International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 05 | May - 2023 Impact Factor: 8.176 ISSN: 2582-3930

Face Controlled Human-Computer Interface (HCI) for Physically Disabled Persons

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Abstract

In order to improve the convenience of human-computer interaction without the need for any physical assistance, we have built an application in this article that is capable of replacing the usual input device (mouse) by employing facial expressions. For patients without hands or those with infirmities that prevent them from using their hands, it can be used as an optional input source. In the suggested application, we used real-time video face recognition machine learning technology to let users interact with various system activities. Moreover, our application is designed to be intuitive and easy to use, making it accessible to users of all ages and backgrounds. The facial expression recognition technology is able to accurately detect a wide range of facial expressions, allowing users to interact with the system in a natural and intuitive way.

Keywords - Human-Computer Interface (HCI), real-time, the disabled, python.

Introduction

In studies of the adoption of computers and the Internet by older adults, positive perceptions of usefulness, ease of use, and efficiency predict use. Computer and

Internet use is also associated with older adults who are relatively young, more

educated, have higher annual incomes, are healthier and more active, are members of community organizations, and do volunteer work. Older adults are also more likely to use tablets when they see others using them, when they can use them, or when family members give them a tablet. These results are consistent with some UTAUT predictors but also highlight the importance of predictors that may be more important for older adults than for younger adults (e.g.health)[1].

In 2021, 96% of 18-29-year-olds own a smartphone, compared to 61% of those aged 65 and over, a gap of 35 percentage points. The gap has shrunk from 53 points in 2012. People over the age of 65 are the least likely to say they use social media sites such as Facebook, Twitter, and Instagram. The social media presence of Americans over the age of 65 has nearly quadrupled since 2010, while usage by the youngest adults remained relatively flat throughout the period.

In 2021, 61% of people aged 30 to 49 own a tablet computer, compared to 53% of those aged 50-64, 46% of 18-29 year-olds, and 44% of those aged 65 and over.

Almost all adults aged 18-29 (99%) and 30-49 (98%) use the Internet, while 96% of 50-64-year-olds use it. However, only 75% of

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those aged 65 and older use it. The gap between the oldest and youngest Internet users has decreased from 56 points in 2000 to 24 points. 64% of people aged 65 and over have home broadband, compared to 86% among 30-49-year-olds and 79% among 50-64-year-olds. The percentage of adults under 30 using home broadband is statistically similar to the percentage of adults 65 and older (70%)[2].

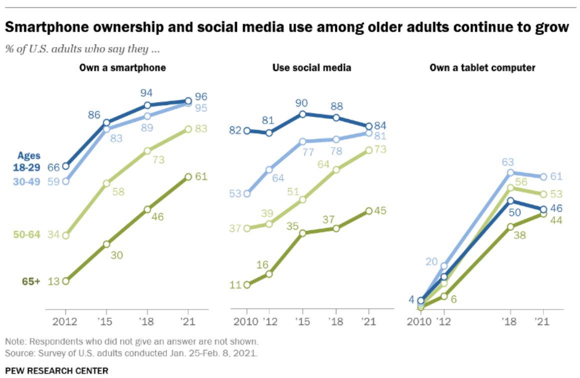


Fig.1 Graph representing adaptation of technology among different ages.

In an era where technology reigns supreme, we've witnessed a transformational shift in how we live, work, and communicate. With the advent of the internet, smartphones, and other digital devices, we've been blessed with the power to access and share information from any corner of the world. But while these technological advancements have revolutionized our lives, they've also presented unique challenges for individuals with physical disabilities. Among them, amputees stand out, having to cope with the loss of a limb or limbs, making traditional computer interfaces such as a mouse and keyboard or touchpad difficult to operate. It's an issue that researchers have started to address, recognizing the importance of developing new and innovative technologies that can cater to the unique needs of this community.

