© December 2023| IJIRT | Volume 10 Issue 7 | ISSN: 2349-6002

An Enhanced approach for Smart Wheelchair Safety System for Physically Disabled People

Loganathan .S[1], Sangeetha.E[2], Avanthika. K[3] , Monicka shree. A[4] , Poovizhi. K[5]
[1,2,3,4,5]*Paavai Engineering College, Pachal, Namakkal*

Abstract— The Raspberry Pi serves as the central processor for this project. The main goal of achieving automated movement is accomplished through various interfaces. The first type of interface is a touchscreen that displays arrow keys, enabling the user to move in any desired direction. Additionally, the wheelchair can be controlled using Hand gestures, Voice commands, or an android phone. The wheelchair circuit includes an RF and Bluetooth receiver, which receives these commands and operates the wheelchair motors accordingly to achieve the desired movement. This system allows disabled individuals to easily operate the wheelchair, while also enabling another person to control it from a distance of 3-4 meters. By incorporating automation and safety features, the Raspberry Pi-based wheelchair safety system takes the wheelchair system to a new level.

Keywords—Raspberry Pi 4 model B, Ultrasonic Sensor, Touch screen display, RF Bluetooth module, GSM/GPS module, DC Motor.

I. INTRODUCTION

The introduction to an improved smart wheelchair safety system utilizing Raspberry Pi could commence as follows. In recent times, there has been an increasing demand for innovative solutions to enhance the safety and mobility of individuals who depend on wheelchairs for their daily transportation requirements. Conventional wheelchairs often lack advanced safety features and real-time monitoring capabilities, thereby leaving users susceptible to accidents and emergencies. To tackle these challenges, we propose an enhanced approach for a smart wheelchair safety system, harnessing the power and versatility of the Raspberry platform.

This system aims to revolutionize the notion of wheelchair safety by integrating state-of-the-art technology, such as sensors, communication modules, and intelligent algorithms. By doing so, our objective is to not only provide wheelchair users with heightened safety but also grant them greater independence and peace of mind in their everyday lives.

Within this document, we will delve into the design, components, and functionalities of our smart wheelchair safety system. We will explore how the Raspberry Pi, a single board computer renowned for its adaptability and affordability, serves as the central hub of our solution.

Furthermore, we will discuss the diverse sensors and peripherals that we have incorporated to monitor and respond to environmental conditions, user health, and potential hazards.

This paper will also emphasize the crucial role of data analysis and real-time communication in our system. Through these capabilities, we enable caregivers and healthcare professionals to remotely monitor wheelchair users, promptly address emergencies, and make well-informed decisions to ensure user safety.

II. LITERATURE REVIEW

The focus of the research paper revolves around enhancing the functionality of a motorized wheelchair to cater to a greater population of individuals with disabilities. This objective is accomplished through the integration of a DC motor, motor drivers, and a microcontroller system. The control circuit, which is based on the Android platform, effectively manages the wheelchair's movement. Bluetooth technology is employed to establish communication between the control circuit and an Android phone that is already in use.

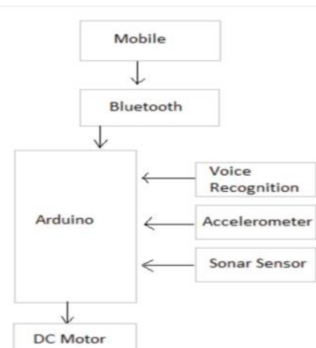

Figure 1. Block diagram of SMART WHEELCHAIR

The primary objective of this research is to utilize hand gestures to control a wheel through smartphones. To achieve this, an android application has been developed. The choice of the android platform is based on its provision of open tools for this purpose, ensuring an efficient system and favorable outcomes.

The motor drivers are controlled using an Arduino controller. In this setup, the Arduino app is connected to the android application through a master-slave configuration. The HC-005 Bluetooth module serves as the slave, while the smartphone acts as the master.

This paper focuses on testing the movement of a wheelchair using voice commands. To accomplish this, user voices are recorded for the forward, backward, left, right, and stop movements. Two main aspects are considered: the accuracy of the voice recognition system and the velocity of the wheelchair. The user's voice is recorded in a quiet environment to minimize noise, and then compared to the stored frequency of words in the system. If there is a match, the wheelchair will respond accordingly.

