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EYE TRACKING BASED HUMAN – COMPUTER INTERACTION

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Abstract: Human-Computer Interaction (HCI) focuses on the interface and interaction between people and computers. The major goal of the HCI is to design an environment that lets people interact with computers in a novel way. One of the most significant methods people use to interact is eye movement and eye blinking, especially for people with physical disabilities. This paper presents an on-screen computer interaction method based on eye blinking and facial movement. The two main components are image processing to detect the eye from the face, facial movement, and eye-blinking. A facial image is captured by the computer's camera and then used to determine the eye location and size. This is done based on the famous "68 points" and the face mesh system of the face detection approach. An eye blink is used in this system to enter a character similar to when a user presses the "Enter" button on a keyboard and facial movement is used to move the cursor similar to the use of a mouse.

***Index Terms* – Facial Recognition, Artificial Intelligence, Human-Computer Interaction, Virtual Keyboard**.

I. INTRODUCTION

With the vast adoption and application of Artificial Intelligence (AI), we are witnessing how technology has become an integral part of our everyday life and how it makes people's lives easier. AI advancements increasingly impact society. "Artificial Intelligence is that activity devoted to making machines intelligent, and intelligence is that quality that enables an entity to function appropriately and with foresight in its environment." Human-Computer Interaction (HCI) is an emerging technology field focused on designing and enhancing the interaction process between humans and computers. HCI is currently being shaped while also shaping AI applications, leading to the rapid emergence of new, exciting technology and research topics. The field contains different techniques to develop systems that can meet users' needs and requirements. HCI is now a days used and implemented in many areas, such as medical technologies, robotics, urban design, gaming, and assistive technologies. AI and HCI have an apparent positive effect on the lives of people with disabilities in many ways, either potential therapeutic or nontherapeutic users of advanced applications. Thus, many technologies become an essential helper for physically disabled people, and this has motivated many researchers to focus on developing systems that meet these users' needs and make their lives more comfortable.

In this paper, we discuss about a human-computer interactive system. We propose an interactive system in which a human being can perform tasks like keyboard typing and cursor movement with the help of eye-blinking and facial movement, which will allow those severely impaired to become more independent and interact with the computer system using an interface adapted to their needs. Our studies' main objective is to help people who are physically disabled to interact with their computer system by using the help of eye-blinking and facial movement.

II. LITERATURE REVIEW

Brain-computer interface (BCI) technology works on signals from the brain. The electrical activity of the brain is determined by an electroencephalogram (EEG). A special cap sensor is placed on the scalp to read the signals, which are then transmitted to the computer. It is a technology that allows direct communication between the brain and an external device, such as a computer or a prosthetic limb, without the need for muscular control. BCI systems typically use electrodes placed on the scalp or implanted into the brain to record brain activity, which is then translated into commands that can be used to control the external device.

BCI technology has the potential to revolutionize the way we interact with machines and the world around us. It has a wide range of applications, from helping people with disabilities to control prosthetic limbs or communicate with others, to enhancing cognitive abilities, to enabling new forms of immersive entertainment and gaming. However, this system has a limitation in implementing and also has various drawbacks. Some BCI systems require invasive procedures, such as surgery to implant electrodes directly into the brain. These procedures can be risky and expensive, and they may not be suitable for all patients. BCI systems are not yet as accurate as traditional input methods, such as a keyboard or a mouse. They may also be affected by factors such as fatigue, stress, or emotional state, which can impact the reliability of the system. BCI technology can be expensive, particularly for systems that require invasive procedures or specialized equipment. This can limit its accessibility to those who need it most.

III. PROPOSED MODEL AND SYSTEM ANAYLSIS

Part of society needs to integrate into the community, communicate with others, and express themselves but they cannot because of varying levels of disability. Some people cannot speak or move at all for many reasons such as chronic illness, a health condition since birth, or an accident in which they have lost the ability to speak or move. Therefore, they cannot communicate with the community. Consequently, there is a need for a system such as an eye blink-controlled keyboard or cursors which move according to the facial movement of the user.

