EYE GAZE CONTROLLED SMART MOBILE ROBOT

THE PROJECT REPORT

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PROBLEM STATEMENT:

To design and develop an Eye-Gaze-Controlled smart mobile robot to help disabled locomotive users move efficiently and independently.

ABSTRACT:

The inability to control one's limbs is the primary factor contributing to the social isolation and limitations experienced by the crippled. More research was done to help those with disabilities communicate with the outside world, as well as others, more effectively. Disabled people can benefit from a variety of methods meant to make daily tasks easier for them. The Eye Controlled Smart Mobile Robot is one of these innovations. With the help of eye movement tracking, this project intends to construct an eye-controlled smart mobile robot. The proposed smart robot has a straightforward design, is simple to operate, and is relatively inexpensive when compared to other options. A camera attached to the robot picks up the movement of the eyes. After some processing and analysis, the collected image can be used to determine the user's gaze direction. Upon receiving the command, the smart robot movement is controlled by an Arduino.

Keywords - Eye Gaze Controller; Viola-Jones Algorithm; Image processing; microcontroller; Smart Mobile Robot.

INTRODUCTION:

Automation Diseases such as Amyotrophic Lateral Sclerosis (ALS) wreak havoc on the lives of individuals by robbing them of motor function, thereby drastically diminishing their quality of life. Due to the development of electric wheelchairs, individuals with mobility impairments have learned to live with minimal exposure for years. The inability to control the limbs is the primary factor affecting the disabled's daily activities, resulting in social restrictions and isolation. Due to spinal cord injuries that may be the result of a lack of nerve supply paralysing every affected body part, these events may result in debilitating neuromuscular disorders that cause severe disabilities.

To utilise and control an electric wheelchair, meanwhile, typically takes a lot of ability. In addition, some individuals with motor disabilities are unable to operate an electric wheelchair manually (even with a manual joystick) due to physical limitations (such as a person suffering from ALS). A wireless intel car uses an eye movement detection camera to assist a paralysed person who is able to move on a car. The car will automatically move in a particular direction as the patient moves his eyes in that direction.

This research focuses on the design of a mobile robot that does not rely on any physical movement of the user, but instead tracks the motion of the user's eye while achieving greater accuracy than others and minimising the detection's delayed response time. The proposed eye-tracking electric mobile robot differs from others with good validation parameters of the controller, which uses simple equations to identify the eye pupil position and direction in the user's face by counting the white pixels in both eyes. This work's central concept relies on capturing the user's image with a webcam. Several image processing techniques were used to determine the location of the face, the eye, and its direction, and then the Arduino board was used to control the wheelchair.

LITERATURE SURVEY:

Numerous fields may now make considerable use of eye-tracking principles thanks to advancements in areas such as automobiles, medicine, modelling of fatigue and tiredness, vehicle simulators, cognitive testing, computer vision, behaviour identification, etc. The value of eye identification and monitoring in commercial settings has increased over time. Many modern appliances rely on eye-tracking technology because it allows for more efficient and lasting construction. In healthcare settings, the literature on eye-tracking systems has been reviewed in depth.

In this paper [1], the authors propose a new method for approximating the pupil plane incrementally by first constructing the front and rear planes and then estimating the point-of-view based on cross-ratio invariance. The simulation results show that the proposed method not only simplifies system configuration and user calibration, but it also eliminates the error caused by non-coplanarity between the corneal surface reflection points and the pupil center. In this study [2], an Internet protocol camera was used to capture an image of an eye frame for cursor movement. They initially focused on the role of the eye and used the Raspberry Pi for pupil detection, which can work with a computer cursor and an eye aspect ratio (EAR) for this purpose. This paper [3] proposes an eyeball-controlled wheelchair to reduce the dependence of disabled individuals on others. A camera has been detected in the goggles in order to detect the location of the eye pupil and acquire an image of the eye using computer vision techniques. To detect the location of the eye pupil, the Open Computer Vision (OpenCV) library was utilized. This paper [4] proposes a topology for a smart wheelchair that is controlled by a hand movement device and a smartphone. It is a hand-held wheelchair equipped with a gyro sensor, an accelerometer, and a Bluetooth phone control module for automatic operation.

