Gesture Controlled Virtual Mouse and Keyboard using OpenCV

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Abstract—**A gesture-controlled virtual mouse makes it easier for people to connect with computers by utilizing hand gestures, voice commands, and eye movements. Computers seldom ever require direct contact. Static and dynamic hand gestures, voice assistance, and eye motions can be used to virtually control all input and output processes. In the project, contemporary approaches in machine learning and computer vision are employed to identify hand gestures, voice commands, and eye movements. This involves the utilization of both internal and external cameras. It uses a Convolutional Neural Network (CNN)-like model implemented by Media Pipe running on top of pybind11. It consists of two modules. The first works with your hand directly using Media Pipe's hand detection, while the second employs a glove with a single color. By maneuvering fingers in the air to access keyboard keys, users of the visual keyboard can work in the air. This is made possible by computer vision technology and artificial intelligence. To make the virtual keyboard function, we employ a variety of modules, including the Hand Tracking and CVzone Hand Detector Modules, as well as the Controller imported from the Pynput keyboard. The suggested system will function as a virtual keyboard and mouse without the necessity of a wire or any other external device. The webcam, which is the only piece of hardware in this system, is used to record images, recognize hand gestures, and eye movements, and receive voice instructions using the Pyttsx3 module.**

Keywords—Virtual Mouse, Virtual Keyboard, OpenCV, CNN, Media pipe, PyautoGUI, Tkinter, Pybind.

I. INTRODUCTION

Image processing is a branch of signal processing that specifically deals with the analysis and manipulation of images that involves using images or videos as input. These inputs may be transformed into images or various parameters of an image using image processing techniques. One type of image processing is the recognition and removal of shadows from gestures. Many different methods for gesture recognition have been put forth recently. Motion capture, human-computer interaction, and behavior analysis are just a few of the functions that hand tracking can perform. For hand motion detection and tracking, a variety of detectors and detection gloves are employed. Less costly detectors can be replaced by basic cameras that track movement and detect gestures.

1.1 Objective

Presently, video conferencing is incredibly common. Because of this, the majority of computer users utilize webcams, and most laptops come equipped with one as well. The suggested solution, which is webcam-based, may be appropriate to do away with the requirement for a mouse and keyboard. A fascinating & successful method of HCI(Human- Computer- Interaction) is the use of hand gestures when interacting with a computer. This subject has been researched quite well. Devices are becoming smaller and more portable as technology advances daily. Some gadgets are now wireless, while others are no longer in use. The system suggested in this study may eventually cause some devices to become inactive. The recognition of gestures to create a virtual mouse and keyboard is the future of Human-Computer Interaction, as proposed.. The goal is to replace conventional bias with a simple camera that can control keyboard and mouse functionalities. The only tool the Virtual Mouse uses to connect the user and the machine is a camera. It enables the user to operate mouse functionalities while interacting with a machine without any mechanical or physical bias. Typically, we communicate with computers through a mouse, keyboard, or another device that is closely related to them. In this study, the webcam can only capture input from the user's bare hand, and the wireless bias needs to be connected to a power source and network technology..

It is therefore a genuinely interactive way to control the keyboard and mouse pointer. Both the standard mouse and machine remote controls could be replaced by this technology. The main obstacle to the system's effectiveness is the lighting condition. As most computers are operated in poorly lit environments, the system may not be able to fully replace the traditional mouse. People who have severe movement problems in particular may have physical limitations that severely restrict their ability to control their fine motor. they might not be able to participate in class and communicate using a standard keyboard and mouse.

II. EASE OF USE

In this work, we present a unique multimodal interactive keyboard and mouse system that uses the camera of the device to monitor and recognise hands in place of a typical keyboard and mouse. This is accomplished without the need for extra hardware by using a camera to capture inputs using a vision-based color identification technique and a hand gesture recognition technique. With the aid of our system, users will be able to use just one hand to control their computer's keyboard and mouse. This research aims to develop a keyboard and mouse interface that enables individuals with limited mobility to interact with a computer's webcam using only one hand.

