

Eye-Controlled Wheelchair by Eye Coordinates Extraction

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Abstract- *This project deals with a motorized wheelchair designed for those who cannot move their limbs. The project aims to motorize a wheelchair, control the wheelchair's speed, interface a camera module to micro-controller and assign controls to the wheelchair corresponding to the movement of eyeballs. Here the motion of the wheelchair is based on tracking of eyeballs. The camera captures the eyeball movement and is correspondingly coded, so that the wheelchair is moved. This method replaces the joystick mechanism, which cannot be used by paralyzed people. First, the code is tested using Python language using the Open-CV library on Anaconda IDE. Later, it will be tested on the Raspberry Pi module*

Index Terms- *Dlib Library, Eye-Tracking, Image Processing, Raspberry Pi.*

I. INTRODUCTION

A motorized wheelchair is used for those who have physical disabilities to move. These disabilities may include old age-related walking problems, any severe injuries, or those whose lower limbs are paralyzed. Different methods have been developed for the control of wheelchair such as joystick control, electro-oculogram (EOG) Method, Lens Tracking Systems, Eye-tracking method, etc. [1]. By considering the drawbacks of specific techniques, the eye-tracking method is preferred. The design, development, and working of an eye-controlled wheelchair are discussed in the above paper. Here, a good quality webcam is used to capture videos, and it is connected to Raspberry Pi. By using coordinate values, corresponding controls are assigned to the micro-controller.

II. LITERATURE REVIEW

People who have paralysis cannot move by their own. Those people need assistance from others [2]. This paper discussed different types of wheelchairs such as manually controlled wheelchair, electric wheelchair, stair-climbing wheelchair, etc. They also mention various techniques used in wheelchair control. Methods are based on

Electroencephalography, which records electrical brain signals from the scalp, EOG signals, which note down the potential difference between the retina and cornea of the eye. Non-bio signal-based techniques include joystick control, tongue control, chin control, touch screen controlled, sip-n-puff, voice actuated, eyeball-controlled, head movement tracking, etc.

Shawn Plesnick et al. (2014) said about the joystick-controlled wheelchair and the advantages of eye-controlled wheelchair over the joystick-controlled [3]. In this paper, NI DAQ is used instead of microcontroller, and LABVIEW is used for programming. A combination of 2 methods is used-C++ handles eyeball tracking, and LABVIEW is used for motor control according to the eyeball movement.

Haar cascade algorithm is used for detecting the face of the person sitting on the wheelchair [4]. For tracking the eyeball, the face of the person sitting in front of the camera should be detected first. Once the face is detected, the eyeball is detected using the Hough circle transform method. This method is used to identify the circle in an image. Raspberry Pi is the heart of the system proposed by the author. Tools used in image processing include thresholding technique, eye detection, colour image to grey conversion, blurring, filtering, etc.

Python coding is more comfortable and flexible compared to other languages. Pre-written codes, libraries, and data can be imported easily in Python. Libraries like OpenCV, NumPy, Dlib perform the image-processing part. By using OpenCV, many lines of code can be eliminated. Dlib library helps to extract facial landmark points, which are classified into primary and secondary landmark points. Primary landmark points are the mouth, corners of the eyes, nose tips, and left-right eyebrows, and the secondary landmark points are chin, cheek, midpoints of lips, and nostrils. These points are essential for recognizing facial expression [5].

Aleksandar Pajkanovic and Branko Dokic (2013) discussed about controlling the wheelchair by

moving the head [6]. This paper also mentioned the condition of people who cannot use their limbs and the reason for such problems. Head movement is translated to coordinate values, and these coordinate values are given to micro-controller. Based on the algorithm used, commands are assigned to actuators, which helps in the wheelchair's movement.

III. RESEARCH GAP

The papers mentioned above discussed various methods of control of the movement of the motorized wheelchair. There are many methods like voice command method, EOG method, IR method, camera mount methods, etc. Out of that eye-controlled wheelchair is found to be a simpler and more accurate method

Different microcontrollers that can be used, like Arduino, Raspberry Pi, NI DAQ, etc., are mentioned above. But by considering cost-effectiveness and flexibility, Raspberry Pi is chosen over other methods as it is a credit card-sized computer and can be used as a microcomputer. Even Arduino can be combined with Raspberry Pi to reduce the workload of Raspberry Pi so that it can perform well.

Most of the paper mentioned illuminating the eye by using a source of light. Some of them include the use of LED, IR light sources, etc. This improves the quality of the frames extracted from the video. Also, the camera can capture bright images if the images were not clearly recorded. But this method also suffers from drawback that prolonged use of torch causes strain and discomfort for the eye. The use of dlib library over the threshold technique was found as an alternative method that avoids using a torch.