According to the World Health Organization (WHO), an estimated 1.3 billion people (16% of the world's population) currently suffer from serious disabilities[3]. In India, a country with a population of 1.21 billion, estimated 23 million people were reported to have disabilities in 2011[4]. With a prevalence of 20.3%, locomotor disabilities were found to be the most common type of disability, followed by mental illness (2.7%), hearing (19.0%), sight (18.5%), other impairments (18.0%), multiple disabilities (8.0%), speech (7.5%), and mental retardation (5.5%) [5].

However, there are assistive technologies available to help amputees overcome these challenges, including specialized prosthetics, voice recognition software, and other adaptive tools.
To address this issue we have developed an application "Face Controlled Human-Computer Interface HCI) for Disabled Persons". With the help of these applications, a disabled person will be able to interact with personal devices without the help of any third person. We have used the Harr Cascade algorithm for face recognition. The HCI system can be used for a variety of purposes, such as controlling home automation systems, accessing the internet, and interacting with computer applications. It is a promising technology that has the potential to

significantly improve the lives of people with disabilities.

Methodology

It is a Python program that uses computer vision techniques and facial landmark detection to track eye blinks, mouth movement, and mouse clicks. The program uses the dlib library to detect and track facial landmarks, OpenCV for computer vision operations, and pyautogui for controlling the mouse.

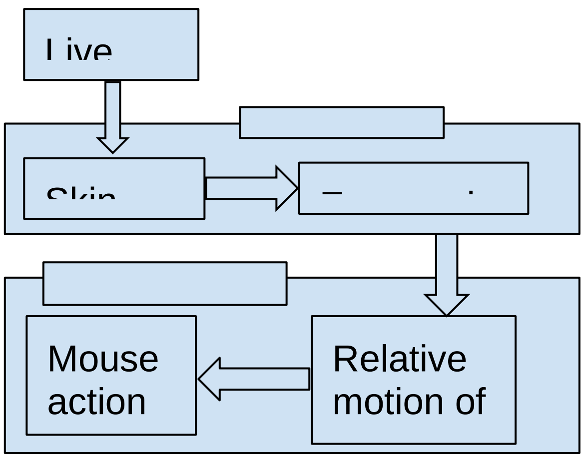


Fig.2 System Block Diagram

Face Recognition

The code is a Python program that uses computer vision techniques to track various facial movements and mouse clicks. It first uses the Dlib library to detect and track 68 facial landmarks (Fig.2) on each frame of a video stream or a video file. These landmarks include the positions of the eyes, nose, mouth, and other facial features.

Fig.3 Facial Landmarks

Once the landmarks are detected, the program uses them to track eye blinks and mouth movement. For eye blinks, the program measures the ratio between the height of the eye's upper and lower eyelids. If this ratio falls below a certain threshold, it is assumed that the eye has blinked. For mouth movement, the program measures the distance between the corners of the mouth, and if this distance exceeds a certain threshold, it is assumed that the mouth has opened.

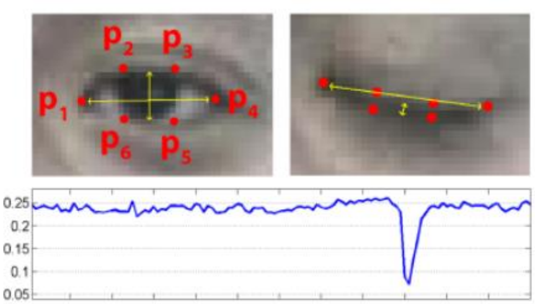
The program also tracks mouse clicks by monitoring the state of the left mouse button. If the button is clicked, the program moves the mouse cursor to a predetermined location on the screen using the pyautogui library.

Finally, the program uses OpenCV to display the video stream with the detected landmarks and the various tracked movements overlaid on top of it. Overall, the program demonstrates how computer vision techniques can be used to track and monitor multiple facial movements and mouse clicks in real-time.

Eye -Aspect Ratio

The program is designed to track eye blinks, mouth movement, and mouse clicks using computer vision techniques and facial landmark detection. It consists of two main parts: calibration and real-time detection.

