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Camera Based Eye Controlled Electronic Wheelchair System Using Raspberry Pi

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***Abstract*— wheelchair is a mobility device designed for shifting patients, moving physically challenged people from one place to another. This paper includes the electronic wheelchair that implemented for disabled person to eliminate the attendee required to propel wheelchair. Controlling of wheelchair is fully depends on eye movement and emergency switch. A camera situated on wheelchair in front of the user for capturing the image of eye and tracks the eye pupil position by image processing techniques. According to the eye movement of user, motor will be move in respective directions such as left, right and forward. Ultrasonic sensor is mounted in front of wheelchair for safety purpose to detect static and dynamic barriers with some specific range of distance. Any obstacle in this specific range, wheelchair movement stops automatically. A switch is mounted on wheelchair for emergency purpose to stop in required direction if someone wants to interrupt or require attention on them. This is independent and low cost wheelchair system. A raspberry pi board is brain of the system.**

***Index Terms*— Image processing, Mobility device, Open computer vision image library, Python, Raspberry pi, Switch, Wheelchair.**

I. INTRODUCTION

There are various types of wheelchair like manual wheelchair, electric wheelchair. Manual wheelchairs are driven with help of man power as source of energy for moving the chair, these are self propelled or propelled with the help of attendee. The wheelchair that runs by means of electric motor is known as electric powered wheelchair. This wheelchair requires navigational controls, usually a small joystick mounted on the armrest for users who can not manage it manual joystick, head switches are provided and chin operated joysticks are provided ,other specialist controls are also provided for independent operation of the wheelchair[21].

Eye movement controlled wheelchair is to enable completely paralyzed patient as well as elderly to make their life more accessible [1]. Person who are unable to walk and are using wheelchair exert great amount of energy using physical strength to turn the wheels. Disabled would save energy and could use their hand and arm for other activities. Currently there are different eye based method will be use for controlling wheelchair such as EOG, ECG, EEG based, Eyeball sensing method [4]-[5]-[17]. To decide the location of eye pupil depends on voltage variation. But for different output voltage will be generates for different user, which gives wrong location of the eye pupil [6].Voice activated power wheelchair system, which works properly when user speak the command clearly, according to it left, right, forward, back and stop. Other voices which come from surrounding user may affect the system [19]. The head movement based system and chin control based system, bad movement gives problem [7]-[8]-[17]. Sip and Puff wheelchair system, not good for people with weak breathing. Infrared reflection based eye pupil detection system provide accurate detection of eye pupil centre location. But the infrared radiation affects the eye and people may loss the eye visibility [20]. Eye controlled wheelchair system is introduced using camera for capture the image [16]. But someone required attention on itself, so here we use central switch to stop.

Camera captured the image in real time based on face, eye and eye pupil detection with minimum delay of time and analyzes the image as input to set the commands to interface the motor driver IC through sending the command to GPIO pins, to perform the different operation such as left, right, forward and stop.

Image processing open computer vision (open CV) library is used for face and eye detection [2]. System includes multistage that is track the eye pupil centre [9]. To detect the single or multiple face and detection of both Eyes, this is ultimate goal of this system. Several Algorithms are used to find exact pupil location direction. Haar cascade like feature detection algorithm is used [3]. Image processing are includes face detection, eye detection, color image to gray conversion, blurring, edge detection, pattern matching , filtering, noise reduction, etc. Figure 1 shows the architecture diagram of the system.

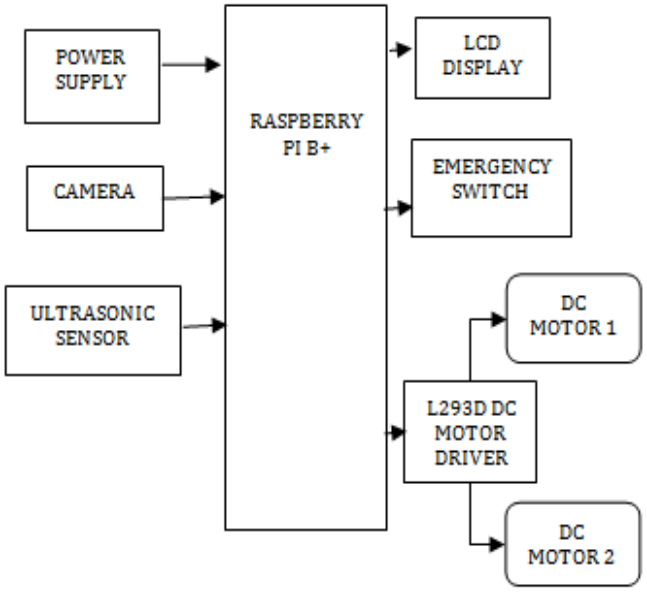

Figure 1: System Architecture Diagram

Raspberry pi board is soul of the system, which control the complete system operation. Image processing based data

