Contents

1. Introduction:

Manual wheelchairs provide mobility for individuals with limited lower body function. However, for those with upper body limitations as well, handling a traditional wheelchair can be challenging or even impossible. This significantly restricts their independence and ability to perform daily activities. This project addresses this challenge by developing a voice-controlled wheelchair prototype utilizing an Arduino microcontroller and an Ai-Thinker VC-01 module for voice recognition. This system leverages speech recognition technology to allow users to control the wheelchair's movement through voice commands by eliminating the need for manual control.

This wheelchair offers two control methods:

1. Voice Commands: Users can navigate the wheelchair by issuing simple voice commands, enhancing independence for those with limited hand and arm function.
2. Joystick Control: A traditional joystick remains available, providing a familiar control method and a backup option for situations where voice recognition might not be ideal.

1.1 Literature Survey:

In the research paper titled "A Study on Smart Wheelchair Systems" by Md Hayyan Al Sibai et al. in 2015 [1], the authors provide a comprehensive overview of the increasing demand for smart wheelchairs to aid individuals with severe disabilities who struggle with traditional wheelchair operations. The review explores various smart wheelchair systems developed to address these challenges, emphasizing the importance of user-friendly interfaces, navigation methods, and additional smart systems. Different human-machine interface methods are discussed, including joystick controls, head/chin controls, tongue controls, sip-and-puff systems, voice recognition, hand gesture controls, and smartphone-based controls. Advanced methods like electroencephalography (EEG) and electrooculography (EOG) are also explored for wheelchair movement control, leveraging brain activity and eyeball movements for intuitive navigation.

In the realm of voice-controlled wheelchairs, researchers focus on making it easier for people with physical challenges to move around independently. They explore using voice commands, aiming to create more accessible and user-friendly wheelchair systems. Qadri et al. in 2009 designed a voice-controlled wheelchair using a TMS320C6711 DSP starter kit [2]. Users speak commands (forward, reverse, left, right, stop) which are processed by the Digital Signal Processor. This processor generates control signals based on the recognized word to operate a stepper motor driving the wheelchair. This approach utilizes a DSP for real-time speech processing. Ali Abed in his paper "Design of Voice Controlled Smart Wheelchair" proposed a voice-controlled wheelchair system utilizing an Arduino microcontroller and speaker-dependent voice recognition [3]. Speech recognition is done by the HM2007 IC. This design offered a speech password for secure operation and employed seven pre-defined Arabic voice commands to control the wheelchair's movement. In 2017, Meena et al. used HM2007 for voice recognition [4]. This design offers both voice and joystick control for user preference. Also, in 2020, M. S. Arsha et al. made a voice-controlled wheelchair using Arduino and a Geetech voice recognition module [5]. They have used the working principle of HM2007, a single-chip CMOS voice recognition module to operate the wheelchair. Rakib et al. in "Smart Wheelchair with Voice Control for Physically Challenged People" propose a voice-controlled wheelchair using Arduino Mega, HC05 Bluetooth module, and Android application to control the wheelchair [6]. In 2023, the research paper from Velalar College of Engineering and Technology, Erode presented the project "Speech Based Wheelchair Controlled Using Voice Recognition Module" in the International Journal of New Innovations in Engineering and Technology [7]. They have used the voice recognition module V3 to control the wheelchair through voice commands, and an Arduino UNO as a microcontroller. The research paper "Design of Voice Controlled Smart Wheelchair for Physically Challenged Persons" by Joshi et al. proposed a wheelchair that offers features like electric power, voice control, line following with obstacle avoidance, and temperature sensing [8]. The control unit integrates an ATmega328 microcontroller with Bluetooth, GSM, ultrasonic/infrared sensors, a temperature sensor, and a motor driver circuit. The voice commands are recognized through an Android application.

