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EYE – GAZE CONTROLLED MOUSE SYSTEM USING MACHINE LEARNING

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***Abstract* - An individual Human computer interference system is being introduced. In olden times, as an input device the mouse and keyboard were used by human computer interference system. Those people who are suffering from certain disease or illness cannot be able to operate computers. The idea of controlling the computers with the eyes will serve a great use for handicapped and disabled person.**

Also this type of control will eliminate the help required by other person to handle the computer. This measure will be the most useful for the person who is without hands through which they can operate with the help of their eye movements. The movement of the cursor is directly associated with the center of the pupil. Implementing a controllingsystem in it enables them to move without the help of another person is very helpful.

First detect pupil center position of eye. Then the different variation on pupil position different command set for virtual keyboard. The signals pass the driver to interface with virtual keyboard itself. The driver will control both speed and direction to enable virtual keyboard to move forward, left, right and stop.

Key Words: Human computer interference, Keyboard, Mouse, Eye, Cursor, pupil.

1. INTRODUCTION

As the computer technologies are growing rapidly, the importance of human computer interaction becomes highly notable. Some persons who are disabled cannot be able to use the computers. Eye ball movement control mainly used for disabled people. Incorporating this eye controlling system with the computers will make them to work without the help of other individual. Human-Computer Interface (HCI) is focused on use of computer technology to provide interface between the computer and the human.

There is a need for finding the suitable technology that makes the effective communicationbetween human and computer. Human computer interaction plays the important role. Thus there is a need to find a method that spreads an alternate way for making communication between the human and computer to the individuals those who have impairments and give them an equivalent space to be an element of Information Society. In recent years, the human computer interfaces are attracting the attention of various researchers across the globe. Humancomputer interface is an implementation of the vision-based system for eye movement detection for the disabled people.

This results the center position of the human eye (pupil). Then the center position of the pupil is taken as a reference and based on that the human or the user will control the cursor by moving left and right. Some people cannot operate computers because of some diseases. The idea of eye control is very useful not only for the future of natural input but especially for the handicapped and disabled. In addition, the implementation of the control system allows them to control the computers without the help of another person.

This gadget is most useful for a person who can control the cursor by eye movement. In this project, the camera is used to capture the eye movement image. First, it detects the center position of the pupil. Then a different change in the position of the pupil causes a different movement of the cursor. The implementation process for pupil detection is done using the OpenCV library in python, which is an open-source library for computer vision and image processing.

It can be used to process images and videos to identify objects, faces, etc. In this project, we instruct the mouse cursor to change its location based on the movement of the eyeball, connect to the webcam, and then extract each image from the webcam. and pass it to OpenCVto detect the position of the eyeball.

Once the position of the eyeball is detected, we extract the x and y coordinates of the eyeball from OPENCV and then instruct the mouse to change its current position to the givenX and Y coordinates of the eyeball.

2. LITERATURE REVIEW

The system proposed by G. Norris and E. Wilson 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.

Vandana Khare, S.Gopala Krishna2, Sai Kalyan Sanisetty3, "Cursor Control Using Eye Ball Movement"[1], Because of their illness , a few people and groups are unable to use computers. In this case, it makes more sense to provide a computer operating method that is easily accessible, even when taking into account the infirmities of the differently abled. The human eye can be usedas a suitable replacement for computer operating hardware. An Internet protocol camera was utilised to capture an image of an eye frame for cursor movement in this paper. In this regard, we must first concentrate on the role of the EYE. We use a Raspberry Pi for pupil identification sinceit can handle the computer's cursor, and in this task, an Eye Aspect Ratio (EAR) is calculated, which corresponds to the snaps of the eye (left or right) using the Python programming language's Open Source Computer Vision module.

The major purpose of our suggested methodology is to improve the computing experienceof physically challenged people by assisting them in overcoming challenges such as mouse usage Aditya Dave1 and C. Aishwarya Lekshmi ,"Eye-Ball Tracking System for Motor- Free Control of Mouse Pointer"[2], Recent developments in the field of image processing have resulted in a number of high-quality feature detection techniques. While there is a constant need for new algorithms, there is also a need for an equal number of applications of such algorithms in order toachieve their full potential and use by the general public. For building a robust eye ball tacking system for directing the mouse pointer, this work uses a combination of Viola-Jones, Kanade–Lucas–Tomasi (KLT), and Circular Hough transform algorithms. The system's new featureis the ability to represent clicks. A single click is represented by one blink, and a double click is represented by two blinks in a short period of time. Other methods that were tried but failed to track characteristics are also described in the study. Because computer dependence has risen so dramatically in recent years, this technique can help people with motor difficulties browse throughtheir files on the computer more quickly. Different algorithms excel at different things.