III. LITERATURE SURVEY

The major purpose of conducting a literature review is to examine the context of the current project, which enables us to identify weaknesses in the system in place and suggest unresolved issues that need to be addressed. Therefore, the following themes not only present the project's history but also expose the issues and shortcomings that prompted the development of this project.

3.1 Virtual Mouse Control through Hand Gesture Recognition and Coloured Fingertips Thumma Dhyanchand; Satish Maheshwaram; Vantukala VishnuTeja Reddy ;Galla Vamsi Krishna; -2020

The implementation of a virtual mouse is done Based on a picture in a live video, with the fingertip and hand gesture detection. It comprises two techniques for tracking fingers: hand gesture recognition and employing colored caps. Detecting the contour and creating a convex hull around it allows for the monitoring of hand gestures. The procedure involves three fundamental stages: hand gesture tracking, finger identification through color recognition, and cursor execution. The hand's features are retrieved using a constructed hull and contour area ratio.Various mouse control actions such as right click, double left click, single left clicks, and scrolling require different combinations of the colored caps to be used in different procedures..

3.2 Real-Time Virtual Mouse System Utilizing RGB-D Images and Fingertip Detection Soo-Hyung Kim & Guee Sang Lee; Hyung-Jeong Yang ;Ngoc-Huynh Ho Dinh-Son Tran -2020

In this paper, a brand-new Virtual mouse technique that utilizes RGB-D images and fingertip detection in real-time. and RGB-D pictures is suggested. Using detailed skeleton-joint information photos from a Microsoft Kinect Sensor version 2, the hand region of interest and the palm's center are first retrieved, and they are then translated into a binary image. A border-tracing method is then used to extract and describe the hands' outlines. K-cosine algorithm locates fingertip by comparing contour direction with line.. Controlling the mouse cursor can be achieved by mapping the fingertip location to RGB pictures on a virtual screen. The system utilizes a Kinect V2 and a single CPU to track fingertips in real time, achieving a rate of 30 frames per second on a desktop computer. The trial results indicated a high level of precision. The system can operate efficiently in real-world scenarios using only one CPU. Humans may readily connect with computers by hand thanks to this fingertip-based interface.

3.3 Development of a Finger Gesture-Recognizing Virtual Keyboard for AR/VR Devices Hyuk & Tae-Ho Lee-2018

Convex-Hull and keyboard layout optimization are used to create a virtual keyboard that uses a multi-tab approach of 3 4 arrays and is popular in mobile environments. The system allows for virtual keyboard typing by recognizing hand gestures in an environment with a single camera. By strategically placing alphabetic keys in relation to how frequently characters appear, the keyboard layout is made more efficient. Definition speeds up typing by allowing users to recognize their own typing behavior. Simulation data indicates that the proposed virtual keyboard accelerates typing speed by an average of 46.16% compared to the widely used "ABC" keyboard. The proposed type-in action for issuing commands with a virtual keyboard is effective, according to experimental data. The thumb making contact with the index finger while the index finger is pointing at the character to be picked is the new definition it suggests for the term "type-in action." A camera sensor can quickly identify this gesture.

3.4 Real-Time AI Virtual Mouse System for COVID-19 Prevention Using Computer Vision and Deep Learning. P. Ajay , Jaya,S, ,Nagaraj,J. Shankar,and S. Shriram,B. -2021

The proposed system in the paper uses computer vision to capture hand movements and detect hand tips using a webcam or built-in camera. This eliminates the constraints of Bluetooth mice, which rely on batteries for power and are therefore not completely wireless. The main objective of the proposed system is to replace the conventional mouse device with a webcam or built-in camera on the computer, enabling it to perform mouse pointer and scroll tasks. The system's algorithm makes use of the machine learning algorithm. The computer can be virtually controlled by hand movements to perform left-click, right-click, scrolling, and computer cursor activities in lieu of a physical mouse. The algorithm used to find the hands is built on deep learning. By eliminating the need for physical contact and external devices to operate a computer, the proposed strategy can help prevent the transmission of COVID-19.