Eye blinks have been used as a means of communication for individuals with severe physical limitations for many years. By using specialized equipment that tracks eye movements, individuals can communicate by selecting letters or words on a screen with their gaze. Facial movement tracking has also been explored as a means of cursor movement for individuals with limited physical abilities. By using facial expressions, such as raising the eyebrows, scrunching the nose, or by movement of nose point, individuals can move a cursor on the screen, allowing them to control the computer in a more intuitive and natural way

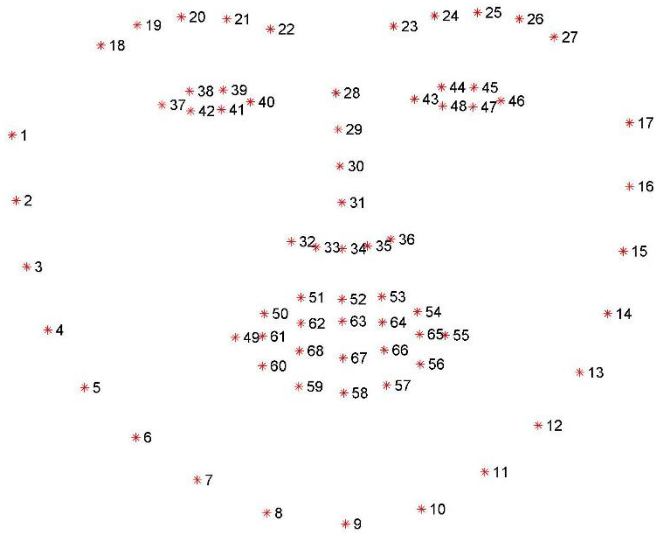

Fig 1: Facial Landmarks

This system works on the basis of real time data which is being collected by the help of a camera module. It detects the presence of a human being while sitting in front of it. This camera module then uses the system's face recognition function to detect the face and from that data, it differentiates the eyes and lips of the user. The system works on the facial movement, eye blinking and smile gesture of the user sitting in front of the system. The user can select the required keyset of letters using eye movement, select the letter highlighted using eye blinking and move the cursor using the facial movement.

Image capturing is a process of capturing the face images using a webcam to detect the face. The latter is a process that identifies human faces in a digital image or video and is used in various applications. The system detects a face and marks points (i.e., facial landmarks) around key parts, identifying the eye, nose, mouth, and eyebrows. An example facial landmark pattern is shown in "Fig. 1" and comprises 68 marks. There is a specific index assigned for each point and for our purposes, we only need to detect the eyes, and specifically the left eye points (p37, p38, p39, p40, p41, p42) and right eye points (p43, p44, p45, p46, p47, p48). The system then detects the point where the eye closes or eye moves and then two lines are drawn vertically and horizontally on the midpoint. When the vertical line is vanishes, that means the eye is closed or blinking, and the eye movement is detected by calculating the white spaces in the eye, i.e., when looking left, the white space in the right side of the eye increases and vice versa. This process is used to select the desired key set, which includes left side key and right-side key. In this study, eye detection is implemented by a training a model using Dlib, which is one of the well-known and open-source facial detection libraries.

We have designed a simple keyboard that is divided into two parts, the left part and the right part. This is designed using the Python code. The division of keyboard is done in order to reduce the complexity while selecting the desired key. For selecting and left or right key set, the user will be provided with an interface where they can select the keyset by looking left or right. On the basis of the user's eye movement, left key set or right key set will be displayed on the computer. The user can select the desired letters from the virtual keyboard by blinking the eye when the letter the need is highlighted. An example of the two key sets of a virtual keyboard is shown in the figure given bellow.

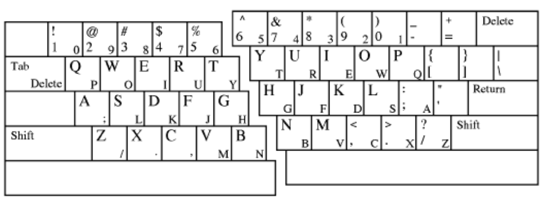

Fig 2. Keyboard Splitting

A cursor is designed specially for this system. The cursor part gets active when the smile ratio of the user exceeds the smiling threshold value, i.e., at a normal use, the virtual keyboard setup is active as default. To get access to the cursor .is reached to the threshold value, the cursor gets active and the user can move the cursor by moving the face to the desired location.

IV. METHODOLOGY

The first step for the system is capturing the image of a face through a webcam using software to detect the face. Then the system detects the eye using the Facial Landmarks method with the help of Dlib function. An example of Facial Recognition is shown in the Fig 1. The next step is to detect eye from the collected frame of face. For this, the "68 Points" facial landmark methodology is used here. The "68 Points" landmarks are shown in the Fig 3

Fig 3. "68 points" representation

The next step is to select the keyboard set, i.e., either left key set or right key set (fig 4). For this purpose, the eye movement is calculated to check whether the user is looking right or left. This process is done by calculating the amount of white spaces in the eye. When the person is looking to the right side, the white spaces will be more in the left part of the eye and thus the right key set will be displayed on the monitor. If the person is looking at the left side, then the amount of white spaces in the eye will be larger at the right side of the eye and thus left key set will be displayed on the monitor. The keyboard set consists of all the letters and numbers along with necessary characters and space buttons. The keyboard is developed using Python Programming Language.