So, rather than creating one algorithm extremely complex in order to perform well on all parameters, combining the best features of all three methods greatly simplifies the work and provides a better result than any of the three alone.

The system was tested in a variety of lighting settings and distances from the screen, and itsuccessfully tracked the iris with an accuracy of about 96 percent, which is impressive given thatthis is a real-time implementation.

The authors' ultimate goal is to create a software package out of this system and make it open source, therefore ease of implementation has been a top priority in order to improve user understanding of the algorithm Sivasangari.A, Deepa.D, Anandhi.T, Anitha Ponraj and Roobini.M.S "Eyeball based Cursor Movement Control"[3],

A human computer interference system is being introduced one at a time. Human computer interference systems used the mouse and keyboard as input devices in the past. Those who are afflicted with a specific ailment or ailment are unable to use computers. For handicapped and impaired people, the idea of controlling computers with their eyes will be extremely useful. This form of control will also eliminate the need for other people to assist with the Vol-7 Issue-3 2021 IJARIIE-ISSN(O)-2395-4396 14512
www.ijariie.com 1921 computer. This approach will be particularly effective for people who are unable to function with their hands and must instead rely on their eyes. The movement of the cursor is directly related to the pupil's centre. As a result, the initial step would be to locate the point pupil's centre. The Raspberry Pi and OpenCV are used to build this pupil detection procedure. The SD card is inserted into the SD/MMC card port of the Raspberry Pi. The operating system that is required to start up the Raspberry Pi is installed on theSD card. Once the application programme is loaded into the Raspberry PI, it will run. Pierluigi Cigliano, Vincenzo Lippiello, Fabio Ruggiero "Robotic Ball Catching with an Eye- in-Hand Single-Camera System "[4] This study proposes a unified control framework for realizing a robotic ball catching job utilising only a moving single-camera (eye- in-hand) system capable of recording flying, rolling, and bouncing +balls in the same formalism. To visually track the thrownball, a circle detection approach is used. Following the recognition of the ball, the camera must follow a baseline in the space to capture an initial collection of visual measurements. To obtain an initial estimate of the catching point, a linear technique is applied. Then, using a nonlinear optimization methodology and a more exact ballistic model, new visual measurements are acquired on a regular basis to keep the current estimate up to date. A typical partitioned visual servoing technology is utilised to operate the translational and rotational components of the camera separately. Experiment results on an industrial robotic system indicate the efficacy of the proposedsolution. Using a motion-capture system, ground truth is employed to validate the proposed estimating technique.

In a paper proposed by S. R. Fahim, et al, 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.

3.PROBLEM STATEMENT

Traditional computer systems mainly depend on input devices such as the keyboard and mouse for user interaction. These devices require proper hand movement, finger coordination, and physical control to operate efficiently. However, many individuals who suffer from physical disabilities, paralysis, muscular disorders, or motor impairments are unable to use these conventional devices. As a result, they face major difficulties in accessing computers, communicating digitally, and performing everyday tasks such as browsing the internet, typing documents, or using software applications. This creates a gap between technology and people who need it the most. Therefore, there is a strong need for alternative input methods that allow such users to interact with computers independently and effectively.

Although several assistive technologies have been developed to support disabled users, many of them come with significant limitations. Some systems require costly hardware such as infrared eye trackers, EEG sensors, or specialized wearable devices, which are not affordable for common users. Other solutions involve complicated setup procedures, continuous calibration, or trained assistance for operation. In many cases, these systems are uncomfortable to wear for long durations and may not provide consistent results in real-world environments. Moreover, certain systems suffer from low accuracy, delayed response time, and poor adaptability under changing lighting conditions. Because of these drawbacks, many disabled individuals still lack access to practical and affordable computer control solutions.