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signal sent to the raspberry pi, raspberry pi received the data and analyze it and send the control signal to motor driving circuit, based on the location of eye pupil. This will decide motor run either in clockwise or anticlockwise direction or stop. Two individual motors are fixed on each wheel. Ultrasonic sensor is mounted on the wheelchair for obstacle detection. If sensor gets any obstacle very close to the wheelchair, it indicates to the raspberry pi and it will sends the signal to motor driving circuit to stop the motor.

II. HARDWARE DESIGN MODEL

In this system there is mandatory to gives the power supply to individual components and standard power supply should be used for raspberry pi, camera, sensor, motors and switch. The figure 2 shows the functionality of the system.

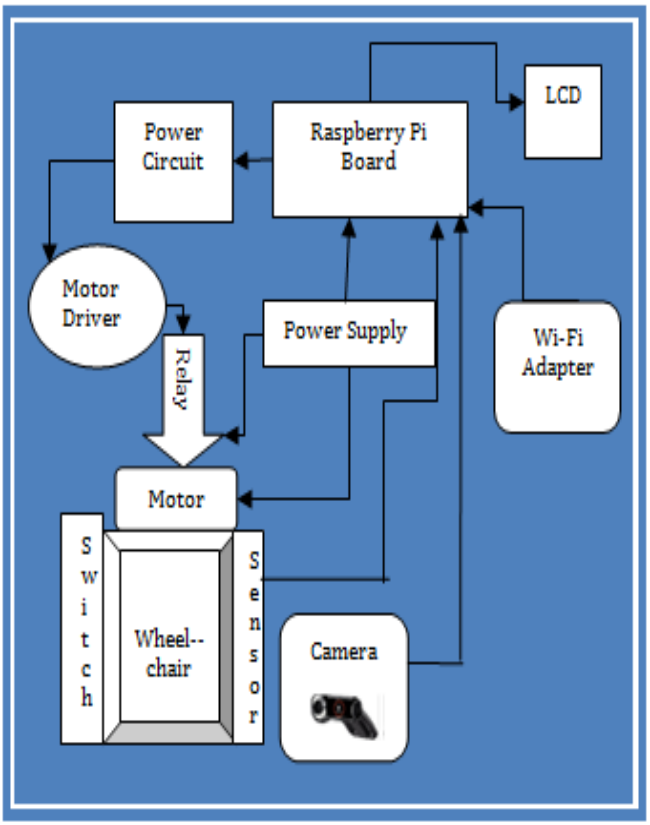


Figure 2: Design Model

In proposed system component like LCD, camera, power circuit and Wi-Fi adapter directly connected through the raspberry pi board and raspberry pi board is connected to the web server for remote access [10], in case of emergency controlling or check the status of wheelchair.

1) HARDWARE DESCRIPTION

A) Raspberry pi board

Raspberry pi board is brain of the system. Raspberry pi board have its own operating system is known as raspbian which is Linux based operating system and compatible with raspberry pi board. A real time data receive and determine the digital data by raspberry pi B+ model board, which is very efficiently work with the multiple images. Raspberry pi sends the command to motor driver which is enabling the GPIO pin to raspberry pi.

B) Web camera

Web camera is used for capturing the image. We can also use HD (high definition) camera but it increase the memory size, system can't able to read the image and it will increase the processing time. UV4L driver is needed for interfacing a camera with raspberry pi board.

C) Ultrasonic sensor

Ultrasonic sensor is used to detect obstacle in the path of wheelchair. Sensor is directly connected to the raspberry pi board. It receives the data and measuring the distance between wheelchair and obstacle. If any obstacle is detected very close to wheelchair, motors will stop to run the wheels. Ultrasonic sensor is a very affordable proximity / distance sensor that has been used mainly for object avoidance in various robotics projects.

D) Motor

Two 12 v DC motor is used in project to demonstrate running of wheelchair in forward, reverse, left and right direction. L293D motor driver is used to interface with raspberry pi which is TTL compatible. Two H bridges of L293D can be connected in parallel to increase its current capacity to 2 Amp.

E) LCD (Liquid crystal display)

LCD is very helpful in providing user interface as well as for debugging purpose. Most common LCD controller is HITACHI 44780 which provides a simple interface between the controller and LCD. LCD is used as a monitor in most of the electronic project.

