AUTONOMOUS CAMERA BASED EYE CONTROLLED WHEELCHAIR SYSTEM USING RASPBERRY-PI

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Abstract:
A novel technique is implemented for the eye controlled based independent and cost effective system. The purpose of Eye movement based control electric wheelchair is to eliminate the necessity of the assistance required for the disabled person. And it provides great opportunity of the disabled to feel of independent accessible life. The implemented system will allow the disabled person to control the wheelchair without the assistance from other persons. In this system controlling of wheelchair carried out based on Eye movements. The camera is mounted in front of the user, to capture the image of any one of the Eye (either left or right) and tracks the position of eye pupil with the use of Image processing techniques. According to the position of the eye, wheelchair motor will be directed to move left, right and forward. In addition to this, for the safety purpose ultrasonic sensor is mounted in front of wheelchair to detect the obstacles and automatically stop the wheelchair movement. To make system cost effective for monitoring, a Raspberry pi board allowed accessing the system without displaying unit.

Index Terms- *Image Processing, Open Computer Vision*
Library, Python, Raspberry Pi, Wheelchair

I.INTRODUCTION

The Wheelchair is dependent system used by elderly and physical disable persons. Here introducing the design implementation models of totally independent Eye control electric wheelchair. As per requirement of the disabilities deferent kind of automatic systems are available in market such as voice control or joystick control system. Sometime for totally paralysis person may be have very difficult to use that type of systems. Here the Eye control system provides the independence to make their life easy and more convenient [1]. And also they save the huge amount of energy or external man power. Camera captured the image in real time and analysis the image as input to set the commands for interface the motor driver IC through sending the commands to GPIO pins. The motor driver circuit is used to perform the different operation such as left, right, forward and stop.

For the advance level of Image Processing open computer vision (OpenCV) library is used for Face and Eye detection [2]. And several application and algorithms are used to find out accurate pupil location detection and tracking of that. One of them is Haar cascade like features detection algorithm used to detects single or multiple face and detection of both eye [3].To detecting the exact Eye pupil and locate its center point is ultimate goal of this system. For automatically find out Eye pupil and tracking eye pupil many computer vision library of Image processing are used like object detection, motion detection, Image

colour conversion, edge detection, pattern matching etc. For eye pupil tracking there are several number of other techniques available [4] [5]. But they have its own limitation. One of them ECG, EEG and EOG sensor based eye pupil detection technique is available [6] [7], where voltage variation based output assumed to decide the location of pupil [8]. But for different user, different output voltage will be generates, which will result faulty location of the eye pupil. The head movement based system have limitation, when user can not able to access the system physically [9] [10].

Moreover, voice activated power wheelchair which works properly, when user speak the command system works according to it like left, right, forward, back, stop. But a noisy environment distracts the system, and system cannot respond properly. And other infrared reflection based eye pupil detection system providing accurate detection of the eye pupil center location, as well as system can track the eye movement. But the infrared radiations affected the eye and user may loss the eye visibility. Therefore, an effective camera captured image based eye pupil detection and tracking system is introduced. Figure 1 indicates the system architecture of the hardware system.

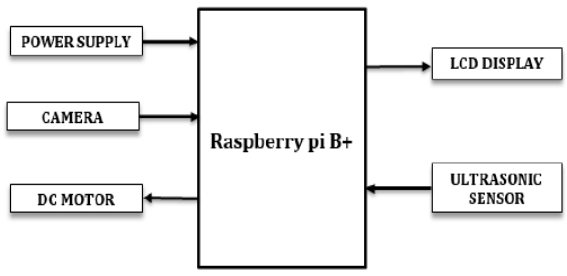


Fig. 1. System Architecture diagram

This is efficient as well as cost effective system. Here real time video image capturing based on Face, Eye and Eye Pupil detection with minimum delay of time is used. The system includes multistage that is mainly track the Eye pupil center [11]. A novel Eye tracking technique, which capture the image and detects the presents of human face. After detecting the face, it detects area of the eye location on the face detected image, and performs several operation of basic image processing like colour image to grey conversion, filtering, threshold, pattern matching, noise reduction and circle detection on it [12].

