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EYE CONTROLLED WHEELCHAIR

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Abstract— Several studied have shown that both children and adults benefits substantially from access to a means of independent mobility. A powered wheelchair is like a boon to the physically handicapped people. There are various kinds of interfaces which have been developed to make an automated wheelchair. Joystick controlled, voice controlled, gesture controlled are the names of some of the interfaces. Many people with disabilities do not have the ability to control powered wheel chair using the interfaces given above. Our project is an alternative. Here the powered wheelchair will be controlled by the eye movement of the person who is sitting on the wheelchair. Whichever direction the eyes look in, the wheelchair will move accordingly.

Key words—Eye controlled, Iris detection, Electronic wheel chair, Daugman's algorithm, Web camera

I. INTRODUCTION

There are number of persons who are paralyzed and therefore dependent on others due to loss of self-mobility which is increasing nowadays. Evolution of the wheelchair for paralyzed users was recently started with the conventional powered wheelchairs which were handled manually to advanced electrical wheelchairs. The use of conventional wheelchair, focuses exclusively on manual use which assumes users who are able to use their hands. Diseases or accidents injuring the nervous system cause people to lose their ability to move their voluntary muscles. Because voluntary muscle is the main factor which enables people to move their body, paralysis may cause a person not move their locomotive organ such as arm, leg and others. Hence, we use powered wheelchair. Powered wheelchair uses independent mobility amongst the handicapped. This thus, increases vocational, educational opportunities and reduces dependence and promotes feelings of self-reliance.

Scientist Stephen W. Hawking is a well-known victim of major paralysis. In 1962, Hawking was diagnosed with incurable Amyotrophic Lateral Sclerosis (ALS), thereafter using a wheelchair to move. Many people suffering from complete or partial paralysis usually can control their eye movements which gave us an idea to construct an eye-controlled wheelchair. This idea of an eye-controlled wheelchair was inspired by our past project voice controlled robot. In that project, the voice commands of handicapped person were used to guide the robot or wheel chair in the desired direction. We wanted to improvise the idea by making the system completely isolated from the person physically, and thus improving the usability of the system.

II. PROBLEM STATEMENT

The main objective of this project is to make a wheelchair which will be controlled by the movement of an eye i.e. on movement of pupil.

III. RELATED WORKS

For developing Automated wheelchair there are various approaches which are as follows:

A. Voice controlled wheelchair:

In this technique, the voice-controlled wheelchair robot is developed for particular elder or physically challenged person by predefining their voices in the system. The voice of the person is detected by voice capture module and that is compared with the voice recognition module with predefined voices loaded into the system. The commands such as front, backward, right, left and hold on are given by the person sitting on the wheelchair. This particular type of wheelchair is useful for paralyzed people or those suffering from disabilities in the arms or legs and is also useful for elderly people. It is not useful for people with speaking disabilities. Background noise is the main hindrance in this particular technique.

B. Joystick controlled wheelchair:

In this particular type, a joystick is provided with which the user can control the movements of the wheelchair. The main advantage of this wheelchair is that it moves precisely in whichever direction the user wants. Proper skills are required to handle the joystick. People with disabilities in their arms cannot make use of joystick controlled wheelchair .The experimental joystick is an IJ with a voltage output proportional to the force exerted on the stick by the human subject. The joystick obtains its power from the batteries and runs on 12 V dc. The test wheelchair used a Dynamic Controls DMC-60 controller with a 7 V nominal center voltage.

C. EEG based wheelchair:

The wheelchair movements are controlled by the signals of brain. This technique is known as Electroencephalogram (EEG). So, basically EEG signals in form of voltages are sent to the wheelchair assembly to move. Here multiple electrodes are connected to the brain in order to know the appropriate commands. So if in case user wants to take any decision, then he/she has to think accordingly so that the required amount of voltage is given to the wheelchair motors to move. This is more precise technique compared to all as it doesn't need any body movement or eye movement but needs accuracy in generating the appropriate commands.

D. Gesture controlled wheelchair:

The wheelchair movements are controlled by hand gestures of the user sitting on it. It is a reliable means for human and computer interfacing which is based on hand gestures made in three dimensions. Now in this method, they have used web camera for detecting the hand gestures. AdaBoost algorithm is used to detect the hand location. The image is in 320*240 resolution which is divided into 9 blocks and the algorithm will check in which block the hand is located.

