

VOICE CONTROLLED AND TFT TOUCHSCREEN CONTROLLED WHEELCHAIR

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Abstract

In today's world, widespread prevalence of lost limbs and sensing system is of major concern in present day due to accident, age and health problems. To assist people with such defects, the proposed intelligent wheelchair system is used which have dual control for navigation in familiar environments. This paper is related to voice command and touchscreen display based model of a wheelchair. The smart wheelchair system used the voice recognition module V3 and a 2.8" TFT Touchscreen display. Wheelchair is facilitating the movement of people who are disabled or handicapped and elderly people. The wheelchair design will allow people to do their basic daily tasks without any dependence on other person. In building the circuit for this project, we are using AURDINO MEGA and its interfacing with TFT Touchscreen module and voice recognition module with direct current motors for movement of wheelchair in different directions. The system has been designed and implemented in a cost-effective way so that if our project is commercialized the needy users in developing countries will benefit from it.

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1. Introduction:

Mobility aids a significant improvement in the quality of life for people with physical disabilities by enhancing their functional performance. Despite the high global prevalence of physical disabilities, people who are using manual wheelchairs continuously needs someone to help them in getting the wheelchair moving. Rehabilitation technology helps persons with disabilities, limitations, or incapacity to perform daily jobs, roles, and activities at the expected levels within physical and social environments. According to WHO (World Health Organization) 10% of population suffer from physical disabilities, in total it makes around 60 million people.[2] And the world disability report shows that 15% of the global population have disability and needed wheelchairs for locomotion [3]

Appropriate wheelchairs remain limited, especially for low-income populations. Automated wheelchairs are more easily accessible to the people who have money, those who can't afford such facility lacks it. According to National Administrative Department of Statics (DANE in Spanish) and the ministry of health and social protection have disability, that represents almost of 1448889 people [5]. In the past years several authors have used different techniques to make a conventional wheelchair more automated. Author in [6] have build a prototype that uses Brain Wave Sensors Neurosky Mindwave Mobile Application that works on the commands that are transmitted through Brain and through the blinking of Eyes, Also Smoke Detectors, Ultrasonic Sensors are used to make the wheelchair more durable and redundant. Whenever the wheelchair detects the

Gas/ smoke presence it will send a message via SDK to the mentioned cellphone number of user's family. But as the system highlights the usage of brain signals more than eye blink, if the threshold set by the user won't be equal to the signal transmitted by human brain, it won't generate any command. Author in [7] have worked on a prototype that is based on robotic platform and uses ML techniques for navigation, obstacle detection and real time mapping of environment. By the use of AI technologies, the system can adapt its surroundings. System is controlled using wheelchair movement 24V DC motors with a 200W power output are used in the system. Despite the successful integration of NVida JetBot Nano, the system still got certain limitations that it depends on strong Wi-Fi or Internet Connection. In the event of network loss, remote control functionality becomes unavailable, which can render the system temporarily inoperable. This dependency highlights the absence of an offline or fail-safe control mechanism that could ensure continued operation during connectivity failures. AI-based image processing and navigation perform best in controlled environments and may degrade in dynamic or unfamiliar settings. Continuous data collection is required for reliable machine learning performance, which can be burdensome for users. Additionally, hardware complexity and limited long-term user testing may affect system reliability and real-world deployment. Using ensemble machine learning models, the study in [8] suggested an EEG-based wheelchair navigation system. The pre-processing of EEG signals (2869 samples, 141 characteristics) included noise reduction, normalization, and artifact correction. Correlation thresholds and recursive feature elimination were used to choose features. After FS, Extra Trees achieved 69% accuracy out of ten ML models that were assessed. It's interesting to note that accuracy increased to 82% while training on outlier-only data, underscoring the significance of outliers. Explainable AI (SHAP, Integrated Gradients) improved the interpret ability of the model by identifying important aspects. ROC and Precision-Recall curves were used to validate performance, and the results demonstrated good class

reparability for forward movement orders. The computational complexity of the system makes real-time processing difficult. Class imbalance and redundant characteristics make some commands more difficult to categorize. The complexity of the model is increased by high-dimensional EEG data. Practical reliability is diminished by user-dependent calibration and vulnerability to noise and artifacts. The paper in [13] presents a BCI-controlled wheelchair using the OpenBCI Ganglion board for EEG signal acquisition and the OpenBCI GUI for real-time processing. Motor imagery patterns corresponding to intended movements (left, right, forward) are extracted and transmitted to an Arduino microcontroller, which actuates the wheelchair motors. The system demonstrates that affordable, open-source tools can enable functional thought-based wheelchair control. However, the approach faces several challenges: limited command set, signal noise and artifacts, latency in real-time response, and dependence on user training to produce distinguishable EEG patterns. Additionally, the low-cost EEG hardware may reduce classification accuracy, and the system's robustness across multiple users and environments is not yet validated. Despite these limitations, the framework provides a feasible foundation for developing practical BCI-based assistive devices. The study in [14] presents a neuro-wave-controlled wheelchair integrated with gesture and voice control systems to assist physically disabled individuals. The Gesture Controlled Wheelchair uses a pseudo glove with an accelerometer, while the Voice Controlled Wheelchair employs a microphone to capture spoken commands. The Brain Controlled Wheelchair sends EEG signals via a Bluetooth-connected brainwave sensor to a laptop, where MATLAB Simulink DSP toolbox processes the data to generate movement commands. An Arduino microcontroller interprets these commands to control the wheelchair motors, enabling independent navigation. While the system demonstrates promising results, it faces several challenges, including signal noise and artifacts, latency in real-time processing, limited command complexity, and the need for user training. Additionally, the

