Wheel Chair Movement through Eyeball Recognition Using Raspberry Pi

Surya Prakash Yalla[1], Archana Uriti[2], Abhisek Sethy[3], KoteswaraRao chintada[4]
1,2,3Department of Information Technology, GMR Institute of Technology Rajam, Andhra Pradesh, India.
4Department of Computer Science & Engineering, Guru Nanak University, Hyderabad, India.

Abstract

When we think of how to help, whether financially or in another way, we often consider how we can provide assistance to those in need. We graduate students, on the other hand, have the advantage of being able to design a device that will benefit those less fortunate. Creating a positive impact on society is demonstrated by this initiative. There have been an increasing number of people who have been paralyzed in recent years. Paralysis describes a complete loss of power in a muscle group. In the most extreme scenario, a disabled individual would only be able to use his eyes. The project of constructing an eyeball movement-based wheelchair will be of the greatest help to these people with disabilities. This type of wheelchair would operate more accurately than earlier automated wheelchairs since noise from outside the environment can cause inaccuracy in voice-controlled wheelchairs and human effort is required to operate a head movement-based wheelchair. With our system, a person sitting in a wheelchair can stare directly at the camera and direct the wheelchair to the correct path by simply staring in the direction they desire. Using raspberry pi we implement this system. It consists of algorithms that let you operate your wheelchair. An Eyeball Localization method has been proposed to control wheelchair mobility. Several executional processes and an efficient system have been designed to reduce the costs and complexity of the algorithm. Through the serial port, an Open CV program analyzes camera signals and controls the motor attached to the Raspberry Pi CPU. As the technology is cost-effective, patients of different socioeconomic backgrounds can benefit from it. A wheelchair like this would have better accuracy than previous models.

Keywords:Quadriplegia, Image Processing, Python, Eyeball Monitored System, Raspberry Pi, Automated wheelchair, OpenCV.

1. Introduction

This research aims to provide ways to operate a wheelchair by using ocular localization. In addition to reducing costs and complexity, algorithms enable efficient data processing. Since the objectives of this research were to monitor and detect eyes in real time, physical parameters of the pupil and eye, as well as pixel values from neighboring locations, were taken into account. Numerous techniques have been developed to simplify the task of achieving the desired outcomes when the eyeball's localization is used.

Considering the limited RAM speed of controllers, none of these algorithms could be implemented, so we had to create one specifically for this application. Using an eyeball's location, this research aims to create a hardware assembly that can be controlled remotely.

The development of an automated wheelchair that includes a fully automated transmission, motor, and power supply will help disabled individuals become more independent. Further, the wheelchair's use of multiple modules and other alternative features made it more affordable and useful for its users. In the creation and execution of this project, the wellbeing of human civilization was considered at every point. Harr Cascade is the classifier employed in this system. The location of the eyeball on the face is identified and its position is then determined based on statistical analysis and geometrical [7]approaches, which prevents undesirable regions of the face surrounding the eyeball from being detected and tracked.

2. Literature Survey

In the past, several works have been related to wheelchairs. These works led us to consider the concept of ocular movement for our smart wheelchair.

The system in [1] contains a webcam, an ultrasonic sensor, an Arduino, and an IC to drive a motor. Through the use ofthe web camera, the pupil of the patient is identified, which is subsequently analyzed using MATLAB. Identifying eye pupils is accomplished using the image acquisition toolkit. Arduino serial interface transmits motor driver IC L293D commands based on movements of the eye pupil. Depending on the signals received from the Arduino, the wheelchair can move forward, backward, left, and right. The wheelchair comes to a complete stop if an obstacle[8] is detected in its path by an ultrasonic sensor.

In [2], the system relies on the user’s head movement as input signal to propel the wheelchair in the direction the user chooses. A voice control feature is also incorporated into this technology. An individual robotic limb is linked to a separate head helmet, which controls head movement. Based on the head movement detected by the head cap, the microprocessor accelerates the vehicle. A sensor, which detects eye blinks, will shut off the device if there are no eye movements for a predetermined amount of time.

