Design and Development of Smart Wheelchair for Physically Disable people

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Abstract— **The project involves eye movement wheelchair control. World Health Organization data suggest that there are 40 to 80 *cases* per million population of quadriplegia (paralysis) per year. Great people like Stephen Hawking have always suffered from quadriplegia. The proposed method involves the design and development of the medical wheelchair which seeks to make the lives of people affected by this condition easier by helping them to move on their own and not be a burden to others. The idea is to make an Eye Controlled System that shifts the patient's wheelchair depending on the movement of the eyeball. A person with quadriplegia can move their eyes and tilt their head slightly, so giving is an opportunity to see this movement. There are a variety of workspaces designed for a powerful wheelchair and there are new and innovative strategies that are affordable for the poor and needy. This paper proposed a simple and inexpensive way to build a wheelchair. A system has been created in which a person sitting in a wheelchair with a camera mounted on it, can move toward it by looking at that position by making eye movements. The captured camera signals are then sent to a CPU, which will then be sent to the Arduino circuit via Serial Interface which will control the motors and allow the wheelchair to move in a certain direction. The system is affordable and can be used by patients spread across a large economy.**

Keywords- **Automatic wheelchair, Iris Movement Detection, Servo Motor, Daugman's algorithm, Arduino.**

I. INTRODUCTION

Advanced Wheelchair for Disabled Person is a fully automated wheelchair specially created for people suffering from paralysis or for physically challenged souls. Paralysis can affect people in many different aspects and one of the most dangerous types is Quadriplegia. Quadriplegia is a condition of the body where the person cannot move any of his body parts. Thus numbness of all four limbs is known as Quadriplegia. Thus Physically it is impossible for people with this problem to control the typical wheelchair available in the market to operate these wheelchairs accessible in the market, the person has to utilize a great amount of physical strength to move the wheels of the wheelchair. The lives of such people have become really tough and hence as a small attempt to make their life easier, this system is introduced where the person can use his eyes to control the wheelchair. The motivation of this project is to develop a wheelchair that will be controlled by the eyes of the person seated in the wheelchair. Eye action controlled wheelchair is to enable completely paralyzed patients as well as the elderly to make their life more accessible [12]. People who are unable to walk and are using wheelchairs, use a great amount of energy using physical strength to move the wheels. With the use of this wheelchair, the disabled would save energy and could use their hand and arm for other activities. Right now, there are different eye based methods used for controlling wheelchairs, such as EOG, ECG, EEG based eyeball sensing method, Face detection and eye detection. Several algorithms are used to find the exact pupil location direction. Haar cascade-like feature detection algorithms can also be utilized.

The main components used in this system are a web camera, Matlab and Arduino. The structure captures the images using a webcam that will be attached to the laptop placed on the wheelchair of the user [1]. These apprehend images will be sent to Matlab where it will compare the images with the pre input images and give the required output to the Arduino. Arduino is further connected to the motor of the wheelchair. Thus these serial commands given to the motor by the Arduino through Matlab will choose the direction of the wheelchair. The instructions given to Matlab can include commands like Left, Right, Stop, Forward, Reverse etc.

To make this system more advanced and more accessible, an ultrasonic sensor is attached to the front side of the wheelchair. With the help of this sensor, the wheelchair will stop automatically whenever any obstacle is placed in front of the wheelchair, thus making this system safe and valuable to life. The existing system includes a voice-based method and an Infrared reflection-based method [2]. The voice-based method works properly when the user speaks the command clearly. But due to background noise and the anatomy of the vocal tract, a voice-based system is not effective.

Infrared reflection-based eye pupil detection system provides explicit detection of eye pupil center location. But the infrared radiation affects the eye of the disabled person and he/she may lose eye visibility. The uniqueness of this system is that no part of the system physically interacts with the user, making disabled persons feel comfortable [8]. The aim of this system is to improve society in a small way by setting out an idea for a system that could actually better the lives of millions of people across the globe [9]. This system is cost-effective and can be used globally and easily by every disabled.

II. PROBLEM STATEMENT

Clinical studies show that 9-10% of severely disabled patients with difficulty find it impossible to use a wheelchair despite having some training to manage and use a wheelchair. This shows that they do not have the ability to move and power and it is difficult to use the functions of a wheelchair [4]. The project aims for an easy-to-use product that does not require solid training.