system's performance depends on sensor accuracy and may be affected by environmental interference, limiting robustness across different users and conditions. The approach in [15] is inspired by existing work on eye-controlled wheelchairs and deep learning-based gesture recognition. developed an eye gesture-controlled wheelchair to assist individuals with mobility impairments. A high-resolution camera captures the user's face, and the eye region is extracted using Haar-Cascade models. Eye movements are classified into four commands (left, right, forward, closed) using a ResNet-18 CNN trained on custom and Kaggle datasets. The classified commands are transmitted via Bluetooth to an Arduino microcontroller, which drives the wheelchair motors through an L298N motor driver. The system includes safety features for engagement and disengagement, as well as battery-swapping capabilities. While achieving 90.25% accuracy, the system faces challenges such as low-light performance issues, limited command complexity, frame rate constraints, and user-dependent consistency. Additionally, hardware limitations and environmental variations may affect reliability across different users. This research in [16] developed a head-movement-based control system for electric wheelchairs using an MPU-6050 6-axis IMU mounted on a wearable cap. An Arduino Nano (ATmega328) records head motions in real time and uses calibrated angular thresholds about $\pm 45^\circ$ to produce directional commands (forward, backward, left, and right). The wheelchair's receiver device receives commands via Bluetooth HC-05 and uses an Arduino Uno and BTS7960 motor drivers to drive the motors via PWM signals. The system was experimentally validated, achieving high accuracy and smooth, responsive control. Limitations include testing primarily in controlled environments with a limited user base, reliance on fixed threshold angles that may not suit all users, and lack of realworld long-term usability studies. Future improvements may involve adaptive learning, integration of additional input modalities, and clinical validation to enhance robustness and personalization. In order to address the physical discomforts and challenges typically associated

with manually operated, conventional wheelchairs, the authors in [5] developed an automated wheelchair specifically for caregivers, older persons, and patients. This wheelchair's Arduino UNO controller allows for motorized mobility, voice command recognition, and Bluetooth, making control more user-friendly. By using these technologies, the wheelchair helps patients move more pleasantly and reduces the physical strain on caregivers, making riding safer and more comfortable for everybody. This technology allows for forward, backward, and sideways travel by mounting two DC motors on the wheelchair wheels. Users may easily operate the wheelchair using voice commands or a mobile application thanks to the Arduino UNO's Bluetooth integration with a voice recognition module and smartphone. This encourages ease of use, particularly for those who have limited hand or arm mobility. The wheelchair's special deception feature, which allows people to transition from the wheelchair to another surface, like a bed, with minimal assistance, is controlled by a reversing motor and may change angles or orientations via a switch. For people with physical disabilities, the authors of [7] have created a smart wheelchair with health monitoring and alerting capabilities. You can operate this wheelchair with your voice. Its integrated autonomous obstacle detection technology makes the ride safer for the passenger by using ultrasonic sensors to detect and avoid obstructions in its route. An additional layer of security is provided by the wheelchair's flame sensor module, which may detect fire in an emergency and instantly notify caretakers. In [9], the authors presented a mobility augmentation system for individuals with physical disabilities that uses a gesture-operated wheelchair that converts hand gestures into accurate motor commands. With its accelerometer sensor and Arduino controller-based design, the method seeks to overcome conventional interface constraints, enabling wheelchair users worldwide to be independent and inclusive. Using a gesture-operated wheelchair that converts hand gestures into precise motor commands, the authors presented a mobility augmentation system for individuals with physical disabilities. With its