Sowmya addressed the aforementioned difficulties in [3], explaining that their eye control system simplifies and improves their lives in many ways. A similar set of image processing commands is used by the gadget to detect pupil movement. Microcontroller signals cause the driver circuit to move in the direction specified by the microcontroller. As a safety measure, wheelchairs are equipped with ultrasonic sensors, which stop the wheelchair from colliding with objects along the route. When a disabled person closes his or her eyes, the wheelchair comes to a halt immediately. Whenever the patient's eyeball moves, this chair moves left, right, forward, and back. Thus, the disabled person is able to live independently.

As presented in [4], Balamurugan introduced a method for wheelchair assembly that uses both motion tracking and eye detection through a microcontroller.

- This first component consists of an open-source webcam that will connect to a user's laptop and run an OpenCV programmer. By taking several photos, this will be accomplished, and then the wheelchair will move in a specified direction based on an individual's eye movements.
- Within the next component, microcontrollers communicate with OpenCV applications and receive a decision based on their processing. The wheelchair's port pin is elevated whenever the controller receives it, allowing it to move in the direction it is intended to travel in within seconds of connection.

As described in [5], Abhishek describes a system that uses a laptop system and a camera mounted on a spectacle to track a wearer's eye movements. After the USB output passes through the laptop's microprocessor, it is directed to the laptop's display, where electrical signals are generated from digital output signals in order to move the wheels A picture capture module and an image analysis module are both included in this system[9]. To determine the pupil's location and direction, the first module will collect the image using MATLAB. The next module will segment and analyze the image to determine the pupil's location and direction.

In [6] GundaGowtham has mainly focused on two modules they are 1. Image capturing and 2.Image Analysis.

- Image Capturing Module: Images of the iris are captured by an image capture camera using an appropriately constructed camera. Capturing an image is a crucial step in iris identification. Due to its tiny size and black color, it is difficult to take a good picture of the iris. A grayscale image is then created from the RGB image for further processing. It entails utilizing a specially positioned camera to acquire a series of iris photos from the subject. Despite its average diameter of 12 mm, the iris pattern requires a camera with a high resolution to properly capture it.

- Image Analysis Module: In this module essentially, segmentation is the process of removing useless data, such as the pupil segment and areas beyond the iris (e.g., skin, sclera, eyelids). Daugman suggests using an integrodifferential operator in order to determine both the pupillary and iris contours. With the algorithm, iris recognition will be accomplished in two stages. During the first phase of the analysis, the pupil is observed as a very black blob in the image of a specific minimum size, whereas no other segment of continuous dark pixels has the same size. This method finds the pupil center and two radial coefficients because the pupil is a complete circle. By using pupil canter data, the second method attempts to determine which way the eye is looking.

3. Methods and Results

Details regarding the implementation of our work can be found here. The division is composed of three stages. Stage one involves identifying and converting images, stage two involves image partitioning, and stage three involves passing logic from the Raspberry Pi to a dc motor through a motor driver.

Eye movement detection and tracking are the main components of the proposed system. To locate the pupil of the eye, the Haar cascade algorithm is used.There are several stages in this technique, such as detecting eye movement, detecting faces and eyes, switching colours, detecting objects, Hough transforms, and detecting edges.

This system initially uses the webcam for taking pictures. In the first phase, the face of the user is recognized correctly, and in the second phase, when there are many faces, the inaccuracy is displayed. In accordance with the algorithm, the system will depict the user's face on the indicated image in a specified area. In order to monitor eye pupil size, a number of image processing methods are used.

3.1. Methodologies-

Centroid Algorithm:

Centroid Algorithm is used for image processing on each frame of the image. Every image is analysed using the traditional Viola-Jones Algorithm to detect the eye. As a result, we devised the Centroid Algorithm to track the iris. Numerous methods are already available for tracking eye movements[10]. These methods often fail to determine eye centres accurately in difficult situations, such as those involving low resolution, low contrast, or occlusions. Scales, poses, contrasts, and lighting don't matter to our method. In addition to reducing latency (the response time of the raspberry pi).

This method crops out only the eye portion of the image. In order to create a binary image, we convert it to grayscale. Binary images have black representing zero and white representing one. Our method is to traverse the image along the x- and y-axes, and then collect the values located where the pixels are black and average them all to find the Centroid [11].