IV. METHODOLOGY

A. Flowchart

The flowchart of the proposed system is shown in figure:

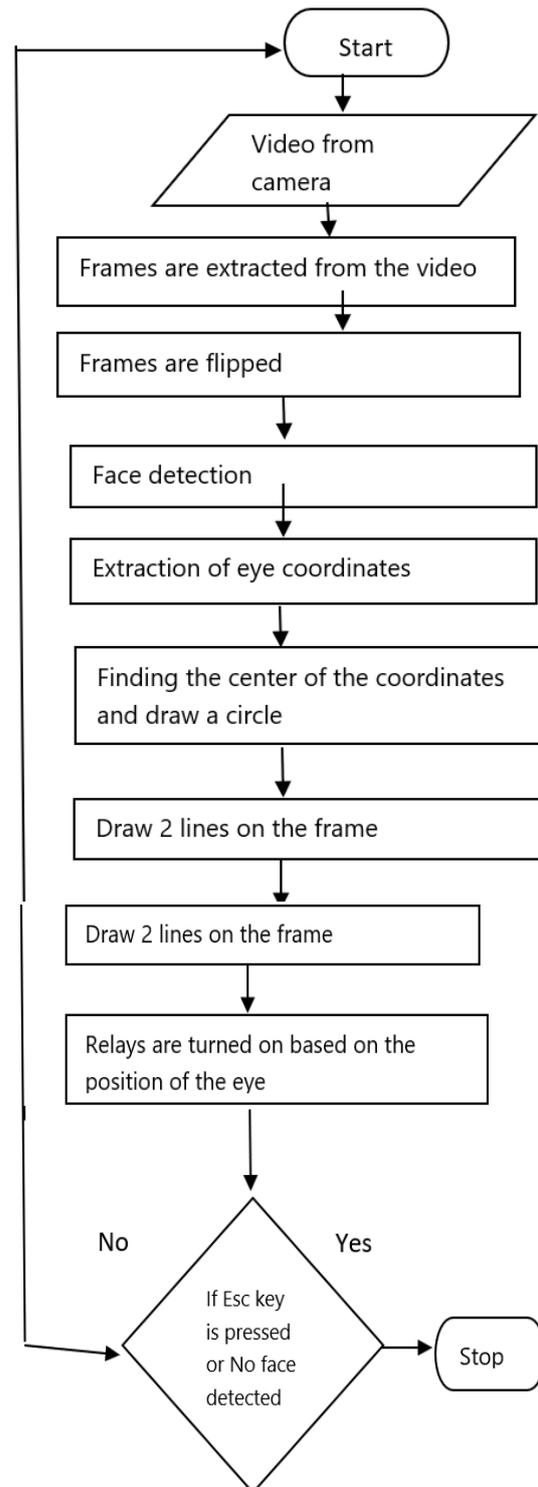


Figure 1: Flowchart of the proposed system

- Video is captured by using a webcam, and it is connected to the Raspberry Pi. The webcam has longer cable so that it can be placed anywhere.
- The camera is turned on by using a suitable code, and the video captured is stored as frames. These frames are used for image processing.

- Now, these frames flipped so that the user can see the laterally inverted video on the screen.
- Dlib package in Python is used to detect the face. In that, the frontal face detector function is used. Our region of interest is the face and left eye of the person sitting in the wheelchair. The dlib library consist of a pre-trained facial landmark detector. It is used to estimate the location of 68 coordinates and maps to facial structures on the face. By using this, coordinates of left eye are extracted.
- The center point of the coordinates extracted is found out by taking the average value of those coordinates. After finding the center point, circle of radius 5 mm encircles our region of interest, i.e., left eye. From the center of the frame, 50 mm is taken from either side and two vertical lines are drawn.
- If the center of the circle, drawn previously, lies within those two horizontal lines, the wheelchair will move forward. If the center of the circle is to the left of the horizontal line drawn, the wheelchair will move towards left. If the center of the circle is to the right of the horizontal line drawn, the wheelchair will move towards the right.
- If the frontal face detector does not detect the face, the wheelchair will stop moving.
- This process is repeated until the escape key is pressed or the user stops the program. Then, the program is terminated.