The Android application utilized in this project is installed on the user's phone, resulting in a reduction in the cost of the wheelchair. The wheelchair can move in four directions: forward, reverse, right, and left. The communication between the phone and the control circuit is conducted wirelessly. The user can control the wheelchair through a joystick, which allows for commands such as moving forward, backward, left, and right. Additionally, the speed of the wheelchair can be adjusted using this joystick. The main objective of this feature is to enable the user to exert less effort while ensuring enhanced safety.

The Head controlled wheelchair, also known as the V-frame and SPDT switch wheelchair, incorporates a new complex feature. It utilizes a V-frame and a single pole double throw (SPDT) switch, along with four SPDT type relays of 12V and 10 Amps, to enable movement in different directions such as left, right, forward, and reverse. These switches are attached to the V-frame and allow the user to easily maneuver the wheelchair as desired. The device architecture consists of an Arduino Uno microcontroller, which acts as the brain of the wheelchair. It is responsible for controlling the 24-volt DC motors attached to the wheels. Additionally, a remote controller is used to control the motion of the wheelchair. The microcontroller communicates through a transmitter and receiver.

The hardware design ensures smooth movement of the wheelchair on a flat surface. The two DC motors provide the necessary torque to move flawlessly, even with a patient weighing up to 80kg. The motors are synchronized to rotate at the same speed, allowing the wheelchair to move in a straight line. To change the direction of the wheelchair to the right or left, the respective motor rotates the wheel, providing easy and safe maneuverability for the user.

Power for the motors and electronics of the project is supplied by a single DC LINO 12-volt 26Ah rechargeable battery. The smart wheelchair is controlled by a single Arduino mega, which connects various components such as Bluetooth, motor drive circuits, MPU sensor, and buck boost circuits.

The motor shaft is connected to the wheels using a strong chain sprocket mechanism. This mechanism was chosen for its durability and ease of maintenance Figure 1

III. PROPOSED METHODOLOGY

The configuration of the proposed system is designed to be beneficial for individuals with disabilities, allowing them to operate using their own hand gestures, voice, and an Android phone. The interaction between humans and machines has previously been achieved through Gesture Recognition using an accelerometer sensor. However, there have been recent advancements in various techniques used in everyday life. Raspberry Pi, a credit card-sized microcontroller, is capable of performing on-chip image processing techniques. One common method of communication is through gesture communication. An algorithm utilizing contour detection can be employed to detect hand movements. By utilizing a web camera, images are captured and processed using Raspberry Pi. The entire system is mounted on a wheelchair and operates wirelessly. Raspberry Pi has a built-in Graphical User Interface module, enabling onboard image processing techniques. The web camera is interfaced through the Raspberry Pi's USB port. Hand movements are captured by the web camera, and based on the algorithm, the wheelchair moves in specific directions such as front, back, left, and right. This hand gesture-controlled wheelchair system is primarily intended for use by disabled individuals. The entire system is controlled by the Raspberry Pi. With their own hand gestures, users can control the wheelchair's movement in a particular direction. The wheelchair can move in four directions. The camera serves as the input module, capturing the user's hand gestures and sending them to the controller. The Raspberry Pi unit sends commands to the wheelchair system to move in the desired direction, whether it be left, right, forward, or backward. In the proposed system, the camera acts as the input module, capturing hand gestures and sending them to the controller. If any obstacles are detected in front of the wheelchair while it is in motion, it will automatically come to a stop. The camera captures this information and sends it to the Raspberry Pi controller, which then sends the appropriate commands to the wheelchair system. As a result, the wheelchair moves in all four directions based on the commands received.

Human communication heavily relies on voice signals, as they serve as the primary means of interaction. Voice signals can be transformed into electrical signals through the utilization of a microphone. This technology is particularly beneficial for individuals who are paralyzed and unable to operate a joystick wheelchair using their hands. Wheelchairs are essential for providing transportation to disabled individuals with impairments in their hands and legs. These wheelchairs offer smooth and autonomous self-driving capabilities both indoors and outdoors. They possess the ability to detect obstacles, stairs, or any other hindrance, and can autonomously come to a halt. By utilizing a microphone, voice commands are transmitted to the raspberry pi, which then employs a speech recognition system to display the recognized commands. Based on these commands, the raspberry pi determines the appropriate action to take, such as moving forward, turning right or left, or stopping.