3.5 Hand Gesture Recognition-Based Virtual Keyboard System for Non-Touch Character Writing Md. Rashedul Islam & Md. Abdur Rahim, Jungpil Shin -2020

The non-touch character writing system that is suggested in this paper enables users to engage with and control Using on-screen virtual keyboards as a safe and healthy alternative to physical keyboards. by detecting a limited set of hand gestures. This work is divided into two sections: Recognition of hand gestures and gestural flick input utilizing a virtual keyboard are both possible. On the monitor is a user-friendly keyboard interface that employs the flick input technique. To extract the features of a gesture, CNN is employed in a deep learning method. Color segmentation is utilized for hand detection and property determination.. HSV (hue, saturation, value) can be used to extract specific color pixels. from the input image and using threshold masking. In order to classify the hand motions more precisely, a support vector machine is used in the last step. The virtual keyboard is viewed by the user to insert characters. and performing non-touch character input using a gestural flick input technique. On the basis of the user's hand gestures being recognised, the character input is carried out. Character input is assessed based on input speed, accuracy, and the typical categorization The accuracy of hand gestures and character recognition is evaluated.. The system is then evaluated against cutting-edge algorithms. The testing results indicate the proposed system's superiority over state-of-the-art algorithms by demonstrating its ability to recognise seven common Gesture functions and input characters are recognized with 97.93% accuracy.

3.6 Eye and Face Gesture-Based Control of Computer Cursor Akshada Dongre;Rodney Pinto; Ameya Patkar; Minal Lopes - 2020

After analyzing the Real-time video input is processed, the system performs face recognition based on the user's input. The system allows the user to operate the pointer on the screen by using a point on their face, and right or left winks to function as right or left clicks respectively. When viewing PDFs and other publications, constricted eyes would make it easier to activate the scroll feature. By using facial gestures, it would make it easier to utilize and move the pointer. The application enables the user to perform various actions such as scrolling, dragging, clicking, and moving the cursor in any direction. The left and right winks are utilized to implement the left-click and right-click functionality, respectively. The user can scroll with squinted eyes and control the pointer on the screen with an anchor point on their face. The distance between the upper and lower lips is a facial feature that can be measured. through mouth opening, enables/disables input. Left and right winks function as left and right clicks.

IV. PROPOSED METHODOLOGY

4.1 Convolutional Neural Network (CNN)

Convolutional neural networks (CNNs) are a subclass of deep learning algorithms that are generally employed for image recognition and classification applications. They are made to recognise patterns in photos automatically and are modelled after the visual processing system of the human brain.

In CNNs, the incoming data is processed by numerous layers of neurons, each of which performs a different function. In most cases, the first layer is a convolutional layer, which produces a set of feature maps by convolving the input image with a number of learnt filters. Aspects of the input image including edges, corners, and textures are represented by these feature maps. While training CNNs, a sizable labelled picture dataset is used, such as the ImageNet dataset, which has millions of annotated images. The network gains the ability to identify patterns in the training data and changes its parameters Training is used to minimize the error between expected and actual outputs.

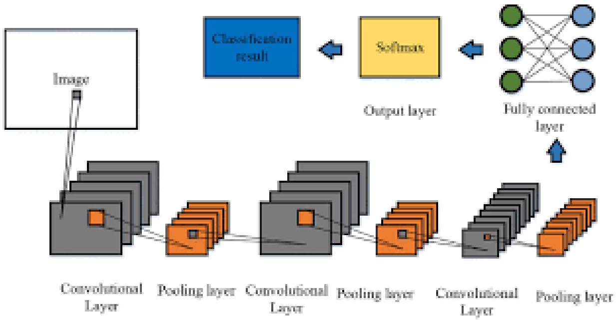

Fig. 4.1 The Convolutional Neural Network

4.2 Media Pipe

For the purpose of creating multi-modal, real-time machine learning pipelines, Google created the open-source Media Pipe framework. It offers an extensive and adaptable collection of building blocks for a range of computer vision and machine learning tasks, including object detection, position estimation, face detection, and tracking.

