
Leveraging Massive Information from Diverse Devices: An Intelligent, Low-Cost, Voice-Controlled Autonomous Wheelchair for Enhanced Mobility

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Abstract

This paper explores the development of an intelligent, low-cost, voice-controlled autonomous wheelchair designed to enhance mobility for individuals with disabilities. The wheelchair integrates diverse data from multiple devices, including a voice recognition module, joystick module, ultrasonic sensors, and solar panels, to provide a comprehensive and adaptive user experience. Leveraging massive information from these interconnected devices, the wheelchair employs artificial intelligence and machine learning algorithms to refine its responsiveness to users' voice commands, improving

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adaptability to individual speech patterns over time. The solar panels contribute to the wheelchair's sustainability by harnessing solar energy for battery charging, ensuring prolonged operation without frequent recharging. This study details the design methodology, fabrication process, and performance testing of the wheelchair, showcasing its capabilities such as an optimum speed of 0.89 m/s, a load capacity of 20 kg, and effective obstacle avoidance. Additionally, the paper addresses the wheelchair's advantages, potential limitations, and future enhancements. By leveraging diverse data sources and intelligent systems, this innovative wheelchair aims to significantly improve mobility, individuality, and worth of life for beings with mobility challenges and the elderly.

Keywords: Artificial intelligence, autonomous wheelchair, low-cost mobility solutions, solar energy, voice-controlled mobility.

1 Introduction

Mobility solutions have undergone a revolution with the introduction of sophisticated technologies, especially for those with disabilities. This study encapsulates the incorporation of state-of-the-art advancements to produce an autonomous wheelchair at a reasonable cost. This method improves the wheelchair's navigation and control by leveraging data from a variety of devices. Voice control makes the device more accessible and user-friendly by allowing users to control the wheelchair with basic spoken commands. This is a big step towards more inclusive and adaptive assistive technologies [13], as well as improving the quality of life for those with mobility issues. The ability of advanced technology [14, 15] to improve everyday experiences for persons with disabilities is demonstrated by the intelligent processing of data from numerous sensors to ensure safe, efficient, and personalized mobility [1].

Mobility is a fundamental human right and a prerequisite for social and economic participation [1]. However, millions of individuals worldwide suffer from some form of disability that impairs their ambulatory function [2], rendering them dependent on assistive devices such as wheelchairs. In Pakistan, a densely populated and underdeveloped country, the prevalence of disability is estimated to be around 15% of the total population, with mobility being the most common type of disability [2]. However, the availability and accessibility of wheelchairs in Pakistan are limited, especially for low- and middle-income families [3]. The existing wheelchairs are either manually operated or electrically powered, both of which have drawbacks such as

high cost, low efficiency, high maintenance, and environmental impact [3]. Therefore, there is a need for a more innovative and sustainable solution that can provide mobility and independence to individuals with disabilities in Pakistan. Currently, the field of assistive technology has perceived significant advancements aimed at improving the lives of individuals with mobility challenges [3, 16]. This paper introduces a groundbreaking solution for enhancing accessibility and autonomy among individuals facing mobility constraints in Pakistan a solar-powered voice-controlled wheelchair. This innovative assistive device not only addresses the pressing need for cost-effective mobility solutions but also integrates cutting-edge artificial intelligence (AI) capabilities [4]. At the heart of this wheelchair's intelligent functionality lies a sophisticated voice recognition module, empowered by machine learning algorithms [5]. This AI-driven module not only enables users to effortlessly control the wheelchair through intuitive voice commands but also exhibits a learning capacity. By continuously adapting to the unique speech patterns of users, the voice recognition system enhances its responsiveness, providing a personalized and seamless interaction experience [5, 9].

Moreover, the integration of a joystick module further diversifies the control options, ensuring flexibility to accommodate various user preferences. The amalgamation of solar power technology adds an environmentally sustainable dimension, with a dedicated solar panel harnessing energy to facilitate battery charging. This dual-powered methodology not only decreases reliance on old-fashioned charging methods but also supports with global shift towards eco-friendly solutions [21].

According to the World Report on Disability, more than one billion individuals worldwide, constituting approximately 15% of the global population, suffer from some form of disability [6]. The World Health Survey conducted in 69 countries revealed that 18.6% of individuals aged 18 and above reported experiencing moderate, severe, or significant difficulty in mobility [7]. Further research conducted in Fiji, India, Indonesia, Mongolia, and the Philippines indicated that one in five people faced challenges in walking or climbing stairs, with one in twenty individuals experiencing serious mobility issues.

The findings of the above-discussed report underscore the critical need for assistive devices in underdeveloped countries that not only aid individuals with disabilities but are also cost-effective. Pakistan characterized as an underdeveloped and densely populated country, harbors a substantial proportion of disabled individuals [8]. The census report of 2023 provides detailed insights into the disability ratio in Pakistan. Conducted by the Pakistan

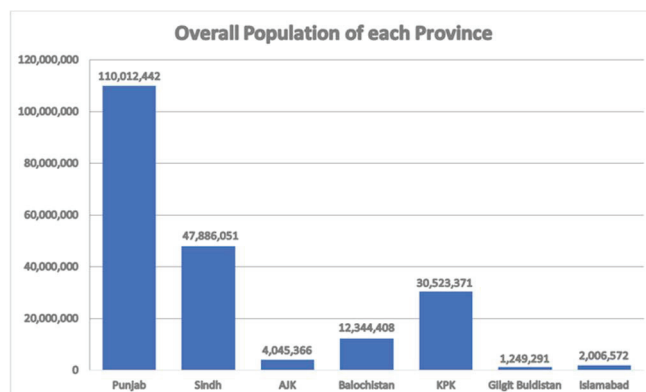


Figure 1 Representation of provincial population [8].

