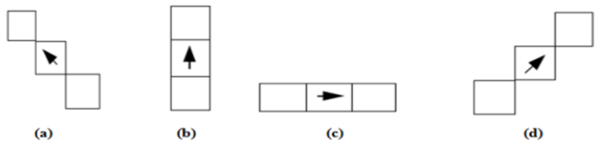


**Figure 4.** Straight window at the point of (a) 135o (b)90o (c) 0o (d) 45o

This process involves detecting the thin edges of objects in an image which can form the boundaries of a circular object within the image. Identification of potential circles can be done by these thin edges detected[6]. To accomplish this, the Freeman Chain Code Calculation is employed, which generates a list of codes ranging from 0 to 7 in a clockwise direction. These codes indicate the direction of the next pixel connected to 3x3 windows. With this information, circles can be detected easily and efficiently from the images. Once the pupil is detected, the mouse is calibrated to the pupil so that the cursor moves in the direction of the pupil

C. Implementation of eye clicks

The aspect ratio of the eyes is calculated to implement eye blinking. The Eye Aspect Ratio (EAR) algorithm is a simple way to detect the blink of an eye[9]. The EAR value is calculated to check whether the eye is blinked or not. Calculation of EAR is performed easily by using landmarks on the eye. Out of 68 landmarks, six landmarks can be located on eye. They are p1, p2, p3, p4, p5, p6 respectively. By using the distances between those landmarks according to the below equation (1), EAR value can be computed.

$$EAR = \frac{(p2-p6) + (p3-p5)}{2(p1-p4)} \qquad (1)$$

p1-p6 are the points located in the eye

p2-p6 and p3-p5 describe the vertical distance between the eyes

p1-p4 describes the horizontal distance between the eyes

This equation(1) involves calculating the distance between certain landmarks on a person's face. The top part of the equation determines the distance between the landmark on the top of the eyelid and the landmark on the bottom of the eyelid, while the bottom part of the equation calculates the distance between two horizontal landmarks[8]. Because there is only one horizontal landmark compared to two vertical landmarks, the bottom part of the equation is appropriately weighted to account for this difference.

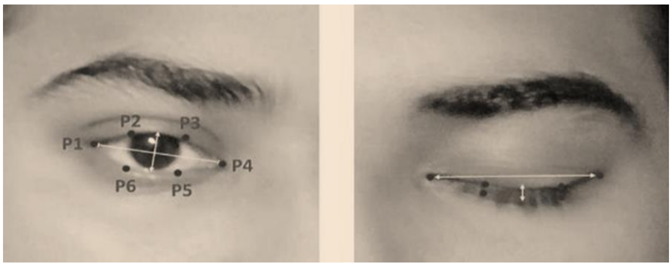


**Figure 5.** Example of open eye and closed eye using facial land mark (Points P1-P6)

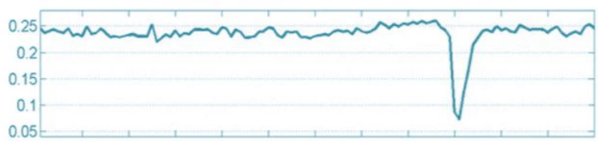


**Figure 6.** Single blink detection process

In the top-left, we have an open eye — the eye angle percentage here would be large(r) and somewhat stable over time. When the individual flickers (top-right), the eye perspective proportion decreases significantly, approaching zero.

For a video clip, the foot figure plots a chart of the eye perspective proportion with time. When we prepare to see, the eye perspective proportion is stable, then rapidly drops to zero, then rises once more, indicating a single flicker has occurred.

The EAR (eye aspect ratio) is a reliable indicator of whether an eye is open or closed. It has been observed that the EAR approaches zero when the eye is closed and is higher when the eye is open. However, the reliability of EAR is affected by a person's head position and posture[7]. The extent to which an open eye is angled varies little among individuals, and it is not affected by changes in image size or orientation. In cases where both eyes are closed at the same time, the EAR of both eyes is averaged to obtain accurate result

**Eye Aspect Ratio Algorithm:**

Input: 6 Eye Coordinate Values of left eye and right eye

Function EAR(p1,p2,p3,p4,p5,p6):

1. Eye_threshold = 0.2
2. $EAR = \frac{\|P2-P6\|+\|P3-P5\|}{2\|P1-P4\|}$ (calculate for both left and right eye)
3. $AVG\ EAR = \frac{1}{2}(EAR_{Left} + EAR_{Right}).$
4. $EAR_{Closed} = \frac{\|P2-P6\|_{min} + \|P3-P5\|_{min}}{2\|P1-P4\|_{max}}$
5. $EAR_{Open} = \frac{\|P2-P6\|_{max} + \|P3-P5\|_{max}}{2\|P1-P4\|_{min}}$
6. $Modified\ EAR_{Threshold} = (EAR_{Open} + EAR_{Closed})/2$
7. if $EAR \leq EAR_{Threshold}$ :

