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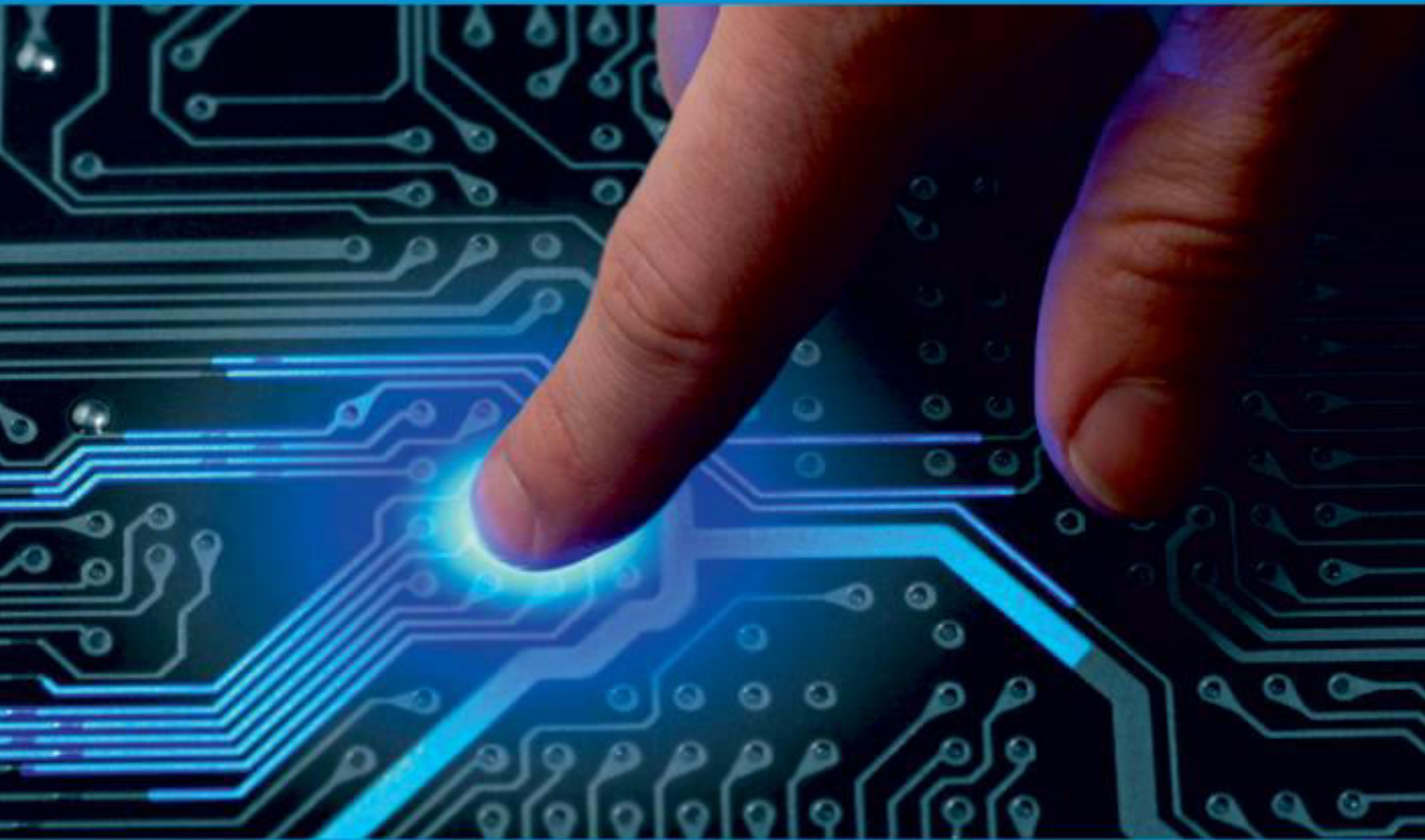

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Eye Pupil Controlled Wheelchair

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ABSTRACT: This project aims to improve the mobility and independence of individuals with disabilities who use wheelchairs by developing a new system that enables them to control the chair with their eyesight. Energy conservation and the ability to use their hands for other purposes can be achieved by enabling wheelchair users with disabilities to control their chair through their eyesight. The project will involve the creation of various components, potentially requiring formatting, styling, and insertion of features to ensure success. Ultimately, this technology will provide a higher degree of autonomy for those with limited mobility.