accelerometer sensor and Arduino controller-based design, the method seeks to overcome conventional interface constraints, enabling wheelchair users worldwide to be independent and inclusive. The accelerometer sensor allows the wheelchair's motorized drive system to smoothly engage with human movements by tracking and interpreting the user's hand gestures. This allows the user to move forward, backward, left, right, or stop using natural gestures. An Arduino controller serves as a bridge for the system, reading gestures and directing the wheelchair's motors to make the necessary motions. An infrared (IR) remote control system is incorporated to further enhance usability, allowing customers to operate their home environment with the same user-friendly control device. The authors proposed in [10] a system design of a system for people with disabilities by creating a wireless, Android-controlled system for a wheelchair. It uses an Android phone in conjunction with a control box in the control of wheelchair motion through motor control using 12 Arduino Nano and a 5V 4-channel relay module as controllers. Data exchange between the control unit of the phone and the phone is done through the use of Bluetooth HC-05 module, which allows the smooth transmission of commands. The motor's direction and rate are controlled using an L298N motor driver so that forward, backward, left, and right movement are easily achieved. Additionally, manual wheelchair movement for ease of accessibility by the user or a care giver is achieved. The wheelchair has a feature of changing positions, e.g., recline or sitting up straight, which is all remotely controlled using Bluetooth commands with an Android smartphone. Other than wheelchair mobility, wireless operation of electric devices is made possible in this project, and the devices can be turned on or off by the users through the Android application, which sends the notifications to the devices. The authors suggested in [11] a system named the "Head Motion Controlled Wheelchair," which relies on Brain-Controlled Interface (BCI) concepts and is designed for people with limited mobility. At the centre of the system is the MEMS sensor, connected to the ATmega328 microcontroller,

which detects head movement to control the direction of the wheelchair. Moreover, sensors are integrated to monitor the user's health and environment. The system includes a heartbeat sensor, a vibration sensor, and an ultrasonic sensor, each serving a particular purpose in providing safety and communication features to the user. The heartbeat sensor, with the use of an LDR and LED, monitors the user's heart rate constantly. In case of any anomaly, the microcontroller gives a call or message to the user's assistant through GSM, hoping that health notifications are relayed instantly. Wheelchair movement is controlled by a toggle switch, and directional adjustments such as forward, left, and right are made through head movements. Relays are utilized in connecting the microcontroller to the DC motors, with the relays utilized for motor control. To detect obstacles, an ultrasonic sensor sweeps through a range of 80 centimetres, and when it finds obstacles, it signals the same by activating the buzzer, thus informing the user or companion. A vibration sensor also senses sudden impacts such as those resulting from collisions and gives a signal to the companion by GSM connectivity. The authors provided an introduction of [12] a Head Motion Controlled Wheelchair with the motive of granting greater mobility to physically disabled people. The wheelchair is controlled with a mix of sensors and an Arduino microcontroller to allow the user to operate its movement as per head movement. The key sensor in the system is MPU6050, which detects tilt or rotation of the user's head. The MPU6050 signal is received by the microcontroller, which reads the data and reverses the direction of the wheelchair accordingly. The wheelchair can move in four directions: left, right, forward, and backward. Besides general navigation, the system also supports activities like obstacle detection and safety monitoring. The system comprises two main sections: the transmission section and the receiving section. In the transmission section, the head movements of the user are tracked by the MPU6050, a gyro sensor. The head movements detected by the sensor are translated into electric signals, and these electric signals are processed by an Arduino

Nano controller. The signals are wirelessly transmitted by a Bluetooth Module to the receiving terminal. In the receiving section, there is a reception of the signal from the transmitter end by the Bluetooth module, which then relays it to another Arduino microcontroller. As it receives them, the Arduino interprets the information and utilizes it to control the DC motors of the wheelchair through a motor driver. The motor driver is utilized to power the motors such that the wheelchair is propelled based on the head movements detected by the MPU6050 sensor. The system includes various sensors and modules for increased functionality and safety. The ultrasonic

sensor helps to avoid obstacles by detecting objects in the wheelchair path and triggering the necessary direction changes. Physical status of the user is tracked using vibration and pulse sensors. When either of the sensors provide abnormal readings, such as over-high pulse or excessive vibration, the microcontroller is alerted. When the readings exceed pre-set thresholds, an alarm is generated and SMS to the caregiver’s mobile number via the GSM module. The device includes a DC motor to propel the wheelchair as well as a battery to accumulate energy to make the wheelchair operate for extended durations autonomously.

Table 1: Showing Limitations of previous research.

S.No.	Reference No	Methodology	Limitation
1	[6]	Neurosky Mindwave EEG + eye-blink commands; ultrasonic/smoke sensors; SMS alert via SDK	Fails to generate commands if brain signal doesn't match user's preset threshold
2	[7]	NVIDIA JetBot Nano; ML-based navigation, obstacle detection, real-time mapping; 24V/200W DC motors	No offline failsafe (relies on Wi-Fi); degrades in unfamiliar environments; needs continuous data collection; complex hardware; limited long-term testing
3	[8]	EEG preprocessing (denoising, normalization) on 2869 samples/141 features; feature selection; Extra Trees classifier (69%, 82% on outliers); SHAP/Integrated Gradients for interpretability	High computational load limits real-time use; class imbalance; high-dimensional data; needs per-user calibration; noise-sensitive
4	[13]	OpenBCI Ganglion EEG acquisition + GUI; motor imagery (left/right/forward) classified and sent to Arduino	Limited command set; signal noise; latency; needs user training; low-cost hardware reduces accuracy; unvalidated across users
5	[14]	Accelerometer glove (gesture) + microphone (voice) + Bluetooth brainwave sensor processed via MATLAB Simulink DSP; Arduino motor control	Signal noise; latency; limited commands; needs training; sensitive to sensor accuracy/interference
6	[15]	Haar-Cascade eye detection + ResNet-18 CNN (4 commands); Bluetooth to Arduino + L298N driver; 90.25% accuracy	Poor low-light performance; limited commands; frame-rate constraints; inconsistent across users