F) Relay

Relay is an electromechanical device and basically consists of an electromagnet and a number of contact sets. Relay is used in this system to change the direction of motor very fast without using the finger.

2) SOFTWARE DESCRIPTION

A) Putty software

Putty is a free and open source terminal emulator and network file transfer application. Putty software is used to connect the desktop to raspberry pi board.

B) OpenCV image library

OpenCV is released under a BSD license and free for both academic and commercial use. It has C++, C, Python and Java interfaces and supports Windows, Linux, Mac OS, iOS and Android. OpenCV was designed for computational efficiency and with a strong focus on real time application.

C) Python language

Python is an interpreter, object oriented, high level programming language with dynamics semantics. Its high level built in data structures, combined with dynamic typing and dynamic binding; make it very attractive for rapid application development. Python's easy to learn syntax emphasizes readability and therefore reduce the cost of program maintenance. The fast edit – test –debug cycle makes this very effective. Moreover Matlab is used for coding but it is quite expensive and algorithms are proprietary, math work puts restriction on code portability.

3) DESIGN METHODS

Algorithm used for detecting the eye pupil location by image processing. Several stages used to determine eye movement such as face and eye detection, colour to gray conversion, canny edge detection, Hough circle transform and eye tracking. Initially the system received the captured images by USB web camera. Our first aims to detect the user face accurately. If there are multiple faces, it will show the error. System indicates the face of user in a specific area of image. After that it will perform the several operation of image processing to track the eye movement. Figure 3 shows the proposed methodology of implemented system.

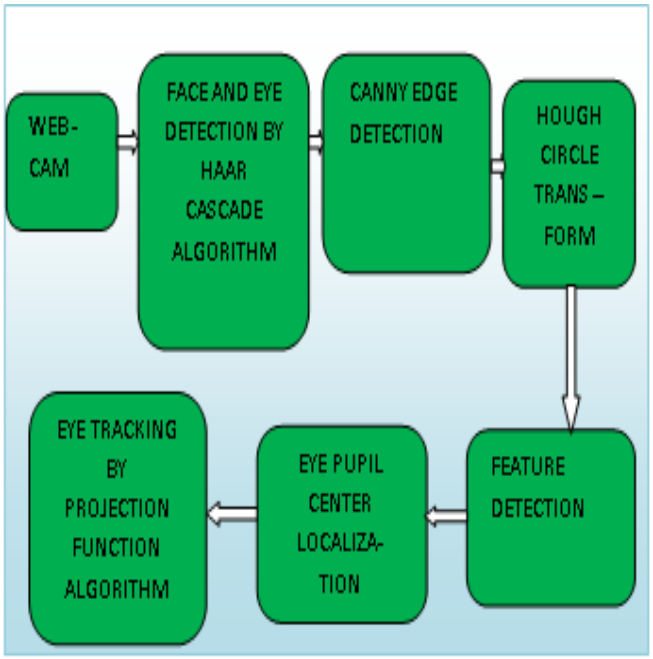


Figure 3: Proposed method

Camera will start to capture the images. For the face and eye detection Haar cascade algorithm is used. After detection of face, it will try to detect the eye inside the face and draw the rectangular box over the eye. To detect the eye pupil and define its centre points is ultimate goal of the system by several images processing technique. The system will crop the eye region of interest and it will draw the all possible circle on that particular area to detect the eyeball. Then we applied corner detection method to detect the corner. Average of these two points indicates the centre point. To measure the distance between the centre point and eye circle centre point using coordinates system. Minimum distance indicates the eye pupil in left and maximum value indicates the eye pupil presented in right. If there is no movement of eye it will indicates eye is in middle position [11]. When eye move in left, left side motor will run and when eye move in right, right side motor will run. If eye will be in centre, both motors moved and wheelchair moving in forward direction. If any obstacle is detected, system will be stop and move either in left or right direction according to eye movement. If someone calls the user, user will stop the wheelchair by emergency switch. Eye blinking logic will be decide the start and stop operation [12]. For edge detection canny edge detection is used. For circle detection Hough circle transform method is used. Image processing based on openCV library is installed in raspberry pi memory. Figure 4 shows the flow chart of system.