In this study [5], a wheelchair with two types of drive systems, such as a thumb and gesture control system, was designed. The user interface (UI) is created so that the user can easily navigate the menu and select their preferred control system. A heart rate sensor is integrated to compute the patient's medical conditions. The primary objective of the titled project [6] is to develop a wheelchair that can be controlled by the user's head movements. The proposed wheelchair is equipped with specialized features that make mobility more comfortable and convenient. The purpose of this paper [7] is to develop a low-cost, easy-to-use electronic wheelchair controlled by gestures rather than a joystick, using the in-built gesture function of a smartphone and a touch sensor. A further feature of this chair is an IP camera that provides visual and audible information to the rider's guardian. This paper [8] introduces and describes a novel method for performing iris segmentation and gaze recognition. Using machine learning, the described method employs a segmentation algorithm that can successfully extract the iris under varying lighting conditions. The algorithm's accuracy was determined to be 86%, and it was also used to control a real wheelchair.

This study [9] introduces a system designed to distinguish eye gaze locations on the screen based on the position of the iris portion of the eye. It aims to distinguish more eye gaze locations than previous webcam-based works. Using the feature vector of the iris center coordinates, a K-nearest neighbors classifier was used to detect eye gaze location. The proposed approach [10] uses a human tracking algorithm to make the wheelchair move without assistance. This paper combines ORB, KAZE, AKAZE, BRISK, SIFT, and SURF to track humans. Each key point descriptor is given a score that determines which one is used until the minimum number is reached. If the best method doesn't work, the second-best is used, and so on. This [11] paper describes the design of an eye-controlled electric wheelchair. A Tobii eye tracker is linked to an electric wheelchair. The Tobii eye tracker converts eye movement signals into coordinates for gaze points. Coordinate data is filtered using the Kalman filter algorithm to obtain optimal data. In this project [12], a wheelchair will be modeled as a robot with an integrated microcontroller and eyeball system that will perform functions such as turning right, left, forward, and reverse.

Inferring from the above papers, we have come to the solution of building an UI using Matlab. Using an Arduino Uno instead of a Raspberry Pi (to work with minimal computation and save money). Transmission is efficient, constructive, and more economical when done through a Bluetooth module from the image processing system to the microcontroller, Instead of the EAR ratio, we used the GAZ ratio.

HARDWARE COMPONENTS:

S.No	Components
1	Processor (for Image Processing)
2	Arduino Uno (Microcontroller)
3	Bluetooth Module
4	Camera
5	Motor Driver
6	Dc Motors
7	Batteries

Arduino Uno:

The Arduino Uno is an ATmega328-based microcontroller board. It features 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB port, a power jack, an ICSP header, and a reset button.

Specifications:

Microcontroller: ATmega328
Operating Voltage: 5V
Input Voltage: 7-12V
Digital I/O Pins: 14 (of which 6 provide PWM output)
Analog Input Pins: 6
DC Current per I/O Pin: 40 mA
Flash Memory : 32 KB
SRAM : 2 KB
Clock Speed : 16 MHz

Fig.1.Arduino Uno

Motor Driver:

L298 Motor Driver is a high-voltage, high-current dual full-bridge driver intended to accept standard TTL logic levels and drive inductive loads, including relays, solenoids, DC and stepping motors. Two enable inputs are provided for independently enabling or disabling the device from the input signals. The emitters of each bridge's lower transistors are connected, and the corresponding external terminal can be used to connect an external sensing resistor. A second supply input is provided so that logic can operate at a lower voltage.

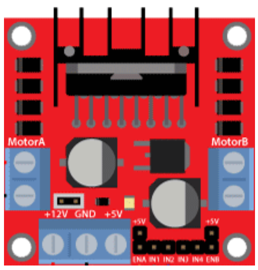

Fig.2.Motor Driver L298

Bluetooth Module:

Bluetooth technology enables wireless communication between devices without the use of cables or wires. In our project, we are utilizing the HC-05 model, which is used to transform image processing output data to Arduino. Bluetooth tx and rx are connected to our Arduino's two and third pins, respectively, for transmitting and receiving purposes.