Bureau of Statistics five years after the previous census, the 2023 census estimated Pakistan's total population to be 241,492,197 people. According to the census data, the province of Punjab emerged as the most populous, with a population of 110,012,442, followed by Sindh with a population of 47,886,051 [8]. Subsequently, Khyber Pakhtunkhwa (KPK), Baluchistan, and other respective areas of Pakistan contributed to the overall demographic distribution. The statistical representation of the census data is effectively depicted in graphical form as shown in Figure 1.

In Pakistan, the disability ratio is examined on a province-wide basis, and the accompanying graph illustrates the prevalence of disabilities categorized by age within each province as depicted in Figure 2. The comparative analysis of disability ratios is presented in the graph, with the province of Punjab leading the list, followed by Sindh, Khyber Pakhtunkhwa (KPK), and other respective areas of the country [8]. The graph effectively captures the distribution of disabilities across different age groups, providing valuable insights into the demographic landscape of disability prevalence in each province as illustrated in Figure 3.

Globally, individuals with disabilities often encounter challenges in accessing continuous assistance for locomotion, particularly 24 hours a day [9]. To address this issue, the implementation of artificial assistance becomes imperative for the movement of disabled persons. The designed system aims to reduce the dependency of disabled individuals on others [10]. The Solar Powered Voice and Joystick-Controlled Wheelchair alleviate the strenuous efforts of disabled persons, empowering them to operate independently without external aid. Through the integration of voice and joystick

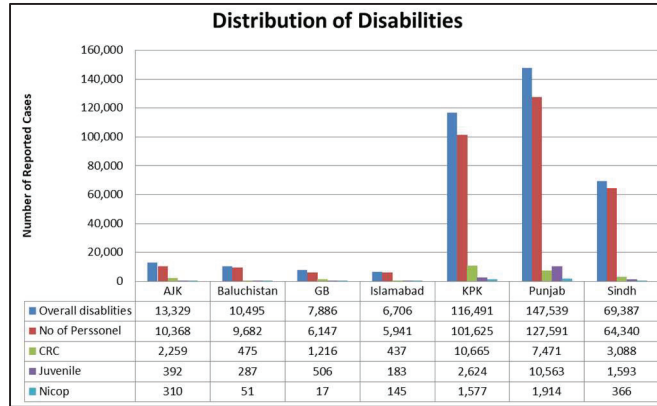


Figure 2 Provincial-wise disabilities.

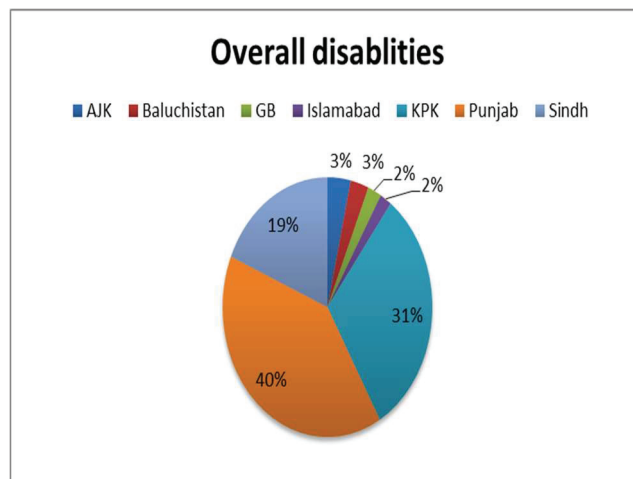


Figure 3 Disabilities ratio.

controls, individuals with locomotive disabilities can seamlessly navigate from one location to another.

Traditionally, wheelchairs for the handicapped in Pakistan have been either manual or electric motor-driven [2]. The primary concerns for individuals with disabilities revolve around the operation, maintenance, and cost of wheelchairs. The proposed solar-powered voice and joystick-controlled wheelchair offer a cost-effective and more assistive solution compared to conventional electric wheelchairs. The project encompasses various engineering

Table 1 Survey of hospitals

Name of Hospital	Quantity	Type of Wheelchair
LUMHS Jamshoro	13	Manual
PUMHS Nawabshah	9	Manual
KMC Khairpur Mirs	7	Manual

aspects, including control systems, power transmission, renewable energy, and embedded operating systems. Surveys serve as essential screening techniques for gathering information from a predefined group of respondents, facilitating the collection of data and experiences on diverse topics of interest. They can unveil insights into people's habits, needs, and household dynamics, providing a means to quantify customer satisfaction and assess assumptions.

Surveys also contribute valuable context to exploratory research. In the context of our project, the first objective is to survey hospitals. Visits to different hospitals, including KMC Khairpur Mir's, PUMHS Nawabshah, and LUMHS Jamshoro, were undertaken for this purpose. The survey data collected is presented as shown in Table 1.

The outcomes of the market and hospital surveys have led to the deduction that the current wheelchair offerings in Pakistan are prohibitively expensive for low- and middle-income families. The survey findings indicate that the wheelchairs accessible in hospitals are singularly functional, relying solely on manual operation. This poses a significant challenge for individuals with disabilities and the elderly, making it strenuous for them to navigate. The proposed wheelchair seeks to address this issue by providing a more accessible and user-friendly solution. Its primary objective is to enrich the worth of life for beings with mobility contests, particularly the disabled and the elderly, who face difficulties in movement.