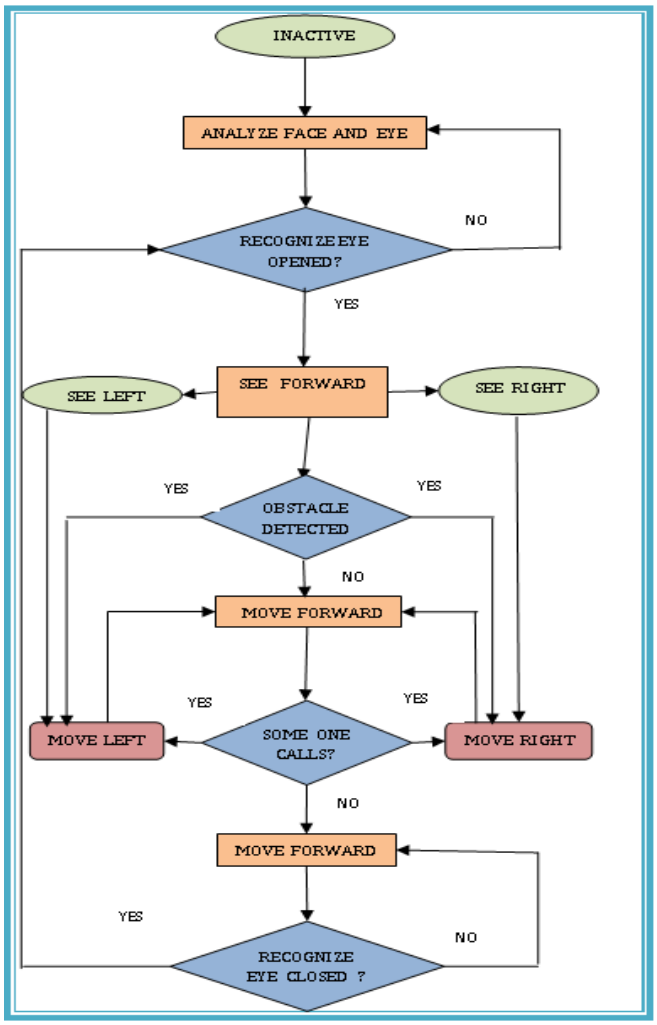


Figure 4: Flow chart of system

III. IMPLEMENTATION AND SYSTEM DESCRIPTION

The low power consumption credit card sized raspberry pi B+ board is used, which have inbuilt 40 pin GPIO, 4 USB ports, UART, PWM, HDMI port and Ethernet adapter port for internet connection via wireless or wired connection. Raspberry pi have a 512 MB RAM and capable of up to 32 GB external memory, controlled based on ARM architecture. Camera is directly connected with raspberry pi board and continuously captures the images, distance between eye and camera device is fixed. It may be 10 to 15 cm. Face and eye detected by Haar cascade algorithm and find out the exact pupil location. Then several algorithms used to measure the centre point from the average of both corners of the eye. This gives the correct information eye movements. The motor driving circuit is connected with raspberry, battery for power supply of motors, relay for controlling the motor driving IC. System continuously generates the directive signal to enable the GPIO pins and perform the required operation like left, right, forward and stop. Central switch is also connected with system for emergency purpose. Ultrasonic Sensor for obstacle detection.

IV. SYSTEM INSTALLATION

To boot a train image in micro SD card win32 diskimager software used. Then putting a bootable memory device on

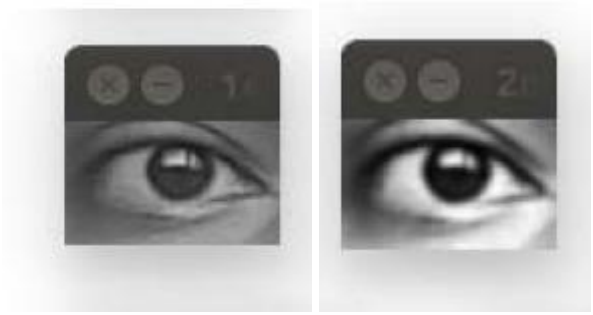
raspberry pi board and admit the raspbian operating system directly without resetting [16].

V. EYE TRACKING

There is several image processing operation performed in system, such as

1) BGR to Gray Conversion

A colored image is converted in to gray image to reduce the system delay time because image frame size should be low for proper processing.



a) Gray images

2) Feature Detection and Blurring Image

The Gaussian blur filter is used for blurring the image, which helps to detect the exact edges of specific area of the cropped image.

b) *Gaussian blurred filter image c) feature detection on image*

3) Canny Edge Detection

Canny edge detection algorithm used a blurred image. It will be applied for soft edges of the image.

d) Canny edge detection

4) Hough Circle Transform

We use Hough circle transform method to draw a circle on eye pupil.

e) Hough circle transform

5) Eye Tracking

To track the eye movement we use coordinate system. Which decide the eye centre point location [13]-[14]-[16]. Figure 6 indicates the eye pupil location using coordinate system graph.