One of the primary capabilities of Media Pipe is its capacity to handle data from several modalities, such as video, audio, and sensors, and fuse them to produce more precise and trustworthy results. It is also compatible with a variety of hardware platforms, including CPU, GPU, and Edge TPUs, making it appropriate for a variety of applications on everything from mobile to edge devices.

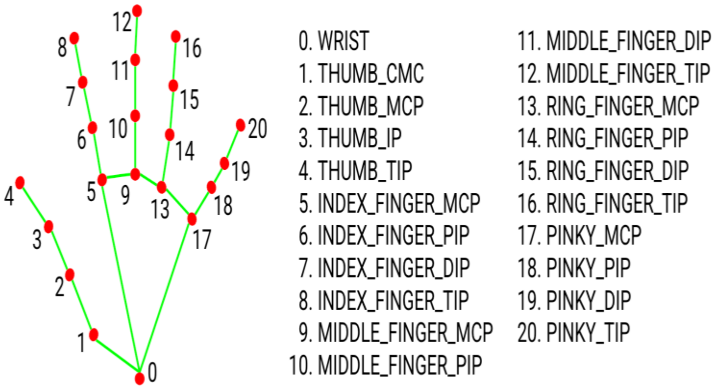

Fig. 4.2 Media pipe Hand Landmarks

4.3 CVzone

The open-source computer vision library CVzone for Python offers a wide range of tools and features for programmers creating computer vision applications. It is simple to integrate with existing code because it is built on top of well-known computer vision libraries like OpenCV, Dlib, and TensorFlow.

Its simplicity is one of CVzone's best qualities. In order to create applications fast and easily without having to write low-level code, it offers a high-level interface for common computer vision tasks. For instance, CVzone gives developers access to an object detection module that enables them to find and follow things in image or video streams with just a few lines of code. Together with a variety of image processing tools, CVzone also offers modules for picture segmentation and feature extraction as well as filters for image enhancement, sharpening, and smoothing. This facilitates the extraction of valuable information from photos after preprocessing.

4.4 Architecture Diagrams

Gesture controlled virtual mouse and keyboard methodology refers to a technique of using hand gestures to control a virtual mouse and keyboard on a computer or other device. This technology allows users to interact with their devices without the need for a physical mouse or keyboard.

The methodology typically involves the use of a camera or other sensor to capture the movements of the user's hands and interpret them as input for the virtual mouse and keyboard. The software then translates these movements into corresponding actions on the computer screen.

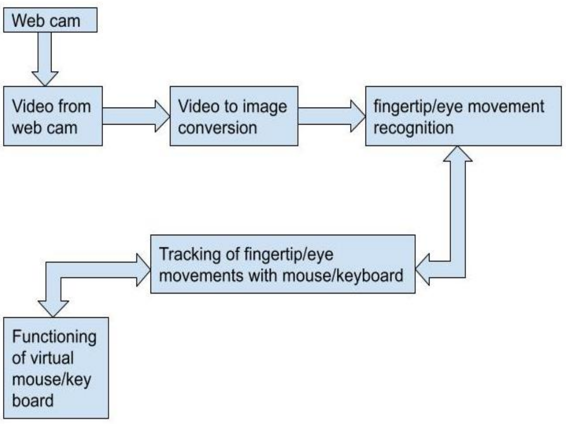

Fig. 4.3 Gesture Controlled mouse and Keyboard

This software program enables users to control their computer without using a physical mouse and keyboard by issuing voice commands. It is known as a voice-controlled virtual mouse and keyboard.With this technology, users can perform tasks such as clicking on buttons, opening files, typing, and scrolling through web pages by speaking commands to the computer. The software uses speech recognition technology to interpret the user's voice commands and then translates them into computer actions.