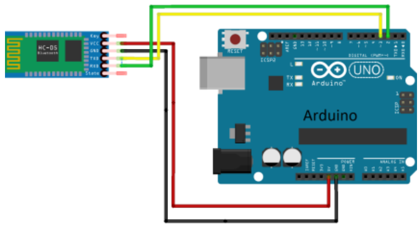

Fig.3.Bluetooth Module HC-05

Hardware Connections:

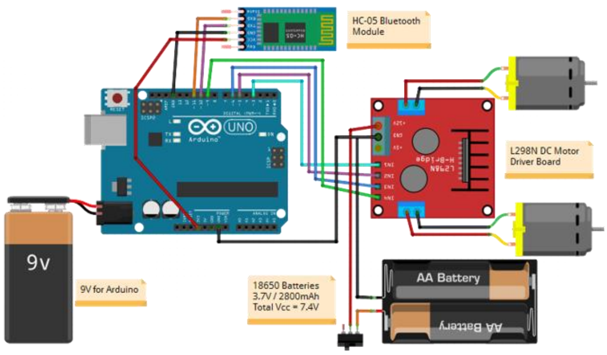

Fig.4.Connections for the Hardware Implementation

<u>SOFTWARE IMPLEMENTATION:</u>

The Viola-Jones algorithm serves as the basis for our work. This component accepts real-time video as input and converts it into individual images, or frames, for processing. It is only the eyes that are removed. Rectangle () in code can identify the eye region by using the region's coordinates, width, and height as parameters. The Vision class of MATLAB can be used to calculate distances, widths, and heights. Internal function CascadeObjectDetector is used to locate the eyes. The step function accepts as inputs the image and the Eye Detect object and returns the X-Coordinate, Y-Coordinate, Width, and Height of the eye region. Now we crop the image using the imcrop() method, passing n by 4 matrices and the image itself as inputs. With the aid of the rgb2gray () function, the RGB image is converted into its grayscale counterpart. Then, we use im2bw to convert the received grayscale image to its equivalent in black-and-white (). The resulting black-and-white image is then enlarged to emphasize the eyes. With the aid of the dilation function, foreground elements can be highlighted. IM2=imdilate (IM, SE) returns a stretched version of the grayscale, binary, or packed binary image IM that was supplied as input. The STREL function returns either a single object or an array of objects representing structuring elements (SE). The edges of regions containing foreground pixels are expanded gradually (white pixels).

The subsequent step will involve processing this in real time. This method relies on the sensitivity of the camera for accuracy. The connection to accuracy is direct. A higher-quality camera is required for greater focus on detail. The webcam must be configured, but prior to that, it must be installed. The imaqhwinfo() function identifies the associated cameras. The next step is to configure the webcam's properties. The Frames per Trigger option must be set. Then, we utilized the start (video object) method to obtain the live feed. Using the vision CascadeObjectDetector command, a FaceDetect object was initialized.

The next step in the process of detecting the eyes was cropping the image so that only the face was visible. To accomplish this, we separate the frames from the live video feed and then apply distinct processing to each one. With the aid of a vision CascadeObjectDetector, an object EyeDetect is configured. We were able to extract individual frames from the movie by using the snapshot () method, which returns a matrix representing an RGB image. The subsequent step consisted of virtually storing the image in a MATLAB script, which is analogous to detecting the eye region in a computer memory-stored static image. The snapshot () method increases processing time because it repeatedly calls the camera. The step function accepts an image and an EyeDetect object as inputs and returns the X-Coordinate, Y-Coordinate, Width, and Height of the eye region. imcrop() accepts as inputs the n by 4 matrices and the image itself in order to crop the image. Using the rgb2gray() method, the resulting RGB image is converted to its equivalent in grayscale.

The image is then converted to black and white by using the im2bw() method. The resulting black-and-white image is then enlarged to emphasize the eyes. If the user's head is tilted to the left, the screen will display the left side. If the eyes are facing the correct direction, the output will be accurate. Indicating direct output if the driver is looking directly ahead. If the face is deformed in any way or the eyes are closed, the output must read "no face."Algorithm of B. Viola Jones. Several applications employ the Viola-Jones method to identify objects. The primary characteristic of this algorithm is its slow training time compared to its rapid detection time. This method does not require multiplication because it employs Haar basis feature filters. If the integral picture is generated beforehand, the Viola-Jones method will run much more quickly.

$$II(y,x) = \sum_{p=0}^{y} \sum_{q=0}^{x} Y(p,q)$$

Fig.5.Formulation of Viola-Jones Algorithm

With the aid of the integral diagram, the integrals for the Haar extractors can be calculated by adding four digits and within a detection window, detection occurs. A minimum and maximum window size is selected, as well as a sliding step size for each size. The detection window is subsequently shifted across the image as follows:

1. Set the minimum window size and the corresponding sliding step.

2. For the selected window size, move the window horizontally and vertically with the same amount of movement. At each step, N face recognition filters are implemented. If one filter returns a positive result, the face in the current window is detected.