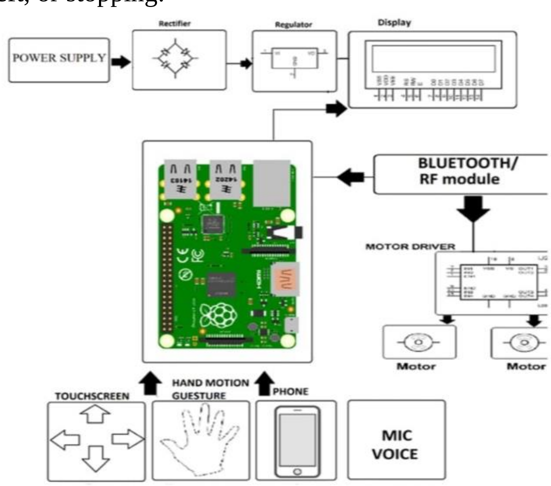

FIGURE 2. SCHEMATIC DIAGRAM FOR SMART WHEELCHAIR

A. Raspberry Pi

In June 2019, the Raspberry Pi 4 Model B was launched. It comes equipped with a powerful 1.5 GHz 64-bit quad-core ARM Cortex-A72 processor, on-board 802.11ac Wi-Fi, Bluetooth 5, full gigabit Ethernet, two USB 2.0 ports, two USB 3.0 ports, and 1, 2, 4, or 8 GB of RAM. Additionally, it supports dual-monitor setup through a pair of micro-HDMI ports. The Raspberry Pi 4 can perform various tasks typically associated with a regular desktop PC, such as word processing, spreadsheet management, high-definition video playback, gaming, and programming. The board also features two USB ports for connecting peripherals like keyboards and mice. Compared to its predecessor, the Raspberry Pi 3 Model B+, the quad-core Raspberry Pi 4 Model B offers significantly improved speed and capabilities. In certain benchmarks, the Pi 4's CPU outperforms the Pi 3's processor by two to three times. Moreover, the new board supports 4K video playback at 60 frames per second, enhancing its media centres capabilities. However, it's important to note that not all videos will play smoothly on the Pi 4, and hardware acceleration for H.265-encoded video is still a work in progress across the Pi's various operating systems. Therefore, this feature may become available in the future rather than being currently accessible.

B. *Ultrasonic Sensor*

The HC-SR04 ultrasonic sensor uses SONAR to determine the distance of an object just like the bats do. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package from 2 cm to 400 cm or 1” to 13 feet. Below is the circuit diagram for connecting -SR04 sensor and LCD with Raspberry Pi for measuring the distance. As shown in the figure, HC-SR04 Ultrasonic Sensor has four pins, PIN1- VCC or +5V. PIN2- TRIGGER (10us High pulse given to tell the sensor to sense the distance.

C. *Touch Screen Display for Raspberry Pi*

The 3.5-inch TFT LCD touch screen display is specifically designed for Raspberry Pi 4, Pi2, and Model B/B+. It utilizes the latest Linux Core system, making it perfect for DIY projects. The module seamlessly attaches to the Raspberry Pi without the need for an additional power source or case. Additionally, a stylus is included for easy interaction with the compact screen. This display serves as an excellent alternative to HDMI monitors and is compatible with all Raspberry Pi revisions. It comes with a complete set of screws and nuts for effortless assembly. With a resolution of 320×480, it offers a superior display quality while remaining lightweight and simple to install.

D. RF Bluetooth Module

The HC-05 Bluetooth Module is a straightforward module that enables the establishment of a wireless serial connection using the Bluetooth SPP (Serial Port Protocol). It utilizes serial communication, providing a convenient interface with controllers or PCs. HC-05 Bluetooth Modules are capable of effortlessly connecting your phone with the UNO board. This module, which is a 6 Pin Wireless RF Transceiver Master-Slave Integrated Module, allows for the swift addition of Bluetooth functionality to your UNO project. Consequently, you can utilize your Android phone to control various gadgets such as switches and LEDs. The connection process for this HC-05 module is extremely simple.

E. GSM/GPS Module

The Gear SIM808 Bluetooth Compatible GSM/GPRS/GPS Development Board with GPS Antenna is a versatile development board that is compatible with both Arduino and Raspberry Pi. It features the SIM808 module, which allows for GSM communication and GPS functionality. With this module, you can send and receive SMS messages, track locations, and even create your own cell phone. The SIM808 module serves as both a GSM communicator and a GPS receiver, making it a convenient two-in-one solution. This development board is based on the latest SIM808 module from SIMCOM, which supports GSM/GPRS Quad-Band network and incorporates GPS technology for satellite navigation. With GPS tracking capabilities, you can accurately determine the position of the device in real-time. Additionally, the GSM communication feature enables connectivity through text messages (SMS) and data transmission, allowing for remote alerts and commands.