1.2. Simulation done on MATLAB software:

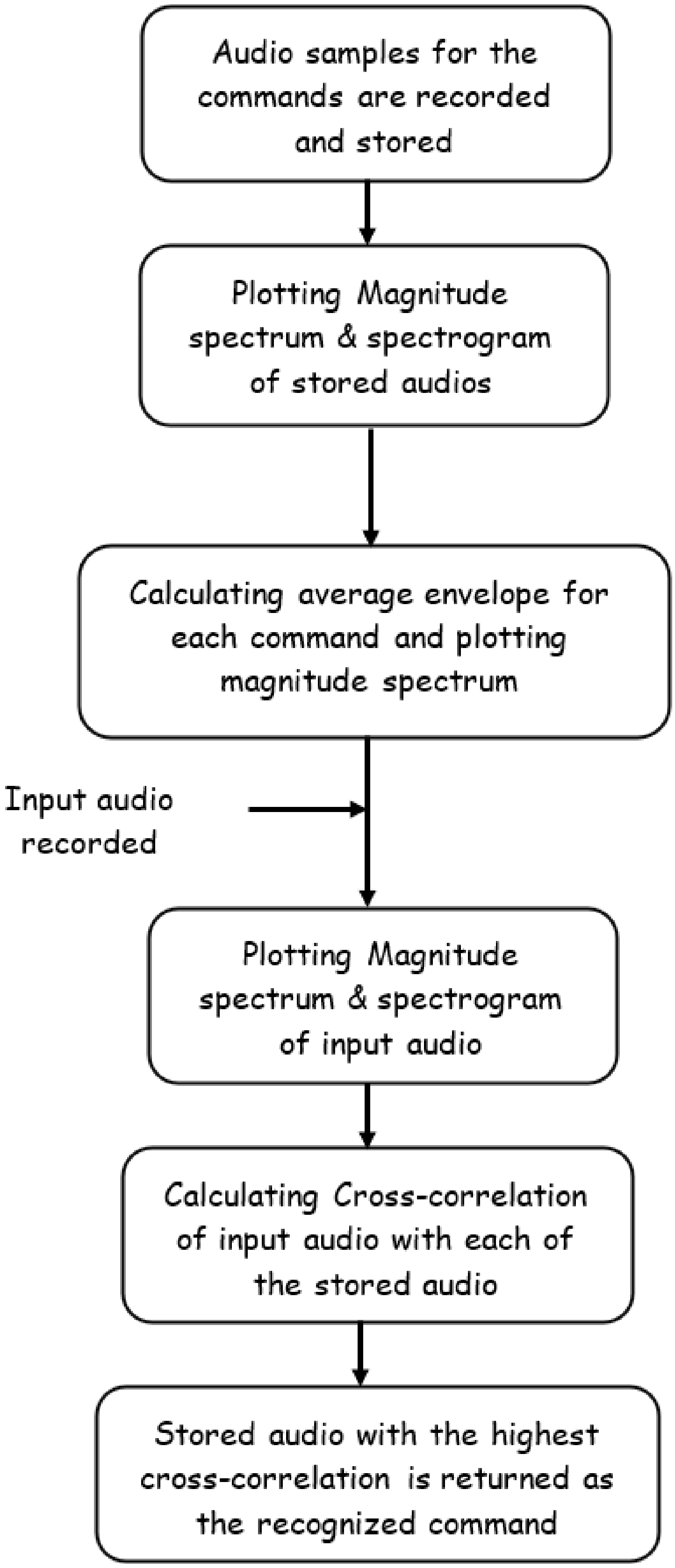

Fig.1.1- Simulation Flowchart

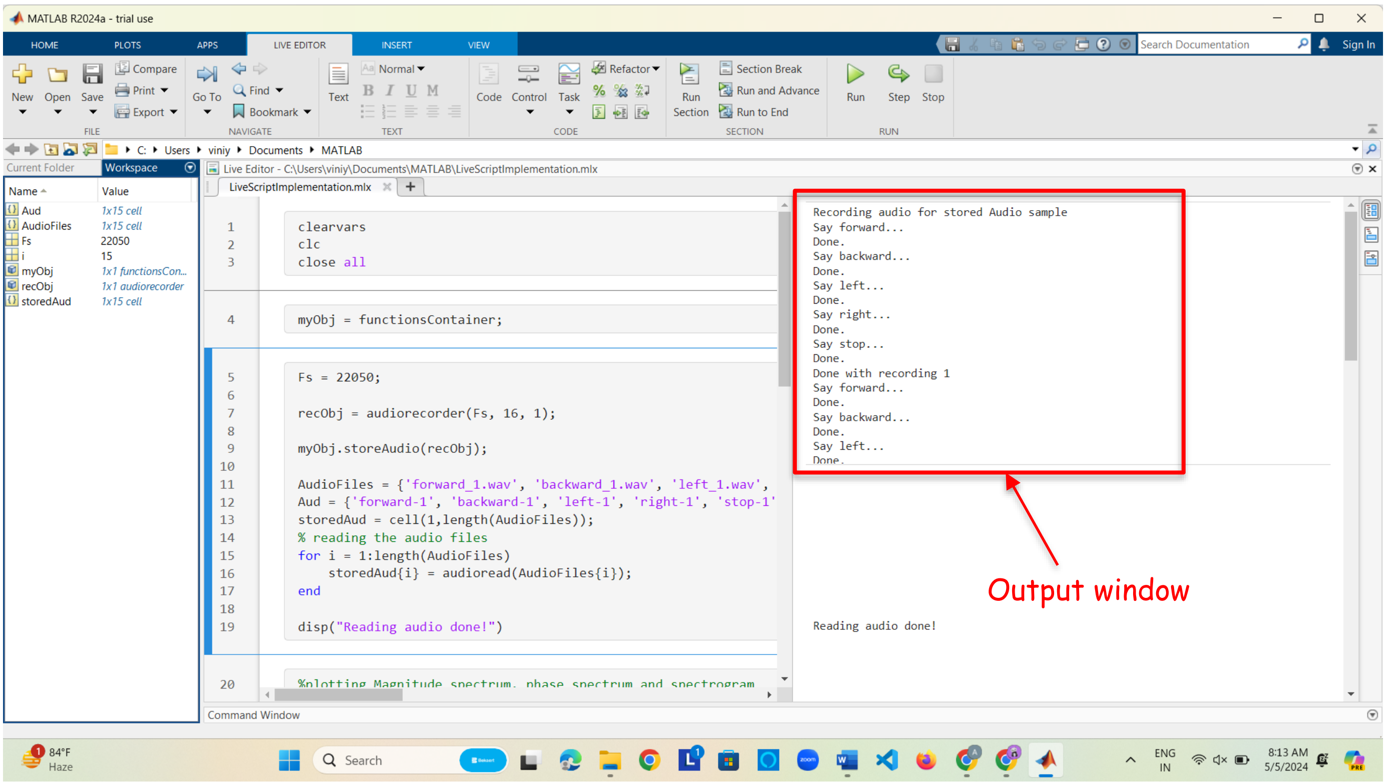

Fig.1.2- MATLAB software

```
Recording audio for stored Audio sample
Say forward...
Done.
Say backward...
Done.
Say left...
Done.
Say right...
Done.
Say stop...
Done.
Done with recording 1
```

Fig. 1.3- Recording audio samples

```
Recording Input Audio...

 Start speaking...
 Done.

 The similarity with forward is 814614.5340

 The similarity with backward is 1324435.3556

 The similarity with left is 1189814.7013

 The similarity with right is 726793.1630

 The similarity with stop is 1957789.5829

 The best matched audio is stop with similarity 1957789.5829
```

Fig.1.4- Recording input audio and calculating Cross-correlation with each of the stored audio

