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Iris movement based wheel chair control using raspberry pi

Jatin Sharma, Anbarasu M, Chandan Chakraborty and Shanmugasundaram M

School of Electronics Engineering, VIT University, Vellore 632 014, Tamil Nadu, India

E-mail: mshanmugasundaram@vit.ac.in

Abstract. Paralysis is considered as a major curse in this world. The number of persons who are paralyzed and therefore dependent on others due to loss of self-mobility is growing with the population. Quadriplegia is a form of Paralysis in which you can only move your eyes. Much work has been done to help disabled persons to live independently. Various methods are used for the same and this paper enlists some of the already existing methods along with some add-ons to improve the existing system. Add-ons include a system, which will be designed using Raspberry Pi and IR Camera Module. OpenCV will be used for image processing and Python is used for programming the Raspberry Pi.

1. Introduction

There has been a rapid increase in the Quadriplegia prone persons with increasing population. Several Wheel Chair Systems have been made for disabled persons. Some of the wheelchair systems present till now are discussed below. Hand Gesture based Wheelchair System [2] uses MEMS Accelerometer Sensor which is attached to the hand. Then based on hand gesture, the Wheelchair system is controlled. Voice Operated Wheelchair System [5] uses the voice of the user to operate Wheelchair. Head and Finger based Automated Wheelchair System [1] uses Accelerometer and Flex Sensor to operate Wheelchair. But all the above systems require much of a human effort and none of these systems help people suffering from Quadriplegia [3-4].

In Quadriplegia, Paralysis is of the extreme level in which a person can only move his eyes. In order to help such disabled persons, Eye Movement based Electronic Wheelchair System using MATLAB [6] came into existence. A head mount camera detects the eye movement and wheelchair is moved accordingly. The head mount camera is connected to the Laptop where a continuously running MATLAB script processes the image and gives command to the microcontroller to control the wheels of a Wheelchair [7-8]. This system came as a boon for such people. But the constraint was that you had to carry your laptop every time along with the Wheelchair System. That was bulky and costly.

To remove the bulkiness and costliness of the Eye Movement based Electronic Wheelchair System, which uses MATLAB, people came up with ideas of using Raspberry Pi to control the whole Wheelchair System. Since Raspberry Pi has its own OS and it is easily portable, people switched to using Raspberry Pi based Wheelchair System [9-15]. Although in the existing Raspberry Pi based Wheelchair System, latency (delay in response) is the biggest issue.

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Hence we have come up with a system that uses efficient algorithms for image processing using OpenCV and reduces the latency as much as possible. OpenCV processes the eye and by applying the two algorithms (Centroid and Threshold), movement of wheelchair is initiated. Python is used for programming the Raspberry Pi [10]. Shell Script is used to continuously run the same procedure when power is supplied to Raspberry Pi through power backups i.e. through power banks.

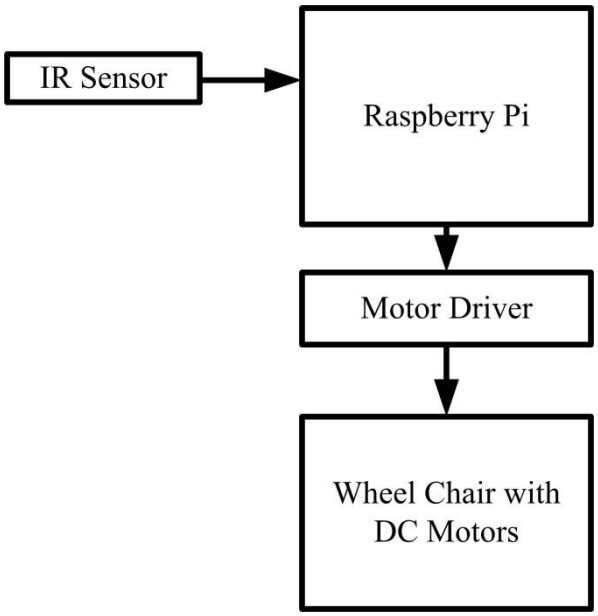


Figure 1. Block diagram.