The Raspberry pi board is used to perform the control of the complete system operation. Digital Image processing based output signal sent to the Raspberry pi board. The Raspberry pi acquired the data and analyzes it. Raspberry pi send the control signal to motor driving circuit based on the location of eye pupil. This will decide to perform operation on motor like run the motor in clock voice direction, anti-clock voice direction and stop the motor. In a Wheelchair two individual motors are embedded on each wheel. The Ultrasonic sensor is also mounted on the wheelchair for detection of any static or mobile obstacle. If sensor gets the obstacle very close to the wheelchair, it will indicate to the raspberry pi and raspberry sends the signal to motor driving circuit to stop the motor. The rest of the paper is organized as follows. In section II discuss the system Design model. The section III describes the methodology applied for overall system and the section IV represents the implementation and system description of the proposed system, and last

section of paper shows the result and conclusion of proposed implementation.

II. SYSTEM DESIGN MODEL

This system is totally autonomous system, and the entire module will work independent each other. For the basic requirement of the any electronic system is Power supply. In this system there is mandatory to gives the proper power supply to individual components and the standard power supply should be used for Raspberry pi, camera, sensor, and motors. The figure 2 represents the overall functionality of the novel implemented system

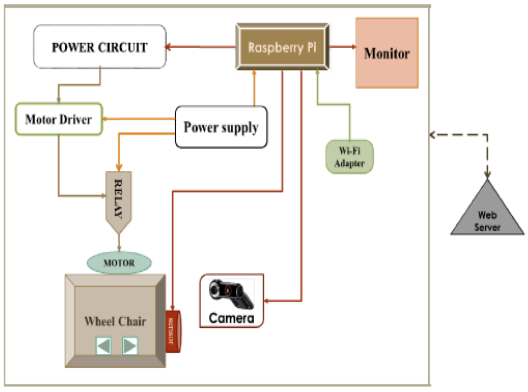


Fig. 2. Proposed system Design Model

The Raspberry pi board is brain of wheelchair. In proposed system model the module like monitor, camera, power circuit and Wi-Fi Adapter is directly connected through the Raspberry pi board. And Raspberry pi board is connected to the internet for remote access facilely [13], In case emergency controlling or monitoring the status of wheelchair, will be carried out by access the raspberry pi board at remote place using web-server (internet).

In this system the Raspberry pi is playing a main role of hardware part. A real time data acquisition and analyzing the signal Raspberry pi B+ model board is very efficiently process the multiple image frames by frame. For capturing the image normal web camera is used in our system. Moreover, High resolution HD web camera can be used but it increases the image memory size in MB. So that system cannot read the image and process efficiently as per requirements, and it will also increase the processing time. The Raspberry gives the commands to the motor driver circuit, which is enabling the GPIO pin to perform operation. Such as forward, left, right and stop operation performed based on eye movements. Sensors are also mounted on the head of wheelchair for detecting the obstacles and controlling the wheelchair. Ultrasonic sensor is used for detecting the obstacle or any moving object in front of wheelchair. The sensor is directly connected to the Raspberry pi board, it acquired the data and measuring the distance between wheelchair and obstacle.

This system is comes under real time data acquisition, data processing and controlling system. There is real time video capturing and advance image processing used on it. For using Raspberry pi board, they have its own operating system is known as "Raspbian", which is Linux based operation system and also compatible with raspberry pi board. To detect the exact eye pupil location is very challenging. A new image processing technique used for eye pupil center detection and tracking, which works based on open computer vision (OpenCV) library. Most of coding part done with the help of OpenCV library. There is a several algorithms like Haar cascade, Hough

transform, edge detection are available for different application. To connect the raspberry pi board to desktop Putty software is used. Python language is used for Codding, which is user friendly and helpful to resolve the error efficiently. Open CV 3.0.0 library with python is used in this system.