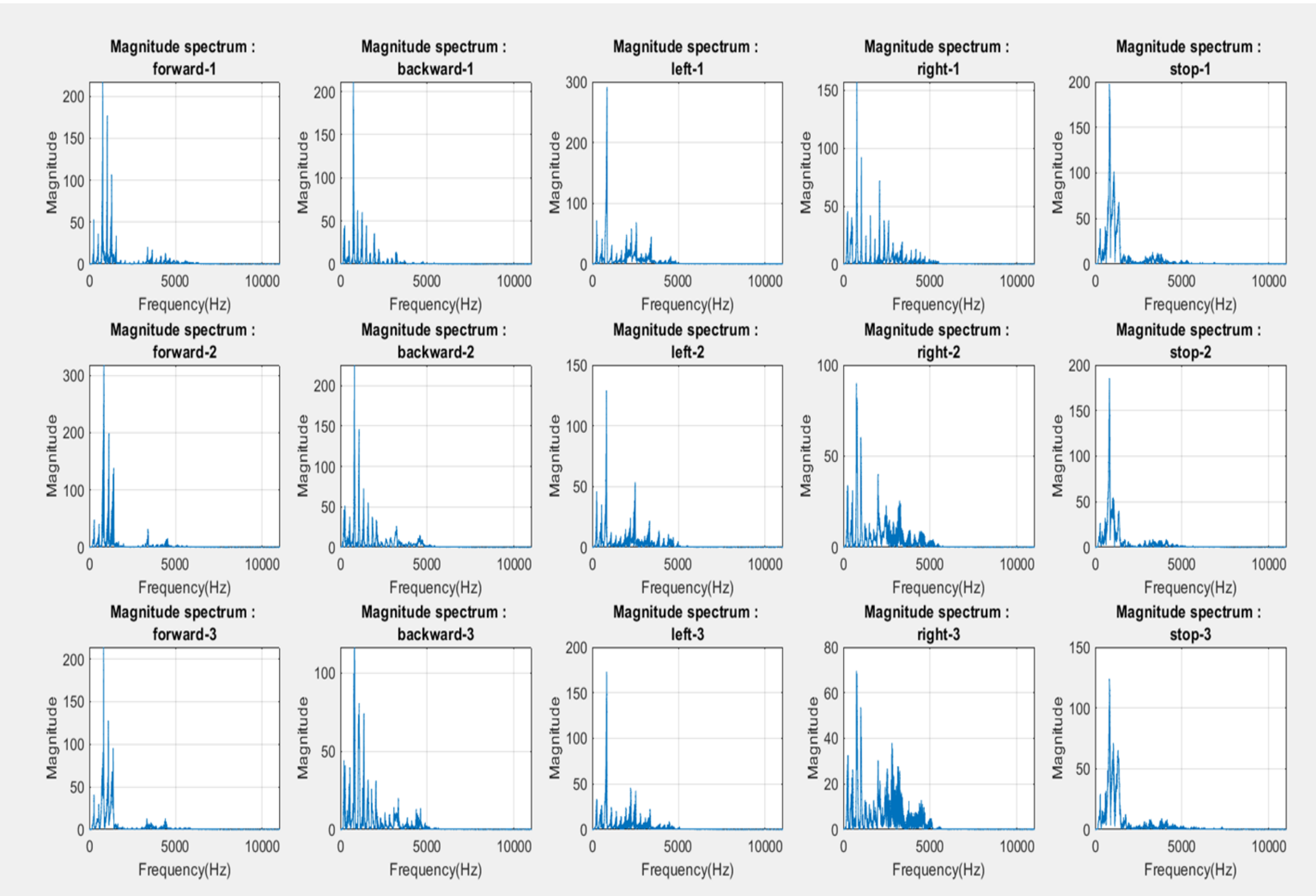

Fig. 1.5- Magnitude spectrum of the stored audio samples

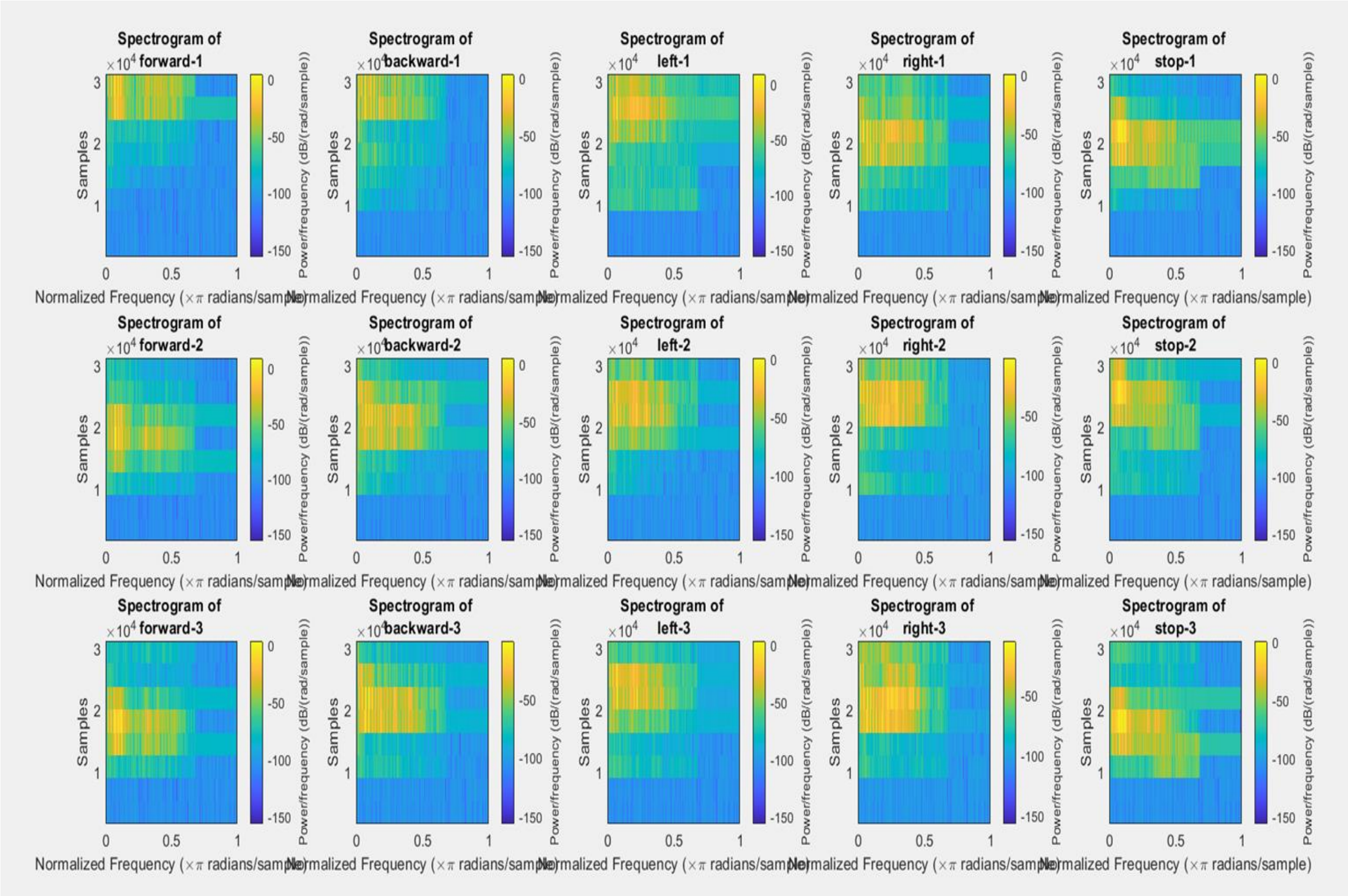