Where A1 and A2 is corner point of eye pupil in X direction, B1 and B2 is corner point of eye pupil in Y direction. The X and Y calibration point represent the direction of eye movements [15]-[16].The eyeball position at the (A0, B0) points is:

A0 = (A1+A2) / 2

B0 = (B1+B2) / 2

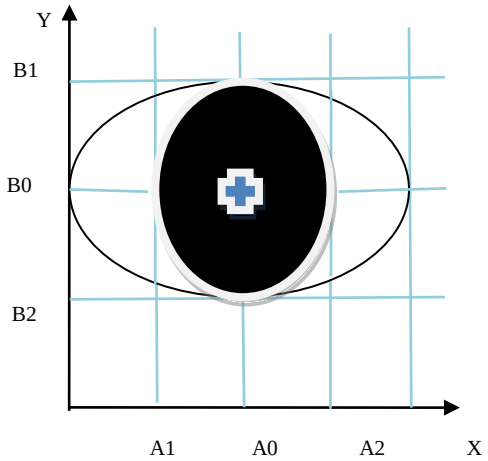


Figure 5: coordinate system with respective eye position

VI. RESULTS

The wheelchair system received the resulted data of image processing and based on eye pupil centre location. It sends the command to motor driving circuit. Then wheelchair moves in required direction according to eye movement. Ultrasonic sensor is used in this system for obstacle detection. It measure the distance between wheelchair and obstacle. When obstacle is very close to wheelchair, motors will stop the wheelchair. Central switch is used for emergency purpose to stop the wheelchair. Figure 6 shows the Output of the system.

Figure 6.1: Eye center localization

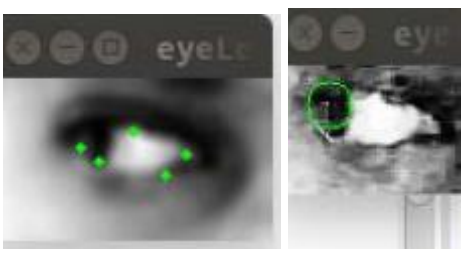


Figure 6.2: Eye pupil in left direction

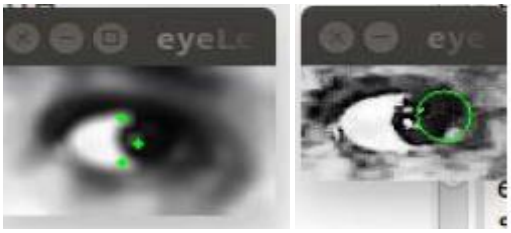


Figure 6.3: Eye pupil in right direction

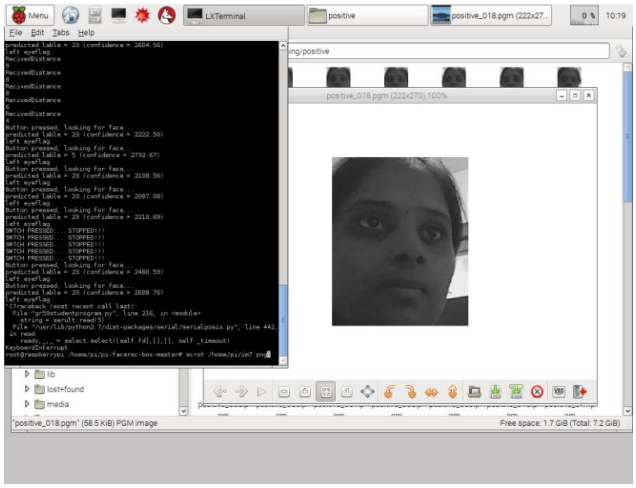


Figure 6.4: Final output of the system

VII. CONCLUSION AND FUTURE WORK

A. *Conclusion*

In this project we developed a wheelchair system which enables the disabled patient to move their wheelchair independently in their own direction. In the real time application, we can use camera, emergency switch and ultrasonic sensor depends on their application. The wheelchair movement operation with some delay time. Dark light places affect the performance of wheelchair, difficult to track the eye pupil in dark light.

Some of the more unusual aspect of this project is that the equipment and parts are all readily available and off the shelf including much of the software. The cost for the eye controlled wheelchair is slight increase in cost over a normal power wheelchair.

B. *Future work*

To make the system more interact with patient we need to add some additional sensors. Delay time may be further reducing to a second. Operation of system depends on eye movement of totally paralyze patients. Thus wheelchair moves in all required direction with good response so it will be used in day to day life like physically challenged, old people unable to walk, physically challenged children.

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