The envisioned wheelchair is designed to facilitate various aspects of daily life, enabling users to manage routines, travel independently, visit hospitals, and pursue employment opportunities [10]. By incorporating user-friendly features and addressing affordability concerns, the proposed wheelchair aims to empower individuals with disabilities and the elderly, fostering increased independence and an improved overall quality of life. The remaining structure of the manuscript is organized as follows: in Section 2 methodology of the design and fabrication of SPWC is covered, in Section 3 the operation and control of the SPWC are discussed, in Section 4 results and analysis of testing and evaluation of SPWC are presented, in Section 5 implications and challenges of the SPWC are discussed, and in last Section 6 conclusion and suggestions for future directions for improvement are given.

2 Methodology

The designed and proposed solar power wheelchair consists of hardware components as well as software as shown in the block diagram, which is shown in Figure 4.

2.1 Design of Prototype

The design objectives for the Solar Power Wheelchair (SPWC) included considerations for weight carrying capacity, optimum speed, obstacle detection, and solar power charging capability. The project utilized AutoCAD software for precise modelling as shown in Figure 5. Components were selected based on these objectives, with a focus on sturdy materials for weight support, motor specifications for speed optimization, sensors for obstacle detection, and high-efficiency solar panels for sustainable charging. The SPWC targets to increase mobility for beings with disabilities while incorporating innovative and eco-friendly features.

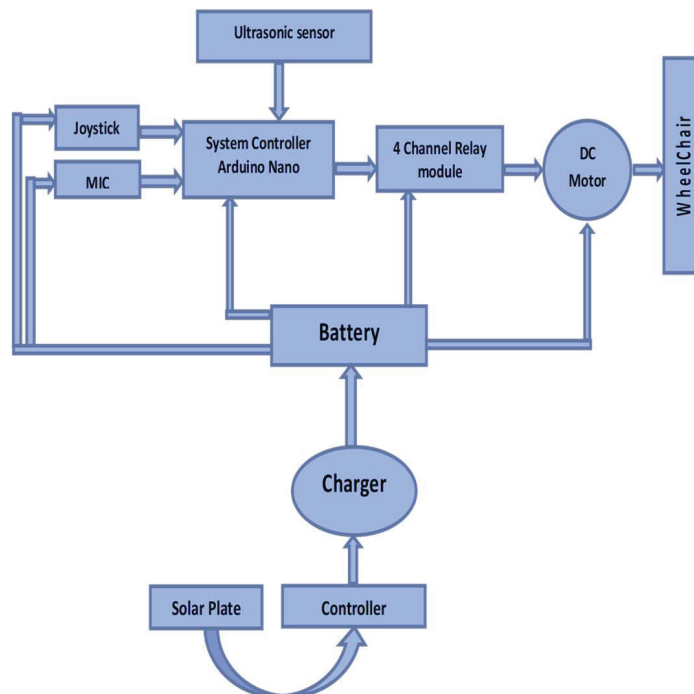


Figure 4 Block diagram.

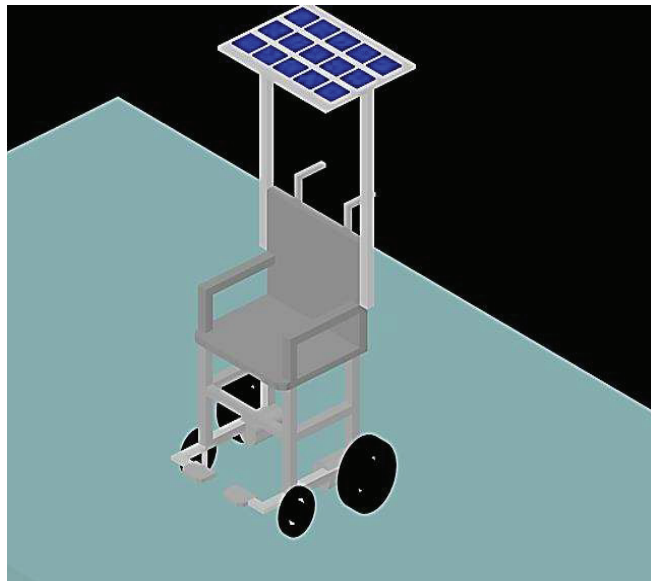


Figure 5 Model of solar power wheelchair in AutoCAD.

Table 2 Difference between brush and brushless

Feature	Brush	Brushless
Budget	*	
Mean time between Repairs		*
Mean time between failure	*	
Flat speed/torque		*
Efficiency High		*
Output High to frame size ratio Speed range High		*
Thrilling atmospheres	*	
Ease in connections	*	

2.1.1 Motor

In selecting a motor for the solar power wheelchair, key considerations include simplicity, compactness, economic performance, durability, quiet operation, cost-effectiveness, and adaptability to various environments [11]. The process involves both quantitative factors like power efficiency and torque, as well as qualitative aspects such as user reviews and manufacturer reputation. A well-chosen motor contributes to the wheelchair’s efficiency, longevity, and overall success [12]. The comparison between the brush and brushless motors is shown in Table 2.