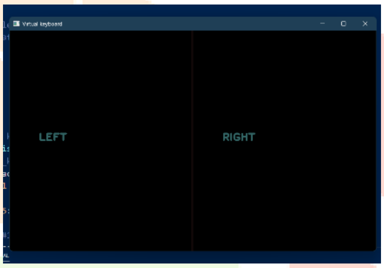

Fig 4. Interface for selecting keyset

After selecting the key set, that particular keyboard will be displayed in the screen. The keyboard is designed in such a way that, the letters in the key gets highlighted from the beginning, key by key. When the desired key is highlighted, the user needs to blink the eye, in order to select the key. Every key will be highlighted for a specific time so that the user can blink their eye for selection. The system identifies eye blinking by calculating the ratio to differentiate between normal eye blinking and the targeted/entering blinking behaviour by setting the threshold value. This is done by comparing the horizontal and vertical ratio of the eye points and time period of the blinking. When the desired threshold value for blinking is reached, that particular letter will be entered.

As by default, in the proposed system, a user can get access to the virtual keyboard when normally using the system. In order to get access to the cursor movement, the system calculates the smile ratio of the user. A threshold smiling ratio is provided during the implementation process, and the user needs to smile a little to get access to the cursor movement module. This means that, whenever the user smiles, the keyboard module will be replaced by the cursor movement module and a virtually movable cursor will pop up on the screen. To move the cursor, the user needs to move the face to the desired location. This is done by setting a point on the nose tip of the user. When the cursor module is accessed, the system focuses on the nose point of the user. As the nose point is moved by moving the head, the cursor will be moved accordingly. The selection process after cursor movement is done by the same eye-blinking method.

V. DESIGN

The overall system is divided into two separate portions. It is divided into two parts to easily switch between the typing module and the cursor movement module. Fig 5 shows the flowchart of the system as a whole.