E. Eye controlled wheelchair:

In this proposed system, wheelchair will move according to the eye movements. First the image is taken using camera which will be mounted in front of any of the two eyes. Then the image will be processed in the Microsoft visual studio 2010 and openCV. For detecting the location of the pupil Daugman's algorithm is used. As the user is not supposed to do any kind of body gestures, making this system more reliable. Hence making comfort to people who have arm disability or who can't make precise body gestures.

IV. INTRODUCTION TO THE SYSTEM

In our approach for developing eye controlled wheelchair we are going to develop prototype of a wheelchair. By using Logitech webcam we will capture the images of an eye. Captured images will be processed in openCV and visual studio 2010. According to movement of user's eye, corresponding commands are generated which are then sent to Arduino and xbee module for communication and wheelchair is controlled.

V. SYSTEM DESCRIPTION

Following are the steps in our approach:

1. Use web-Camera to get the real time video.
2. Processing the individual image frame.
3. Convert each frame to a greyscale image.
4. Extraction of iris from captured image.
5. Finding the region of the image and calculating its centroid.
6. Connection to the wheelchair.
7. Forming a grid to check the position of calculated gradient.
8. Sending commands to Arduino on receiver side via xbee.

VI. PROPOSED SYSTEM

A. Proposed method:

The method which we are using for controlling wheelchair is based on eye. i.e. eye controlled wheelchair. We are using Daugman's algorithm for detecting pupil location. We will be running that algorithm in Visual Studio 2010 software. The basic components which we are using includes a camera, a wheelchair, a microcontroller-Arduino Uno. The serial communication between Visual Studio 2010 and Arduino is done via serial ports.

B. System overview:

(1) WEB CAMERA:

Spectacle mounted camera is used for capturing images.

(2) VISUAL STUDIO 2010:

Microsoft visual studio 2010 is used for programming using openCV libraries. First we were using MATLAB application for image processing but due to lagging problems in processing, openCV is used.

(3) ARDUINO UNO:

The microcontroller will take a USB output from the laptop and it will convert the obtained digital output to electric signals that will be sent to the wheels. The microcontroller which we are using is Arduino Uno. Arduino Uno is a microcontroller board based on the ATmega328P.

(4) XBEE:

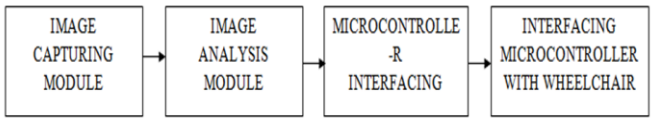
Xbees are used for wireless communication. We can make networks using it. We are using two xbees for communication. One as transmitter and one as receiver.

(5) WHEELCHAIR:

A wheelchair prototype instead of an actual wheelchair is used in this project.

C. Block diagram:

In Image Capturing Module, we capture the images using camera and after perfect capturing of image, it is sent to Image Analysis Module where segmentation of image is done. Processing for finding the location of the pupil and its direction is found out. In Microcontroller Interfacing, how to interface the generated electric digital output to electric input is discussed. And finally Microcontroller interfacing with wheelchair is discussed in that module.



VII. METHODOLOGY

A. Image Capturing Module:

Image Capturing is to capture a sequence of iris images from the subject using a specially designed camera. In iris recognition image capturing is a very important step. Since iris is small in size and dark in color, it is difficult to acquire good image. The image is then changed from RGB to gray level for further processing. It is to capture a sequence of iris images from the subject using a specifically arranged camera. A camera must have enough resolution to capture the details of the iris. pattern[6]

