PUPIL CONTROLLED WHEELCHAIR

Soupal Paul, Bukkapatnam Kaushik Narasimha

Abstract— Over the past few decades, many types of research have been conducted to come up with a more efficient way of controlling a wheelchair to ensure the comfort and safety of people with physical disabilities or chronic diseases as well as for elderly people. The main motive for coming up with such a prototype was to come up with a way to allow patients with hand-leg impairment to explore the beauty of the world with more comfort and less strain on the pocket. This prototype will use an optical image recognition system to track the movement of the eyeball. The captured data will then be fed to the processor where the proper image processing takes place and the processed data will be fed to the motor drivers to control the movement of the wheelchair as shown in Fig.1. The challenging part was to come up with an efficient algorithm to get the required data from the eye without any distortions.

Index Terms— Pupil, Raspberry pi, Pi camera, classifiers, Open-Cv, python, image-processing.

1. INTRODUCTION

THE Pupil Controlled Wheelchair allows the patient to control the wheelchair without any direct physical contact and only through the movement of the eye ensuring increased serenity. A camera will be used to receive user images and to analyze the patient's intent using the movement of the eyeball. The objective was to come up with a design that is not expensive and thus can be afforded by all and at the same time produce the desired results. Since this system is designed for human use, extra care about safety is to be ensured. People using this type of wheelchair will save a lot of energy as the eyesight will be the main guide avoiding any physical movement to control the wheelchair.

These days, patients can choose from a variety of electric wheelchairs. Yet, these need to be operated through a controller (joystick or a remote) and so the patient is assumed to be able to move his/her hands. But, this is not the case for people with paralysis or with no hand movements and can carry out just the tiniest movement of the head and the eyes. Besides, controlling an electrically guided system requires the subject to be skillful and instructed. The control mechanism that has been implemented here is different from these above-mentioned mechanisms as this technique does not require any direct physical contact or physical efforts other than just the movement of the pupil in the desired direction which will allow the patient to cruise with ease and less energy utilization [1].

With the help of capturing, detecting, and tracking the pupil movement, the corresponding vector values pertaining to the suitable angular movement of the pupil will be found out through image processing methods in a python-based platform [16],[17].

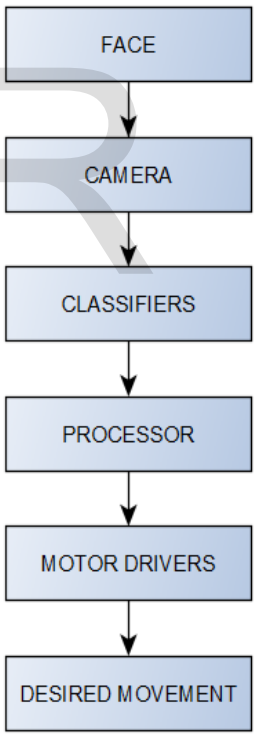

Figure. 1. Overview of the system.

2 METHODOLOGY

In this prototype, the microprocessor used was Raspberry Pi and to capture the image a camera module (Pi-cam) has been used. The programming language called Python has been used to code the algorithm in the processor. A library called Open-Cv has been used to carry out the image processing op-

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erations [2],[9]. To drive the two motors of the wheelchair a motor driver L293D has been used.

The Pi-Cam with the resolution (320-240) and a frame rate of 10 frames per second have been used to acquire the image. Only 10fps has been used to ensure the stability of the algorithm and also for safety so that the wheelchair does not deviate from its path rapidly. After acquiring the image, classifiers have been used to extract the face and eye from the input frame[12],[13]. Classifiers are a collection of data that have been mapped into a particular category using neural network and machine learning techniques [6]. If any data received from the input matches with the classifiers then it will crop that portion from the input image and will give an output. There are different classifiers for different types of categories. For the proposed algorithm the following two classifiers have been used [18],[19].