KEYWORDS: Pupil controlled, Haar cascade, Facial landmark, Eye-tracking technology, Sensors, Autonomy, Independence.

I. INTRODUCTION

The loss of nerve fibers due to accidents can result in an inability to move, particularly in cases where the optic nerve system has been injured. It can be difficult for individuals to learn how to operate a conventional power wheelchair, as more than half of its users have reported experiencing difficulties with maneuvering it. Even after training, some patients find power wheelchairs extremely challenging to use. However, research has revealed that eye-ball movement mechanisms can enable fully paralyzed individuals, who cannot move their limbs, to use transportation independently. To improve the mobility of people with physical disabilities, this wheelchair can be controlled through eye movements, eliminating the need for manual effort to operate the chair. The wheelchair will also be equipped with sensors to monitor the user's body temperature, heart rate, and oxygen levels. Ultimately, this technology will promote greater independence for individuals with disabilities, enabling them to move around without relying on the assistance of others

II. SOFTWARE AND HARDWARE COMPONENTS

Software:

A. Python:

Python is a popular interpreted programming language that is utilized for web development, general-purpose programming, and scientific computing. Its versatility, user- friendly syntax, and simplicity are well-known. Python comes with a rich standard library and an extensive range of third- party libraries, making it a favored choice for a broad range of applications.

B. Raspbian OS:

Raspbian is an operating system that is based on Debian and is specifically designed to operate on the Raspberry Pi, a well- known single-board computer. It is optimized for the ARM architecture and includes a range of software tools and libraries that are useful for developing and running embedded systems. Raspbian is open-source software and is widely used in education, hobbyist projects, and professional applications.

C. Embedded C:

Embedded C is a programming language that is used for developing software for embedded systems, which are small computers that are integrated into larger systems. Embedded C is a variant of the C programming language that is optimized for use in embedded systems. It includes a range of features that are specifically designed for embedded applications, such as low-level hardware access, memory management, and interrupt handling.

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D. Arduino software:

The Arduino software is a development environment that is used for programming the Arduino microcontroller, a popular open-source hardware platform for building electronics projects. The Arduino software includes a range of libraries and tools that are designed to make it easy to write code for the Arduino. Its programming language is primarily based on C++, and it provides a user-friendly programming interface that is accessible to both novice and advanced programmers. The Arduino software is open source and is widely used in education, hobbyist projects, and professional applications.

Hardware:

A. Raspberry pi 3:

The Raspberry Pi 3 is device that is intended for use in personal and recreational projects. It includes a range of features that are useful for building embedded systems, including a quad-core processor, Wi-Fi and Bluetooth connectivity, HDMI and Ethernet ports, and GPIO pins for interfacing with other hardware components.

B. Camera:

A camera is a hardware component that captures images or video. Cameras can be built into other devices, such as smartphones or laptops, or can be standalone devices. Cameras are widely used in a range of applications, including security systems, digital photography, and computer vision.

C. Arduino Uno:

The Arduino uno is a microcontroller designed for creating electronic projects. The board features a range of inputs and outputs that enable interaction with other devices, such as sensing devices and motors. The Arduino Uno is based on the ATmega328P microcontroller and can be programmed using the Arduino software.

D. Ultrasonic sensor:

Ultrasonic sensors are devices that detect an object's distance by utilizing sound waves, and they are often utilized in robotics and automation contexts, such as for obstacle detection or distance measurement.