   Eye is closed

   else:

   Eye is open

**Figure 7.** Eye Aspect Ratio Algorithm

## 5. Results and Discussion

The results of the project are as follows:

### A. Facial Landmark detectors and detection of pupil

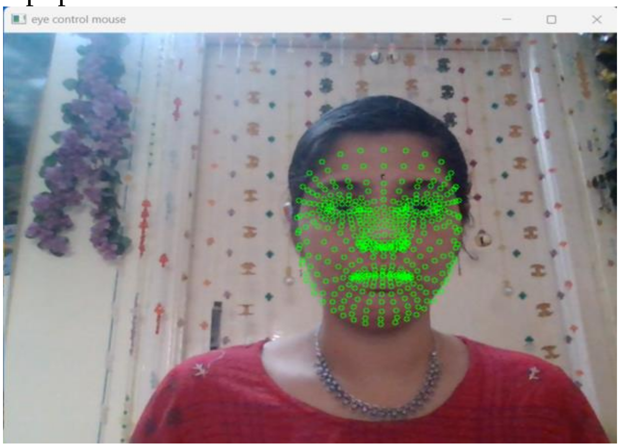


**Figure 8.** Detection of facial landmarks

Figure 8 shows all the landmarks that are detected by the algorithm on the user's face.

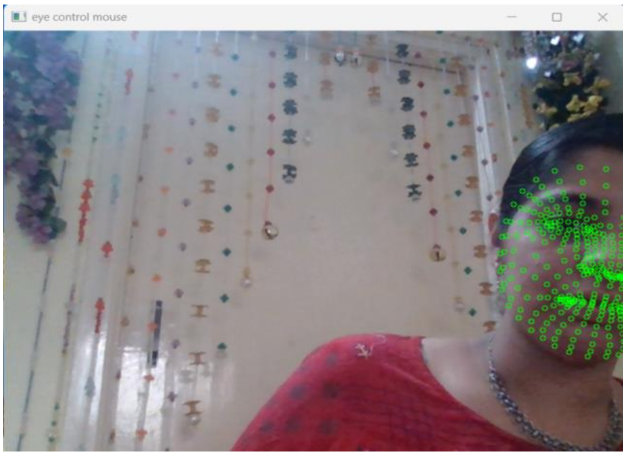


**Figure 9.** Landmarks are detected on the face even though half part of face is visible

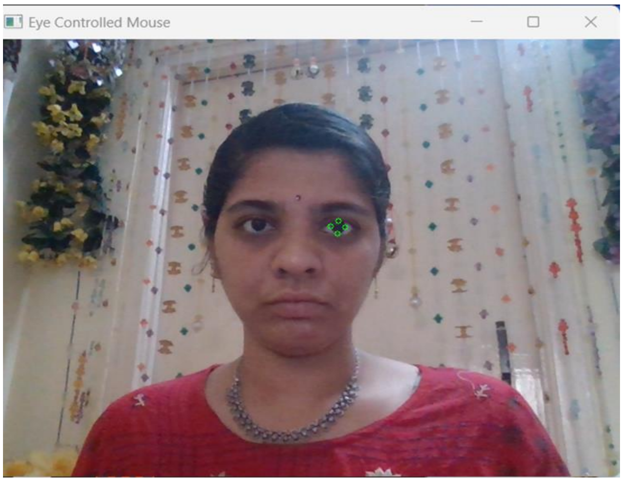


**Figure 10.** Pupil of eye is detected

 