III. LITERATURE REVIEW

There were preceding works carried out on electric wheelchairs. A few of them assist us to get ideas for our project.

Dulari Sahu proposed an eye control wheelchair for disabled people. This abolishes the personal assistance required for those persons. The whole structure is controlled by Raspberry PI [3].

Reona Cerejo issued a proposal on the Arduino circuit. The whole structure is controlled by the Arduino [4]. Arduino is a simple microcontroller board and open source development environment that allows making functional and creative projects by using Arduino microcontroller and software. And make the system affordable. And this paper also concentrates on finding the direction in which the eye looks using a MATLAB frame. Depending upon the location of the pupil in these blocks, action is carried out. Gunda Gautam suggests an image capturing module and image analysis module.

Image Capture Module:- Image Capturing is to capture a chain of iris images from the subject using a camera. In iris recognition image capturing is a mandatory step. Since the iris is small in size and dark in color, it is challenging to achieve a good image. The image is then changed from RGB to gray level for further processing. It is to capture a chain of iris images from the subject using a camera.

Image Analysis Module:- Image analysis is achieved by segmentation. Segmentation is to eliminate non-useful information namely the pupil segment and part outside the iris. Segmentation is done by the Baughman algorithm [5]. Daugman's algorithm presents an integrodifferential operator to find both the pupil and iris contour. This operation works even if the image is taken in a little dark environment.

Ankur Thakur proposed a Matlab component and script. Matlab constituent includes the topics are as follows [6]

1.Initialization of variables and setting communication.

2. Image capture and eye detection.

3. Image processing.

4. Movement detection.

Using the idea listed in the survey we developed a wheelchair for paralysed persons.

IV. PROPOSED METHODOLOGY

The issue of the utmost importance in a proposed system is the robustness against different user types, illumination changes, user movement, vibration, and accuracy. With respect to considering these as vehicle systems, if the user changes, the system should work without any input parameter changes. In accordance with EWC movement, illumination conditions may vary. Also, disturbances due to EWC vibration are a major problem.

The conventional WC control system uses human eyes only, the camera is placed on the WC. This may cause a vulnerability when WC is vibrated. Also, when the user moves their head, gaze estimation is hard. Furthermore, illumination conditions may vary during EWC movement. The proposed WC system utilizes an IR camera placed on the user's glass. This way will eliminate problems of illumination changes. Furthermore, pupil detection and recognition based on pupil knowledge will improve the robustness against different users.

A. Hardware Configuration

The Hardware configuration of the proposed structure is shown in Figure 1.

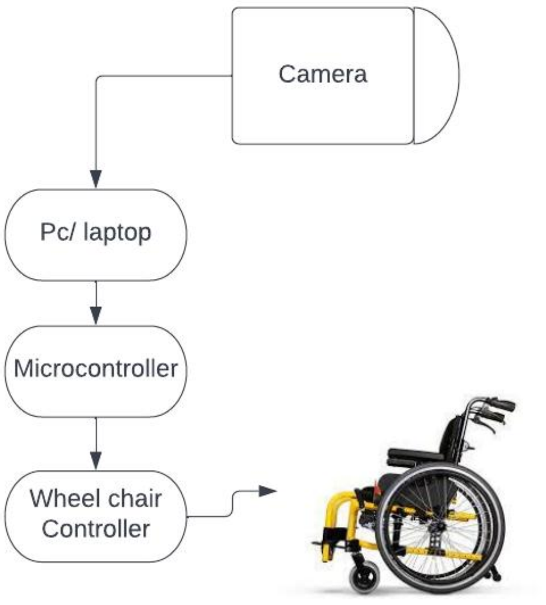

Figure 1: Hardware Configuration

System of HP pavilion with AMD Quad-Core Ryzen 5 Processor, 8 GB DDR4 RAM, 1 TB HDD hard drive and run Windows 10 operating system. the development of software under MatLab software and Viola Jones Algorithm [14]. The proposed system utilizes a web camera, Therefore it is robust against illumination changes. In order to allow user movement and EWC vibration. The distance between camera and eye is set at 15.5 cm as shown in Figure 2 [7]. This microcontroller can convert serial output from the operating system to digital output for control.