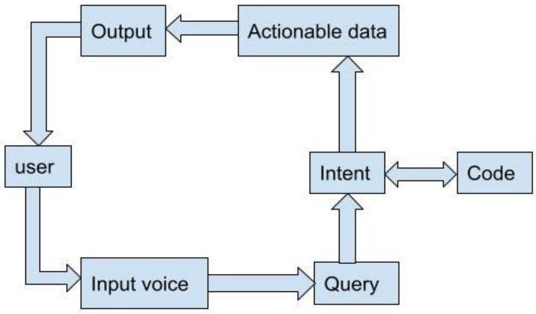

Fig. 4.4Voice Commands

4.5 Pybind

A well-known open-source package called Pybind11 offers a seamless connection between the Python and C++ programming languages. It eliminates the need for manually writing intricate C++ code to expose C++ classes' functionality to Python and enables developers to create C++ programmes that can be invoked from Python. A group of contributors are now responsible for maintaining Pybind11, which was created by Wenzel Jakob, a researcher at the University of California, San Diego.

Pybind11's simplicity of usage is one of its main advantages. Modern C++ features C++ features such as lambda functions, range-based for loops, and automatic type deduction allow programmers to write code that resembles Python. To make it simple to transport data between the two languages, Pybind11 additionally offers automated type conversion between C++ and Python data types. It offers a straightforward interface for generating custom data types and supports a broad variety of data types, including strings, arrays, integers, floating-point numbers, and floating-point numbers.

4.6 PyautoGUI

A cross-platform Python package called PyAutoGUI enables programmers to simulate keyboard inputs, mouse movements, and other input methods in order to automate graphical user interfaces (GUI). It is mostly employed for testing graphical user interfaces and automating repetitive processes.

The ability of PyAutoGUI to remotely control the mouse and keyboard is one of its main advantages. This enables programmers to mimic key strokes and releases as well as mouse movements and button clicks. Developers may automate actions like completing forms, clicking buttons, and even playing games with PyAutoGUI. Further tools for working with photos in PyAutoGUI include screenshotting, image recognition, and pixel color detection. This makes it simple to find and use GUI elements in automated ways.

4.7 Pyttsx3

Pyttsx3 is a Python module that allows developers to add text-to-speech capability to their applications. Working on Windows, macOS, and Linux, it is a cross-platform library. Pyttsx3 is a straightforward and user-friendly library that doesn't need any additional hardware or software to be installed.

Pyttsx3 comes with a number of pre-installed voices that can be modified to suit the requirements of the application and supports both offline and online text-to-speech engines. Also, programmers can add their unique custom voices to the library. The simplicity of usage of Pyttsx3 is one of its main benefits. It offers a straightforward and user-friendly API that enables programmers to quickly and easily integrate text-to-speech capability to their apps.

4.8 Pynput

Python's Pynput package offers programmers a mechanism to manage and keep track of input devices like the mouse and keyboard. It enables programmers to mimic keyboard and mouse movements and to recognize and react to user input. The simplicity of usage of Pynput is one of its main benefits. It offers a straightforward and user-friendly API that enables programmers to manage and control input devices with just a few lines of code. Because of this, it is usable by developers of all experience levels.

4.9 Technologies

4.9.1 Python

Python is a programming language with an interpreted functionality, an object-oriented design, dynamic typing, and dynamic binding, allowing for flexibility in coding and handling data. It also supports dynamic semantics. enable rapid application development, scripting, and gluing components together. Python has a user-friendly and readable syntax that helps reduce the cost of maintaining programs. This makes it an attractive option for developers looking to quickly create applications or connect existing components.

4.9.2 OpenCV

OpenCV is a freely available, comprehensive library that is widely used for computer vision, image processing, and machine learning applications. It has become crucial in today's systems, particularly for real-time operations. OpenCV allows for image and video processing to identify objects, faces, and human handwriting. The integration of OpenCV with other libraries, such as NumPy, enables Python to analyze the OpenCV array structure. This makes it possible to process and analyze large amounts of visual data in a way that was previously not feasible.

4.9.3 Tkinter

Tkinter is a GUI library that is considered the standard for Python. By combining Python with Tkinter, developers can create GUI applications quickly and easily. Tkinter provides a robust object-oriented interface to the Tk GUI toolkit, making it a powerful option for developers.