- Face classifier
- Eye classifier

Firstly by using the face classifier the face of the user will be extracted from the acquired image [11]. Then from that cropped image, the eye classifier will extract one eye from the face. Further, all the operations have been performed to this cropped image. In the processing section to proceed with the algorithm, the image has been converted to gray-scale as shown in Fig.2. This has been done for the purpose of processing is to emphasize more on the luminous nature than different colors [3],[5]. It also increases the processing time and reduces the complexity of the code as it works in an 8-bit format.

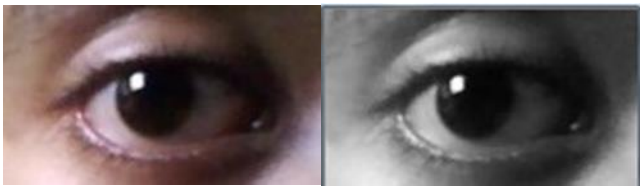

Figure.2. Conversion to gray-scale

The cropped eye image has a very low resolution due to which it was difficult to process the image. To overcome this problem an open-cv function called cv2.equalizeHist() has been used to enhance the contrast of the image as shown in Fig.3. This process is known as Histogram Equalization [7]. This function is used where the images are bright or dark. This basically allows the most frequent intensity values to effectively spread over an area to achieve a higher contrast as shown in Fig.4.

By the means of adaptive thresholding, the image has been made more prominent to identify the pupil from the rest of the eye [3]. With this method, only one black contour remains whereas the remaining portion of the image becomes white as shown in Fig.5. A function called cv2.dilate() has been used to make the pupil more accurate. This function increases the white region in the image so as to reduce the size of the pupil to make it more accurate [14],[15].

Contours are a curve joining all the continuous points which have the same intensity or the same color. So now with the help of contour function cv2.findContours() the position and the corresponding axis value of the pupil (contour) has been noted. Now by using the x-axis values, appropriate movement of the wheelchair will be assigned [4]. The motor driver will then make use of this information to drive the wheelchair. The values used in the functions cv2.equalizeHist(), cv2.dilate(), cv2.findContours() have been optimized to achieve the best results [8]

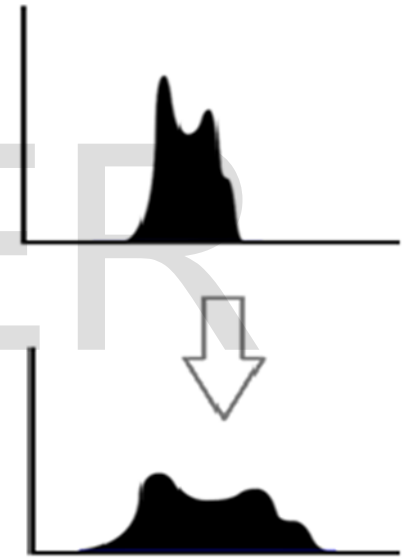

Figure 3. Histogram Equalization

Figure.4. Application of histogram function

Figure.5. Application of threshold function

3 METHODOLOGY AND INTERFACING

Raspberry Pi is a widely used microcontroller for projects. It is very useful due to its small size and its performance like a real computer. It has 4x ARM Cortex processors with 512 MB RAM and has a 1.2GHz processing speed. It has inbuilt Bluetooth, WLAN, and LAN ports. For interfacing with the other sensors, it has 40 General Purpose Input Output (GPIO) pins. It costs around 35$.

In order to carry out the process, the basic requirement is to boot the Raspberry Pi with its own personal operating system called 'raspbian'. This operating system has been installed in a 16GB memory card which has been used as a memory for Raspberry Pi. A laptop has been used to get all the displays from the raspberry pi and to perform all the operations. Raspberry Pi can be powered using any Micro-USB B type cable as the standard power supply recommended for Raspberry Pi is around 5.1V @2.5A.

The connection between putty and Raspberry Pi has been done using a wireless router. A software named Putty has been used to interact with the Raspberry Pi and to display the desktop of the Raspberry Pi another software called VNC-viewer has been used as shown in Fig.6.