Fig. 1.6- Spectrograms of the stored audio samples

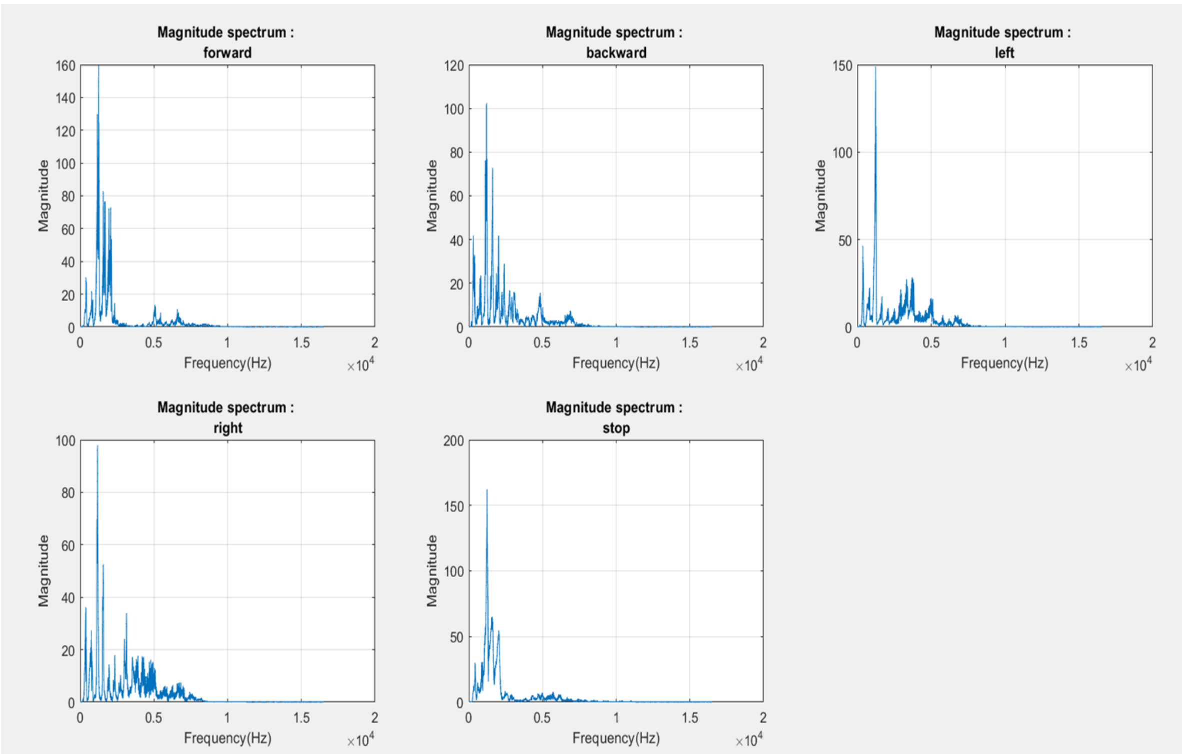

Fig. 1.7- Magnitude spectrum of the average envelopes of the stored audio samples