V. RESULTS

As a result of using advanced techniques in machine learning and computer vision, the suggested gesture-controlled virtual mouse and keyboard system is capable of identifying hand gestures, voice commands, and eye movements. The system functions as a virtual keyboard and mouse without the need for a wire or any other external device, utilizing only a webcam to record images, recognize hand gestures, eye movements, and receive voice instructions using the Pyttsx3 module. It can enhance the user experience by allowing them to control their computers using hand gestures, voice commands, and eye movements. It comprises two modules, one that works directly with the user's hand using Media Pipe's hand detection, while the other employs a glove with a single color.

GUI (GRAPHICAL USER INTERFACE)

GUIs use visual elements to represent hidden commands. To invoke this function, simply select a button or icon. The simple use of the graphical interface makes it possible to use any kind of system every day by everyone, regardless of experience or knowledge. There are many other advantages of using a GUI. And some of the most common are ease of use, ease of communication, quick access features, and multitasking capabilities. GUIs, or graphical user interfaces, are created to enhance Visual and intuitive interfaces can improve user experience, simplifying software application use and task execution. Common examples of GUIs include the desktop interface of a computer operating system, the user interface of a smartphone or tablet, and the interface of various software applications such as video games, photo editors, and web browsers.

Our **GUI** has different buttons supported with features as mentioned below:

- **Voice Bot** – allows controlling system through voice commands.
- **Keyboard** – enables control keyboard using hand gestures.
- **Eye** – allows controlling mouse operations using eye movements.
- **Gesture**- controls mouse operations using hand gestures.

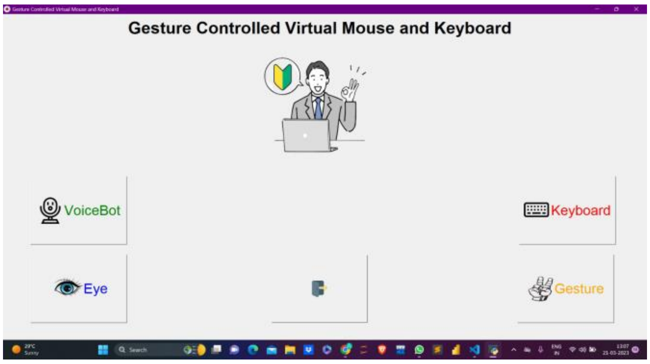

Figure 5.1 GUI

5.1 FEATURE 1 – VOICEBOT

Our Voice Bot named as proton has following commands:

5.1.1 Current Date and Time

To obtain the current date, ask "Proton date?"/ “Proton what is today's date” and for the current time, ask "Proton time?"/ "Proton what is today's time?" This will return the current date and time information.

5.1.2 Google Search

This command will open a new tab or window on Chrome The browser and perform a Google search for the specified text. The command is "Proton search {text_you_wish_to_search}

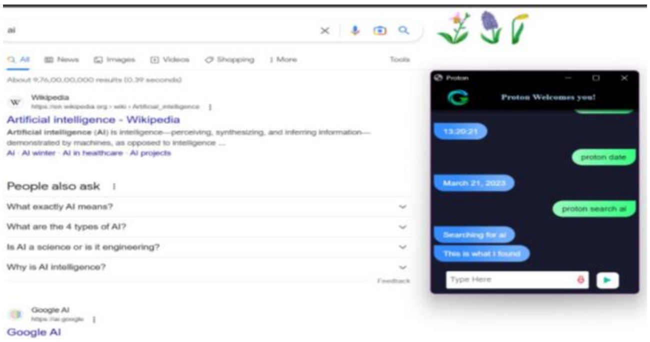

Fig. 5.2 Google Search

5.1.3 Find Location

With the "Proton Find a Location" command, users can enter a location they want to find, and Proton will search for it on Google Maps in a new tab on the Chrome Browser. The results will display information about the location, such as its address and directions to reach it. The command is initiated by saying "Proton Find a Location" followed by the location's name.