During the calibration process, the program captures video from the computer's camera and detects the face, eyes, and mouth using the Dlib library. The Eye Aspect Ratio (EAR) difference between the left and right eyes are calculated for each frame of the video, and the average EAR difference is computed over the calibration period, which is typically 25 seconds. This baseline EAR difference is used as a reference point for detecting eye blinks in real time.



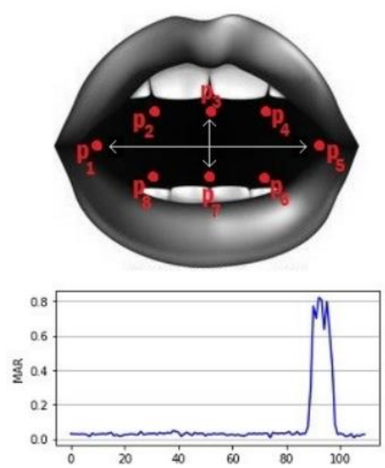
$$EAR = \frac{||P2 - P6|| + ||P3 - P5||}{||P1 - P4||}$$

Fig.4 Eye-Aspect Ratio (EAR)

Mouth-Aspect Ratio

Mouth Aspect Ratio (MAR) is a measure of how open or closed the mouth is. It is calculated by measuring the ratio of the distance between two sets of facial landmarks on the mouth region. Specifically, the landmarks used are:

- 49: the left corner of the mouth
- 55: the right corner of the mouth
- 52: the midpoint on the top of the mouth
- 58: the midpoint on the bottom of the mouth



$$MAR = \frac{||P2 - P8|| + ||P3 - P7|| + ||P4 - P6||}{||P1 - P5||}$$

Fig.5 Mouth Aspect Ration (MAR)

The MAR value is a normalized ratio between 0 and 1, where 0 indicates that the mouth is completely closed, and 1 indicates that the mouth is completely open. In the code, a threshold value is set for the MAR, and if the calculated MAR exceeds this threshold, it indicates that the mouth is open, and the program records a mouth movement.

Result

The mouse control program is designed to allow users to move their cursor, scroll, or click using their mouth. This is especially useful for individuals who may have difficulty using a traditional mouse or trackpad, such as those with physical disabilities.

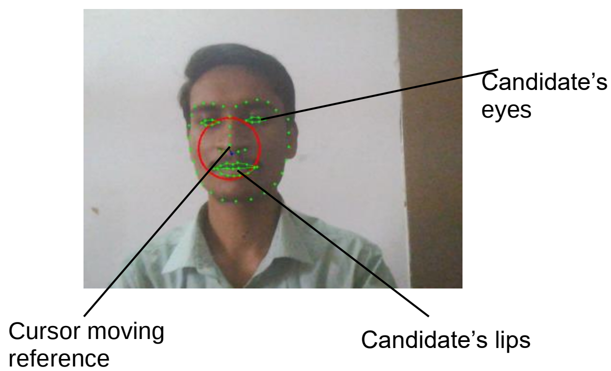


Fig.6 Face Region

The program works by monitoring the user's facial expressions using a technology called facial recognition. Specifically, it tracks the movement of the mouth and uses that information to control the cursor on the screen. When the user opens their mouth beyond a certain threshold, the program registers this as a command to activate the mouse control.

Once the mouse control is activated, the user can adjust the amount of change in the position of the cursor along any axis. This allows for fine-tuned movements, which can be especially important for tasks that require precision, such as graphic design or data entry.

In addition to controlling the cursor, the program also enables scrolling and clicking. This allows the user to perform a wide range of actions without ever having to touch a physical mouse or keyboard.

Fig.7 User-performing mouse events

Conclusion

The use of real-time face recognition technology for creating a computer interface system for individuals with disabilities has shown great potential. While there may be some challenges with partially varying illumination, the system has demonstrated its robustness in normal office lighting conditions with complex backgrounds. By incorporating camera pre-processing characteristics into the color model, the system can achieve even higher precision and become more suitable for computer control.

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