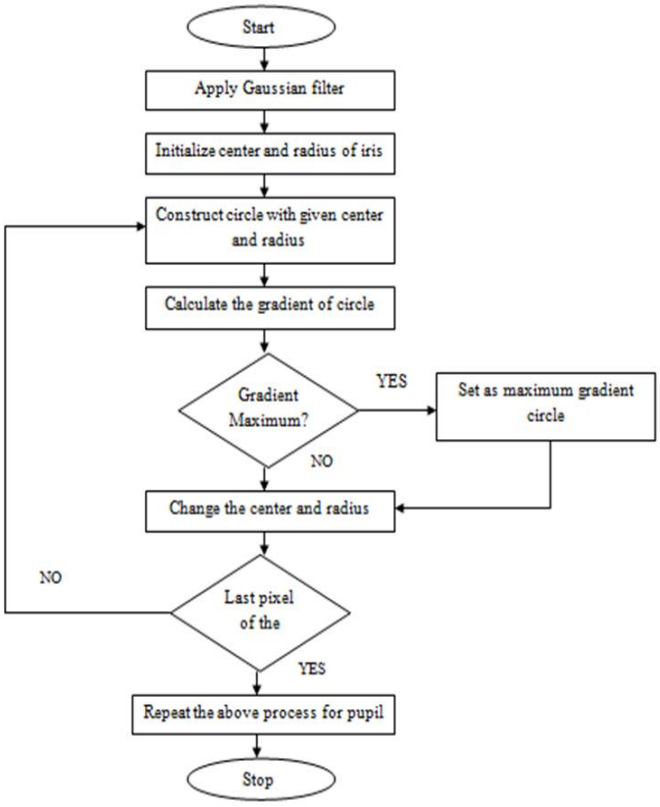


Fig. 5 Flowchart

B. Image Analysis Module:

The main objective of segmentation is to remove non useful information, namely the pupil segment and the part outside the iris (sclera, eyelids, skin). Daugman proposes an integrodifferential operator to find both the pupil and the iris contour. The algorithm will perform the iris recognition in two phases. The algorithm used in the first phase, uses the knowledge that a pupil is a very dark blob of certain minimum size in the picture, and no other segment of continuous dark pixels are of the same size. The algorithm finds the center of the pupil and the two radial coefficients as the pupil is always a perfect circle. The second algorithm takes the information of the pupil canter and tries to find direction in which the eye looks.

1. Finding center of the pupil.
2. Finding the direction in which eye looks[6].

STEP 1: Finding Center of the pupil

Libor Masek's idea that reduces complexity significantly by scaling down all images to a constant image size to speed up the whole process. First step is to calculate the Gaussian blur function. A Gaussian blur (also known as Gaussian smoothing) is the result of blurring an image by a Gaussian function. Mathematically, applying a Gaussian blur to an image is the same as convolving the image with a Gaussian function. This is also known as a two-dimensional Weierstrass transform. The Gaussian blur is a type of image - blurring filter that uses a Gaussian function (which also expresses the normal distribution in statistics) for calculating the transformation to apply to each pixel in the image. The equation of a Gaussian function in one dimension is,

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-x^2}{2(\sigma^2)}} \qquad (1)$$

Where x is the distance from the origin in the horizontal axis, y is the distance from the origin in the vertical axis, and σ is the standard deviation of the Gaussian distribution. When applied in two dimensions, this formula produces a surface whose contours are concentric circles with a Gaussian distribution from the center point. Values from this distribution are used to build a convolution matrix which is applied to the original image. Each pixel's new value is set to a weighted average of that pixel's neighborhood. The original pixel's value receives the heaviest weight (having the highest Gaussian value) and neighboring pixels receive smaller weights as their distance to the original pixel increases. This results in a blur that preserves boundaries and edges better than other, more uniform blurring filters. Pupil location is found using Daugman's algorithm or otherwise known as integrodifferential operator for finding iris location. Using this we will track the location of pupil and get the coordinates of the center of the pupil. Formula used by Daugman is,

$$max_{(r,x_0,y_0)} \left| G_\sigma(r) * \frac{\partial}{\partial r} \oint_{(r,x_0,y_0)} \frac{I(x,y)}{2\pi r} ds \right| \qquad (2)$$

Where G(r) function represents Gaussian Filter where the image is scaled to sigma size. It is the smoothing function blurred at a scale set by sigma, searching iteratively for the maximal contour integral derivative at successively finer scales of analysis through the three parameter space of centre coordinates and radius with x0, y0 and r values. The equation thus becomes as,

$$max_{(r,x_0,y_0)} = \left\{ \frac{\partial}{\partial r} \int_0^{2\pi} I\left(r * \cos\theta + x_0, r * \sin\theta + y_0\right) \right\} \qquad (3)$$

The specialty of this equation is even when the eye is at certain phase angle it can detect the center of the pupil, this is because line integration is checking the maximum gradient circle in that particular center values. That is for particular point it going to check at what angle the gradient is maximum. After obtaining the center coordinates of both iris and pupil we check both circles doesn't overlap and stays one inside the other that is inside iris circle pupil circle should be present and therefore decided that the obtained circles are correct and if fails then restart of the whole process takes place[6].