Before starting up the Raspberry Pi the camera module has to be connected with the Raspberry Pi so as to start and enable the camera module. After starting the Raspberry Pi a server has been created with the help of putty software by the means of the IP address about the connection between the Raspberry Pi and the router. VNC-viewer utilizes the server created by putty to display the desktop of the raspberry pi. An open source library namely Open-Cv has been used. It is a python library which is used for real-time image processing operations. After completing the installation of the Open-Cv library, the python coding has been carried out.

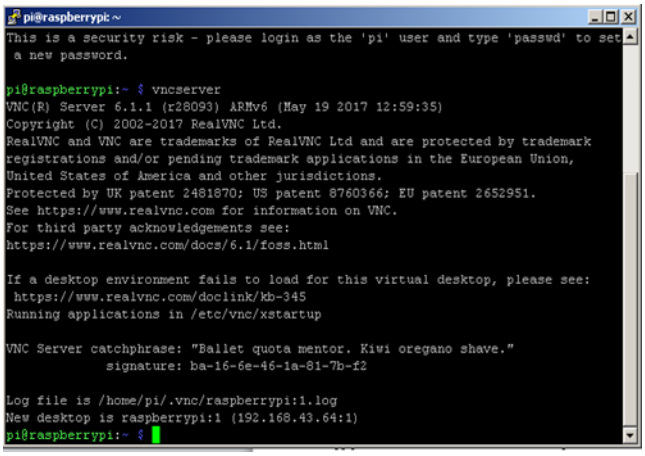

Figure.6.1. Initialization of server using putty

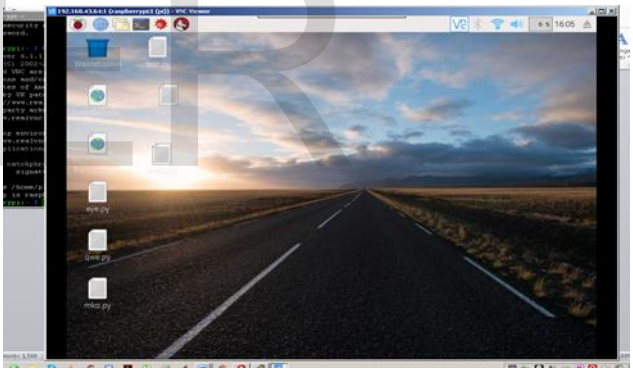

Figure.6.2. Display of Raspberry Pi using VNC-viewer

The processed information from the Raspberry Pi is transferred to the motor driver (L293D) by using jumper cables. A 12 volts DC supply has been used to drive the two 300rpm motors as shown in Fig.7.

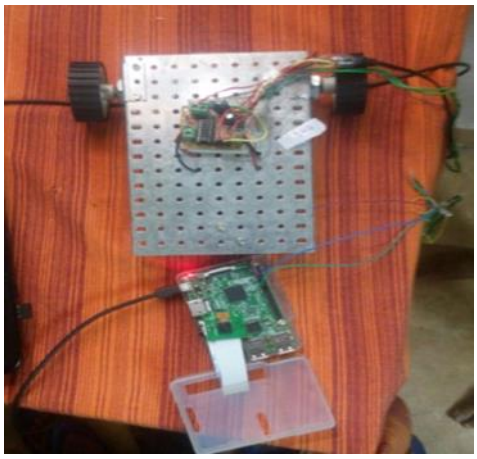

Figure.7.1. A prototype of the wheelchair

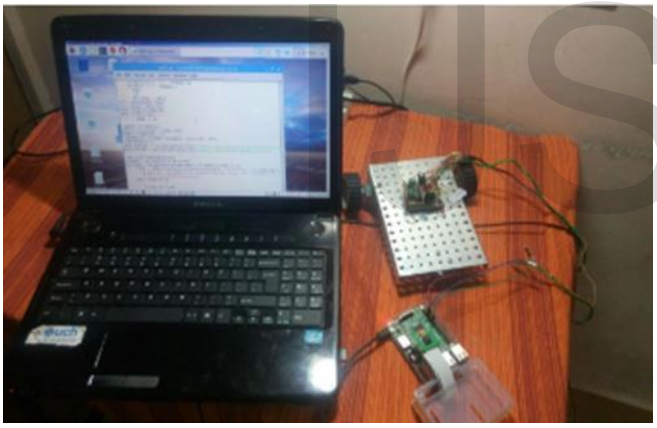

Figure.7.2. Implementation of the setup

mum results, the distance between the user and the camera module should be at least 5 centimeters apart. After capturing the image, the cropped image of the eye will get displayed on the screen as shown in Fig.9 with the center, left and right positions [10].