2. Literature Survey

S. No.	Various Types of Wheelchair Technologies	Drawbacks
1.	Hand Gesture Based Wheelchair Movement [2] [11]	• It requires human effort to navigate devices which proves to be difficult for people with deformities.
2.	Voice Operated Wheel Chair [5]	• Less accurate on • Background Noise • Speaker variability • Speaking style • Speed of the speech.
3.	Head and Finger Based Automated Wheel Chair [1]	• It proves to be a burden to user. • Issues in accuracy.
4.	Eye Movement based Electronic Wheelchair System which uses MATLAB [6] [12] [13]	• You have to carry your Laptop along with wheelchair every time. That is burdensome and costly.
5.	Eye Movement based Electronic Wheelchair System which uses Raspberry Pi [16] [17]	• Latency is more for detecting eye movement and the Raspberry Pi to respond.

3. Methodology

Our system consists of the following modules.

3.1. Iris Detection

For simplicity, we have attached an IR web camera onto the handle part of the Wheelchair that is used to detect the eye motion. Then we have designed an algorithm to track the iris part of the eye using centroid calculation method and implemented the same in the Open CV. Once the iris is tracked, then the threshold is set.

3.2. Threshold

A very basic principle is used for the movement detection. The feature point of both the eyes is considered as the reference. The difference between the pixel values of eye positions is calculated by comparing current snapshot and the previous one.

The minimum movement of the eye for a valid attempt is considered as threshold. By evaluating the difference, and if the difference is above the threshold in any direction left or right, the corresponding flag is set. If the difference is less than the threshold value, then there is no need of movement. Sometimes failure in detection occurs due to non-linearity. At such instances a bias can be given to the eye, which was detected in the previous snapshot.

3.3. Driving Wheel chair

The diagrammatic representation of block diagram is given below.

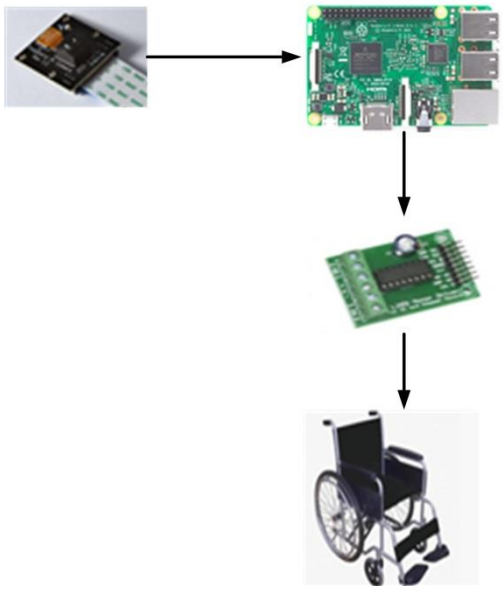


Figure 2. Diagrammatic representation **of** Block diagram

The method contains a Raspberry Pi in which OpenCV has been installed. IR Camera has been interfaced with the Raspberry Pi. IR Camera is used to capture real time images of person's eye and send it to continuously running OpenCV Python script. OpenCV Python script processes the image using Iris Detection Algorithm (Centroid Algorithm) and Threshold Algorithm. Then the command is given by the Raspberry Pi to the Motor Driver circuit regarding the position and direction in which the wheelchair has to move.

The Flow Chart of the methodology is given below.