Table 3 Specifications of DC motor

Parameters	Value
Type	GR 63*55 FAAC
Voltage	12V
Power	10W
Frequency	50 Hz
Speed	3450 rpm
Torque	27 N.cm
Net weight	2700g

2.1.2 Weight carrying capacity for DC motor

Maximum mass carrying capacity = 20Kg

Co-efficient of friction = 0.02

The reaction force of friction = R

Formula to overcome friction

$$F = \mu R \quad (1)$$

Where R is the reaction force in Newton, μ is the coefficient of friction. The mass of a wheelchair is 25 Kg if the person sits on it mass will be 40 Kg.

Reaction force = mg

Reaction force = 45×10

Reaction force = 450N

Now,

$$F = \mu R = 0.02 \times 450 = 9N \quad (2)$$

It means 9N force is required to overcome the limiting friction. Now to attain optimum speed for wheelchairs we have used 10-watt DC motors. Based on quantitative and qualitative analysis and weight carrying capacity, GR 63x55 FAAC brushed DC motors are selected for solar power wheelchairs. The features of the GR 63x55 FAAC DC motor are specified in Table 3.

2.1.3 Arduino Nano

The Arduino Nano is a compact microcontroller based on the ATmega328 architecture, developed by Arduino cc [11]. It shares similarities with the Arduino Due Milanovic but differs in the absence of a power jack, replaced by a USB-B mini port. The key microcontroller is the ATmega328, renowned for its small size [12]. Some notable features of the Arduino Nano include its

Table 4 Arduino Nano features

Parameters	Value
Microcontroller	ATmega328
Architecture	AVR
Operating Voltage	5V
Flash Memory	Boot loader 2 KB from all 32 KB
SRAM	2KB
Clock speed	16 MHz
Analogue Input/output pins	8
EEPROM	1KB
DC Current on IOs	40 mA
Input Voltage	7–12V
Digital Input/output pins	22
PWM output	6
Power Consumption	19 mA
PCB Size	18×45 mm
Weight	7 grams
Product code	A000005

compact form factor and utilization of the ATmega328 controller, making it a popular choice for various projects as demonstrated in Table 4.

2.1.4 Ultrasonic sensor

The wheelchair incorporates an ultrasonic module that emits ultrasonic sound waves and translates the echoes into electrical signals [9]. This functionality aids in obstacle avoidance during wheelchair navigation. Ultrasonic waves, being faster than normal audible sound, are employed to detect obstacles. The ultrasonic sensor is equipped with four pins: VCC and GND operate at +5 volts, while TRIGGER and ECHO connect to Arduino Nano at PIN D6 and D7, correspondingly. The sensor serves as a detector, identifying obstacles within a 20 cm range in front of the ultrasonic module. If an object is detected, the motor ceases forward or backward movement, enhancing safety during wheelchair operation.

2.1.5 Four-Channel relay

A 4-relay module is employed to control heavy loads with high voltage and current, such as AC, motors, and other substantial appliances [12], further, the specifications of the Relay module are demonstrated in Table 5. Designed to interface with small controllers like Arduino and PIC, the relay module facilitates the operation of motors in various directions, both alternate and

Table 5 Specifications of relay

Parameters	Value
Supply Power	DC 5V
Current	15 mA
Frequency	40 Hz
Range Distance	4 m
Resolution	0.3 cm
Measured angle	15 degree
Input pulse width	10 μ S
Dimension in mm	45 \times 20 \times 15

direct current. To connect the 4-relay board with Arduino, the initial two connections involve linking the ground and power pins. Arduino +5V connects to the VCC pin, and Arduino ground connects to a GND pin of the four-relay board. The relay board has 6 pins (VCC, 2IN4, GND), with 2IN4 serving as the four inputs, two of which are connected to motor 1 and motor 2 for motor control.

2.1.6 LCD 16x2

The LCD (Liquid Crystal Display) is an electronic device utilized for data visualization. The LCD 16 \times 2 configurations consist of 16 columns and 2 rows, allowing for the display of a total of 32 characters (16 \times 2 = 32). Every character is composed of 5 \times 8 (40) pixel dots. Therefore, the total number of pixels within this LCD can be measured as 32 columns multiplied by 40 pixels, resulting in 1280 pixels. LCD 16 \times 2 shows primarily rely on multi-segment LEDs. While various display types exist, such as 8 \times 2, 8 \times 1, 16 \times 1, and 10 \times 2, +LCD 16 \times 2 is extensively favoured in devices, DIY circuits, and electronic projects due to its cost-effectiveness, programmable friendliness, and ease of accessibility.

2.1.7 Joystick

A joystick is a device commonly used in computers to control the movement of an arrow on the display. In the context of a wheelchair project, the joystick serves as an analog sensor. It operates by allowing the pivoting of the shaft, which, in turn, rotates the contact arm. As the joystick's knob is moved, a potentiometer instructs an arm to turn as needed by altering the resistance in the potentiometer. This mechanism facilitates precise and variable control over the wheelchair's movements based on the user's input through the joystick. The parameters for the selection of the joystick module are clarified in Table 6.