STEP 2: Finding the direction of the pupil

The input image given to the Visual Studio 2010 for processing will produce an output image with the coordinates of iris and pupil. The size of the output image will be 320*240. The output image will be put into a grid of yellow color which will be activated after connection with serial port to which transmitter is connected. Now the centroid calculated is in cyan color. So when cyan point is

above the square formed using a yellow grid then the user is looking up and wants to move forward. And so on for the other commands [6].

VIII. HARDWARE

Once the commands are received on serial port, they are sent to Arduino connected to the particular port. It will accept the commands and it will be sent to the xbee connected. And then wirelessly it is transmitted to another xbee on the receiver side mounted on wheelchair.

IX. RESULT

1] User looking in upward direction. Centroid will be located in upper square grid. So wheelchair will move forward.

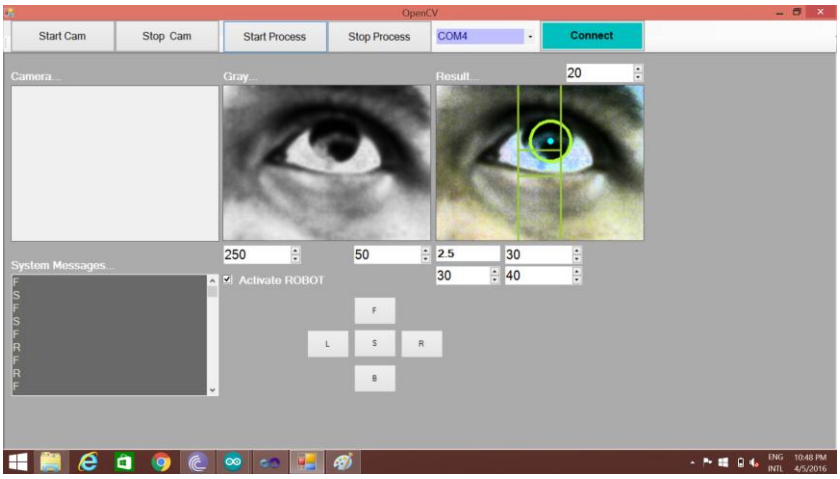


Fig. 8 Looking upward

2] User looking in downward direction. Centroid will be located in lower square grid. So wheelchair will move backward.

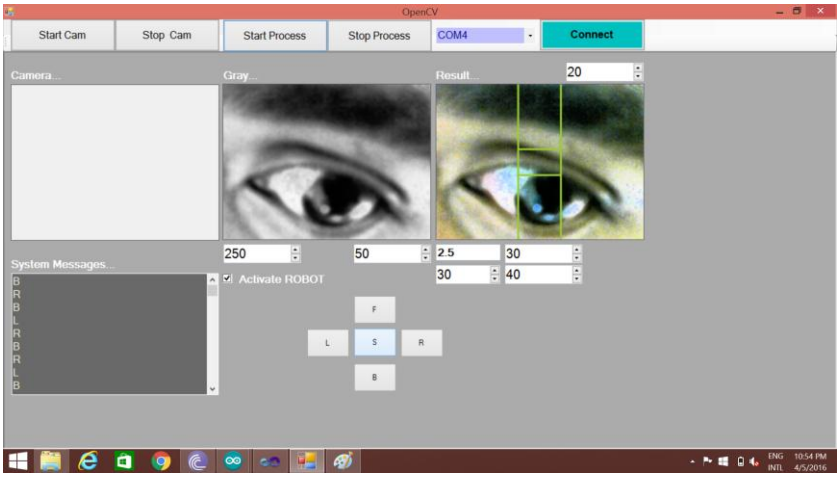


Fig. 9 Looking downward

3] User looking in left direction. Centroid will be located in left square grid. So wheelchair will move in left direction.