7	[16]	MPU-6050 IMU on cap; Arduino Nano with $\pm 45^\circ$ angular thresholds; Bluetooth HC-05; BTS7960 drivers	Tested only in controlled settings, small sample; fixed thresholds may not suit all users; no long-term real-world data
8	[5]	Arduino UNO; Bluetooth voice recognition + mobile app; dual DC motors; reversing motor for bed-transfer feature	(Inferred) Voice recognition accuracy may drop in noisy environments; mechanical transfer feature adds fall risk if misaligned; no obstacle detection mentioned
9	[7]	Voice control; ultrasonic obstacle avoidance; flame sensor with caregiver alert	(Inferred) No fallback if voice command is misheard; ultrasonic sensors may miss low-lying or irregular obstacles; single-sensor fire detection may give false positives/negatives
10	[9]	Accelerometer-based gesture sensing; Arduino motor control; IR remote for home devices	(Inferred) Unintended hand movements could trigger false commands; limited to users with sufficient hand/arm mobility; no obstacle detection
11	[10]	Android app + control box; Arduino Nano + 4-channel relay; Bluetooth HC-05; L298N driver; recline control	(Inferred) Dependent on paired smartphone and Bluetooth range; no safety sensors (obstacle/fall) mentioned; relay-based control may introduce switching delay
12	[11]	MEMS sensor + ATmega328 for head-direction control; heartbeat sensor (LDR/LED); vibration sensor; ultrasonic sensor (80 cm); GSM caregiver alerts	(Inferred) 80 cm detection range may be too short for fast-moving obstacles; heartbeat sensor via LDR/LED is prone to ambient light interference; GSM dependent on network coverage
13	[12]	MPU6050 gyro (transmitter, Arduino Nano) + Bluetooth to receiver Arduino; motor driver; ultrasonic + vibration/pulse sensors; GSM SMS alerts	(Inferred) Two-Arduino transmitter-receiver setup increases latency and points of failure; pulse sensor accuracy can be affected by motion artifacts; no mention of weatherproofing for outdoor use

2. Materials and Method:

Our project “Controlling Wheelchair with Voice Command and Touch Screen” uses Voice recognition module V3, 2.8” TFT touchscreen display, Arduino Mega, Motor Driver L298N and

DC motors for the movement of wheelchair. We are using two different techniques for controlling about wheelchair, Voice recognition module and 4-wired TFT resistive touchscreen display that uses 8 bit parallel data transfer to transfer the data.

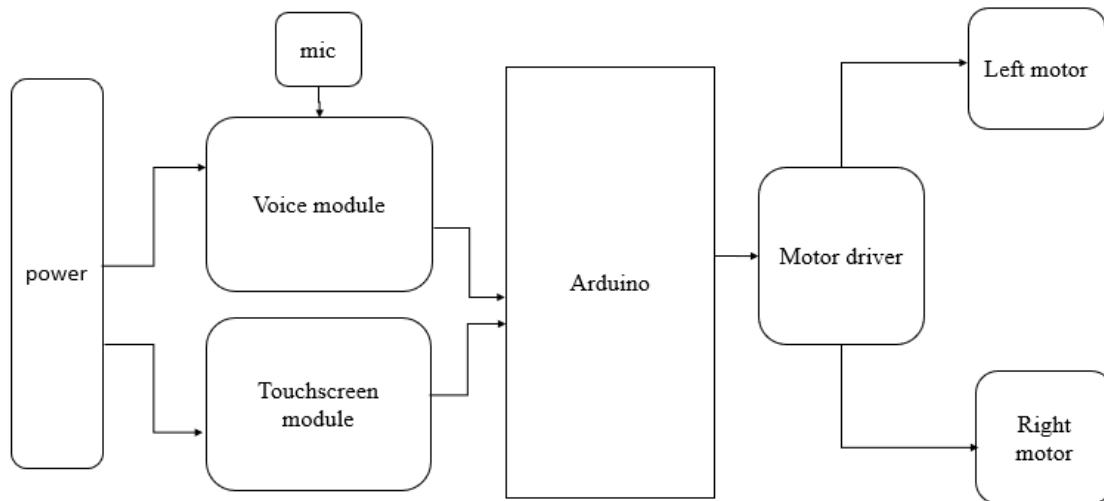


Figure 2: Proposed Architecture

2.1. Voice Recognition Module

Voice or speech recognition is the ability of machine to receive and interpret the trained words or commands. The one we are using is “Voice Recognition module V3”. A microphone is connected to the module to send the input commands. There are two ways for using this module: Built-in GPIO pins and serial port pins. This module does not convert our commands to the text, but it trains the commands with already recorded commands or set of voices. The main advantage of this module is that the user is able to record the commands in any language. To use the voice module, two distinguished phases, training phase and testing phase have been used. Front-end analysis, which is also referred to as feature extraction, is the first step in an automatic speech recognition system. This process extracts acoustic features from the input speech signal. In the next step, which is called Pattern training, the speaker has to provide a sample of voices so that a reference template can be build, here the words or commands are trained. The output of front-end analysis is a compact, efficient set of parameters that represent the acoustic properties observed from input speech signals. The testing phase