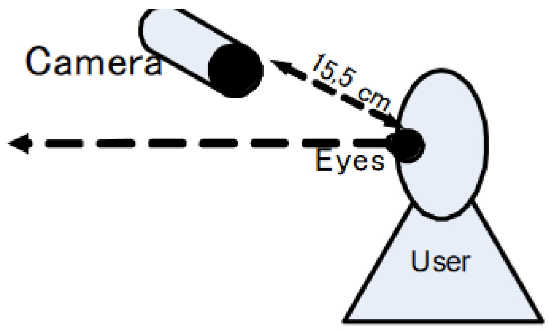

Figure 2: Electric Wheelchair Hardware

In order to instruct EWC using HP Pavilion, an Arduino microcontroller circuit is used to modify the standard control of the wheelchair. Traditionally control of the WC is made by a joystick. A microcontroller is restored with the joystick. The command is delivered by HP PC, and then the Arduino works to move the EWC. The USB interface on the HP pavilion PC is used to connect with the other peripheral. The interface of the Arduino circuit is RS232 [10]. To connect between HP pavilion PC and the microcontroller, a USB to the Serial converter is used. The Arduino is driven by the relay equipped with the EWC. The Arduino connection is shown in Figure 3.

B. Gaze Estimation

With respect to estimating gaze, the eye should be detected and Recognized. Figure 4 shows the process flow of eye detection and Recognition. The proposed EBEWC system detects the eye based on the Viola-Jones Algorithm method [13]. The movement detection is done with a standard principle. We took in the feature points for both left and right eyes and saved them. Thereafter take the difference in pixels of the left eye position and right eye position in the current shot from the previous candid camera shot.it has defined the threshold for the minimum movement of the eye required to be qualified as an actual valid attempt. In each candid camera shot the difference is evaluated, and if this difference is above the threshold in any direction left or right, the flags indicating left movement or right movement are set. If the difference is not above the threshold, the flag which says that no action has occurred is set.

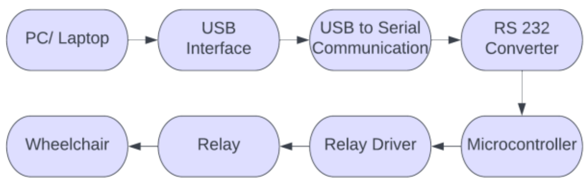

Figure 3: Microcontroller connects to other peripherals through serial communication. Serial communication type should be converted to USB communication using a USB to serial converter.

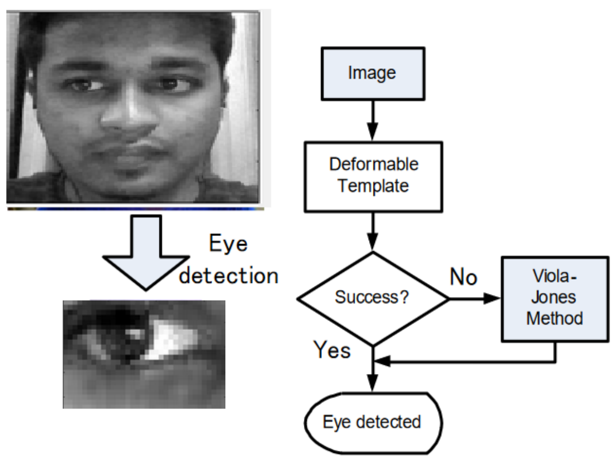

Figure 4: The flow of Eye Detection, the eye is detected by using Viola-Jones methods.

Eye movement is monitored to detect eye movement. According to the eye area, the direction of possible movement is available. Based on this prescribed guide, the command is transmitted to the vehicle control device via Arduino. Eye-tracking hardware as shown in Figure.

Image Recovery Device: This contains a webcam with a convenient interface to connect to a PC.

Processor: Contains a personal computer or dedicated image processing unit.

Image Analysis: Some tools are used to analyze the content of a captured image and to draw conclusions e.g. Matlab 7.0

Machine Control: After making a conclusion, the action of the machine should be taken e.g. using a PC parallel port to control vehicle movement.

Arduino Board: The Arduino board is used to transmit the MatLab signal to the driving circuit.