Table 6 Parameters of joystick module

Parameters	Value
Operating Voltage	5 V
Potentiometer	10 K
Pin Interface Leads	2.54 mm
Dimensions	1.57 in × 1.02 in × 1.26 in
Operating temperature	0 to 70°C

Table 7 General features of solar charge controller

Parameters	Value
Application	Solar electrification
Use	Indoor, battery charging using solar module
Operating Temperature	0°C to 60°C
Temperature storage	−10°C to 60°C
Charge controller type	Two steps charging algorithm
Battery temperature compensation	−4 mV to −5 mV/V/cell
Size of solar module	40 WP

2.1.8 Voice recognition module

A voice recognition module is a compact and user-friendly device designed for speech recognition, capable of recognizing and supporting up to 80 different commands. The module operates on a talker-based system, where installed voice commands are stored in a large cluster. The module can effectively identify and respond to a set of 7 distinct commands, making it a versatile tool for voice-controlled applications.

2.1.9 Solar charge controller

A charge regulator, also known as a charge controller, plays a crucial role in managing and regulating the voltage or current supplied to batteries from solar panels. Its primary function is to prevent overcharging of batteries by modifying the incoming current and voltage. Many solar panels labeled as “12 volts” actually produce outputs in the range of 16 to 20 volts. Without a charge regulator, this higher voltage could lead to damage to the batteries over time. The charge regulator ensures that the batteries receive the optimal voltage for charging, typically around 14 to 14.5 volts, thereby preventing overcharging. Additionally, it serves to safeguard batteries from complete discharge, contributing to an extended battery life. In summary, the charge regulator acts as a critical component in a solar power system, optimizing the charging process and enhancing the overall longevity of the batteries. Furthermore, the feature of the solar charge controller is illustrated in Table 7.

In a solar power system, the battery is charged through solar panels, and the charge controller plays a crucial role in ensuring proper charging of the battery. The battery supplies direct current (DC) and voltage to an inverter, which converts the DC into alternating current (AC). Charge controllers are especially important for charging deep-cycle lead-acid batteries commonly used in solar PV systems. To protect against reverse polarity, two techniques are commonly employed: shunt and series diodes. In the shunt procedure, a fuse within the charge controller blows if the input is reversed-connected because the diode becomes forward-biased. This action prevents damage to the DC system, but it requires replacing the fuse after activation to restore functionality and protection.

2.1.10 Solar panel

The solar energy source is the sun. Photons, which are energy particles found in the sun, are converted into electricity by solar panels (sometimes referred to as “PV panels”), which can then be utilized to power electrical loads.

The solar plate collects energy from the sun and converts it into electricity that we may use at home. It is made up of photovoltaic cells. Each cell is constructed of pure silicon. This provides us with a negative charge, and boron is also utilized, which has a positive charge. Solar plates capture photons and produce electrons, which are then utilized to generate electricity. The energy created when photons impact the solar panel’s surface knocks electrons out of their atomic orbits and releases them into the electric field formed by the solar cells, which subsequently draws these liberated electrons into a directed current. The entire process might be referred to as photovoltaic effect.

2.1.11 Battery

Although lead acid batteries haven’t changed much since the 1880s, advances in materials and manufacturing techniques continue to increase energy density, life, and dependability. All lead acid batteries have flat lead plates submerged in an electrolyte pool. Most types of lead acid batteries require regular water addition, though low- maintenance models come with extra electrolytes calculated to compensate for water loss over time [11].

2.2 Fabrication of SPWC

After designing the model of a project, the manual wheelchair was purchased from the market. To fabricate SPWC as per design consideration, the fabrication process was continued in the following manner;

2.2.1 Motor installation

DC motors were purchased as per the required specification, and then they were welded near the hub of the rear wheels through the welding process. Before installation of motors, they were separately tested on battery.

2.2.2 Circuit design and testing

Arduino programming is done through Arduino Integrated Development Environment (IDE), and C++ computer programming language is used. Since Arduino Nano, joystick, voice module, and ultrasonic sensors operate on 5 volts that's why buck convertor is used so that it could convert 12v to 5v. Moreover, Arduino Nano, joystick, voice module, and ultrasonic sensors are electronically connected through the soldering process in a circuit as demonstrated in Figure 6.

A channel relay was tested on all five commands before fitting to the wheelchair. The voice module was first programmed on voice commands then it was tested. Similarly, the joystick was checked and tested before the installation of the circuit to the wheelchair as shown in Figure 7.

2.2.3 Installation of solar panel and charge controller

The solar frame is made of iron rods having a square cross-section. Iron rods were cut using a grinder in the desired length. Then they were welded in the

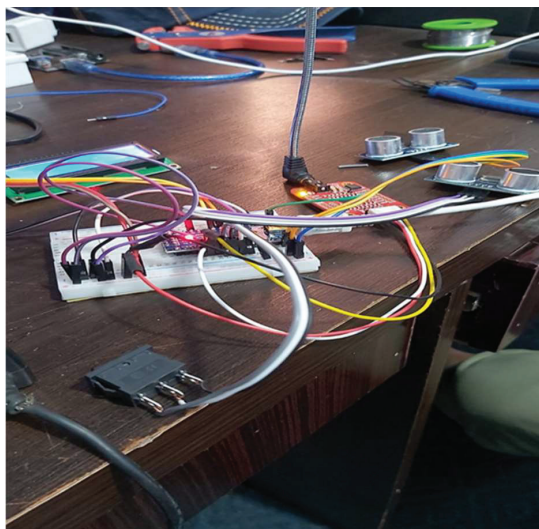


Figure 6 Circuit testing.