III. METHODOLOGY

The principle of this system is eye pupil detection and eye tracking based on computer vision technology. A new algorithm introduced for detecting the eye pupil location by Image processing. In this technique several stages used to find out the movement of eye, such as Face detection and Eye detection, color conversion, Edge detection, Hough Transformed, motion detection and object tracking. During initial stage the system acquired the captured Images by USB Web camera. The first direction is to detect the user Face accurately. If there is multiple faces are presented it will display the individuals and also showing the run time error. A system indicates and represents the face of user in a specific area of image. After that system will performed the several operation of image processing to track the Eye pupil. The figure 3 represents the complete methodology of proposed implementation. Here it will give the step by step information of the system working.

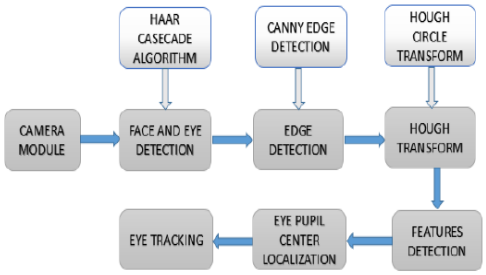


Fig. 3. System Process diagram

First camera module will start to capture the images. For the face detection Haar cascade algorithm is used. After detection of proper face, it will try to detect the eye inside the face region of interest. And again Haar cascade algorithm is used like as face detection to detect eye. It will draw the rectangular box over the Eye. Now, the main target is to detects the eye pupil and define its center points. There is several image processing operation performed in system, such as blur Image, color conversion, thres holding, filtering, edge detection and Hough transform is used. For circle detection Hough transform method is used. By using the USB webcam allowed to capture the images on raspberry. And Image Processing based all OpenCV libraries are installed in raspberry pi memory. There it will process and working without any processing delay. The figure 4 shows the Flowchart of system working.

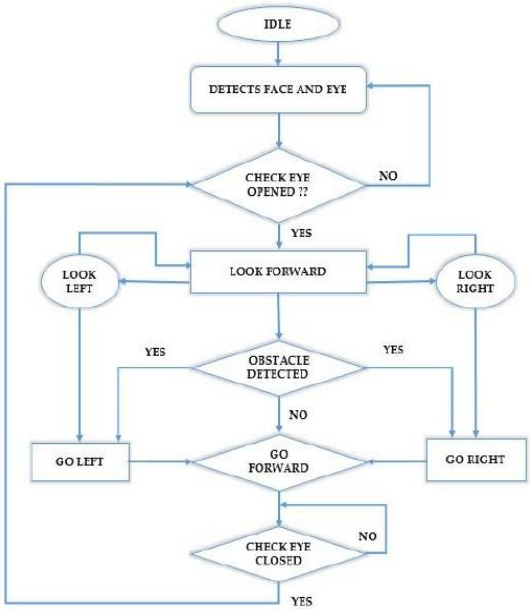


Fig. 4: Flowchart of system working

The system will crop the eye region of interest initially and it will detects all possible circle presented on that particular area. Than it will successfully detects the eye ball. After that corner detection method we applied for eyes region of interest, and find out the corners. Where average of both two point defined its Center point. Now we measure distance between the Center point and eye circle Center point using coordinates system logic. According to the eye pupil movements, distance will be vary. A minimum distance indicates the eye pupil presented in left, and maximum values indicates the eye moved on right. And if there is no movements of the eye, than it concludes eye is in the middle position [14]. Than the commands applied for all operation, when eye movement is left, a wheelchair left side motor will run. And when the eye moved is right the right side motor should be moved. If eye will be in Center both motor moved, and wheelchair moving in forward direction. For start and stop operation of wheelchair movements for eye blinking logic applied [15]. If eye closed for 3 sec. a system completely stops and once again it will close the eye for 3 sec, system reactivated.

A system started with capturing images continuously by camera. And captured images processed in Raspbian system. USB camera is used to capture the image at high pixel rates. In idle condition the eye will be consider open. Once the power supplied is on, the system will start working, and according to the command values system will work.