Motor Driver Circuit: Depending on the signal received from the microcontroller it will send a specific signal to the DC motor to avoid driving the wheelchair forward, backward, left and right

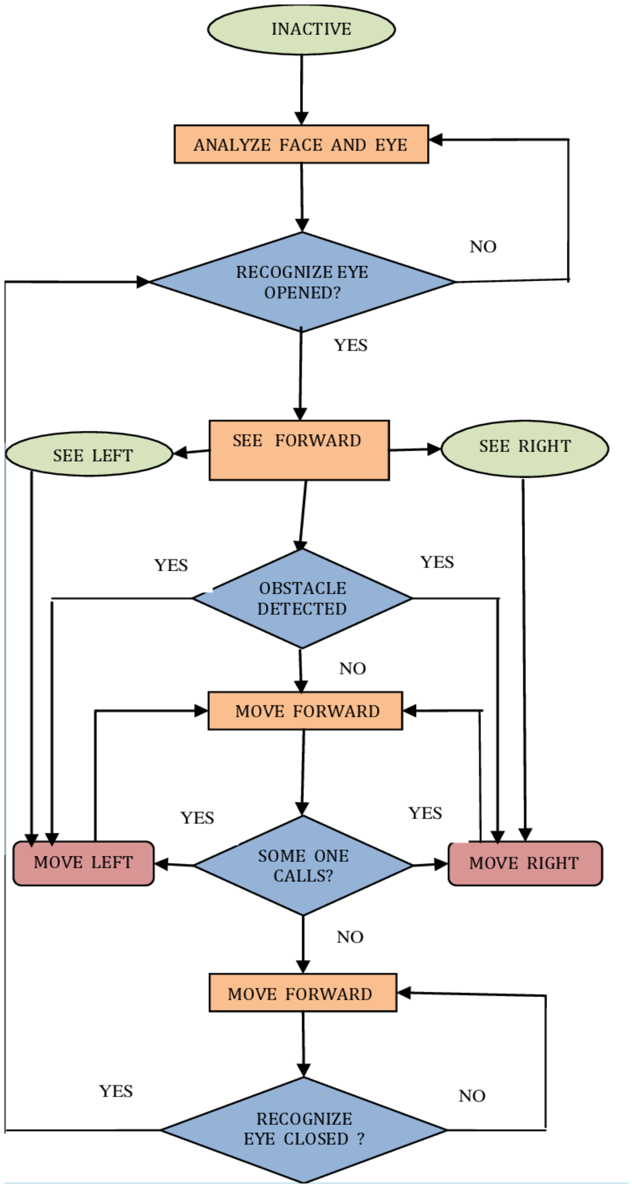

Figure 5: System Description flowchart

C. Algorithm

1. Upload a photo from the camera to Matlab.

2. Use the Gaussian blurring function. This creates two straight circles [11]. Values from this distribution are used to form the convolution matrix.

3. This convolution matrix is used in the first image. This causes the middle pixel to be heavier and the neighboring tool to have smaller values.

4. The student center is available in the form of Daugmans $\int_0^{2\pi} I(r * \cos\theta + x0,\ r * \sin\theta + y0)$ $(r,0,y0) = \partial/\partial r$, where are the radial distance from the center and the phase angle.

5. The Matlab frame is divided into a 3x3 matrix where the frame size is 320 * 240. Since the width of the rectangle is responsible for dividing the rectangle into three rows, 240 should be divided into three parts. But in order to minimize errors, the Middle or Second Line is given a slightly wider range. Similarly, the length of a rectangle is responsible for dividing the rectangle into three columns 320 should be divided into three parts. To reduce the errors the center or second part is made to a smaller extent.

Depending on the position of the learner in these blocks the action is performed.

- **Block (1, 2)**

The output coordinates of the iris satisfying the below condition will detect the pupil position as **Top**.

Condition: if ((x > 120 and x < 188) && y < 105))

- **Block (2, 1)**

The output coordinates of the iris satisfying the below condition will detect the pupil position as **Right**.

Condition: if ((y > 105 and y < 130) && x <

120))

- **Block (2, 2)**

The output coordinates of the iris satisfying the below condition will detect the pupil position **Straight**.

Condition: if ((x > 120 and x < 188) && (y > 105 and y < 130))

- **Block (2, 3)**

The output coordinates of the iris satisfying the below condition will detect the pupil position as **Left**.

Condition: if (x > 188 && (y > 105 and y < 130))

- **Block (3, 2)**

The output coordinates of the iris satisfying the below condition will detect the pupil position as **Bottom**.

Condition: if ((x > 120 and x < 188) && y > 105))

V. EXPERIMENTAL RESULTS

(1) The system UI is designed in such a way that it is easy for users to use. It also has a threshold adjustment area to capture the user's movement.