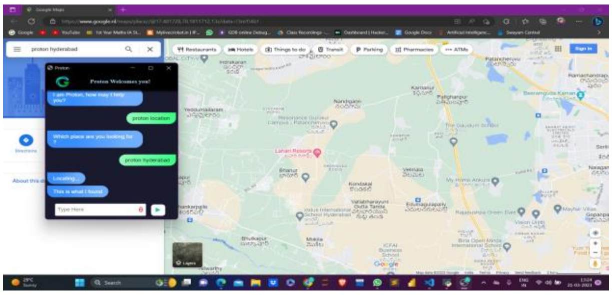

Fig. 5.3 Find Location

5.1.4 File Navigation

"Proton list files" or "Proton list" command will show a structured list of file names and their corresponding numbers in the current directory, which is usually the C: drive.

5.1.5 Copy and Paste

"Proton Copy" is a command that copies the selected text to the clipboard. This enables users to easily transfer text between applications or locations without having to retype it. Once the desired text is copied, users can use the "Proton Paste" command to paste the copied text in the desired location. This functionality makes copying and pasting text a quick and easy process with Proton. The commands are initiated by using the phrases "Proton Copy" and "Proton Paste".

5.1.6 Sleep/Wake-Up

When a user wants to take a break from giving voice commands to Proton, they can use the "Sleep" command (also triggered by saying "Proton bye"). This command will pause the execution of voice commands until the user wakes up the assistant. To wake up Proton, the user can say "Wake up" or "Proton wake up", which will resume the voice command execution. These commands enable the user to take a break from using Proton without having to exit or restart the program.

5.2 FEATURE 2 – KEYBOARD

This virtual keyboard allows for all keyboard functions to be controlled through hand gestures without physical contact. When two fingers, specifically the index and middle fingers, meet on a specific key on the virtual keyboard, a click is generated, and the desired text is displayed in the corresponding textbox. This allows for hands-free text input, offering an alternative input method for individuals with mobility impairments or for situations where traditional keyboard use is not possible. The process is demonstrated in Figure 5.2.

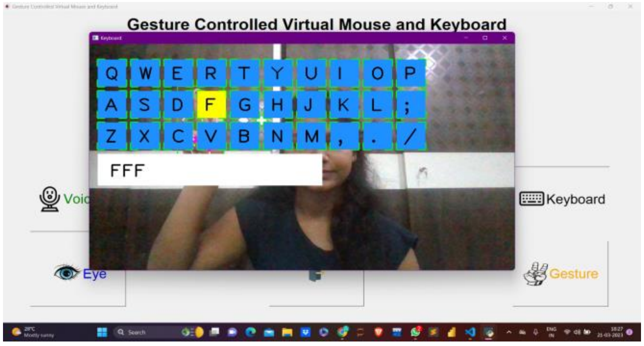

Fig. 5.4 Keyboard

5.3 FEATURE 3- EYE MOVEMENTS

This feature enables all mouse operations to be controlled through eye movements without physical contact. Blinks of the right eye are registered as right-clicks, while blinks of the left eye are registered as left-clicks. In the example shown in the figure, an Amazon product is being searched using eye movements. This technology offers an alternative input method for individuals with physical disabilities or for situations where traditional mouse use is not possible.

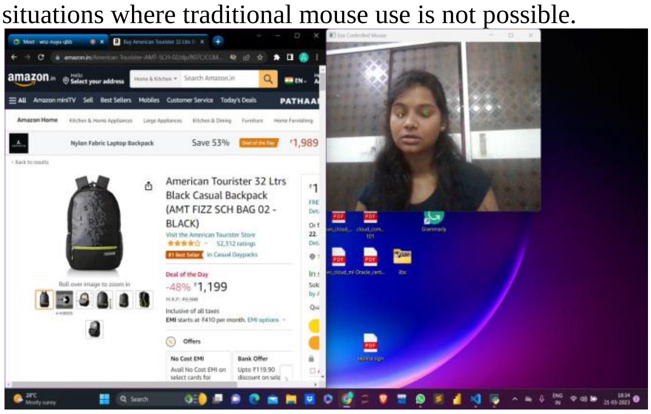

Fig. 5.5 Eye Movements

5.4 FEATURE 4 – GESTURE CONTROLLER

The suggested system for virtual mouse and keyboard control through hand gestures makes use of contemporary techniques in machine learning and computer vision to identify hand gestures, voice commands, and eye movements. The system functions as a virtual keyboard and mouse without the need for a wire or any other external device, utilizing only a webcam to record images, recognize hand gestures, eye movements, and receive voice instructions using the Pyttsx3 module.