Threshold algorithm:

Next, right of the distribution corresponds to left of the distribution, and left of the distribution corresponds to right of the distribution. Centroids should move in a straight line if they are situated between these two divisions. The right side of the arc should be moved if the Centroid position exceeds the right threshold. Basically, if the position of the Centroid is less than the left threshold, start moving left.

Stage one - Image conversion and eyeball detection:

The eyeball is virtually black in colour. To determine the orientation of the eye, it must be counted how many black pixels are in the eye. We need to provide the person's eye picture as input to the code that must be executed in order to complete the aforesaid procedure. In order to accomplish this, a picture of the person is taken, and then an image of the eyes is sent to the Raspberry Pi through a camera compatible with the Raspberry Pi. An image [12]captured by the camera is coloured.

The increased number of pixels makes the process of calculating a colour picture more challenging. Using a binary image converter, the acquired colour image will be converted into a black and white image. A grayscale image is then generated from the colour image by using colourspaces and thresholding. An eyeball photograph taken in grayscale will always show the brightest gray in the deepest part of the eye. We must set the threshold value close to zero, since black pixels have a value of zero.Whenever the threshold value is equal to or greater than the threshold value, the pixels will be converted to white. Black pixels will be generated if the threshold value is equal to or less than threshold value.

Figure 1 5MP Pi Camera

Figure 2 Pi camera with Raspberry pi

Stage two – Image segmentation

At this point, we must divide the image into three vertical halves. By developing Python code, we will be able to calculate the number of black pixels in the image. In the case of black pixels in the right section, it must travel right, and in the left section, it must travel left. The image must be divided into three horizontal sections in the other case. At its centre, the image has a higher amount of black pixels.

With the Python code[13] we developed, we will determine the black pixel count in each zone. In the event that the dark pixels count in the top area increases, we'll need to proceed. Likewise, when the black pixels at the bottom are higher, we move backward. As the count of black pixels in the central area of the chair exceeds a certain threshold, the chair comes to a halt.

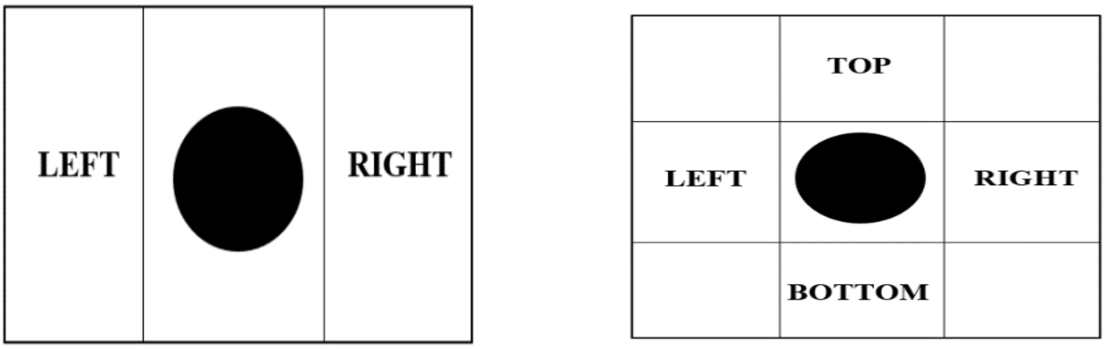


Figure 3 Diagrammatic representation of image division

Stage three – Connecting Raspberry Pi to a DC motor using the driver motor IC.

The L293D motor driver IC is used in this application. Based on the H-bridge circuit concept is the motor driver IC. Electrical power is generated in an H-bridge circuit by connecting four switches in parallel. Motors are located between parallel connections. Motor rotation occurs when both S4 and S1 are switched on; motor rotation occurs when both S3 and S2 are switched on. By flipping the polarity of a voltage, an H-bridge circuit delivers a voltage to a load. In robotics and other applications, these circuits are commonly used to enable DC motors to move forward or backward. The purpose of this H-primary bridge is to control motors. Drivers should avoid changing directions while changing lanes simultaneously because the H-bridge may catch fire.

A L293D driver motor is an electric motor that drives DC motors. Once the IC is connected to the dc motors, the L293D driver motor will be connected to the Raspberry Pi's GPIO pins. Whenever the input is HIGH-LOW, the motors will now travel forward; conversely, when they are LOW-HIGH, they will travel backward. Two dc motors are employed since the device needs to turn. By transferring signals from the CPU to the appropriate motors, the L293D receives signals from the CPU and sends them to the motors. There are two voltage pins on the integrated circuit. The motors are powered by one, while the L293D draws current from the other.