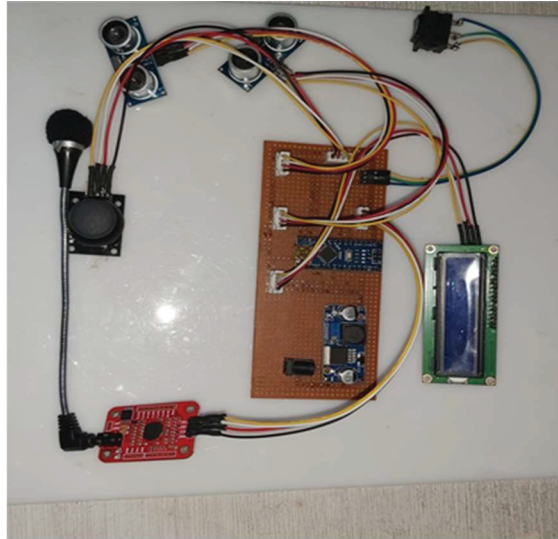


Figure 7 Main circuit.

required shape using Arc welding. After the successful design and fabrication of the Solar Frame, the solar frame was installed on a wheelchair in the supportive welded columns on the wheelchair. A solar Panel was fitted in the Solar Frame. A charge controller was installed on the wheelchair. It was connected with a Solar Panel as well as a battery. The polarities of the Solar Panel, charge controller, and battery were connected properly by connecting the positive terminal to the positive and negative terminal to the negative terminal; furthermore, the final design of the prototype is demonstrated in Figure 8. Solar Charge successively controlled the input charge of the Solar Panel and provided the required charge to input the battery.

3 Operation and Control

The solar power voice control wheelchair can be operated by two methods one is by giving a voice command through a voice recognition module and the second is manually by pressing a joystick module.

3.1 Manual Method

The joystick mode is very simple and the wheelchair can move in all directions as forward, backward, left, and right by pressing a joystick in



Figure 8 Prototype of SPWC.

the required direction. The wheelchair will be in the rest position when the joystick position is at the center.

3.2 Voice Command

The voice recognition module is used for giving voice commands. By giving the appropriate command word through the mic, as forward, backward, left, and right wheelchair moves in that direction as per the given command. When some obstacle comes in the front or back of the wheelchair it stops to avoid any accident.

3.3 Circuit Operation

Figure 9 demonstrates the interfacing of all components. The operation of the circuit is dependent on the joystick and microphone (Mic) connected to an Arduino Nano. The voice module is linked to D2 of the Arduino Nano, while the joystick is connected to A1 and A2. When the joystick is moved or specific instructions are given through the microphone, the Arduino Nano decodes these instructions and sends signals to 4-channel relays. The connections involve the first two couples of ground and power pins, where +5V is connected to the 4-relay VCC pin, and the Arduino ground is connected to

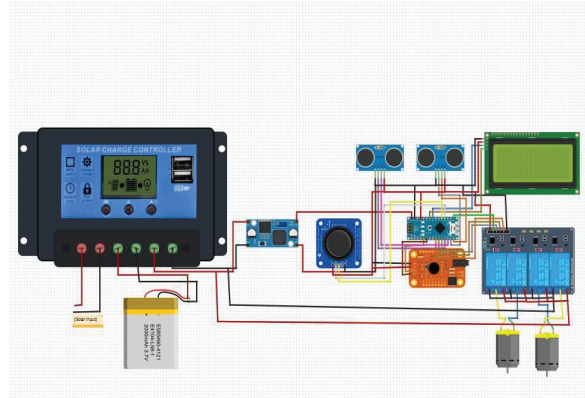


Figure 9 Circuit diagram of SPWC.

the 4-relay board GND pin. Four relays are employed in a circuit, with two relays dedicated to motor 1 and two for motor 2 as shown in Figure 9.

The joystick/MIC controls the relays as follows:

- Pushing forward activates IN1 and IN3.
- Pushing backward activates IN2 and IN4.
- Pushing left activates IN1 and IN4.
- Pushing right activates IN2 and IN3.

The relays drive the motors in the specified direction: forward, backward, left, or right. This configuration allows for motor control based on joystick movements or voice commands through the microphone, enabling the wheelchair to move in desired directions as per user input.

As Shown in Figure 4 of the Block diagram of the project, the battery is the main source that provides input power to all other components. From the Battery, power is supplied to DC motors, four-channel relay, Arduino Nano, LCD, voice module, joystick, and ultrasonic sensors. A buck converter is installed that controls the input voltage. The function of the Buck converter is to convert 12 volts of battery to 5 volts and then supply it to Arduino, Voice module, Joystick, LCD, Four Channel Relay, and Ultrasonic sensors. However, DC motors run on 12 volts. Now there are two modes of operation: joystick mode and voice mode. Users can shift between two modes by simply pressing the button provided on the circuit box. If a wheelchair is to be operated on joystick mode, then the user can press the joystick in forward, backward, left, or right direction. Wheelchairs will move in the selected direction. Four-channel relays executed the function of controlling

the direction of the wheelchair. If a user is operating it on voice mode, then the wheelchair will move in the same four directions based on a command given by the user. While the wheelchair is in voice mode, sensors will be activated by Arduino Nano, Sensors are installed at the back and front of the wheelchair so that the wheelchair cannot strike an obstacle. In both modes of operation signal to the motors is sent by Arduino Nano after receiving a voice command or joystick signal.

Additionally in Figure 9 Solar Panel and Charge controller are displayed. The solar panel works as a backup of the battery. The function of solar panels is to convert solar energy to electrical energy. Solar panel output is 18 volts which is greater than the required power input for charging the battery. Hence for that, a solar charge controller is used that converts 18 volts to 12 volts and charges the battery, and when a battery is fully charged it automatically cuts the power supply.