ensures that the input test voice is matched with stored reference model. The accuracy here depends upon the vocabulary size, pitch, roughness, volume, speaker dependent vs speaker independent. When the received input matches the already trained command the word is then received. The algorithm used in front-end processing technique is Hidden Markov Model. Hidden Markov Models (HMMs) are a class of probabilistic graphical model that allow us to predict a sequence of unknown (hidden) variables from a set of observed variables. The Markov process assumption is simply that the “future is independent of the past given the present”. Once we know the sequence of hidden states, we determine the best possible sequence that is. the sequence with the highest probability and choose that sequence as the best sequence of hidden states. Hidden Markov Model is so called because the sequence of states visited over time is hidden and the sequence of the output generated over time is observable. The challenge is to determine the hidden parameters from observable data. Hidden Markov Model is a part of all speech recognition systems. It is also used for facial, handwriting recognition also.



Figure2.1: Speech recognition technique

2.2. Controlling Wheelchair Using Voice Module

In first phase, we have used a voice module V3, in which the user will train the required commands. The voice module compares receive commands to the trained commands. If the commands are same as mentioned in the code. The wheelchair motors will work accordingly. If the user has given forwards command, the motors will become High and they will start to move in clockwise direction.

In case when Backward command is spoken as input in mic, The motors interfaced with motor driver will move in anticlockwise direction. In this way the wheelchair will move in backward direction. For Right command, only Motor 1 will move and allow the wheelchair to move in right direction. For left, only Motor 2 will be in working condition and it will allow the wheelchair to move left. Whenever the user gives command, stop to the wheelchair the wheelchair will stop.

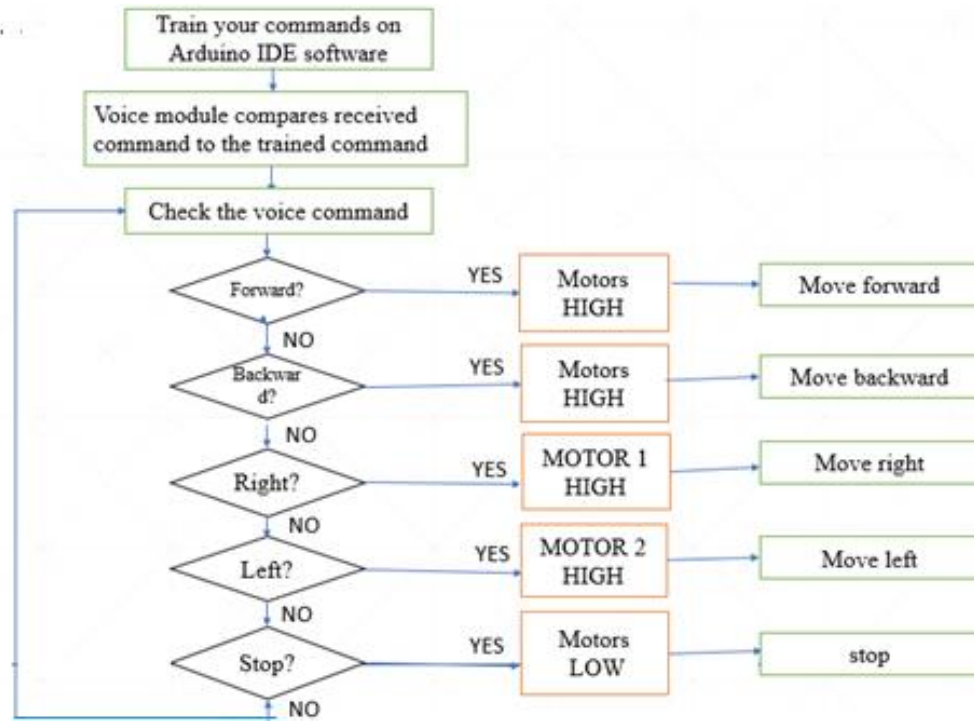


Figure 2.1: Flow chart of working of Voice Module.

2.3. Touch Screen Module:

Resistive touchscreen display is preferred in this project as it is composed of multiple layers that are separated by thin spaces. Pressure applied to the surface of the display by a finger or stylus causes the layers to touch, which completes electrical circuits and tells the device where the user is touching. A touchscreen is capable of

detecting and effectively locating a touch over its display area. When the top surface of the screen senses a touch, its resistance in both X and Y plain changes according to the variation of voltage. The contacting position can be found since the values in both X and Y electrodes are noted. Accordingly, it sends instruction to direct the wheelchair in the preferred direction.