F. DC Motor

The Motor Driver is the key component in controlling a DC Motor with Raspberry Pi. It is a specialized circuit or IC that supplies the motor with the required power (current) for smooth and safe operation. Even a small 5V DC Motor initially draws a high current of approximately 300-400 mA, which then decreases to around 150-200 mA as the motor gains speed. This high current is too much for devices like Microcontrollers, Arduino, and Raspberry Pi. Therefore, it is crucial to never directly connect a motor to Raspberry Pi or any other microcontroller. Instead, Motor Drivers play a vital role in this scenario. They receive control signals from Raspberry Pi and provide the necessary current to the motor from the power supply.

In this project, the motor driver (L293D) is connected to Raspberry Pi through GPIO Pins, receiving two control signals. Based on the Python Program, the motor will rotate either in the forward or reverse direction.

G. *Microphone Sensor*

A microphone is a device that converts sound into electrical energy, allowing us to manipulate and utilize it in various ways. It acts as a sensor or transducer, capturing acoustic energy and transforming it into a form that can be amplified, digitized, displayed, recorded, and more. The microphone operates within a voltage range of 3.3 to 5 V, with an operational current of 4-5 mA. At a voltage of 6V and a frequency of 1kHz, it provides a voltage gain of 26 dB. The microphone's sensitivity at 1kHz ranges from 52 to 48 dB. Additionally, many microphone sensors offer the flexibility to adjust the sensitivity, enabling the detection of sounds within a specific range or threshold. Depending on the type, microphone sensors can provide either analog or digital output. Analog output corresponds to the sound intensity, while digital output produces a discrete signal when a sound threshold is reached.

I. Python Software

A Python compiler is an essential element of the Python programming ecosystem. It is responsible for transforming human-readable Python source code into low-level machine code or bytecode. Unlike Python interpreters that execute code line by line, compilers generate a compiled code version that can potentially result in performance enhancements.

A compiler is a program that converts a high-level programming language into a lower-level language that can be understood by the assembly and interpreted into logical inputs. Although Python is often classified as an interpreted language, it actually has different implementation versions, such as C Python and Iron Python. C Python is the standard version that converts code into bytecode, which may lead to the misconception that Python is interpreted. However, these interpreted codes are not directly understandable by the CPU unit and require an interpreter. The Python Virtual Machine then converts the bytecode into machine code.

IV.RESULT

The primary focus of the wheelchair system is to determine its speed. While the Speech operated wheelchair moves in a straight line, the velocity is determined by the distance and time. The velocity of the wheelchair needs to be tested under two conditions. Firstly, the speed is measured when the wheelchair is unloaded. It was designed to travel in a straight line, and a speed of 0.8 m/s was observed. Secondly, the wheelchair was tested while carrying a load of 15 kg, and the velocity was found to be 0.76 m/s. Subsequently, a person weighing 78 kg sat in the wheelchair, requiring it to travel in a straight line. The velocity of the wheelchair with this additional weight is 0.72 m/s. The voice recognition system will undergo initial testing with one user in a quiet room, where all words are accurately recognized. Additionally, we will examine another individual's machine that has not been trained on the system. In this scenario, there were approximately 5 percent errors, such as the word "true" being recognized as "write." This occurred due to the machine hearing a different pronunciation previously. However, after the user spoke the word multiple times, the system had enough examples to correctly determine the words being spoken.

V.CONCLUSION

The prototype grasscutter robot was developed by leveraging IoT technology, enabling remote control through a solar energy source. By sending seven signals to the Bluetooth module of the Blynk app, the robot can effectively cut the grass. The control mechanism of the prototype encompasses forward, backward, right, left, and stop movements. The utilization of solar panels ensures the grasscutter operates in an energy-efficient manner.

ACKNOWLEDGMENT

We express our appreciation to the Paavai Engineering College for their support, and we extend our gratitude to the teaching and non-teaching staff of the Department of ECE. Additionally, we would like to thank our parents and friends who have provided direct or indirect support for this research endeavor.

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