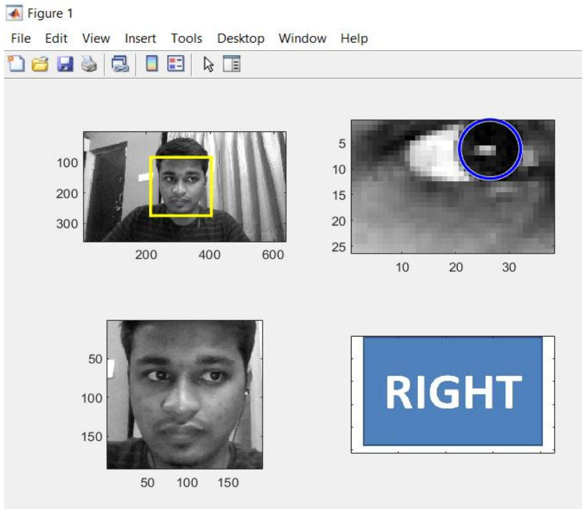

Figure 6: Snapshot of user looking leftward

(2) Input and related images shown below are generated after using the Daughman algorithm in the input image that is processed in MATLAB. The shape of the iris and the user will be determined. Also, the image location is detected and the inserted image resolution given below will be generated as LEFT or RIGHT respectively.

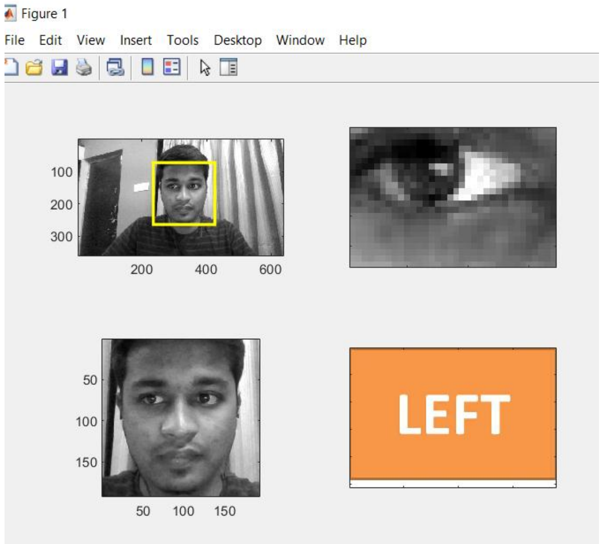

Figure 7: Snapshot of user looking rightward

(3) The input and related images shown below are generated after using the Daughman algorithm in the input image to be processed in MATLAB. The shape of the iris and the student will be determined.

Also, the image location is detected and the input image resolution given below will be reproduced as a center in Figure 8.

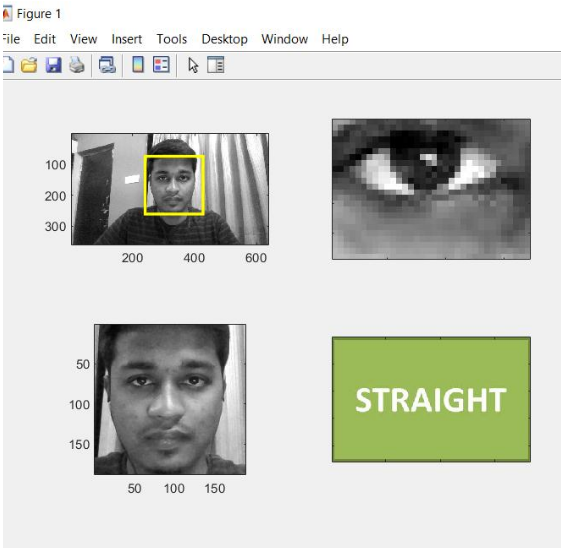

Figure 8: Snapshot of the center position

VI. CONCLUSION

In this research paper, a new wheelchair model is introduced by adding a car-type approach and making the wheelchair simpler and easier to manage using eye-tracking for the physically disabled and disabled. The purpose of this project is to contribute to the community in a small way by setting a vision for a program that can improve the lives of millions of people around the world.

The future scope of this system could be to upgrade a mobile app to manage a wheelchair controller. Also introducing home automation to the system can be an additional feature of a wheelchair where a person with a disability is able to turn on / off household appliances without moving from place to place.

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