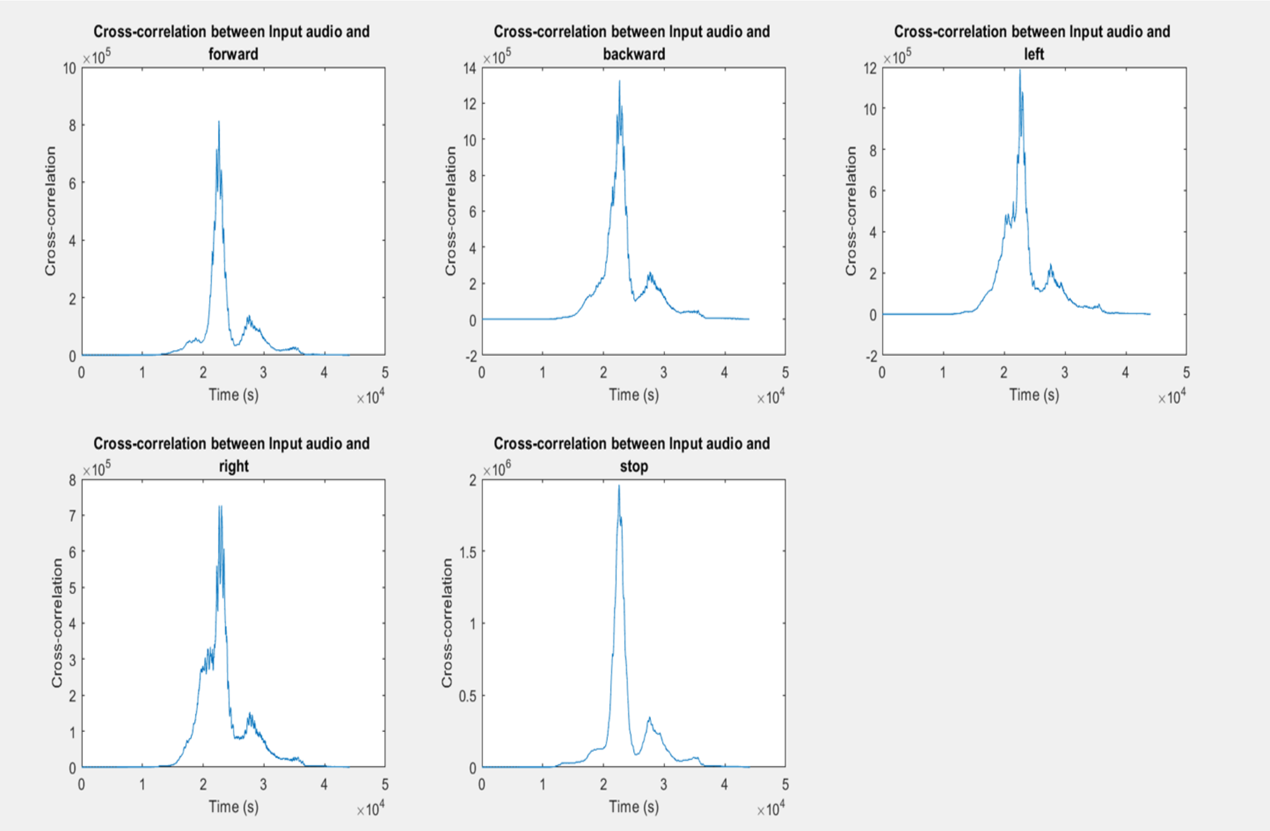

Fig. 1.8- Plotting Cross-correlation between input audio and stored audio

2. Impact of the Project on society and the environment:

This voice-controlled wheelchair with joystick support offers significant societal benefits, promoting empowerment for individuals with physical limitations.

2.1. Societal Benefits:

1. Increased Independence and improved quality of life: This project directly addresses the challenge of complex control mechanisms in traditional wheelchairs. By offering a user-friendly voice-controlled interface, the system empowers individuals with greater control over their mobility. Enhanced mobility translates to a significant improvement in quality of life. This fosters a sense of independence, allowing users to navigate their surroundings more easily.
2. Reduced Caregiver Burden: Voice control simplifies wheelchair operation, potentially reducing reliance on caregivers for assistance with movement. This empowers users to perform tasks independently.
3. Economic Benefits: Increased independence through voice-controlled wheelchairs can potentially lead to greater employment opportunities and economic participation for individuals with physical limitations.

2.2. Environmental Impact:

1. Low Environmental Footprint: The project utilizes readily available, commercially produced components, minimizing the need for specialized manufacturing processes and associated environmental burdens.
2. Long-Term Sustainability: Promoting the longevity and durability of voice-controlled wheelchairs can contribute to environmental sustainability by reducing the need for frequent replacements and minimizing electronic waste. In case of improper working of voice control, joystick control is also available and Wheelchairs can still be used for other people who can operate the wheelchair using a joystick instead of being completely useless.

3. Block diagram and Functional description

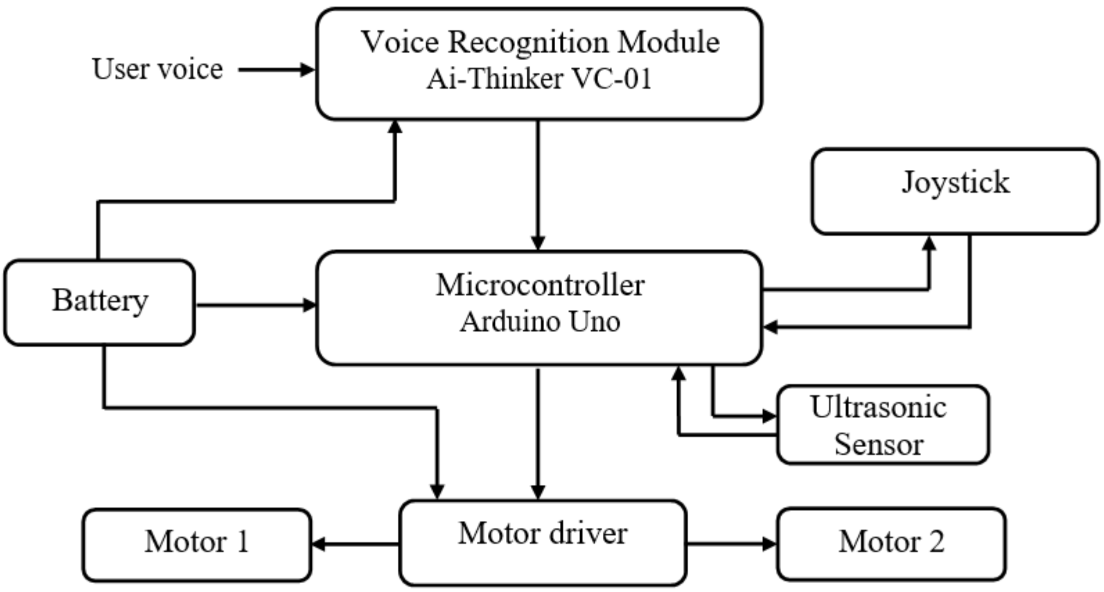

Fig. 3.1- Block Diagram

1. Voice Recognition Module (Ai-Thinker VC-01): The VC-01 is a low-cost offline speech recognition module. It utilizes pre-programmed algorithms to convert spoken commands into digital data. This data is then sent to the microcontroller for interpretation and control of the wheelchair's movement.
2. Microcontroller (Arduino Uno): The Arduino Uno is a versatile open-source microcontroller board. The Arduino Uno is programmed to understand the received voice commands and translate them into control signals. These signals are then sent to the motor driver to regulate the wheelchair's movement according to the user's intent.
3. Joystick: The joystick acts as an alternative control method for users who may prefer it or require it in situations where voice commands might not be ideal. It's a hand-held device used to control the direction and speed of the wheelchair motors.
4. Motor driver (L298N): It receives control from the Arduino. It amplifies the weak control signals from the Arduino to a level sufficient for driving the wheelchair motors.
5. 2 DC Motors: Propel the wheelchair based on the control signals received from the motor driver. The direction and speed of rotation determine the wheelchair's movement (forward, backward, turn).
6. Battery: Provides the power to all the components of the system.