B. Block Diagram

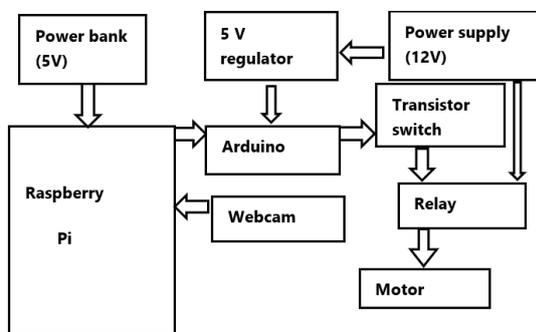


Figure 2: Block diagram of the proposed system

The block diagram of the model is shown in figure 2. All the sensors, actuators, and Raspberry Pi need to be powered up by a DC power supply. Power for all the devices is powered from the battery. For Raspberry Pi, a separate power bank is used because it requires 2A. Raspberry Pi is the heart of the system. It controls the movement of the wheelchair according

to the data from the webcam. After processing the image read by the camera, the Raspberry Pi sent data to the serial monitor to access Arduino.

Arduino controls the direction of rotation of motors. It energizes corresponding relays by using transistor switches. If the eye lies within those two horizontal lines, the wheelchair will move forward. If the eye is to the left of the horizontal line that was drawn on the left from the center, then the wheelchair will move towards the left. If the eye is to the right of the horizontal line that was drawn on the right from the center, then the wheelchair will move towards the left.

A. D-lib Library

Dlib is used for detecting facial landmarks by using some pre-trained models. It is used to extract the location of 68 coordinates and maps the facial points on a person's face. The facial points, including mouth, eyes, eyebrows, nose, and jaws are estimated using this library.

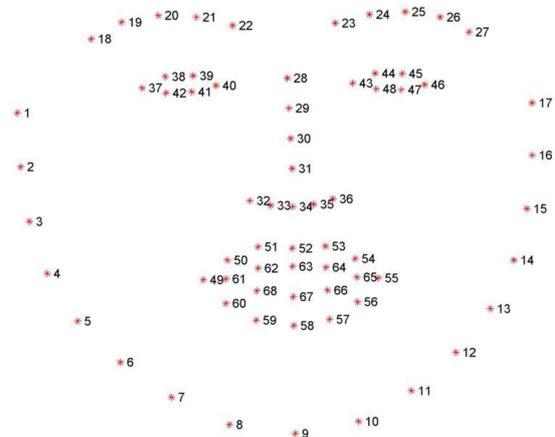


Figure 3: 68 facial landmark points [Anita Jindal, Rashmi Priya (2019)]

By observing the figure 3, it is clear that facial regions can be accessed via simple Python indexing. Since the area of interest is the left eye, the video is flipped first so that laterally inverted video is seen on the screen. Thus, 36 to 42 points are our Region of Interest (ROI). Other points are neglected. These points are used to find the center of the eyeball.

V. RESULTS AND DISCUSSIONS

Using the VNC viewer, which is a remote desktop application, the Raspberry Pi monitor is accessed. The program written in Python is loaded in Raspberry Pi, and it sends serial data to Arduino. Both

Raspberry Pi and Arduino programs are executed, and all the libraries, pre-trained Shape predictor code and Arduino are loaded.

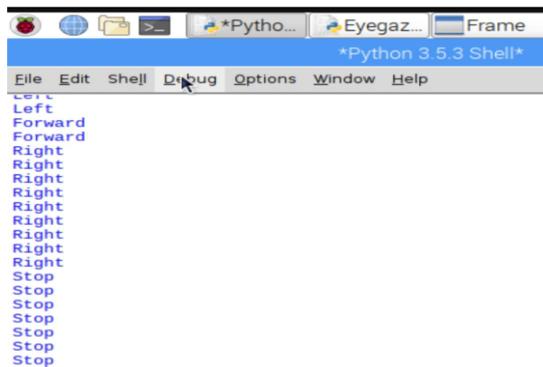


Figure 4: The direction of motion of wheelchair displayed on serial monitor

The direction of the movement of wheelchair is also displayed, as shown in figure 4. The direction is shown in Python shell according to the rotation of the motor. For the forward motion of the wheelchair, the iris should be at the center of the display screen. Two vertical lines denote center of the screen. As figure 5 shows, eyeball should be within those lines to move the wheelchair in the forward direction. "Forward" is printed on the serial monitor, as seen in figure 4. For moving towards the right, the eyeball should be to the right of the vertical line, which is right from the centre. As shown in figure 6, the iris is to the right of the vertical line. Thus, the wheelchair moves towards right, and "Right" is displayed on the serial monitor, as shown in figure 4. If the wheelchair is to be moved towards the left side, the eyeball should be to the left of the vertical line at the left of the centre. As shown in figure 7, the iris is to the left of the vertical line. "Left" is printed on the serial monitor, as seen in figure 4. Thus, the wheelchair can move forward, left and right based on eyeball movement