3. If the size of the window exceeds the maximum size, the procedure is terminated. If not, increase the window's size and the corresponding sliding step to the next level, chosen size and go to step 2. Each of the N face recognition filters consists of a set of cascade-connected classifiers. Each classifier examines a subset of the detection window and determines whether or not it resembles a face. If so, the following classifier is applied. If all classifiers return a positive result, the face is recognized and the filter returns a positive result. Otherwise, the next filter in the set of N filters is run.

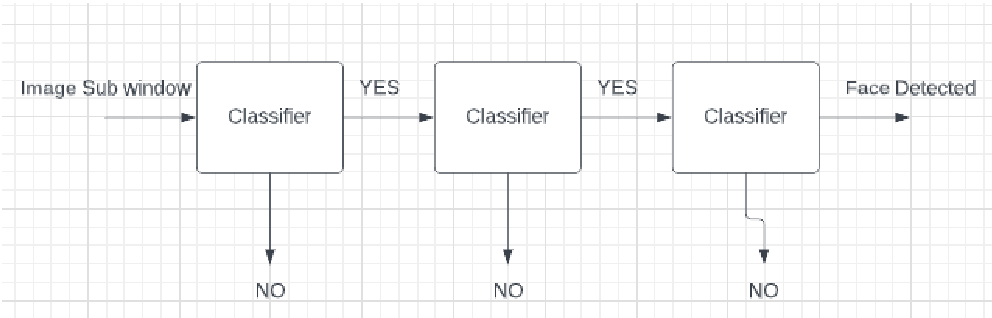

Fig .6. Object detection Viola-Jones algorithm

Every classifier consists of Haar feature extractors (weak classifiers). Each Haar feature is the weighted sum of 2-D integrals of contiguous small rectangular areas. The weights may take values ±1. Fig.7 depicts examples of Haar features relative to the detection window's enclosure. White areas have a negative weight, while gray areas have a positive weight. Haar feature extractors are scaled with respect to the detection window size.