4 Introduction Results Analysis and Discussions

This section highlights the results and analysis that were carefully tested with the SPWC. The results include solar panel readings and speed calculation of wheelchairs with weight and without weight.

4.1 Solar Panel Testing

The readings of the Solar panel were taken at 90 angles. Time was carefully noted from the start of solar panel readings. Output power, Voltage, and Current were recorded using a digital multimeter at different times with an hour gap between each successive reading. Results were constantly recorded from 8 AM to 6 PM. It can be observed from the graph that power output continues to increase up to 2 PM due to an increase in solar intensity, however, then afterward the 2 PM power output of the panel decreased. The variation of power, voltage, and current is displayed in Figure 10.

4.2 Battery Charing Test

We have only begun timing when the battery is completely dead to measure this, and we have ensured that the multimeter registered a zero. The equipment and timer were then turned on at roughly 8:30 a.m. We continued to record measurements every hour and closely monitored the multimeter until it climbed over 800 watts; at 840 watts, the operation was stopped and the time was taken, as shown in Table 8.

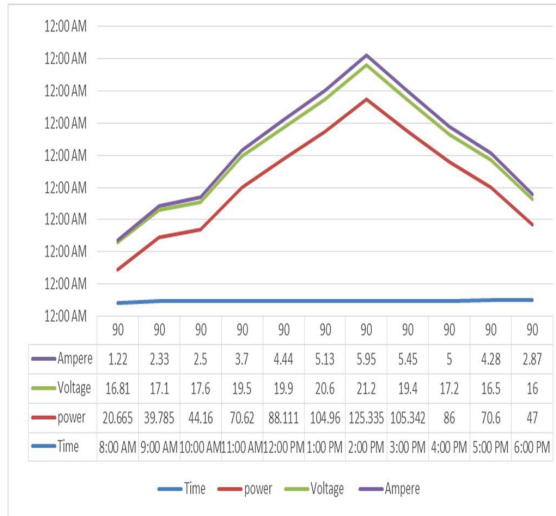


Figure 10 Variation in voltages, current, and power with time.

Table 8 Charging test results for 12V battery using a charge controller

Time	Battery Voltage (V)	Charge Rate (%)	Status
10:00 am	12.05	14.0%	On charge
10:30 am	12.44	25.0%	On charge
11:00 am	12.60	30.0%	On charge
11:30 am	12.72	37.0%	On charge
12:00 noon	12.87	45.0%	On charge
12:30 noon	12.96	51.0%	On charge
13:00 pm	13.07	58.0%	On charge
13:30 pm	13.21	64.0%	On charge
14:00 pm	13.45	72.0%	On charge
14:30 pm	13.62	80.0%	On charge
15:00 pm	13.80	85.0%	On charge
15:30 pm	13.97	90.0%	On charge
16:00 pm	14.04	95.0%	On charge
16:30 pm	14.19	98.0%	Float Charge
17:00 pm	14.41	100%	Fully Charged

4.3 Battery Charging with Solar Panel

It is important to match panel output with the controller that is to be used.

If the sunshine is 6 hours/day, the power output will be 150 watt/day

$$6 * 25 = 150 \text{ watts/day}$$

Table 9 Relay activation with user commands

Voice Command	R1	R2	R3	R4	Results
Forward	1	0	1	0	Moving forward
Backward	0	1	0	1	Moving Back
Right	0	1	1	0	Moving Right
Left	1	0	0	1	Moving Left
Stop	0	0	0	0	Wheelchair stops

Table 10 Relay activation with commands by other than the user

Voice Command	R1	R2	R3	R4	Results
Forward	0	0	0	0	No action
Backward	0	0	0	0	No action
Right	0	0	0	0	No action
Left	0	0	0	0	No action
Stop	0	0	0	0	No action

If the battery that is to be charged is 7amp and 12-volt battery having a drain 50%. Then the power needed will be 42 watts for battery charging.

$$12 \times 7 / 2 = 42 \text{ watt}$$

The 25-watt solar panel will require 1.68 hours in a single day to charge a small battery.

4.4 Voice Command Results

Voice command tests of the wheelchair were conducted by giving the voice command of the saved person's voice as well as the other person's voice. It was observed during testing that the wheelchair operated on command of the user's voice and activated the desired relays, the results are shown in Table 9. It did not recognize the other voice and, hence did not move as results are illustrated in Table 10. The wheelchair was tested on five commands that are forward, backward, right, left, and stop.

4.5 Discussion

After testing the all results, the solar power wheelchair is moved straight forward to calculate the velocity without load and with a load. The results achieved without load are demonstrated in Table 11, which shows the velocity in unloaded condition which is 0.89 m/s and then it was recorded under load

Table 11 Trial of 1000 m without load

Battery Consumption	Distance	Time (s)	Speed m/s
17.7 V	10 m	8.11	1.23
To	20 m	16.66	1.20
17.5	25 m	27.42	0.93
Consuming voltage = 0.2	50 m	56	0.89
	100 m	113	0.89
	200 m	226	0.89
	300 m	339	0.89
	400 m	452	0.89
	500 m	565	0.89
	600 m	678	0.89
	700 m	791	0.89
	800 m	904	0.89
	900 m	1017	0.89
	1000 m	1130	0.89