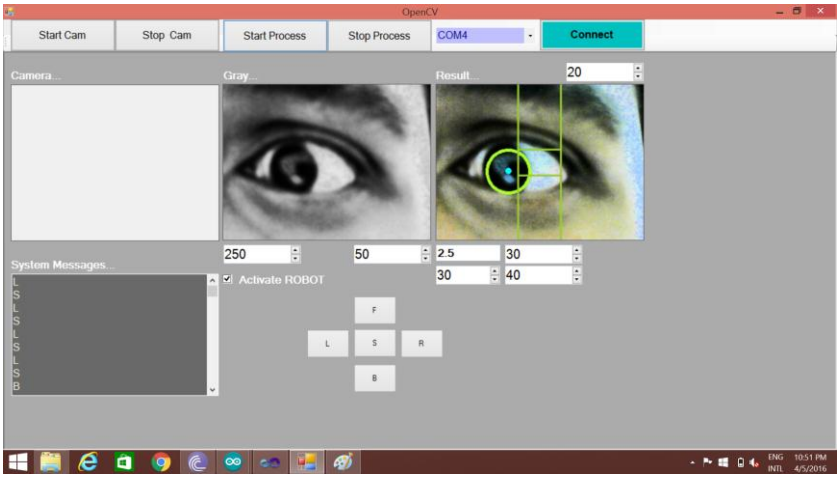


Fig. 10 Looking left

4] User looking in right direction. Centroid will be located in right square grid. So wheelchair will move in right direction.

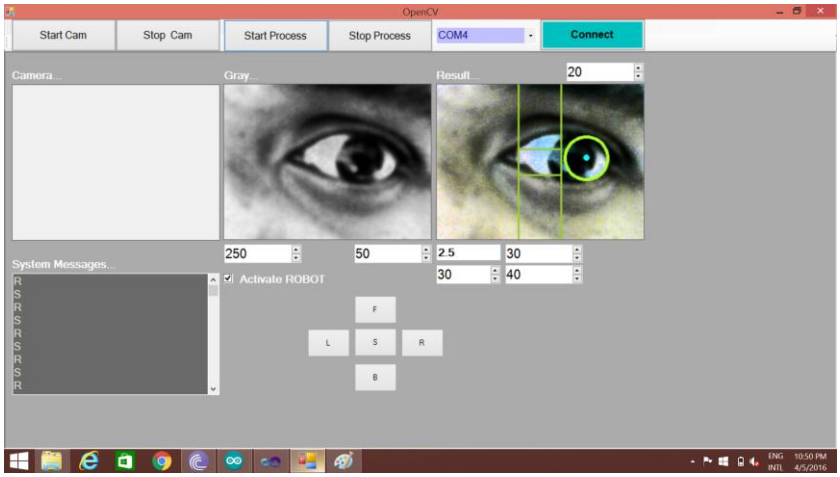


Fig. 11 Looking right

5] User looking in forward direction. Centroid will be located in middle square grid. So wheelchair will stop.

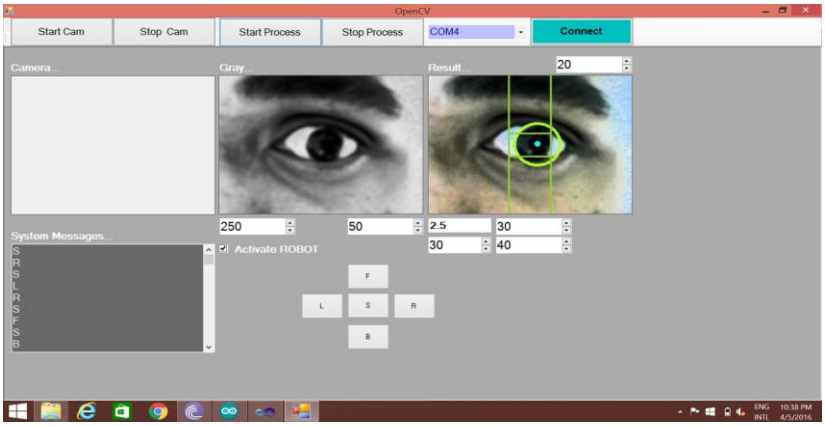


Fig. 12 Looking forward

X. CONCLUSION

Eye controlled wheelchair method is convenient for handicapped people compare to other methods mentioned. As there is no need of any other body parts for handling the movement of the chair.

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