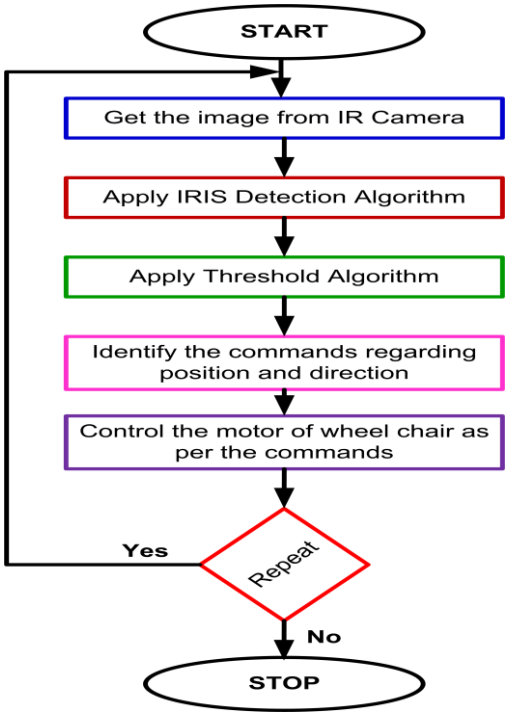


Figure 3. Proposed Flow Chart

3.4. Centroid Algorithm

Image Processing is done on every frame of image. From every image, eye is detected using the traditional Viola-Jones Algorithm. But to track the iris we have come up with an idea of using Centroid Algorithm. There are various methods already used for tracking eye movement. But these methods often fail to accurately estimate the eye centres in difficult scenarios, e.g. low resolution, low contrast, or occlusions. Our method is invariant to changes in scale, pose, contrast and variations in illumination. This method also reduces the latency (response time of the raspberry pi) to a very large extent.

What is does is that it crops out the only the eye part from the image. We convert it into gray scale image and then into binary image. In binary image, black represents zero and white represents one. So, we start traversing through the image along x-axis and y-axis and wherever we find zeros (black region), we make a set of those values and average them all to find the Centroid point.

The same has been replicated by the diagram given below.

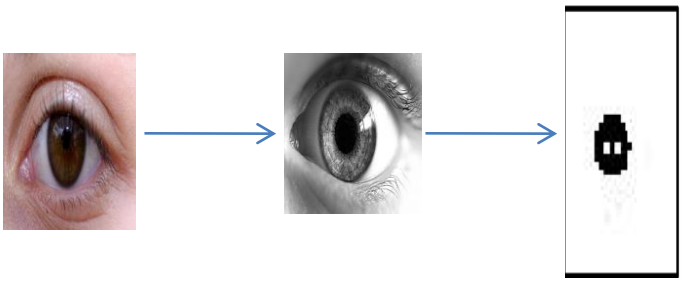


Figure 4. Steps in Centroid Algorithm

3.5. Threshold Algorithm

First find the length of the image captured. Along the length make two divisions using mathematical approach as shown the figure given below. The right division is the right threshold and the left division is the left threshold. If the Centroid position is between these two divisions, then the movement should be in straight direction. If the Centroid position is greater than right threshold, then initiate right movement. If the Centroid position is lesser than left threshold, then initiate left movement.

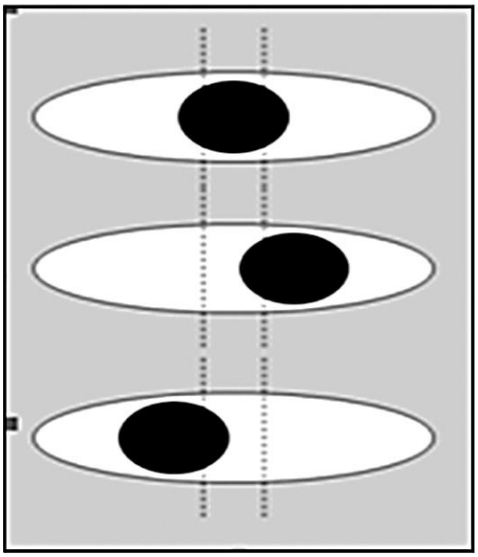
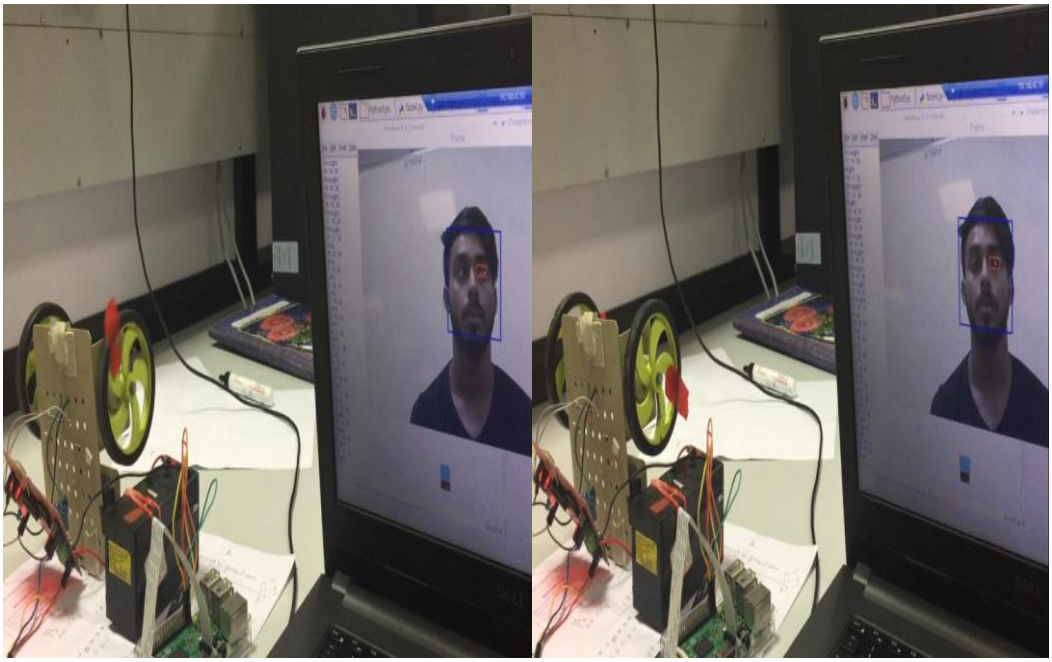