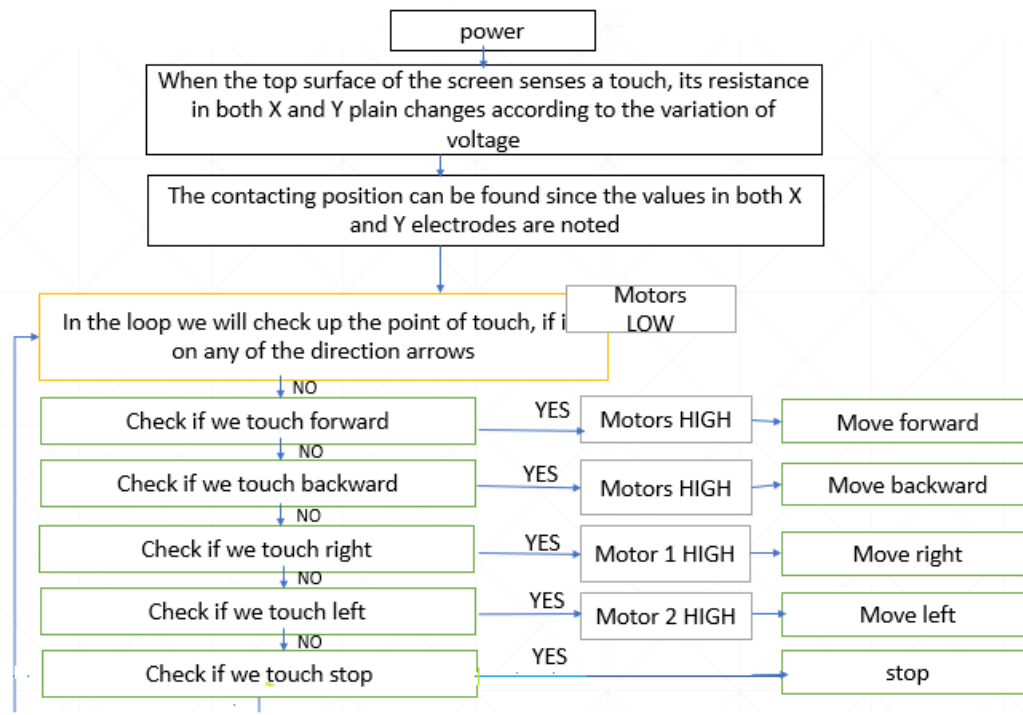


Figure 3.4.1: Flow chart of working of Touchscreen Module

2.4. Proteus Simulation of Wheelchair:

Working We have represented the voice module simulation results in below finger 3.5. On making connection in Proteus, we know that

Microphone is not available, so we have used Virtual terminal to give the input command. When we write the command on the virtual terminal, two DC motors works accordingly.