E. Temperature sensor:

The hardware device, referred to as a temperature sensor, is designed to measure the temperature of the surrounding area. Temperature sensors are versatile devices that can be employed in various areas, such as environmental monitoring, HVAC systems, and industrial settings.

F. Heartbeat sensor:

A hardware device, known as a heartbeat sensor, is used for measuring an individual's heartbeat rate. Heartbeat sensors are commonly used in medical applications, such as heart rate monitoring and ECG measurements.

G. Zigbee:

Zigbee is a communication protocol that employs wireless technology and is primarily optimized for applications requiring minimal power usage and low data transfer rates. Zigbee is commonly used in IoT (Internet of Things) applications, such as home automation and industrial control systems. Zigbee devices can form mesh networks and can be used to transmit data over long distances.

H. DC Motor:

It is a type of electric motor that transforms electrical power into motion. It uses a magnetic field to create rotational motion. DC motors find wide application across various fields, including robotics, automation, and electric vehicles.

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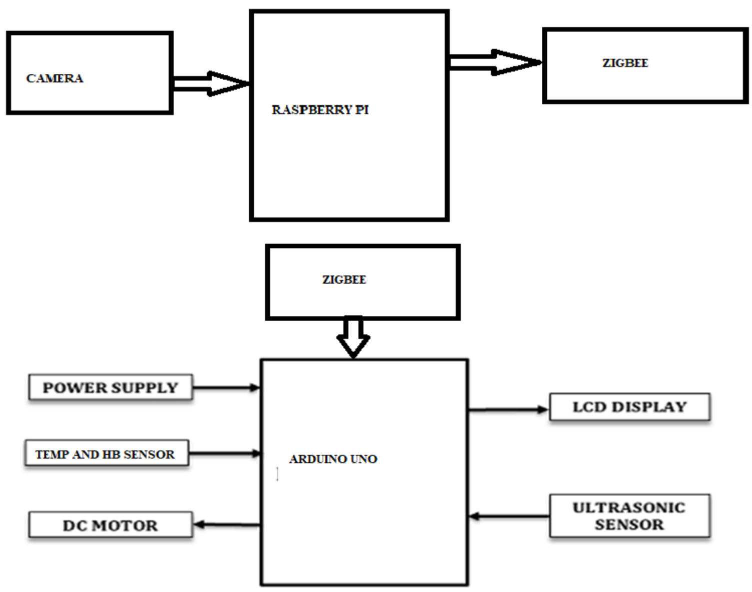
I. DC Motor driver:

DC motor drivers are hardware components that regulate the velocity and orientation of a DC motor. DC motor drivers provide a current to the motor based on the control signals received from a microcontroller or other control circuit. They can be used to drive different types of DC motors, such as commutator motors and electrically commutated motors.

III. SYSTEM ARCHITECTURE

A diagram of system architecture is a graphical depiction of the system's elements and their interconnections. It provides a visual representation of the system's internal structure, allowing for a better understanding of the relationships between the different components.
The diagram typically consists of blocks representing the components of the system and consists of lines or arrows representing the relationships between those components.



IV. METHODOLOGY

The eye-controlled wheelchair was developed using a combination of hardware and software components. The hardware includes an eye-tracking device that is used to detect the position of the individual's gaze. The wheelchair is equipped with motors and a controller that are used to move the chair in response to the individual's eye movements. The system also includes sensors to monitor the individual's body temperature, heart rate, and oxygen levels. The software includes algorithms to process the eye-tracking data and translate it into wheelchair movements.