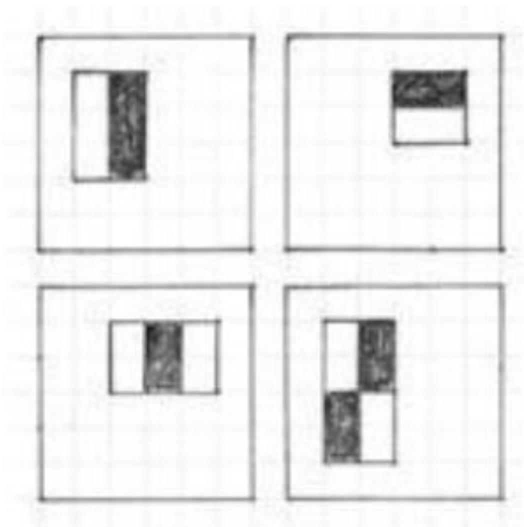

Fig.7.Representation of HAAR features

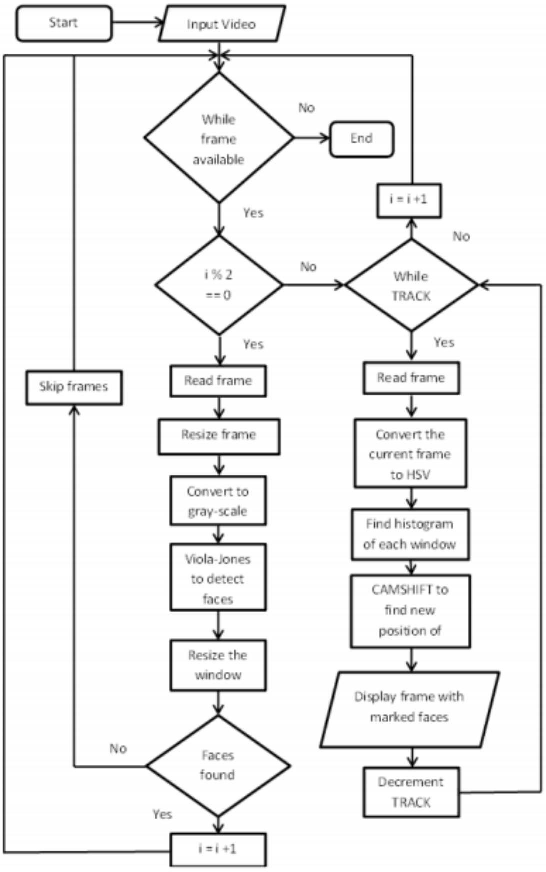

Fig.8.Software Implementation Architecture

Algorithm and Analysis:

KLT Algorithm:

The Kanade-Lucas-Tomasi (KLT) feature tracker is a computer vision method for extracting features. It is primarily intended to address the issue of the expensive nature of conventional image registration techniques.

SMQT Feature-based Classification:

The SMQT employs a technique that mechanically separates data into its constituent parts. Our SMQT experience up to this point is detailed in [3]. These characteristics will be applied to specific image regions in order to isolate elements unaffected by lighting conditions. There are numerous ways to categorize nearby places. A straightforward method involves cutting the image into squares of a specific size. An alternative method for extracting values involves interpolating between points on a circle centered at a given location. However, once the neighbourhood has been mapped, it will exist only as a collection of pixels. Let x represent a single pixel in an image, and let D(x) represent |D(x)| = D adjacent pixels. Consider the neighbourhood's SMQT transformation.

Model	Algorithm Accuracy Over Face Data
Viola Jones	62.3
KLT	61.1
SMQT	50.9

Fig.9. Accuracy Analysis of Multiple Algorithms

METHODOLOGY AND DESIGN:

First, it takes our face as input through the camera on our laptop. Then, it uses the Viola-Jones algorithm, which is an image processing algorithm that can take real-time video as input and process it by turning it into individual pictures, or frames. It finds the person's face and cuts it out. After that, it finds the eye and crops it out. Then, it finds the eyeball's movement and direction and figures out which way the eye is moving. This information is then sent to the microcontroller (Arduino) in the form of a character string through the HC-05 Bluetooth module. Based on the values sent by the Arduino board, the motor driver will send the correct values to the motors to make the robot move in the direction the user wants.

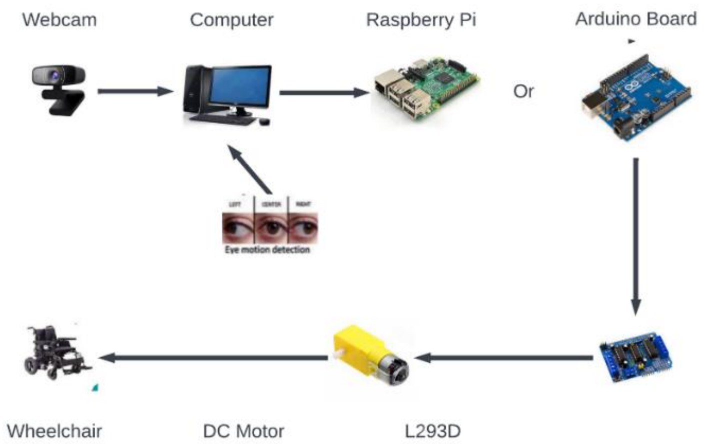

Fig.10. System Architecture

Research into eye-tracking is fascinating because it has the potential to greatly benefit the lives of those who are utterly unable to move around or speak for themselves. A functional circuit was constructed between a prototype wheelchair (a mobile robot) and a camera to record the user's face for the planned eye-tracking device. A Harr feature-based face detection algorithm was applied (the Violation Jones algorithm), and segmentation was done to get the eye as a region of interest. When this distance on the left is less than the distance on the right, the eye's pupil is pointing in the left direction, and when the same is larger, then the eye's pupil is pointing in the right direction. It is considered straight if it is nearly identical.