Human eye movement is one of the most natural and effective forms of communication. Even individuals with severe physical disabilities often retain control over their eye movements and blinking actions. This creates an opportunity to design systems that use eye gaze as an input method for controlling computers. By tracking the movement of the eyes and detecting blink patterns, a computer can interpret user intentions and convert them into actions such as moving the cursor, selecting options, clicking buttons, or scrolling through pages. Such a system can greatly reduce dependency on others and provide users with a sense of freedom and confidence while interacting with digital devices.

The main problem is to develop a low-cost, accurate, non-invasive, and real-time eye-controlled computer system that can replace the traditional mouse for users with physical limitations. The system should be capable of detecting the user's face, locating the eyes, tracking iris movement, and identifying blinks using a normal webcam without requiring expensive sensors or additional hardware. It should function smoothly under different user positions and lighting conditions while maintaining good speed and precision. In addition, the system must be simple to install, easy to use, and comfortable for long-term usage so that it can be adopted by a wide range of users.

To address these challenges, the proposed Eye-Gaze Controlled Mouse System using Machine Learning uses computer vision and facial landmark detection techniques to control cursor movement through eye gaze and perform click operations through blinking. The system uses software tools such as OpenCV, MediaPipe, and PyAutoGUI to process real-time video input from a webcam and translate eye movements into mouse actions. This solution aims to improve computer accessibility for disabled individuals, enhance human-computer interaction, and provide a practical hands-free interface for future smart systems.

4.SYSTEM ANALYSIS

4.1EXISTING SYSTEM

Mat lab detect the iris and control curser. Eye movement-controlled wheel chair is existing one that controls the wheel chair by monitoring eye movement. In mat lab is difficult topredict the Centroid of eye so we go for OpenCV.

We are instructing mouse cursor to change its location based on eye ball movement, in this application using OPENCV we will connect to webcam and then extract each frame from thewebcam and pass to OPENCV to detect eye balls location. Once eye ball location detected then we can extract x and y coordinates of eye balls from OPENCV and then using python pyautogui API we can instruct mouse to change its current location to given eyeballs X and Y Coordinates.

4.2. PROPOSED SYSTEMS

In our proposed system the cursor movement of computer is controlled by eye movement using Open CV.Camera detects the Eye ball movement which can be processed in OpenCV.By this the cursor can be controlled. The user has to sit in front of the display screen of private computer or pc, a specialised video camera established above the screen to study the user's eyes.

The laptop constantly analysis the video photo of the attention. To "pick out" any key, the user seems at the key for a exact period of time and to "press" any key, the user just blink the eye.

This aims to develop a system for controlling the computer cursor using the movement of the user's eyeballs, providing a hands-free alternative to the traditional mouse. We developed a program using image processing techniques and machine learning algorithms in Python to obtain the eyeball movements and blink and translate them respectively into cursor movements and click actions.

Our system was able to achieve a high level of accuracy in tracking the user's eye movements. Users were easily able to adapt to the new input method.

This system has great potential to improve the accessibility and usability of computers for individuals with motor impairments or disabilities. This hands-free control method has great potential in the area of applications in gaming and virtual reality environment etc.

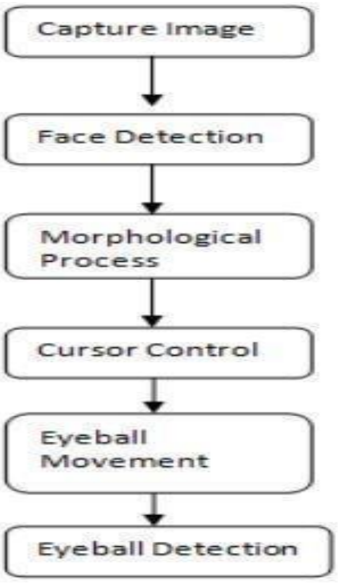

Fig. 1. Flow of Proposed Work

5.ALGORITHM

The Eye-Gaze Controlled Mouse System using Machine Learning follows a step-by-step process to enable hands-free computer interaction through eye movements and blinking actions. The algorithm begins by starting the system and initializing the webcam or camera device to capture real-time video frames of the user's face. Required software libraries such as OpenCV, MediaPipe, and PyAutoGUI are loaded into the system for image processing, facial landmark detection, and mouse control functions. Once the camera is activated, the system continuously captures video frames and converts them into a suitable format for further analysis. Preprocessing techniques such as resizing, noise removal, image enhancement, and color conversion are applied to improve the quality of the captured frames and ensure better detection accuracy.