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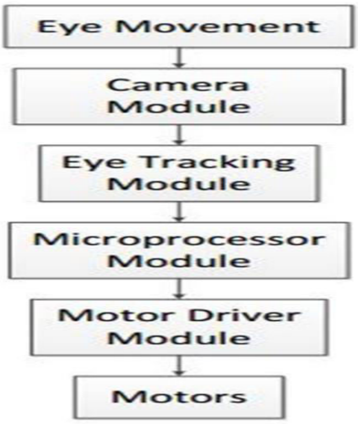
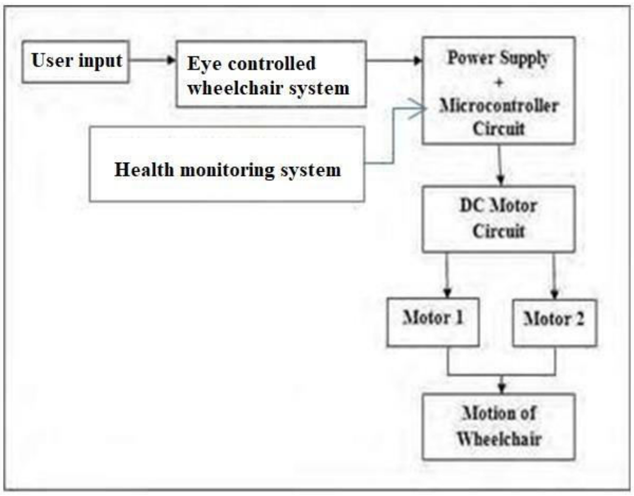


V. WORKING PRINCIPLE

The central goal here in this endeavor is to develop a powered wheelchair which is maneuvered through eye movements. The system is designed to provide both control systems for people with lower limb injuries as well as upper limb injuries, and also includes some therapy facilities to help them regain strength. In addition to the eye-tracking technology, the system includes an obstacle detection unit that uses an ultrasonic sensor to sense hurdles in its way. When a hurdle is sensed, the controller halts the wheelchair without any delay. The motors used in the system are DC series motors with high starting torque, uncomplicated design, and affordable. Both motors have a voltage and current rating of 24V and 5A respectively, and their RPM is 1050. The radius of the rear wheel is 0.35m, while the radius of the front cluster is 0.05m. The rotation of the front casters is dependent on changes in the speed of the rear wheels when the wheelchair turns.

The system is controlled by an ESP32 microcontroller that also checks the user's heart rate, ultrasonic sensor readings, and messages that are integrated together to enable the user to navigate the wheelchair. Eye movements are used to maneuver the wheelchair, and this setup includes a touch screen or voice recognition control switch for alternative methods of control. The system architecture includes data transfer between the microcontroller and external devices, as shown in the figure. This system provides a user-friendly interface for the disabled people, allowing them to control the wheelchair movement through their eyes, providing them with a sense of independence and autonomy. Additionally, the obstacle detection unit provides an extra layer of safety and ensures that the wheelchair stops instantly in case of any obstacles in its path, making it a reliable and secure system. Overall, the eye-controlled wheelchair system provides a more accessible and flexible option for people with mobility disabilities, allowing them to navigate their environment with greater independence and ease.



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VI. ALGORITHMS AND EQUATIONS

The Eye Aspect Ratio (EAR) is a measure of how the dimensions of the eye relate to each other, used in computer vision applications for detecting and tracking eye blinks. The value of EAR is calculated by measuring the vertical and horizontal distances between the landmarks of the eye, including the upper and lower eyelids and the inner and outer corners of the eye.

The formula for calculating EAR is:

where Pi (i = 1 to 6) are the six facial landmark coordinates identified on the eye, as shown in the image below:

In the EAR formula, the numerator calculates the vertical distance between two sets of landmarks (P2 and P6, and P3 and P5) and adds them together. The denominator is equal to twice the distance between the horizontal landmarks of the eye, measured from one point to the other (P1 and P4).
In general, when the eye is open, the distance between vertical landmarks is greater than that between the horizontal landmarks, resulting in an EAR value close to 1. When the eye is closed, the distance between vertical landmarks decreases while the distance between the horizontal landmarks remains relatively constant, resulting in a decrease in the EAR value. By setting a threshold EAR value, eye blinks can be detected and used as a cue for a range of computer vision applications, such as driver fatigue detection, drowsiness detection, and human- robot interaction.