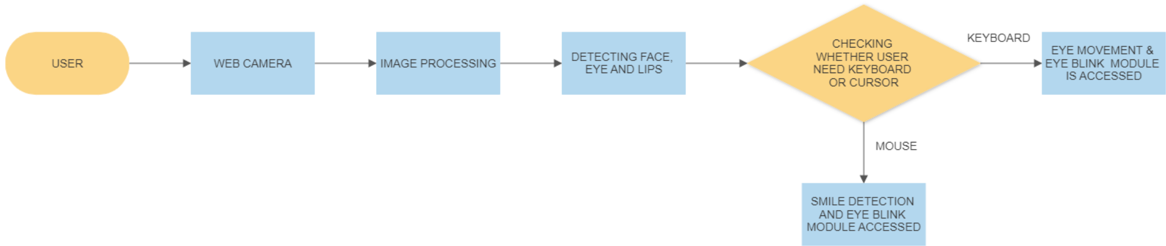

Fig 5. Overall system flowchart

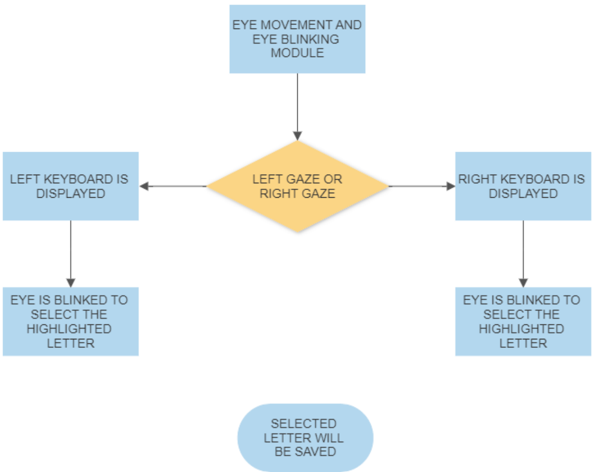

Fig 6. Flowchart of Keyboard Module

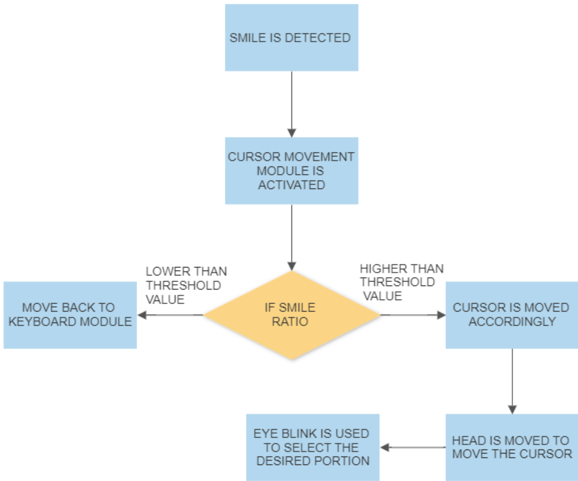

Fig 7. Flowchart of Cursor Module

VI. REQUIREMENTS

The Python, OpenCV, Numpy, Dlib, Math, PyautoGUI and other programming functions and languages are used for face detection, mathematical calculations, keyboard development and various other tasks in the proposed system. The system is implemented in real time and the results are recorded.
The Mediapipe face mesh function is used in this system to make it easier in recognising the eyes and other parts of the face more efficiently and faster.
An external web camera can be used if necessary to record the real time facial data of the user. This data is processed by the system to perform each task of typing and cursor movement accordingly.

Hardware Requirement of the system is given bellow:

- Processor : Intel 3 or above
- Installed memory (RAM) : 4 GB or above
- Hard Disk : 500 GB or ABOVE
- Operating System : Windows 10 - 64 bit or Above
- Display : 800 x 500 OR ABOVE

The system is developed using Python 3.10. It can provide with the easiest and most efficient method to perform tasks such as image processing, face recognition and various mathematical calculation, compared to any other programming language.
It is implemented in the Visual Studio Code platform, which the most efficient platform to implement any type of programming languages.

VII. COMPARISON OF PROPOSED SYSTEM AND EXISTING SYSTEM

The existing system is based on Brain Computer Interaction (BCI). It depends on the pulse variation from the human being's brain activity. To implement that system, a special type of chip or sensing dive is needed to be implanted into the brain of the user. The proposed system doesn't need any type of implanting devices. It works on the basis of eye, eye movement, eye blinking and facial movement of the user.

EXISTING SYSTEM	PROPOSED SYSTEM
Expensive to implement	Cheap
Special implant on user's brain	No need of any type of implants
Not mainly focused on disabled peoples	Focused on creating an environment for disabled peoples
Not user friendly	Flexible and user friendly

Table 1 - Existing system v/s Proposed system

VIII. CONCLUSION

An eye-tracking-based human-computer interaction system is presented in this paper. The computer's camera is used to capture the facial image, so as to detect the eye from the face using the face detection module. To select the desired key set, eye movement is detected to check whether it is right or left. Eye blinking is used to select the desired letter which is highlighted as that of the "Enter" button. The cursor movement is achieved by activating the cursor model with the help of smile ratio recognition. The cursor is moved by moving the face of the user.
This system is primarily designed for people with physical disabilities. As a beginning project, it shows better results during the testing and implementation. In future work, we would like to make a more accurate system where the user can simultaneously use both typing and cursor movement together

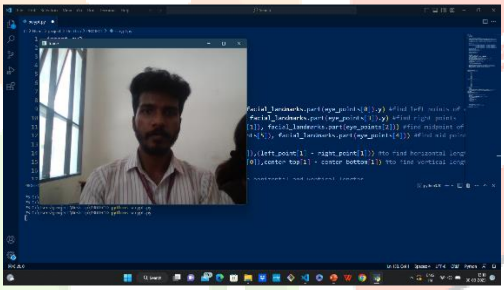

Fig 8. Camera Module

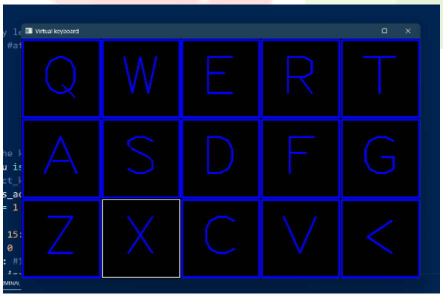

Fig 9. Left Key Set

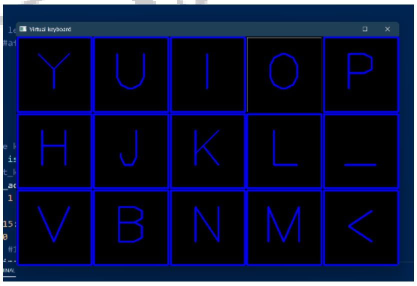

Fig 10. Right Key Set

IX. FUTURE SCOPE

As a beginning project, it shows better results during the testing and implementation. In the future work, we would like to make a more accurate system where, the user can simultaneously use both typing and cursor movement together. With the advancement in technology, the development of Artificial Intelligence is growing at a rapid speed and with that as an advantage, we would like to make this project as a new stage of innovation.

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