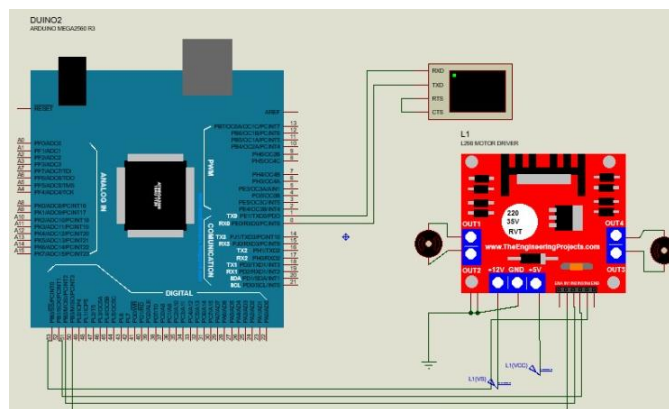


Figure 2.4(a): Proteus Simulation

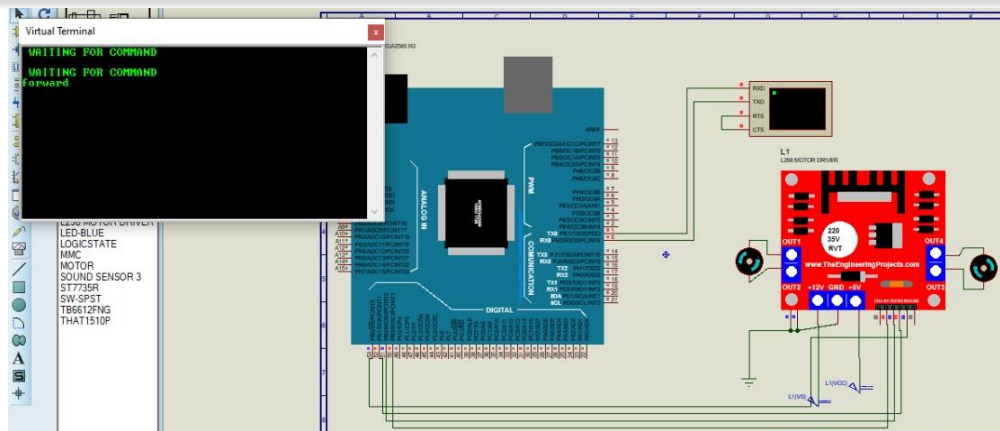


Figure 2.4(b): Proteus Simulation for Forward Command

Whole circuit is build up in FritZing also

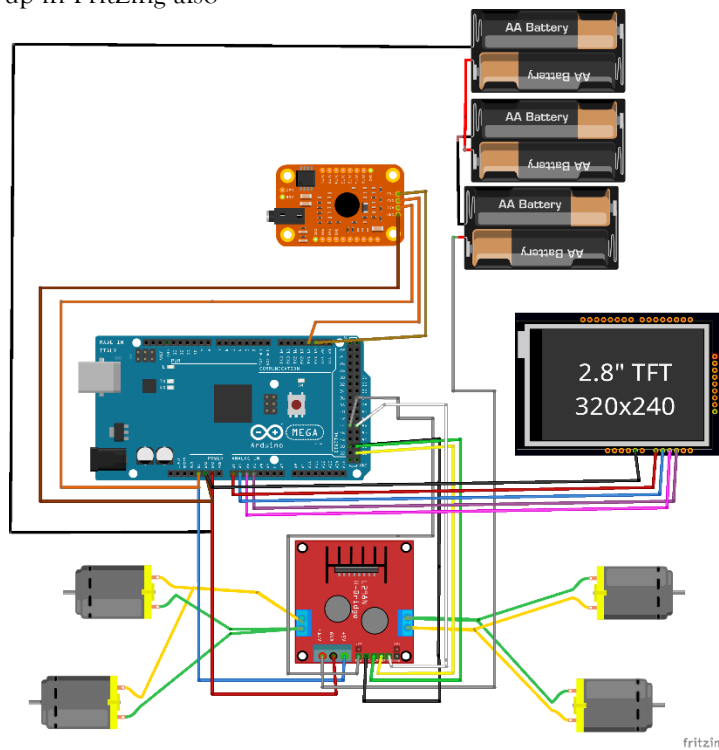


Fig 2.4(c): FritZing Circuit Diagram

3. Experimental Results and Discussion:
 Voice commands and a touchscreen interface were used in the successful design, implementation, and controlled testing of the suggested smart wheelchair system. To provide dual mode navigation, the system combines an Arduino Mega, Voice Recognition Module V3, 2.8-inch TFT display, and DC motors with an L298N motor driver. Through the use of two control mechanisms—voice recognition and a touchscreen

interface—the experimental evaluation of the suggested smart wheelchair system shows efficient and dependable performance. The Arduino Mega, Voice Recognition Module V3, and 2.8-inch TFT Touchscreen Display used in the system’s implementation allowed it to successfully carry out directional orders including forward, backward, left, right, and stop. While the touchscreen interface offered nearly instantaneous and extremely accurate control, the voice-controlled

mode achieved an accuracy of about 85–92% in low-noise situations with a response time of less than one second. Smooth navigation on level surfaces with adequate directional stability was guaranteed by motor performance using DC motors and an L298N driver. Proteus uses simulation to further evaluate system functionality before implementing hardware. However, the speaker-dependent nature of the voice module led

to performance loss in noisy surroundings, and the lack of obstacle detection restricts safe operation in dynamic scenarios. Future research will concentrate on incorporating cutting-edge technologies like GPS-based tracking, AI-based navigation, and ultrasonic sensors for obstacle avoidance to improve system safety, robustness, and practicality—especially for users in developing nations.

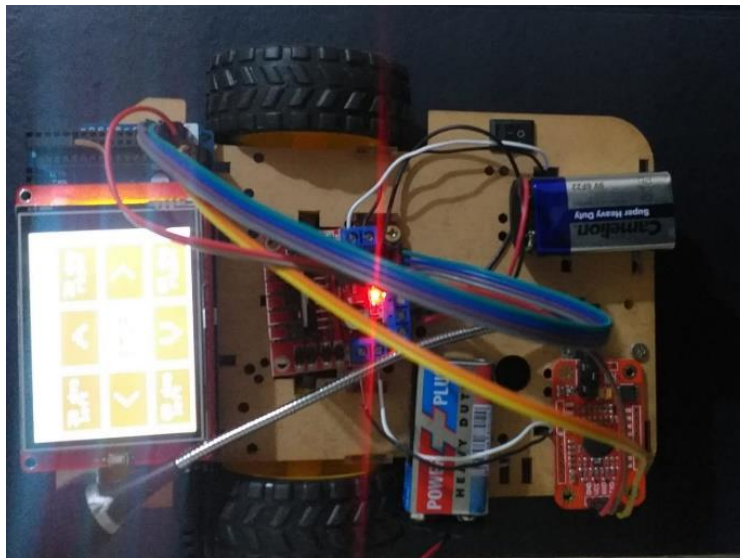


Fig 3(a): Final Prototype



Fig 3(b): Clear View of TFT LCD Display

References:

- N. K. Sarkar, M. Roy, and M. M. Zaman, "Brain controlled wheelchair with smart features," *Electronics Communication Engineering Discipline*, Khulna University, Khulna, Bangladesh, 2025.
- K. Kwolek, W. Wojnarowska, and S. Miechowicz, "Analysis of the feasibility of using the NVIDIA JetBot Nano system to control a wheelchair for people with disabilities," 2025.
- A. M. Hamed, A. Attia, and H. El-Behery, "Optimization of EEG-based wheelchair control: machine learning, feature selection, outlier management, and explainable AI," *Journal of Big Data*, vol. 12, no. 1, 2025, doi: 10.1186/s40537-025-01238-y.
- Y. Dale, N. K. Anirvan, S. S. Karjigi, and S. H. S., "A novel method for brain control interface wheelchair implementation," in *Proc. 2025 Int. Conf. Modern Sustainable Systems (CMSS)*, Shah Alam, Malaysia, 2025, pp. 324-329, doi: 10.1109/CMSS66566.2025.11182424.
- S. Rahman et al., "A neuro-wave controlled wheelchair combined with gesture and voice control," in *Proc. 2024 15th Int. Conf. Computing Communication and Networking Technologies (ICCCNT)*, Kamand, India, 2024, pp. 1-7, doi: 10.1109/ICCCNT61001.2024.1072507.
- A. Koirala, G. Subedi, S. Paudel, and B. T. Magar, "Eye controlled electric wheelchair: Proof of concept using an Arduino robotic car," *International Journal on Engineering Technology*, vol. 2, no. 1, pp. 176-186, 2024, doi: 10.3126/injet.v2i1.72569.
- A. Haddoun, D. Djabri, M. Saidani, and M. Benbouzid, "Development and evaluation of a head-controlled wheelchair system for users with severe motor impairments," *MethodsX*, vol. 15, 2025, Art. no. 103485, doi: 10.1016/j.mex.2025.103485.
- D. Kaliannan, T. Thamilarasu, and M. B. Dolmala, "Smart wheelchair," 2020. [Online]. Available: <http://repository.psa.edu.my/bitstream/123456789/3190/1/WHEELCHAIR.pdf>
- Q. Au, B. Co, T. Mulvey, and K. Nguyen, "Automated smart wheelchair," 2018. [Online]. Available: <https://www.csus.edu/indiv/t/tatror/season/SD%20F17S18/Team1AutomatedSmar.D.SRI>, "Health monitoring and alerting smart wheel chair for physically disabled," 2023.
- A. Abimaanyu, T. Rajalakshmi, H. Varma, and P. Kalyan, "Gesture-controlled wheelchair and home automation using IR remote," in *Proc. 2024 3rd Int. Conf. Intelligent Techniques in Control, Optimization and Signal Processing (INCOS)*, 2024, pp. 1-6.
- F. Mazlan and S. Yursi, "Wireless control wheelchair," 2019. [Online]. Available: <http://repository.psa.edu.my/bitstream/123456789/2119/1/WIRELESS>
- V. Purushothaman, R. Androse, M. Lokesh, S. Chander, and R. Rajkamal, "Head motion controlled wheelchair," *International Journal of Recent Technology and Engineering*, vol. 7, no. 6S3, pp. 188-192, 2019.
- H. R. S. D and S. N, "Wheelchair controlled by head motion," *IJIREEICE*, vol. 11, no. 12, 2023, doi: 10.17148/ijireeice.2023.111204.
- A. K. Chaudhary, V. Gupta, K. Gaurav, T. K. Reddy, and L. Behera, "EEG control of a robotic wheelchair," *IntechOpen*, 2023.
- M. A. Palumbo, V. Gramigna, B. Calabrese, and N. Ielpo, "Motor-imagery EEG-based BCIs in wheelchair movement and control: A review," *Sensors*, vol. 21, no. 18, 2021.

- M. A. Hossain, M. F. K. Khondakar, M. H. Sarowar, and M. J. U. Qureshi, "Design and implementation of an autonomous wheelchair," in Proc. 4th Int. Conf. Electrical Information and Communication Technology (EICT), 2019, doi: 10.1109/EICT48899.2019.9068851.
- P. Alvira, E. Tomas-Pejo, M. Ballesteros and M. J. Negro, Pretreatment technologies for an efficient bioethanol production process based on enzymatic hydrolysis: A review, *Bioresour. Technol.* 101 (2010) 4851-4861.
- W. C. Xie. *Differential equations for engineers.* Cambridge, UK: Cambridge University Press, 2010.
- T. Basten, In terms of nets: system design with petri nets and process algebra, Ph.D. Thesis, Eindhoven University of Technology, The Netherlands, 1998. 19.
- D. L. Eaton, Porous glass support material, US Patent No. 3 904 422 (1975).