4. Circuit connections and its description

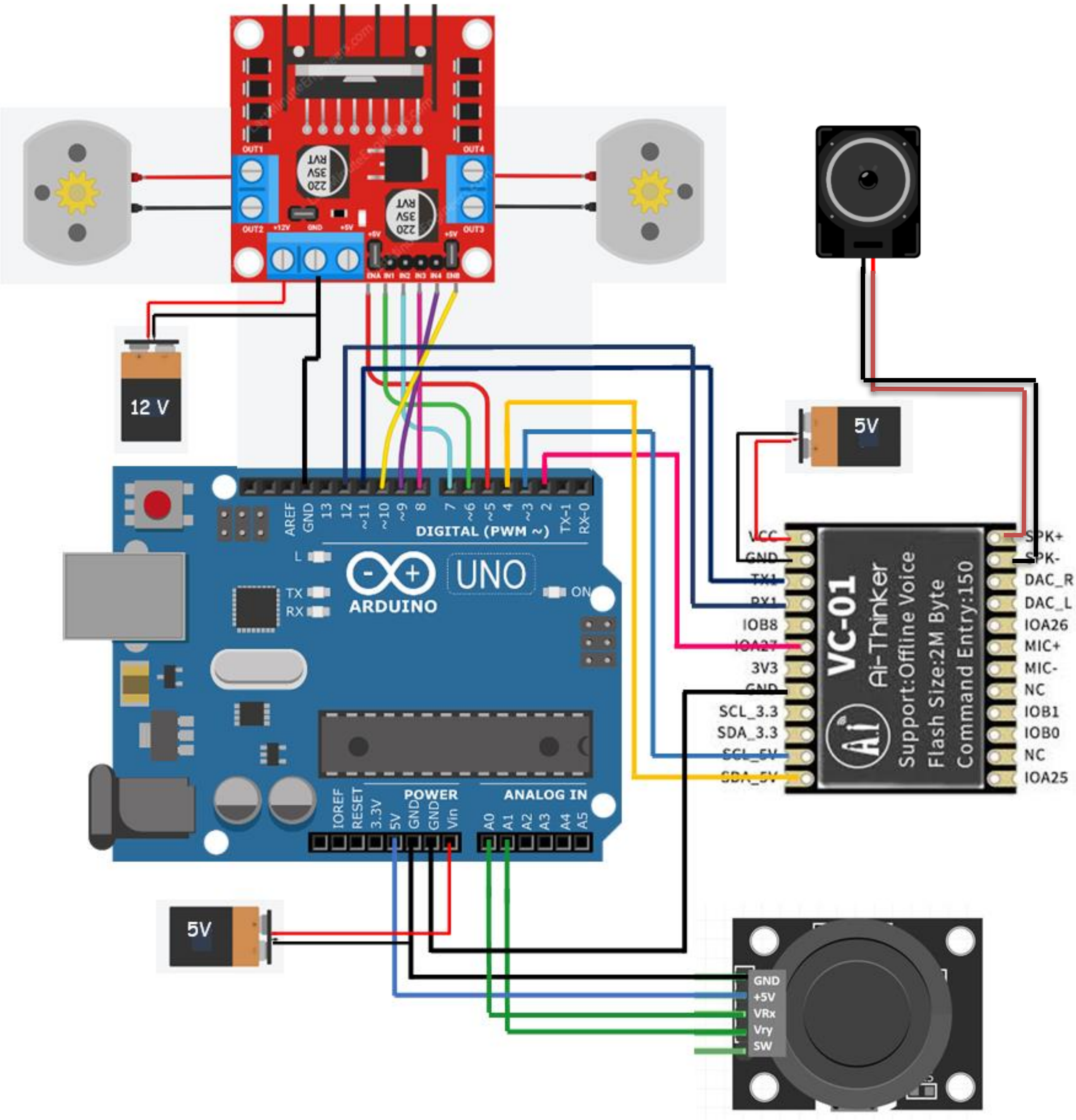

Fig.4.1- Circuit Connections

1. Arduino Uno microcontroller: The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller (MCU) and developed by Arduino.cc and initially released in 2010. It has 14 digital input/output pins (6 pins capable of PWM output), and 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable.

2. Ai-Thinker VC-01 voice recognition module: VC-01 is a low-cost pure offline speech recognition module developed by Shenzhen Ai-Thinker Technology Co., Ltd. The module uses the voice chip US516P6. This chip uses a 32-bit RISC architecture core, running at 240 MHz, and incorporates a DSP instruction set specifically for signal processing and speech recognition, an FPU arithmetic unit that supports floating-point operations, and an FFT accelerator. It has a total of 24 pins with 5 GPIO pins. It can be programmed for voice commands, to get required responses. Also, the controls can be added to get the digital output on the GPIO pins. A microphone is connected to get the voice input and a speaker is connected to give the output response.

3. L298N motor driver: The L298N is a dual H-bridge motor driver IC, controlling two DC motors direction and speed independently. It operates on a DC supply voltage of 5V to 35V and delivers a continuous output current of up to 2A per motor. In1/In2 and In3/In4 pins control motor direction, while Enable pins (ENA & ENB) activate/deactivate each motor. The H-bridge design allows bi-directional control for forward or backward motion.