IV. IMPLEMENTATION AND SYSTEM DESCRIPTION

This system implementation is working based on real time data acquisition operating system. The low power consumption Raspberry pi B+ advance board computer is used. Which provides well enough in/out pins, USB ports, UART, PWM, HDMI port and Ethernet adapter port for connecting it through internet via wired or wireless connection. Also raspberry pi have up to 32 GB external memory capably. The raspberry pi have a 512 MB RAM and controlled based on ARM architecture. The figure 5 represents the experimental setup of the system.

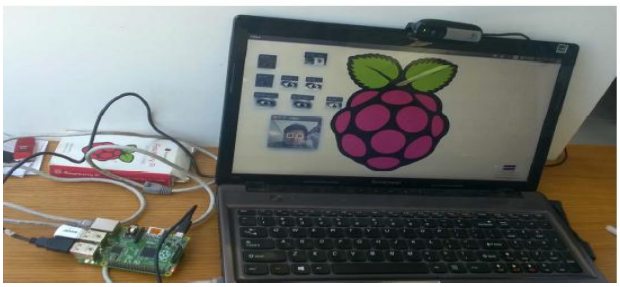


Fig. 5: Experimental setup of System

The camera module is mounted in front of user Eye. And important part is a distance between eye and camera device is fixed. It may me 10cm to 14cm. Camera will capturing the images of user face, and find out the exact pupil location.After detecting pupil location, system algorithm measure the center average value from the corner of the Eye. Which gives the correct information of Eye movements. For controlling the motors driving IC, 2-channel relay board and battery for power supply of motors is used. The motor driving circuit is connected with Raspberry pi, which is operates the entire system. Camera module is directly connected with raspberry pi, and continuously capturing the Images. Than system generates the command signal to enable the GPIO pins and perform the Left, Right, forward and stop operation.

A. Raspberry pi operating system installation:

A very basic step is followed to install its own operation system in micro SD card (memory device). To boot a Raspbian image file win32 disk imager software used. While putting a bootable memory device on raspberry pi board, then it can access the Raspbian operating system directly without rebooting.

B. System algorithms:

In our system open computer vision (OpenCV) free access library algorithm used for Image processing. The OpenCV library plays a very important role, and it gives the knowledge of Image processing. A novel algorithm used for system execution and perform the operation. To find out the pupil center point of the Eye, we followed some steps:

1) Face detection and Eye detection:

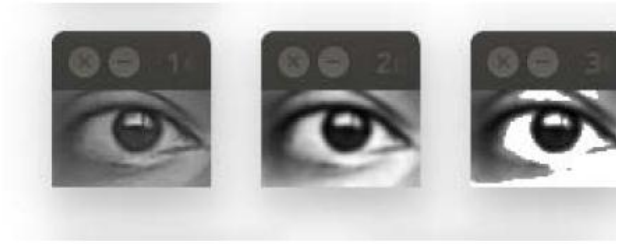
For the face detection and eye detection the OpenCV library can be used directly, which is shows in figure 6.1. A very first Haar cascade algorithm is used for both Face detection and Eye detection individually.

Fig. 6.1. Face and Eye detection

A system camera detects the face of user. Once it will detect, system found the eye location and marked the eye region using Haar cascade algorithm. And system accurately detects both the eyes based on the proper distance of the each other.

2) BGR to Gray conversion:

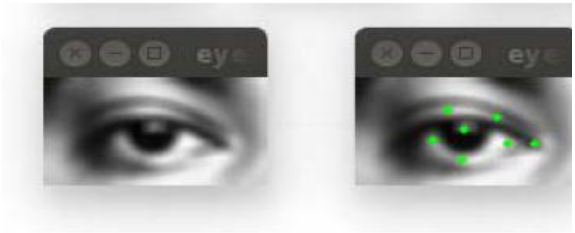
A very next operation of the image color convention to reduce the system delay time. The Image frame size should be low, because the processor cannot processing the image frames in run time condition. So, by using the BGR to GRAY conversion a colored image converted into gray image. The given figure 6.2(a) indicates the crop color image of the Eye, figure 6.2(b) indicates the colored image to gray converted image and figure 6.2(c) shows the threshold image.