5.4.1 Neutral Gesture

A neutral gesture is activated when our palm is open. It is a way to stop or pause a current gesture being performed. It is used to signal the desire to discontinue or interrupt the current action.

5.4.2 Mouse Cursor

The cursor in this system is placed at the midpoint of the index and middle fingertips. Moving the hand moves the cursor accordingly, with the speed of movement determining the speed of cursor movement. The gesture referred to enables users to accurately position the cursor on the screen.

5.4.3 Left Click

A single left click can be performed by making a fist and then releasing the index finger.

5.4.4 Right Click

A quick swipe down with the middle finger is used as a gesture for a single right-click.

5.4.5 Multiple items selection

The gesture for selecting multiple items is achieved by gradually bringing the fingers closer together.

5.4.6 Double Click

Gesture for double click is registered when the index and middle fingers come together.

5.4.7 Drag and Drop

To initiate drag and drop functionality, press and hold the palm together on the desired file, and then move the hand to the desired location while keeping the palm pressed. Finally, release the palm to drop the file.

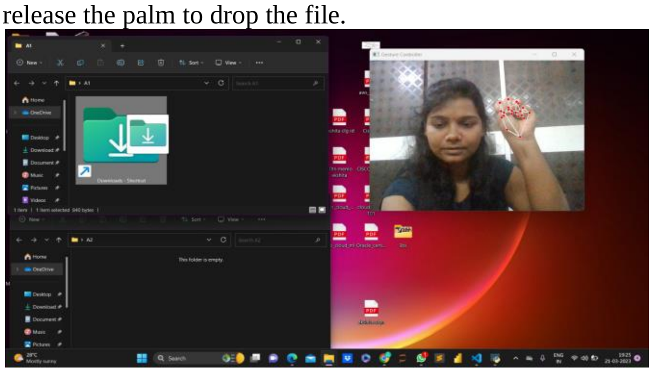

Fig. 5.6 Drag

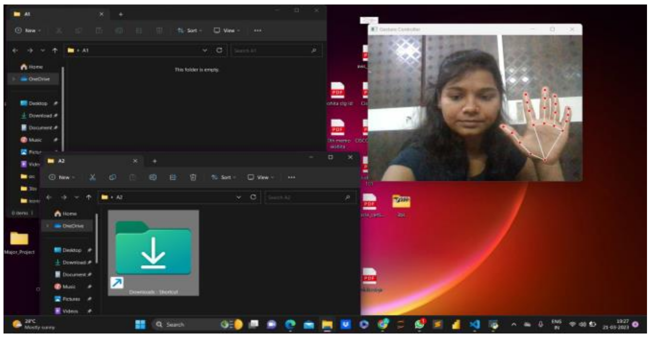

Fig. 5.7 Drop

5.4.8 Volume Control

The pinch gesture is employed to adjust the volume, with the rate of increase or decrease being linked to the vertical distance traveled from the starting point. Volume can be controlled using dynamic gestures, with the speed of volume change determined by the vertical distance traveled by the pinch.

VI. CONCLUSION

In conclusion, the gesture-controlled virtual mouse system offers an innovative way for users to interact with computers without the need for direct contact or external devices. The system allows users to control all input and output processes by utilizing advanced techniques in machine learning and computer vision to recognize hand gestures, voice commands, and eye movements. By employing Media Pipe's hand detection and a glove with a single color, users can access keyboard keys by maneuvering their fingers in the air. The virtual keyboard functions with the help of various modules, including the Hand Tracking and CVzone Hand Detector Modules and the Pynput keyboard's Controller. The system's only hardware requirement is a webcam that captures images, recognizes hand gestures and eye movements, and receives voice instructions through the Pyttsx3 module.

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