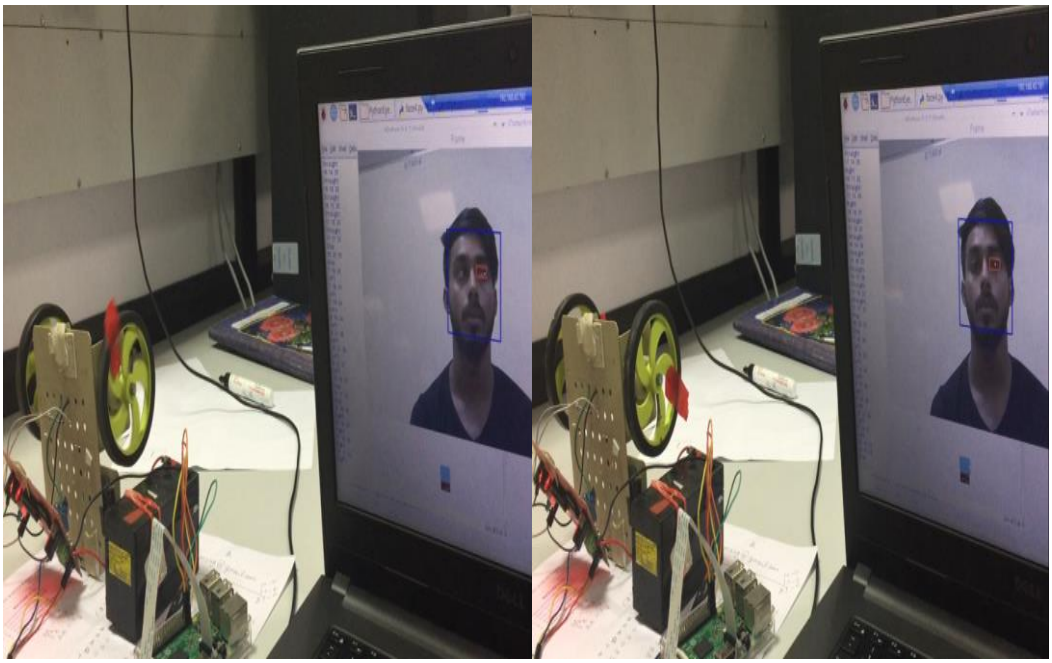
Figure 5. Steps in Threshold Algorithm

Table 1. Iris based Wheel Chair Control.

Eye Movement	Direction of Motion of Wheel chair
UP	Straight
Right	Right
Left	Left
Down	Stop



(a) UP Direction (b) DOWN Direction



(c) RIGHT Direction (d) LEFT Direction

Figure 6 (a – d). Movement of Wheel chair

4. Conclusion

Raspberry Pi is the latest of the technologies available in the modern world. But what makes Raspberry Pi special is that it has its own Operating System, thereby reducing the circuitry on the person's body. Cost also reduces a lot compared to other systems. Therefore, this method works as a boon for disabled persons. We have been able to make the system very accurate. Latency has also been reduced by using the Centroid and Threshold Algorithm. Self-Reliance is what we want to reinstate in disabled persons.

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