Table 12 Trial of 100 m with a load of 20 Kg

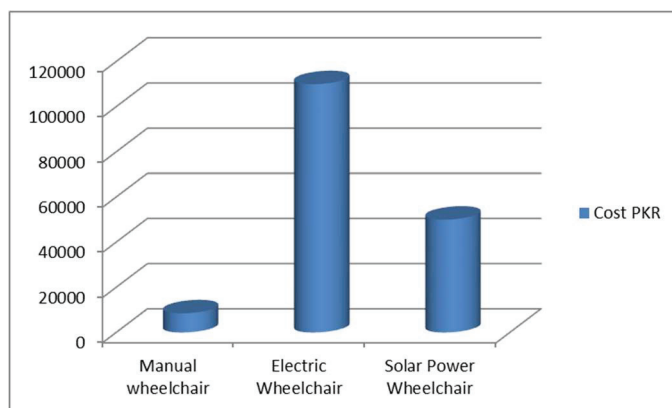
Consuming of Battery	Distance	Time (s)	Speed m/s
17.7 V	10 m	17	0.59
To	20 m	34.5	0.58
17.4	25 m	43	0.58
Consuming voltage = 0.3	50 m	86	0.58
	100 m	172	0.58
	200 m	344	0.58
	300 m	516	0.58
	400 m	688	0.58
	500 m	860	0.58
	600 m	1032	0.58
	700 m	1204	0.58
	800 m	1376	0.58
	900 m	1548	0.58
	1000 m	1720	0.58

of 20 kg. The results achieved as shown in Table 12, the velocity in loaded condition is found to be 0.63 m/s. Furthermore, the results in Table 12 show that as a wheelchair covers more distance its speed reduces. Moreover, it was also observed that velocity decreased with an increase in load.

Moreover, the main features and characteristics available in solar power voice recognition wheelchairs are illustrated in Table 13.

Table 13 Main characteristics of solar power voice control wheelchair

Parameters	Value
Turning angle (right/left) side	90
Time taken per rotation (joystick/voice)	3sec
Total Turns to a complete revolution	4
Speed	0.89 m/s
Speed in KM	3.2 km/h
Diameter of rear wheel	28 cm
Sensor range	100 mm
Battery stand-by use	13.5-13.8 volt
Battery charging time (if current is 1 imp)	5 to 8 hours
Required least volts from solar panel to charge Battery 12V	13.6 volt
Battery consumption time without weight	10 to 12 hr
Battery consumption with weight	5 to 6 hr
Weight carrying capacity	20 kg

**Figure 11** Cost comparison of wheelchairs.

4.6 Cost of Proposed Wheelchair

The list of components that were purchased during the fabrication of the voice and joystick-controlled wheelchair is discussed above. The required components can be purchased from the market at a given price or a little bit costly. This wheelchair is cheap compared to the electric wheelchair as shown in Figure 11. The comfort provided by the chair depends on the quality of the chair purchased, but the designed chair has the advantage that it can operate in voice mode with optimum speed.

5 Conclusion

This project aimed to address mobility challenges by designing a low-cost, voice-controlled autonomous wheelchair. Traditional manual wheelchairs often require assistance, causing user exhaustion. This innovative wheelchair enhances independence and reduces physical strain. Leveraging massive data from diverse devices, AI plays a key role in its functionality. The voice recognition module, powered by AI algorithms, allows hands-free control, adapting to users' speech patterns for improved responsiveness.

Extensive testing showed the wheelchair's efficiency, achieving optimal speeds and safe obstacle detection using AI-enabled sensors. Solar panels provide eco-friendly, sustainable energy, reducing reliance on traditional charging. Trials confirmed its versatility with both voice and joystick controls. The solar panel effectively charges the battery quickly, supporting renewable energy trends.

Compared to electric and manual wheelchairs, this intelligent design is cost-effective, user-friendly, and adaptable to various terrains. The integration of AI and diverse data sources enhances performance, setting the stage for future intelligent assistive technologies. This advancement fosters independence and improves the quality of life for individuals with mobility impairments.

6 Future Recommendations

After the successful fabrication and testing of the intelligent, low-cost, voice-controlled autonomous wheelchair, several enhancements are suggested to further improve its effectiveness. These recommendations leverage massive information from diverse devices to optimize performance:

- i. **Noise Filtering for Voice Module:** Implement a filter to reduce background noise, ensuring that only the user's voice is recognized, enhancing the accuracy and reliability of voice commands.
- ii. **Wireless Communication:** Integrate wireless communication technologies to improve the wheelchair's connectivity and control, allowing for more seamless operation and remote monitoring.
- iii. **Adjustable Solar Panel Frame:** Modify the solar panel frame to be adjustable, optimizing solar energy capture throughout the day and increasing the efficiency of battery charging.
- iv. **Enhanced Sensor Range:** Upgrade the sensors to extend their detection range, improving obstacle detection and navigation safety in diverse environments.

- v. Manual Braking System: Install a manual braking system to provide users with an additional safety measure, ensuring better control and stopping capability when needed.

By incorporating these recommendations, the wheelchair can achieve even greater efficiency, user satisfaction, and adaptability, further enhancing the mobility and individuality of individuals with disabilities. Additionally, these improvements can enhance security aspects by ensuring safer navigation, protecting user data, and providing more reliable and secure operation overall [41].

Conflict of Interest

The authors state that none of their known financial conflicts or interpersonal connections might have had an impact on the work presented in this paper.

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