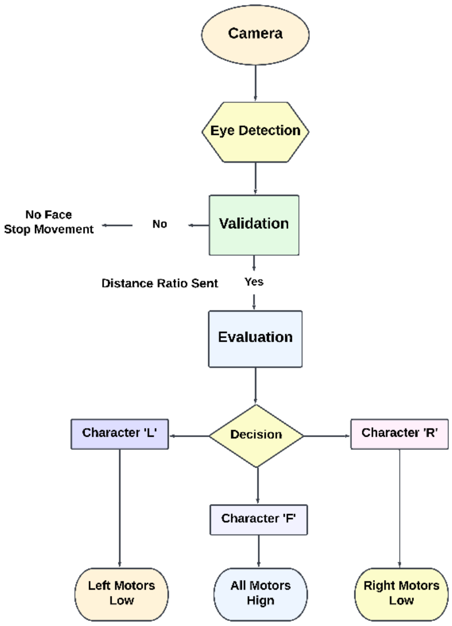

Fig.11.Integrated System Architecture

IMPLEMENTATION RESULTS:

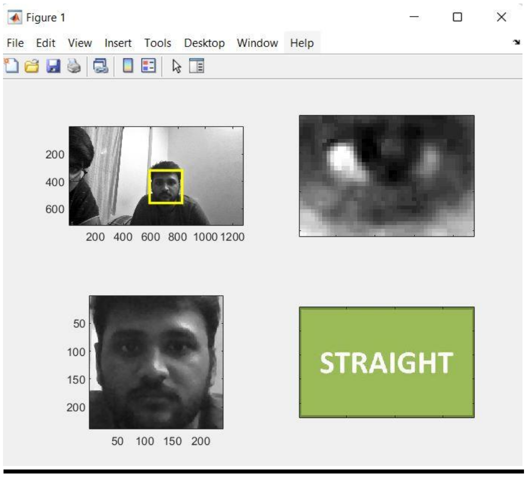

Fig.12.Matlab Code Output when looking Straight

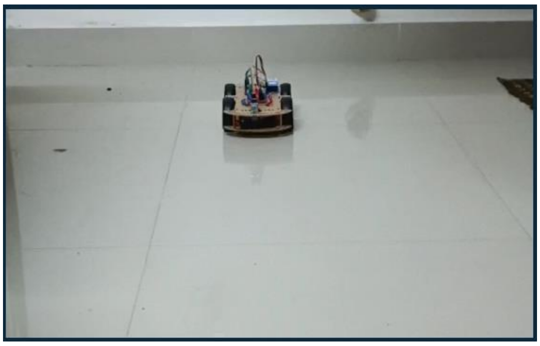

Fig.13.Robot moving in straight direction

If the person is looking straight, it indicates straight output, and the output will pass to the Arduino board with the help of Bluetooth. After taking the values from the Arduino, the motor driver will give the same power to all the dc motors and make the robot move in a straight line.

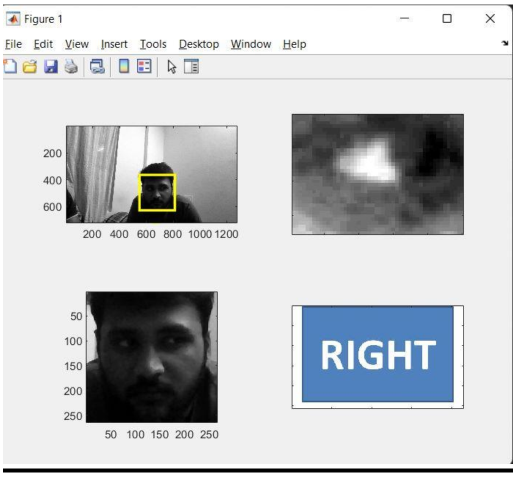

Fig.14. Matlab Code Output when looking Right.

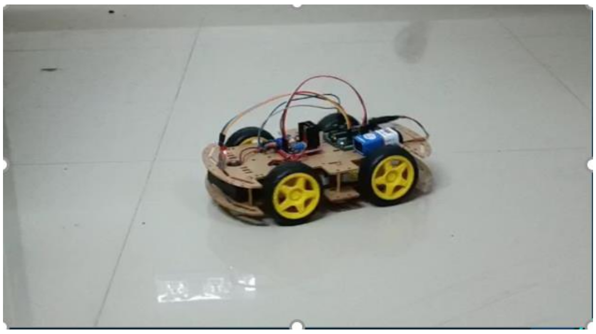

Fig.15. Robot moving in Right direction

If the person is looking in the right direction, it indicates the right output, and the output will be transmitted to the Arduino board via Bluetooth. After receiving the values from the Arduino, the motor driver will increase the power to the two left-side dc motors, causing the robot to move in the right direction.