Haar cascade algorithm for eye-pupil tracking:

- Capture images: The first step is to capture images of the user's eyes using a camera. The images should be captured at a high frame rate to ensure that the system can track the user's eye movements in real-time.
- Pre-process images: The images should be pre-processed to enhance the contrast and remove any noise or artifacts that may affect the accuracy of the algorithm.
- Detect pupils: The Haar cascade algorithm can be used to detect the location of the user's pupils in the pre-processed images. This involves training a classifier using a large dataset of positive and negative examples.
- Track pupils: Once the pupils have been detected, the system can track their position in subsequent frames of the video. This involves using a tracking algorithm to estimate the movement of the pupils over time.
- Control wheelchair: Finally, the movement of the wheelchair can be controlled by tracking the position of the pupils. For example, the position of the pupils could be mapped to the direction and speed of the wheelchair's movement.

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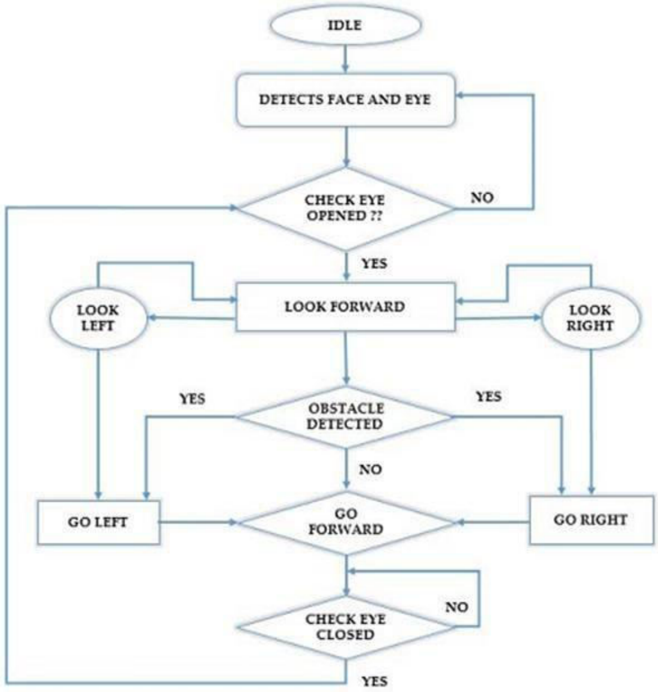
Flow chart diagram



VII. BENEFITS

- The Eye-Pupil Controlled Wheelchair has several benefits over other traditional wheelchair control systems:
- Increased Independence: The Eye-Pupil Controlled Wheelchair allows individuals with disabilities that prevent them from using their hands to move the wheelchair independently. This system eliminates the need for caregivers or assistants to operate the wheelchair for them.
- Improved Accuracy: The Eye-Pupil Controlled Wheelchair offers greater precision and accuracy than other control systems, as it directly tracks the user's eye movements. This can improve the user's ability to navigate in tight or complex spaces, as well as to perform more delicate maneuvers.
- Reduced Physical Strain: Traditional wheelchair control systems can require significant physical effort to operate, which can be challenging or impossible for individuals with limited mobility or strength. The Eye-Pupil Controlled Wheelchair reduces the physical strain on the user by eliminating the need for manual manipulation of the wheelchair's controls.
- Non-Invasive: Unlike some other alternative control systems that require surgery or other invasive procedures, the Eye-Pupil Controlled Wheelchair is non-invasive and does not require any physical modification of the user's body.
- Overall, the Eye-Pupil Controlled Wheelchair offers a more intuitive, precise, and accessible means of controlling a wheelchair, enabling greater independence and mobility for individuals with disabilities.