(a) Color image, (b) BGR to Gray conversion image,
(c) Thresholding on image.
Fig. 6.2

3) Features 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. Features is nothing but it found some special pattern on image which is unique, based on it will make a pattern. A figure 6.3(a) indicates the blurred image and figure 6.3(b) indicates the featured detected image

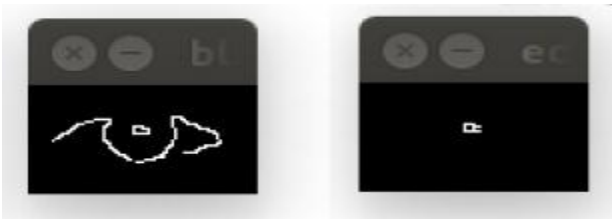


(a) Gaussian blur filtered image and (b) featured detection on image.
Fig. 6.3

The next operation of Hough circle transform algorithm. Worked based on it. In canny edge detection algorithm system
used a blurred image. In the figure 6.3 shown the blurred image.

4) Edge detection:

A canny Edge detection and corner edge detection algorithm is applied for determine the soft edges of the image. To set the proper threshold value it will allowed easy to recognize rectangles or circle presented in Image. A figure 6.4 indicates the edges of pupil.



5) Hough Transform:

Over the edge detection resulting image we use Hough circle transform method to draw a circle on eye pupil. Camera capture the images continuously and according to eye movement, a Hough circle transform detects the movements of eye pupil and drawing the circles. In given figure 6.5(a) indicates the features detection on image and in a figure 6.5(b) indicates circle draw on image.

***6)* Eye Tracking:**

To track the Eye movements we use projection function algorithm was used, where the coordinates system points the eye center point location [16] [17]. In figure (7) indicates the eye pupil location with respective coordinate's system graph.

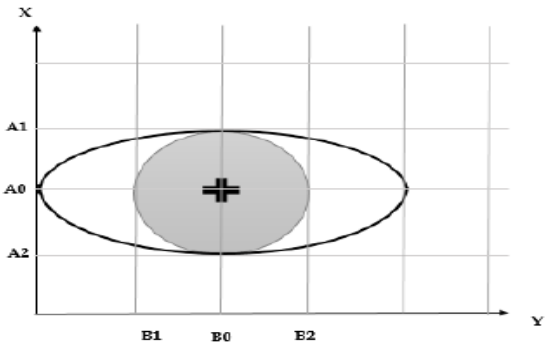


Fig. 7. Coordinates system with respective eye position The horizontal and vertical axis based two directional graph represents the eye movements in left or right direction. And detects average point of eye pupil location. A captured Projection function graph shows relation between the eye center and respective projection points. The X and Y scale points indicates the directions of the eye movements [18]. The eyeball position at the (A0, B0) point is:

A0= (A1+A2) /2

B0= (B1+B2)/ 2

Where the A2 and A1 is the corner point of the eye pupil, and A1 and A2 indicates the corner points of the eye in X direction. In vertically B1 and B2 indicates the corner of the eye pupil in Y direction. The coordinate points (A0, B0) represents the actual eye location. And based on that system send the commands for wheelchair movements. The figure 7.1 shows the Eye located in center position, figure 7.2 indicates the Eye pupil position located in left side of Eye and figure 7.3

indicates the Eye position on right side of the Eye. A system is working according to the position of the Eye pupil and perform wheelchair movement in left, right and forward direction.