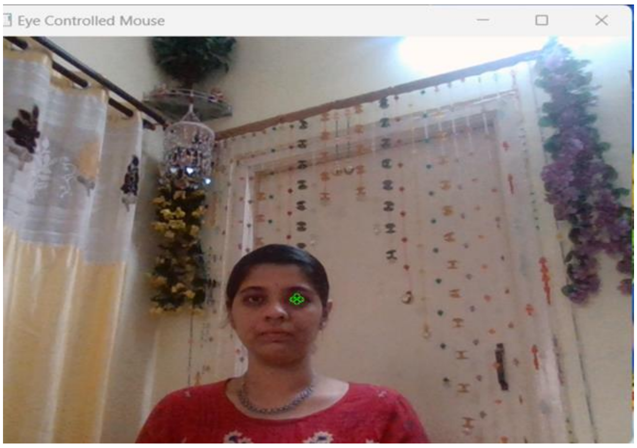


**Figure 11.** Pupil is detected even though user is at long distance from web camera

B. Calibration of mouse to pupil

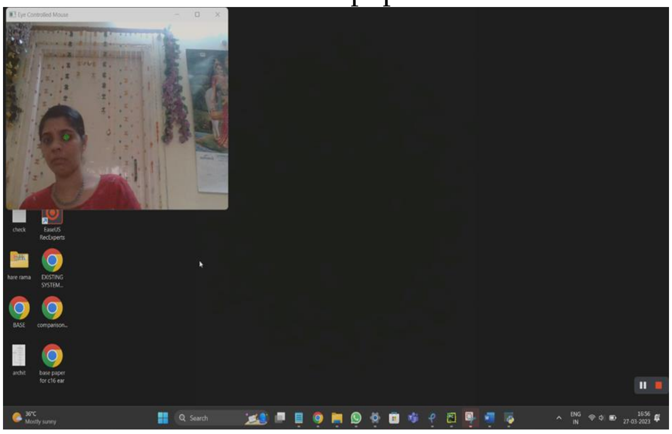

**Figure 12.** When pupil is at the left corner of screen, the pointer is at left side of screen

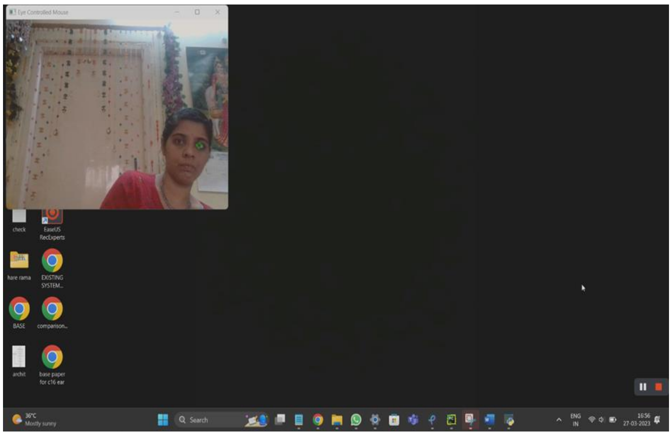

**Figure 13.** When pupil moves right, the mouse pointer also moves right

Figure 12, 13 shows the position of the cursor according to the position of the user. In figure 12, the user is at the left corner of the web camera range, the cursor also moved to the left corner of the screen. In figure 13, the user is at the right corner of the web camera range, the cursor also moved to the right corner.

C. Implementation of left click

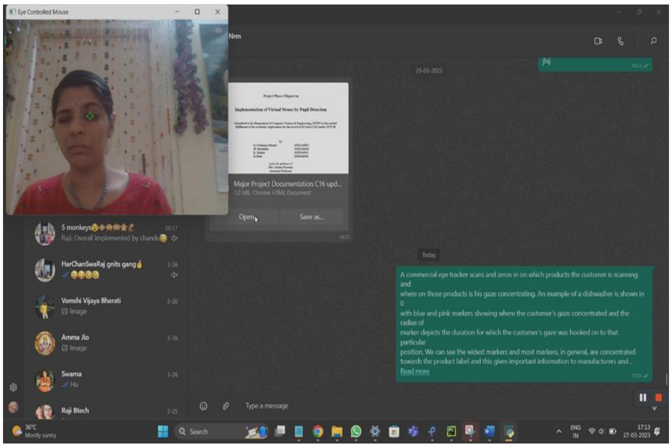

**Figure 14.** Opening a pdf

The pointer is on the open button of the pdf. Then the left eye is blinked.

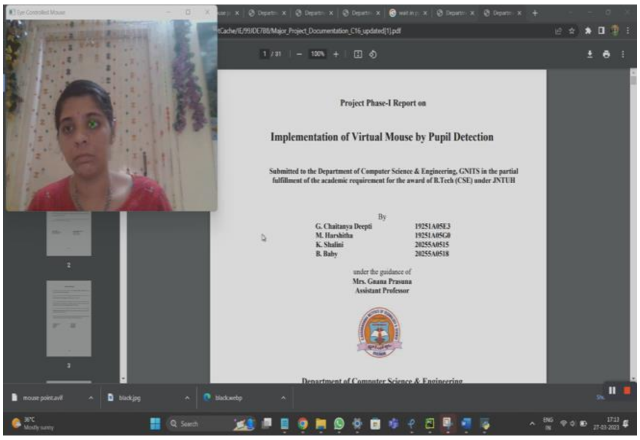


**Figure 15.** PDF is opened

Figures 14, 15 show the implementation of left click. In figure 14, user moved the cursor onto the pdf and blinked their left eye. In figure 15, the pdf is opened in the browser.