There are a total of 16 pins on the motor driver, including four input pins, four output pins, and two pins linked to enable pins 1,2,3,4. Ground must be linked to every motor driver; ground is attached to pins 4,5,12,13, and the vcc's are connected to two pins, where vcc signifies the voltage at the common collector. On a circuit, the letter V represents the supply voltage.

The supply voltage is indicated by letter CC that is either positive or negative. Enable Motor A's speed is controlled by a pin. Similarly, the speed of motor B is controlled by the Enable B pin.

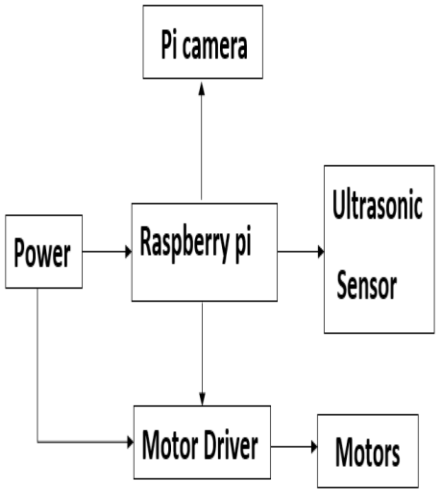


Figure 4 System’s block diagram

Based on their construction, DC motors can be classified into two different categories: self-excited motors and separately excited motors. Since it converts electrical energy into mechanical energy, this DC motor is unique among motors. In this case, the electromagnetic principle plays a key role[15]. This motor consists primarily of rotors, stators, commutators, field windings, axels, and brushes. Connecting those motors and motor drivers is accomplished using male to male, female to female, and female to female connections. It will be the Raspberry Pi code that sends output to the L293D IC. After this, the motor driver transforms the data into a signal that is then sent to the DC motors. A specific movement[14] of the eyeball will cause the motors to move in the exact direction indicated by the signals. In the event the motors are connected to the wheelchair[16], the wheelchair will also move in the same direction. Individuals who are quadriplegic will be able to use the final product.

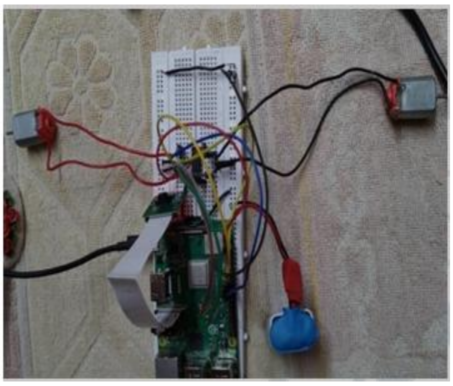
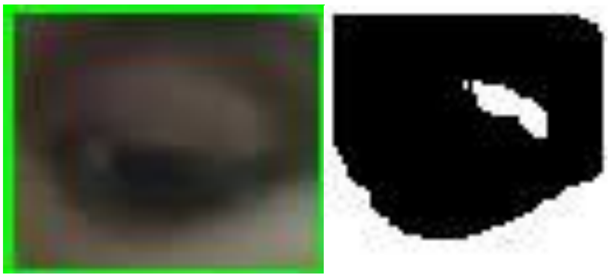


Figure 5 Prototype of our System

Move Left

Move Back



Move Front

Move Right

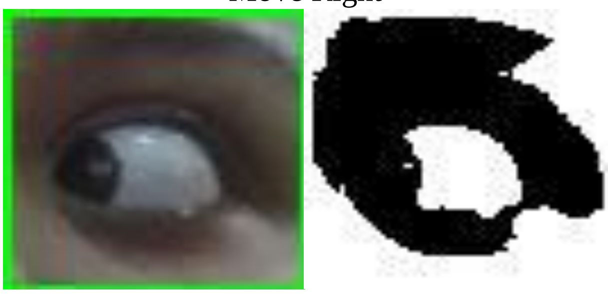


Figure 6 Binary and Grayscale image along with direction

4. Conclusion

A major objective of this project is to create an autonomous wheelchair to assist physically challenged individuals by using eyeball detection. Despite their age, physically challenged individuals are able to use wheelchairs with ease regardless of their age. The process is accomplished by moving the eye in one direction, causing the wheelchair to follow the eye. A more accurate result is obtained if all frames of the eyeball are caught, along with the quantity of pixels from each frame.