4. Motos: The DC motor is an electrical motor that uses direct current (DC) to produce mechanical force.

5. Joystick: The joystick, in this project, functions as an alternative control input for the wheelchair. It typically has two axes (X and Y) that translate movement to electrical signals. As the user tilts the joystick, the voltage on the corresponding axis changes. These voltage variations are then read by the Arduino Uno. By interpreting these analog signals, the Arduino determines the desired direction (forward, backward, turn) and sends appropriate control signals to the motor driver for movement. This provides a user-friendly backup control method for situations where voice commands might not be

5. Working of Project

1. Voice Recognition Module (AI Thinker VC-01): The VC-01 module is responsible for recognizing voice commands spoken by the user and providing feedback in the form of voice responses.
2. Arduino Uno: The Arduino Uno serves as the central processing unit, receiving input signals from both the voice recognition module and the joystick. It processes these signals and sends appropriate commands to the motor driver.
3. Motor Driver: The motor driver receives commands from the Arduino Uno and controls the movement of the wheelchair's motors accordingly.
4. Voice-Controlled Mode: By default, the wheelchair operates in voice-controlled mode. The user can issue commands such as "up," "down," "left," "right," "stop," etc., using voice input. When a voice command is detected by the AI Thinker VC-01 module, it triggers a signal to the Arduino Uno.
5. For example, when the user says "up," the AI Thinker VC-01 module sends a signal to the Arduino Uno indicating the "up" command. The Arduino Uno then translates this signal into motor commands and sends them to the motor driver.
6. Joystick Control: Alternatively, the user can switch to joystick control mode by issuing the command "joystick on." When this command is recognized by the AI Thinker VC-01 module, it triggers a signal to the Arduino Uno, indicating that joystick control is enabled.
7. Once joystick control is activated, the user can manipulate the joystick to control the wheelchair's movement. The Arduino Uno reads the input signals from the joystick and sends corresponding commands to the motor driver.
8. Feedback: When a voice command is successfully recognized and executed, the VC-01 module provides auditory feedback to the user, confirming the action taken. For example, if the user says "move forward," the VC-01 module might respond with "Moving forward" to indicate that the command was understood and executed.
9. This integration of voice recognition with auditory feedback enhances the user experience by providing real-time confirmation of their commands and actions