After preprocessing, the system performs face detection to identify the presence and position of the user's face within the video frame. Once the face is detected successfully, the algorithm focuses on locating the eye region. Using facial landmark detection methods, the system identifies important points around the eyes, eyelids, iris, and pupil. These landmark points help in accurately tracking the movement of the eyes. The algorithm extracts the iris or pupil center coordinates and uses them as reference points to determine the user's gaze direction. If the face or eyes are not detected properly, the system continues capturing frames until successful detection is achieved. This ensures smooth and uninterrupted operation of the eye-controlled system.

The next stage of the algorithm is eye movement tracking. The detected iris position is continuously monitored in each video frame. When the iris moves left, the algorithm interprets it as a command to move the cursor left on the screen. Similarly, when the iris moves right, the cursor moves right. If the eye moves upward, the cursor moves upward, and if the eye moves downward, the cursor moves downward. The extracted eye coordinates are mapped to the screen resolution so that the cursor position corresponds accurately to the user's gaze direction. To avoid sudden jumps or unstable cursor motion caused by minor eye vibrations, smoothing techniques are applied to provide stable and natural cursor movement.

Another important part of the algorithm is blink detection, which is used to perform click actions. The system calculates the distance between the upper and lower eyelids or uses the Eye Aspect Ratio (EAR) to determine whether the eye is open or closed. If the eyelid distance falls below a predefined threshold value, the system recognizes it as a blink. Once a blink is detected, the algorithm sends a command to perform a mouse click operation. Single blinks can be used for left-click actions, while multiple blinks or longer blinks may be extended for additional commands such as right-click or scrolling in future improvements. This method allows users to interact with buttons, menus, and files without touching any physical device.

The algorithm repeats all these steps continuously in real time to provide uninterrupted control of the computer system. Video frames are captured, eyes are detected, gaze direction is analyzed, cursor movement is updated, and blinks are checked in every cycle. The system remains active until the user provides an exit command, such as pressing a specific key or closing the application. Once the program is terminated, the algorithm releases the webcam resources and closes all active windows properly. Overall, this algorithm offers an efficient, low-cost, and accessible solution for controlling computers using only eye movements and blinking actions, making it highly beneficial for physically disabled individuals and modern hands-free computing applications.

6.RESULT ANALYSIS

The Eye-Gaze Controlled Mouse System using Machine Learning was tested under different environmental conditions to evaluate its performance, accuracy, and usability. The system successfully captured real-time video input through a webcam and accurately detected the user's face and eye regions using computer vision techniques. Facial landmark detection effectively identified iris and eyelid positions, which were used for cursor movement and blink detection. During testing, the system showed smooth and responsive cursor movement according to the direction of the user's eye gaze. Users were able to move the cursor left, right, upward, and downward with minimal delay, demonstrating the efficiency of the proposed model.

The Eye-Gaze Controlled Mouse System using Machine Learning was tested to evaluate its performance in terms of accuracy, response time, blink detection, and cursor control efficiency. The system uses a webcam to capture real-time facial images and processes them using OpenCV and MediaPipe. Experimental testing showed that the proposed model successfully detected the face and eye region of users under normal environmental conditions. After detecting the iris position, the system converted eye movement into cursor movement with smooth and responsive performance. The cursor moved left, right, upward, and downward according to the user's gaze direction, which proves the effectiveness of the proposed system for real-time human-computer interaction.

The cursor movement performance was analyzed using coordinate mapping formulas. The detected iris coordinates from the webcam frame were mapped to screen resolution coordinates so that the mouse cursor could move accurately on the monitor screen. The mapping formulas used are:

MouseX=ScreenWidth\FrameWidth×EyeX

$$MouseY=ScreenHeight\backslash FrameHeight\times EyeY$$

Where EyeX and EyeY represent the iris position coordinates, while ScreenWidth and ScreenHeight represent the display resolution. By using these formulas, the system achieved stable cursor movement with good positional accuracy. Cursor instability caused by minor eye tremors was reduced using smoothing methods, resulting in a natural user experience.