Refrences

[1] Mrs.Namrata Lade, Advance Eye Controlled Wheelchair for Disabled Person. International Journal of Engineering Research & Technology (IJERT), ICIATE - 2017.

[2] Karibasavaraju T. S, Niranjan S. H, Sushma K. S, Veena E, Pavan Kumar P. J, Vinay K.C, Intelligent Eyeball Controlled Wheelchair for Paralyzed Patients using Arduino. International Journal of Engineering Science and Computing, Volume 10 Issue No.6, 2020.

[3] Sowmya M S, Eye Gaze Controlled Wheelchair. International Journal of Engineering Research & Technology (IJERT), Volume 9 Issue 05, May-2020.

[4] Balamurugan K, Sindhu S, SelvaSuba Jenifer J, Saranya P, Auto Comforted Wheelchair for Quadriplegics. International Journal of Innovative Science and Research Technology, Volume 3, Issue 3, March– 2018.

[5] Abhishek, AbhishekKhandelwal, Gautam Kumar Singh, Kumar Rahul, Shilpashree P. S., Eye Movement-based Electric Wheelchair. International Journal of Current Engineering and Scientific Research (IJCESR), Volume-3, Issue-5, 2016.

[6] GundaGautam, GundaSumanth, Karthikeyan K C, ShyamSundar, D.Venkataraman, Eye Movement Based Electronic Wheelchair For Physically Challenged Person. International Journal of Scientific & Technology Research Volume 3, Issue 2, February 2016.

[7] Uriti, Archana, Surya PrakashYalla, and KoteswaraRaoChintada. An Approach of Understanding Customer Behavior with an Emphasis on Rides.In 2021 Innovations in Power and Advanced Computing Technologies (i-PACT), pp. 1-5.IEEE, 2021.

[8] Chintada, KoteswaraRao, Surya PrakashYalla, and ArchanaUriti. A Deep Belief Network Based Land Cover Classification. In 2021 Innovations in Power and Advanced Computing Technologies (i-PACT), pp. 1-5.IEEE, 2021.

[9] UritiArchana. (2020). An Approach to Analyze YouTube Data using Hadoop . International Journal of Advanced Science and Technology, 29(06), 4910 - 4918.

[10]Archana, Uriti, and Urlam Sridhar. "A Novel Quantization Approach for Approximate Nearest Neighbor Search to Minimize the Quantization Error." 2017.

[11] Sethy, Abhisek, Prashanta Kumar Patra, and SoumyaRanjanNayak. "A Hybrid System for Handwritten Character Recognition with High Robustness."Traitement du Signal 39.2 (2022).

[12] Sethy, Abhisek, AjitKumaRaut, and SoumyaRanjanNayak. "Face Recognition Based Automated Recognition System." In 2022 12th International Conference on Cloud Computing, Data Science & Engineering (Confluence), pp. 543-547.IEEE, 2022.

[13] Sethy, A., Patra, P. K., &Nayak, S. R. (2022). A Deep Convolutional Neural Network-Based Approach for Handwritten Recognition System.In Computational Intelligence in Pattern Recognition (pp. 607-617).Springer, Singapore.

[14] Sethy, Abhisek, Prashanta Kumar Patra, RudraKalyanNayak, and Deepak Sahoo. "Transform Based Approach for Handwritten Character and Numeral Recognition: A Comprehensive Approach." In International Conference on Artificial Intelligence in Manufacturing & Renewable Energy (ICAIMRE). 2019.

[15] Sethy, Abhisek, and Prashanta Kumar Patra. "Optical Character Recognition of Odia Handwritten Scripts and Numerals: A Survey on Web Based Utility Application." Journal of Web Engineering 17, no. 6 (2018): 3629-3653.

[16] Yalla Surya Prakash, “IoT Based Location Survelliance Using QuadrappedRobot ”, IJAST, vol. 29, no. 04, pp. 4825 -, Jun. 2020.