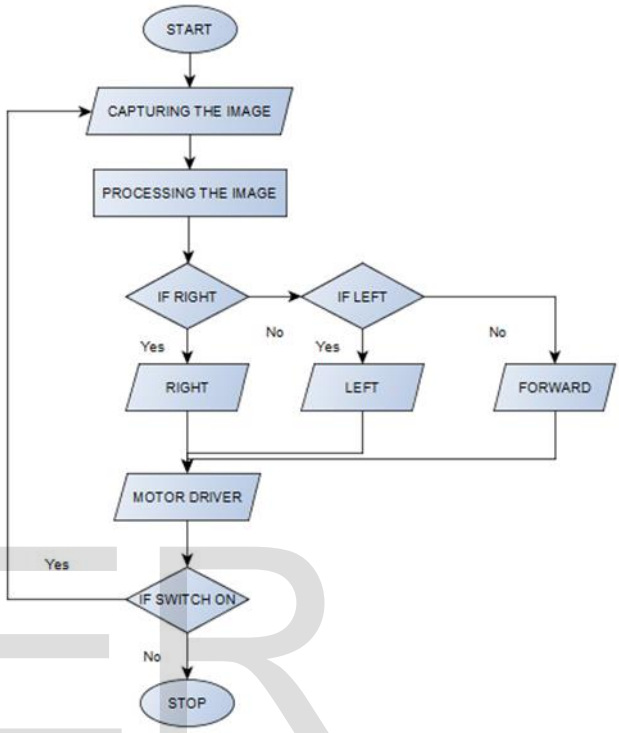

Figure.8. The process flow for the output

When tested on 10 different subjects for nearly 15 times each, the system efficiency was found out to be greater than 80%, which is good considering the small-scale prototype. The efficiency can be increased by making use of a better resolution camera with better low light performance.

4 RESULTS

This section mainly shows the prototyping and experimental results. Initially, the raspberry-pi will analyze the motion of the eye pupil and successfully send out signals to the motor driver circuit to perform the motion of the wheelchair in the desired directions.

When tested on several subjects, it was found out that if the axis value lies between 250 to 360, then the subject intends to move in the forward direction, if the axis value is less than 250, then the subject intends to move in the right direction and if the axis value is greater than 360, then the subject intends to move in the left direction, as shown in Fig.8.To get the opti-

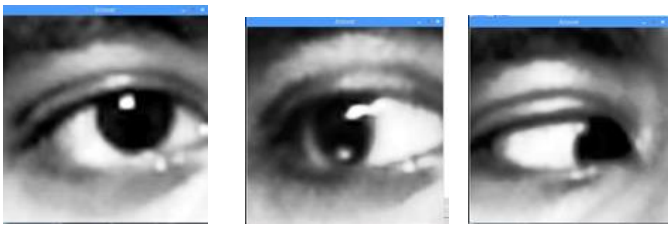

Figure.9.Different positions of the pupil

Figure.10. Final Outcome

5 Conclusion

The idea of controlling the wheelchair with the pupil movement is not only an alternative and effective technique but more importantly, makes the life of a physically disabled individual independent and allows him/her to explore the beautiful surroundings with comfort. However, there are some minor curbs pertaining to this prototyping like the system will take a tizme of 3 seconds between the capture of the image from the real-time video and its processing part for further execution. Therefore, there will be a minimal delay in the operation of the wheelchair if this technique is used. Moreover, since a camera will be used at the input stage to acquire data pertaining to pupil movement, there will always be a decrease in the efficiency if used under low light conditions. Even though the overall prototype works with a good efficiency, a lot of work has to be carried out before implementing it for commercial purposes.

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