Blink detection was tested to analyze the system's ability to perform click operations. The Eye Aspect Ratio (EAR) formula was used to detect whether the eye was open or closed. When the EAR value fell below a threshold level, the system recognized it as a blink and performed a mouse click action. The formula used is:

$$EAR=\|p2-p6\|+\|p3-p5\|\backslash 2\|p1-p4\|$$

Where p1,p2,p3,p4,p5,p6p_1, p_2, p_3, p_4, p_5, p_6p1,p2,p3 ,p4,p5,p6 are eye landmark points. If

$$EAR<T$$

then blink is detected, where TTT is the threshold value. Experimental results showed that blink detection performed accurately under normal lighting conditions and successfully executed click operations without repeated unwanted clicks.

The Euclidean distance formula was used internally to calculate distances between eyelid points and iris landmarks for precise movement tracking and blink recognition. The formula is:

$$d = \sqrt{(x_2-x_1)^2 + (y_2-y_1)^2}$$

improved reliability and reduced accidental operations. In repeated trials, blink recognition performed consistently under normal lighting conditions and for different users. However, users with spectacles.

This distance measurement helped the system determine eyelid opening and eye center position. Based on repeated tests, the system showed consistent performance for users sitting directly in front of the webcam at a moderate distance. Detection accuracy slightly decreased under poor lighting or excessive head movement, which is common in vision-based systems.

Overall, the result analysis confirms that the proposed Eye-Gaze Controlled Mouse System is an efficient, low-cost, and user-friendly solution for hands-free computer control. The system demonstrated high cursor movement accuracy, reliable blink detection, and smooth real-time performance. It is especially useful for physically disabled users who cannot use conventional mouse devices. Future improvements such as better low-light optimization, advanced deep learning models, and additional eye gesture commands can further enhance the system's efficiency and practical usability.

Overall, the result analysis shows that the Eye-Gaze Controlled Mouse System is a practical, low-cost, and efficient solution for hands-free computer interaction. The system achieved high usability, good cursor control accuracy, and reliable blink-based clicking functions. It proved especially useful for physically disabled users who cannot operate traditional input devices. The proposed model demonstrates the potential of machine learning and computer vision in accessibility applications. Future enhancements such as advanced calibration, better low-light detection, and multi-command blink gestures can further improve the system's performance and usability.

7. CONCLUSION AND FUTURE WORK

The Eye-Gaze Controlled Mouse System using Machine Learning provides an efficient and innovative solution for hands-free computer interaction. The system successfully converts eye movements into cursor movement and blinking actions into mouse click operations. By using computer vision and machine learning techniques, the proposed model enables users to control a computer without depending on traditional input devices such as a mouse or keyboard. The integration of OpenCV, MediaPipe, and PyAutoGUI allows real-time eye tracking with good accuracy, smooth cursor navigation, and reliable blink detection. Since the system uses a standard webcam instead of expensive hardware, it is cost-effective and accessible for common users.

The performance analysis shows that the system works effectively under normal lighting conditions and responds accurately to the user's gaze direction. Users were able to quickly adapt to the interface after minimal practice, proving that the system is user-friendly and practical. This technology is especially beneficial for physically disabled individuals, paralyzed patients, and users with motor impairments who cannot operate conventional computer input devices. It improves independence, accessibility, and digital communication by providing a non-invasive and touch-free interaction method.

In addition to assistive technology, the proposed system has wide applications in modern fields such as gaming, virtual reality, smart home automation, medical monitoring, and touchless user interfaces. The project demonstrates how machine learning and image processing can significantly improve human-computer interaction and create smarter, more inclusive systems for future users.

As future work, the system can be further enhanced by improving tracking accuracy under low-light and challenging environmental conditions. Advanced calibration methods can be introduced to support different face shapes, eye sizes, and users wearing spectacles. Additional eye gestures such as double blink, wink detection, and gaze hold actions can be implemented for right-click, scrolling, drag-and-drop, and other mouse functions. Integration with voice commands can also provide a hybrid hands-free interaction system.

Furthermore, deep learning models can be applied for better eye detection and faster response time. The system can be extended to mobile devices, smart TVs, wheelchairs, and IoT applications for broader real-world use. With continuous improvements, the Eye-Gaze Controlled Mouse System has strong potential to become an advanced accessibility tool and a next-generation contactless computing interface.

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