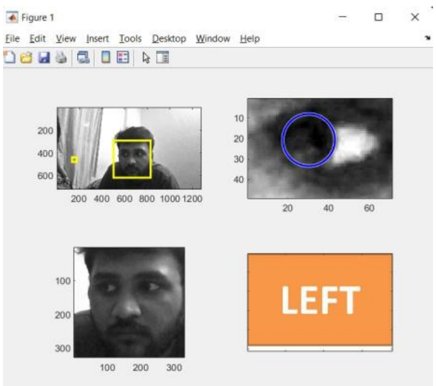

Fig.16. Matlab Code Output when looking Left

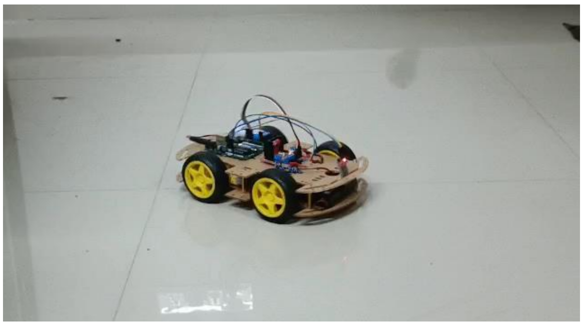

Fig.17. Robot moving in Left direction

If the person is looking left, it indicates left output, and the output will pass to the Arduino board with the help of Bluetooth. After taking the values from the Arduino, the motor driver will give more power to the two right-side dc motors and make the robot move in the left direction.

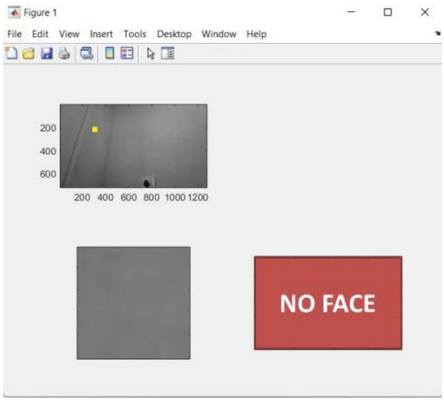

Fig.18. Matlab Code Output when is there is no face

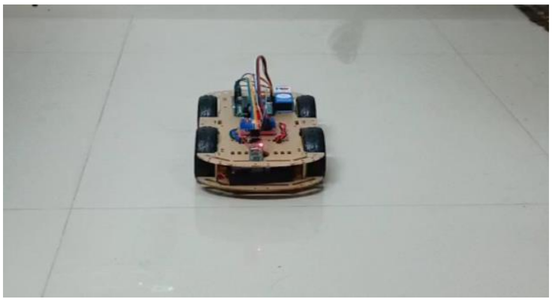

Fig.19. Robot stops moving

If the person's face is not captured or visible in the camera, it indicates output as "No Face," and the output will pass to the Arduino board with the help of Bluetooth. After taking the values from the Arduino, the motor driver will stop giving power to the side dc motors and make the robot stop.

CONCLUSION AND FUTURE SCOPE:

We are able to successfully control the robot with the gaze of an eye, and it moves accordingly. This prototype can also be controlled flexibly with a smartphone remote. To improve the mode's movement accuracy, we can add additions to the sensor verges. In addition to being viewed as a potential alternative energy source, the concept of the eye-gaze wheelchair can be incredibly useful in allowing individuals with physical disabilities to live their lives independently.

The primary goal of implementing the eye-gaze wheelchair was to draw attention to the characteristics of digital image processing technology, which was accomplished through the successful construction and testing of a prototype. While our concept is especially beneficial to those with physical disabilities, it does have some limitations. The system's delay of around 2 seconds slows wheel motion. Pupil detection in low-light environments is notoriously difficult. Aside from these issues, the system operates normally. To improve accuracy and efficiency, we could also host the model on a Wi-Fi-based local server.

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