5.1. Flowchart of Working

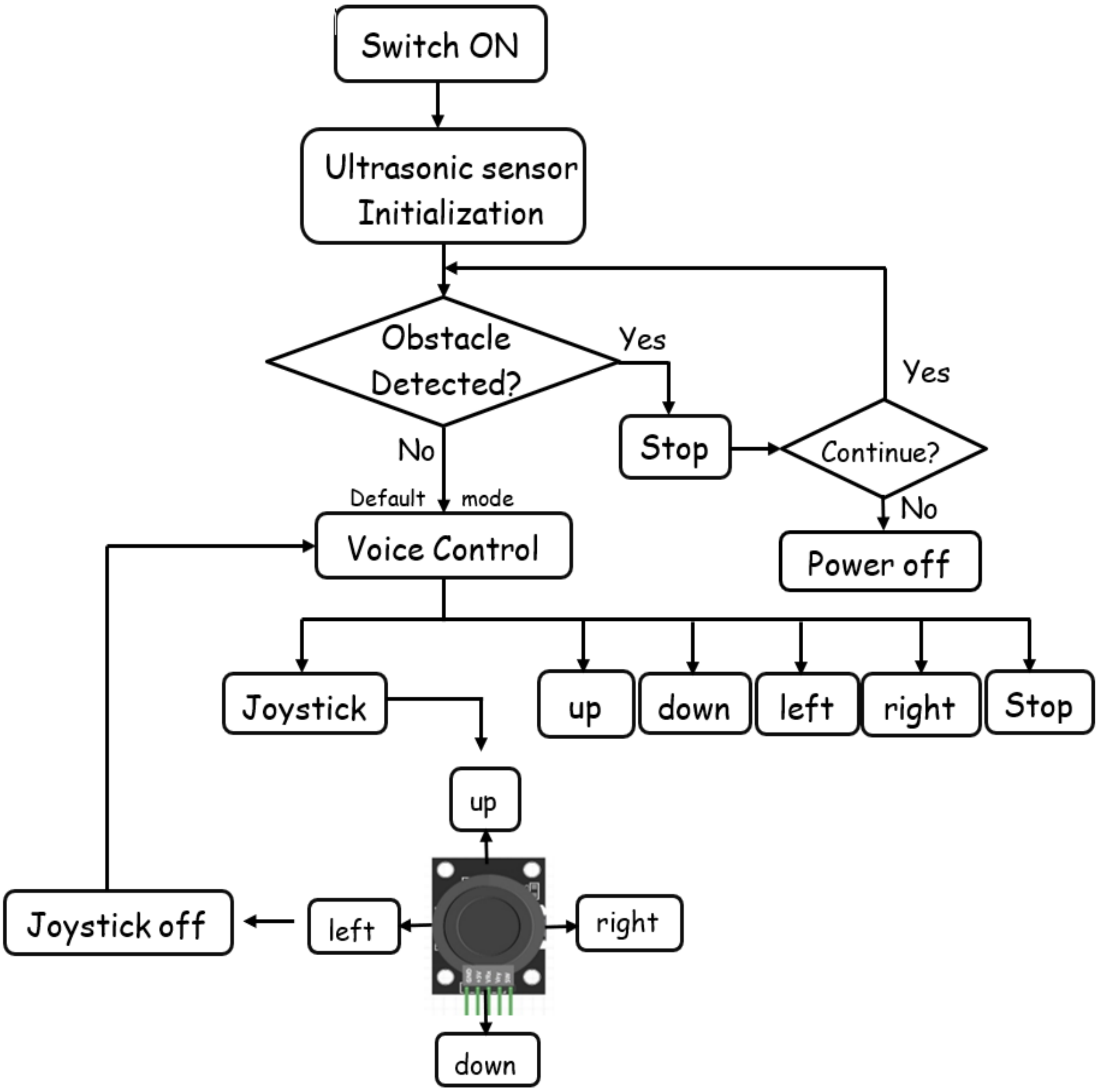

Fig.5.1- Flow Chart of working

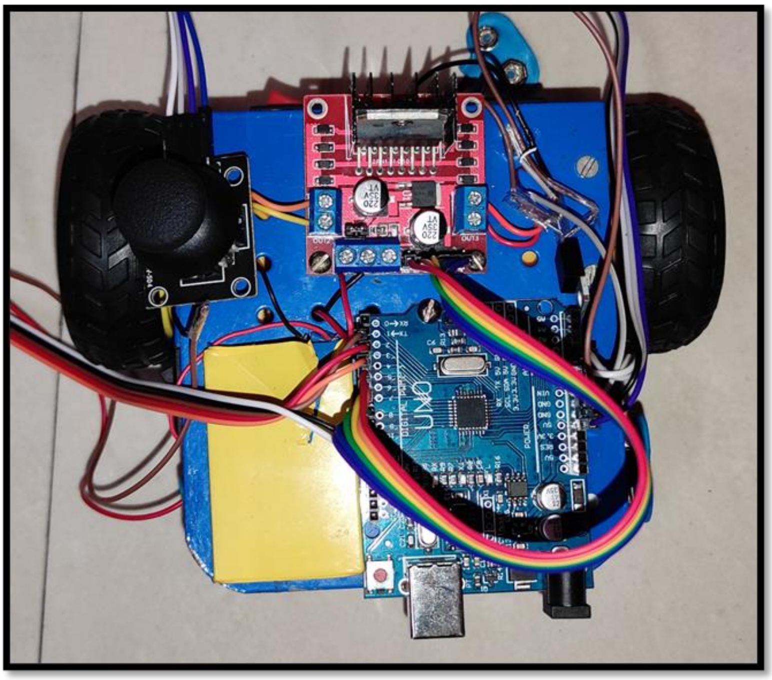

Fig. 5.2- Stage 1 Prototype with only joystick control

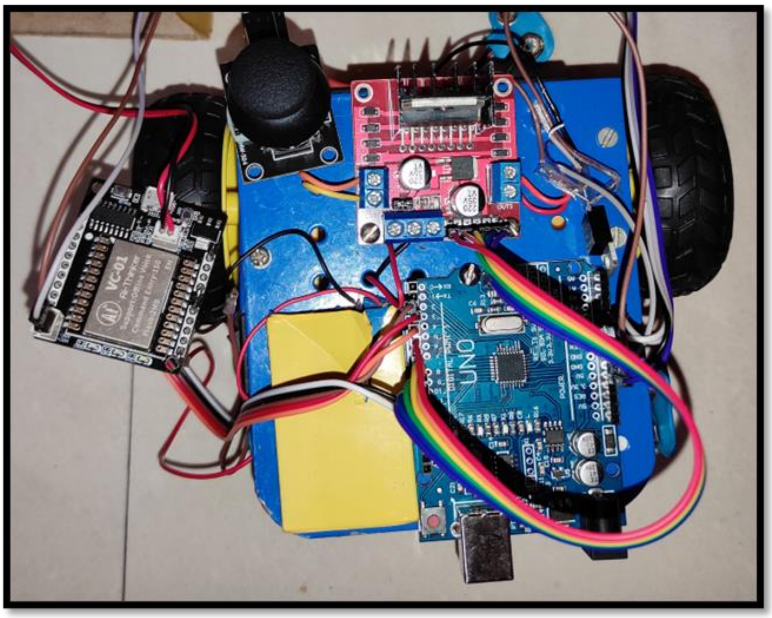

Fig. 5.3- Stage 2 Prototype with joystick and Voice control

Fig. 5.4: Final Prototype with joystick and Voice control

6. Result and Future Scope

6.1. Results

The voice-controlled wheelchair is a functional and accessible mobility solution that empowers users to navigate their environment using voice commands or a joystick. Here are some key outcomes:

1. Accessibility: The voice-controlled wheelchair provides an accessible means of mobility for users who may have limited dexterity or mobility impairments. By allowing control via voice commands, it enables users to operate the wheelchair independently without relying on manual controls.

2. User-Friendly Interface: The integration of voice recognition technology and joystick control offers users flexibility in how they interact with the wheelchair. Whether through verbal commands or joystick manipulation, users can choose the method that best suits their preferences and abilities.

3. Real-Time Feedback: The inclusion of auditory feedback from the VC-01 module enhances the user experience by providing real-time confirmation of commands. This feedback mechanism helps users to better understand and interact with the wheelchair's control system.

4. Versatility: The project's design allows for seamless switching between voice-controlled mode and joystick-control mode, giving users the option to adapt the control interface based on their immediate needs or preferences.

5. Integration of Components: The project demonstrates the successful integration of various components, including the voice recognition module, Arduino Uno, motor driver, and joystick. This integration showcases the ability to combine hardware and software elements to create a functional system.

6. Cost: The prototype cost is approximately INR 1300. It has a huge market and application.

6.2. Future Scope

1. Ambulatory Patient Monitoring: Integration of health monitoring sensors into the wheelchair, such as heart rate monitors, blood pressure sensors, and temperature sensors, could provide real-time health data for ambulatory patients.

2. Smart Navigation: Implementing advanced navigation algorithms and map integration could enable the wheelchair to navigate complex environments autonomously, including indoor navigation in hospitals or shopping malls.

3. Fall Detection and Prevention: Incorporating fall detection sensors and algorithms can enhance user safety by automatically alerting caregivers or emergency services in the event of a fall and deploying preventive measures to avoid falls.

4. Remote Assistance: Integration with remote monitoring systems allows caregivers or healthcare professionals to remotely monitor the user's condition, location, and wheelchair status, providing timely assistance and support as needed.

5. Voice Assistant Integration: Integration with voice assistants like Amazon Alexa or Google Assistant enables users to control smart home devices, make phone calls, send messages, or access information hands-free, enhancing convenience and independence.

6. Gesture Recognition: Adding gesture recognition capabilities allows users to control the wheelchair through hand gestures, providing an alternative control method for users with limited mobility or speech impairments.

7. Cloud Connectivity: Cloud connectivity enables data storage, analysis, and sharing, facilitating remote monitoring, data-driven insights, and collaborative healthcare management for users and caregivers.

8. Adaptive Seating and Comfort: Incorporating adjustable seating options, pressure relief systems, and ergonomic design features enhances user comfort, reduces fatigue, and prevents pressure ulcers during prolonged wheelchair use.

9. Integration with Smart Home Systems: Integration with smart home systems enables seamless interaction with home automation devices, such as door locks, lights, and thermostats, improving accessibility and convenience for users.

10. Integration with Wearable Devices: Integration with wearable devices, such as smartwatches or fitness trackers, allows for synchronized health monitoring and activity tracking, providing comprehensive insights into the user's health and well-being.

7. References

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