D. Implementation of right click

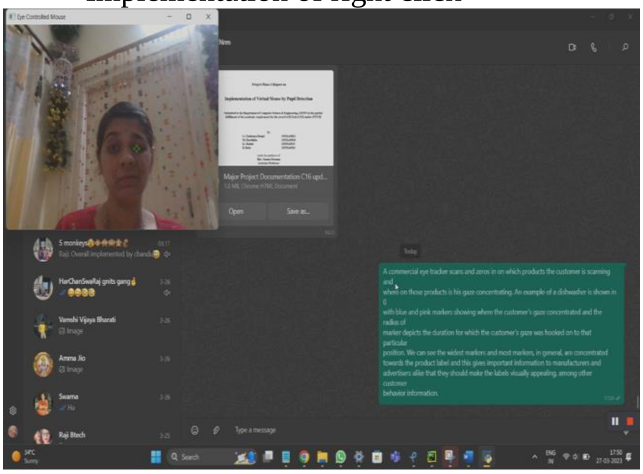

**Figure 16.** Right eye is blinked on message

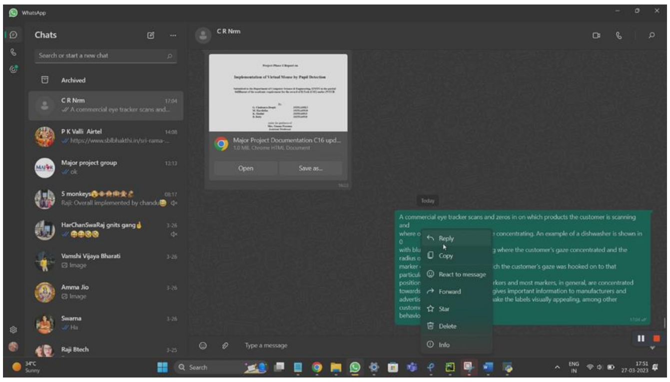

**Figure 17.** The options related to text message are displayed

Here figures 16, 17 shows the implementation of right click. In figure 16, the cursor is placed on the text message and the right eye is blinked. In figure 17, the options are displayed.
For individuals with disabilities, performing basic tasks on a computer can be challenging. In such situations, an eye-tracking system is employed that identifies the pupil of the eye. This system detects a person's pupil and establishes a connection between their mouse and eye movements. As the person's pupil moves, the mouse cursor starts moving accordingly. Moreover, the system interprets eye blinks as mouse clicks. This enables individuals with disabilities to perform computer tasks using only their eyes.

## 6. Conclusion

The main objectives of this project are (i) To detect the pupil with Canny edge detection algorithm. (ii) Calibrating mouse to the pupil detected by Canny edge detection algorithm. (iii) Implementing Eye Aspect Ratio algorithm for blink detection. (iv) Enabling left click and right click.

Therefore, we implemented a powerful algorithm and developed a virtual mouse that can automatically locate the pupil in the live video using the Canny Edge Detection algorithm and act as a mouse according to the movement of the pupil. This technology is not resource-intensive and does not require high-performance hardware to function effectively. It can be implemented in various embedded systems, and it has numerous practical applications in various fields of human activity, including marketing, medicine, gaming, space exploration, military, electronic communication facilities, and the media industry.

The aim of this system is to offer a cost-effective way for users to control the computer mouse pointer using eye-tracking technology. The proposed system is both affordable and efficient as it only requires the use of a computer's webcam. Additionally, the system has the capability to incorporate a spatial visual field history, which allows the user to customize the interface or gain spatial visual field history, which allows the user to customize the interface or gain spatial awareness. The system is versatile and can be used in any environmental conditions with slight adjustments. Eye tracking can be achieved affordably by this system.

The paper introduces an algorithm for detecting eye blinks in real-time. The study shows that face boundary detectors that rely on regression are precise enough to estimate eye opening levels with reliability. The proposed method uses the eye ratio (EAR) temporal window to overcome the EAR threshold. Alternatively, a thresholding approach can be used to classify eye conditions based on a single image when a longer sequence is not available. However, one of the limitations is that a fixed blink duration was assumed for all subjects, while in reality, blinks vary in duration.The authors suggest that using an adaptive approach could improve the results.

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