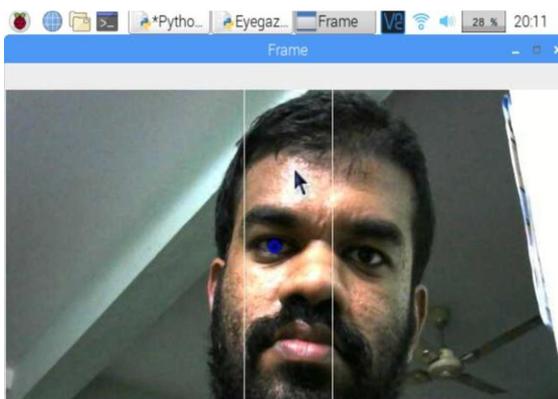


Figure 5: The eye ball is at the center position



Figure 6: The eye ball is at right side

If the camera fails to recognize any faces, the wheelchair will remain stationary. This condition is used for stopping the wheelchair. In figure 8, the face was not detected by the camera. Thus, the wheelchair stops moving, and "Stop" is displayed on the serial monitor as in figure 4.

By considering facts like the combined weight of the person and wheelchair and acceleration and speed of motor, torque and power ratings of the motor were found out.

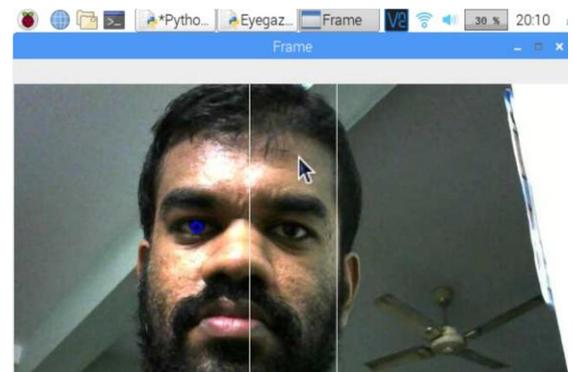


Figure 7: The eye ball is at left side

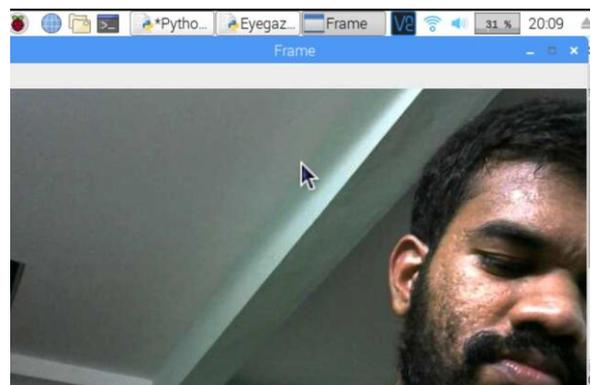


Figure 8: The eye ball not detected

Since the motor has high torque, the current required for rotation of the motor is high. H-bridge driver IC

like L293D cannot be used since the maximum current it can allow is less than 1.2A, and the max current motor can draw is above 1.4 A. So, relays are used to control the direction of rotation of the motor instead of relay driver IC.

VI. CONCLUSION

This proposed model discusses the design and operation of the Eye-controlled Wheelchair for the disabled. This wheelchair acts as an assistive method to deal with the loss of mobility for patients who cannot walk normally due to some injury or other age-related walking disabilities. With this, weighing the wheelchair and approximate weight of a human being, the motor having the necessary power and torque to pull down the combined weight is selected. The selection of the micro-controller is also a crucial part of building the prototype. Raspberry Pi, which acts as a mini-computer, controls the image processing part. The wheelchair movement operation occurs with some delay time because of the Raspberry Pi's processing speed. Places with less light affect the performance of the wheelchair. It would be difficult to track the pupil in the absence of light. But this project works well with an ample amount of light. This project can prove to be an effective system to make the lives of paralyzed patients independent.

VII. FUTURE SCOPE

This system tries to control the wheelchair using the eyeball movement, making it easier to manage as there is no requirement of the external joystick and, thus, makes it hands-free. The system's reliability and safety can be improved by making the system semi-automatic with the help of ultrasonic sensors for automatically detecting obstacles and taking appropriate actions to avoid collision automatically. Using some threshold value, the wheelchair can be made to stop when encountering an obstacle in the path. Also, a piezo buzzer can be used to give a signal to the patient that there is an obstacle nearing that wheelchair. It can also allow the wheelchair to follow a black line if the patient is unaware of different rooms in the hospital like X-ray room, Ultrasound Scanning room, etc. This black line will allow the patient to reach these locations without any help from the attendant. An IR sensor interfaced with Arduino can be used for the line follower.

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