VIII. USER CENTERED EVALUATION

- Advancements in Eye-Tracking Technology: The Eye- Pupil Controlled Wheelchair is made possible by advancements in eye-tracking technology, which has become increasingly precise and affordable in recent years. This technology allows for highly accurate tracking of eye movements, which can be used to control a wide range of devices.

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- Comparison to Other Alternative Control Systems: While the Eye-Pupil Controlled Wheelchair has many benefits over traditional wheelchair control systems, it's also important to compare it to other alternative control systems that are available. This could include systems that use head movement or speech recognition, for example.
- Accessibility Challenges: While the Eye-Pupil Controlled Wheelchair can greatly improve accessibility for individuals with disabilities, there are still some challenges to be addressed. For example, the system may not be effective for individuals with certain eye conditions, or in environments with poor lighting conditions.
- Future Directions: The Eye-Pupil Controlled Wheelchair is a promising technology, but there is still room for improvement and innovation. Future research could focus on developing more advanced eye-tracking algorithms, improving the user interface, or integrating additional sensors to improve safety and functionality.
- User Experience: It's important to consider the user experience when evaluating the Eye-Pupil Controlled Wheelchair. This could include factors like ease of use, comfort, and reliability. Conducting user studies and gathering feedback from individuals who have used the system could provide valuable insights into how to improve the design and functionality of the wheelchair.

IX. USE CASE

- The user sits in the wheelchair and puts on the eye-tracking device.
- The eye-tracking device captures the movements of the user's pupils.
- The captured data is processed by the Raspberry Pi and converted into commands for the motor driver.
- The motor driver controls the DC motors that move the wheelchair in the desired direction.
- An ultrasonic sensor is used to detect obstacles that may be in the path of the wheelchair. When an obstacle is detected, the sensor sends signals to the Raspberry Pi.
- Raspberry Pi processes obstacle data and sends instructions to the motor driver to alter the wheelchair's direction to evade the obstacle.
- The temperature, heartbeat, and oxygen sensors attached to the user send data to the Zigbee module.

X. RESULTS

The focus of this section is on the experimental findings. The system received video feed using a camera and then proceeded to analyse the motion of the eye pupil. Signals were successfully transmitted by the Raspberry-Pi controller the circuit responsible for controlling the motor and the relay, enabling the desired movement of the wheelchair in specific directions. A visual representation of these functions is provided in Figure 6, while Table I presents further details.

To evaluate its precision, a set of instructions were given and captured by a camera for the system. The number of instructions was then counted, also the number of successful instructions was noted. The accuracy was then calculated using this information and presented in Table III.

The accuracy was determined using a specific equation. Upon completion of the testing procedure, it was discovered that the overall accuracy results were greater than 87%.

According to Table III, the accuracy of the instruction for backward movement is significantly lower (65.63%) than the accuracy of other types of movement instructions. This is because blinking tends to cause the eyelid to compress, resulting in variations in the position of the eye pupil, which makes it difficult to detect its exact location with accuracy. As a result, the precision of the retrograde guidance is comparatively insufficient.

XI. CONCLUSION

In conclusion, the eye-controlled wheelchair has the potential to enhance the standard of living of people with restricted mobility in a substantial way. The system not only provides a means of mobility but also allows for greater independence and control over their surroundings. The use of sensors to monitor vital signs adds an additional layer of safety, which is particularly important for individuals with disabilities that make them more vulnerable to health

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issues. While the system is still in the early stages of development, it shows great promise and further refinement could make it a widely used solution for individuals with physical disabilities. Overall, the eye-controlled wheelchair represents an innovative and exciting approach to assistive technology that could make a significant impact on the lives of many people. In addition, the system has potential to enhance the quality of life for individuals with physical disabilities by providing a means for them to participate in daily activities and interact with their surroundings more easily. As technology continues to advance, it is likely that eye-controlled wheelchairs and other assistive technologies will become more accessible and affordable, making them available to a wider range of individuals who could benefit from their use.

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