Fig. 7.1. Eye center localization and circle detection

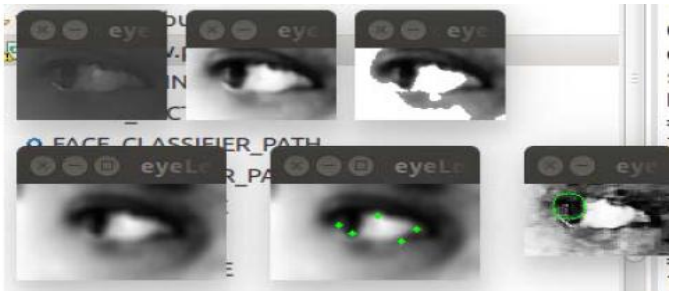


Fig. 7.2. Locate the Eye pupil in left direction

Fig. 7.3. Locate the Eye pupil in right direction

C. Peripherals interfacing with Raspberry pi board:

A system used USB 2.0 webcam for capturing a video, and also Ultrasonic sensor is used to detect obstacle. The pixel resolution of transferring image is 680x480 pixels. To support the video processing gsstream properties setting required and for interfacing a camera with Raspberry pi UV4L driver is needed. The VLC video player used for taking snapshot of the experiments and testing results. The motor driving circuit is connected with the raspberry pi board. In case to control a device or monitor the status of system, system can be monitored in remote place. The Tenda Wi-Fi adapter used to make it remote accessible.

RESULTS:

The system acquired the resulted data of image processing, and based on the Eye

pupil center value signal send to the motor driving circuit for movement of Wheelchair. The exact figure of resulted video processing output shown in figure (8).

Fig. 8. The center of Eye pupil and circle detection output

There the system used the ultrasonic sensor for obstacle detection. And successfully measure the distances between the wheelchair and obstacles. When the object is detected very close to in front of Wheelchair and cross the minimum distance threshold value, emergency brake will be applied to stop the Wheelchair.

CONCLUSION

The concept of the eye controlled wheelchair is not only represents the alternative resources but more important to help physically disabled persons to make their life independent. The aim of implementing an autonomous eye controlled wheelchair is to highlight the features of digital Image processing. There are some real time design constants measured like a system takes some time (4second) to execute the system for processing the video in Real time Environment. Therefore the system performs the Wheelchair movement operation with some delay time. It's very hard to track the Eye pupil in dark light places, so the system works perfect on environmental light and in a room light with fluorescent mercury vapor lights, which is low in infrared.

REFERENCES

[1] Sarangi, P., Grassi, V., Kumar, V., Okamoto, J.:"Integrating Human Input with autonomous behaviours on an Intelligent Wheelchair Platform", *Journal of IEEE Intelligent System*, 22, 2, 33-41, [2007].

[2] Matt Bailey, ET. Al, "Development of Vision Based Navigation for a Robotic Wheelchair", in *Proceedings of 2007 IEEE 10th International conference on rehabilitation robotics*.

[3] Shafi. M, Chung. P. W. H:"A Hybrid Method for Eyes Detection in Facial Images", *International Journal of Electrical,Computer, and Systems Engineering*, 231-236, [2009].

[4] Automation of wheelchair using ultrasonic and body kinematics,Preethika Britto, Indumathi. J, Sudesh Sivarasu, Lazar Mathew, *CSIO Chandigarh*, INDIA, 19-20 March 2010.

[5] Poonam S. Gajwani & Sharda A. Chhabria, "Eye Motion Tracking for Wheelchair Control", *International journal of information technology and knowledge management*, Dec 2010.

[6] Eye Controlled Wheel Chair Using EOG, Alex Dev, Horizon C Chacko and Roshan Varghese, *International Conference on Computing and Control Engineering (ICCCE 2012)*, 12 & 13 April, 2012.

[7] Peng Zhang, Momoyo Ito, Shin-ichi Ito, Minoru Fukumi,
"Implementation of EOG mouse using Learning Vector Quantization and EOG-

feature based methods", *IEEE Conference on Systems, Process & Control (ICSPC)*, dec.-2013, SPC.2013.6735109.

[8] Culpepper, B.J, Keller, R.M: "Enabling computer decisions based on EEG input", *IEEE Trans on Neural Systems and Rehabilitation Engineering*, 11, 354-360, [2003].

[9] Lee W. O, Lee H. C, Cho C. W, Gwon S. Y, Park K. R, Lee H, Cha J (2012) Auto-focusing Method for Remote Gaze Tracking Camera. Optical Engineering. 51: 063204-1-063204-15.

[10] Automation of wheelchair using ultrasonic and body kinematics, Preethika Britto, Indumathi.J, Sudesh Sivarasu, Lazar Mathew,CSIO Chandigarh, INDIA, 19-20 March 2010.