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Development of a Voice-Controlled Wheelchair for Physically Impaired Individuals

By Jenina R. Amoguis, Mabel A. Lingon, Edwin R. Arboleda, Airah Cahigan

Department of Computer and Electronics Engineering, Cavite State University, Indang, Cavite, Philippines

ABSTRACT

Background and Objective: Traditional manual wheelchairs provide mobility to individuals with physical impairments but are poorly suited for individuals with a combination of physical and cognitive or perceptual impairments. Manual wheelchairs are more physically demanding than powered wheelchairs; however, powered wheelchairs require cognitive and physical skills that not all individuals possess. The general objective of this study is to develop a voice-controlled wheelchair that allows a disabled person to move around independently using a voice-recognition application that is interfaced with motors. The study will be beneficial for quadriplegic individuals who are paralyzed in both arms and both legs.

Material and Methods: This study aims to modify a standard wheelchair controlled by voice commands where the EasyVR 3 Voice Recognition Module, ultrasonic sensors, microcontroller, and 12V wiper motor were integrated. Based on the signal given by the motor driving circuit, the controller switches the motor accordingly. The added safety feature is the ultrasonic sensor that senses obstacles with a fall detection system and sends a signal to the microcontroller to stop the chair.

Results: Through testing and evaluation, the device's functionality was proven to meet the desired objectives, and the limitations of the device were concluded. The motors and sensors were also found to be 100% functional. The average speed of the wheelchair is 0.2 m/s, and it can move with the user weighing up to 80 kg. The wheelchair lifts at an angle of up to 10˚. The overall acceptability of the unit, analyzed using statistical parameters like mean method and standard deviation analysis, gives a 4.53 average, 4.53 on usability, 4.07 on correctness, 4.37 on control, 4.50 on reliability, 4.33 on safety, and 4.8 on comfort, which means the unit meets the objectives.

Conclusion: Based on the evaluation results, the project met the given objectives. The system was able to move following the voice command given. The device also proved its functionality, responsiveness, usability, correctness, control, reliability, safety, and comfortability. While the current study demonstrates the feasibility of voice-controlled wheelchairs, future research should focus on improving the accuracy and robustness of voice recognition systems and the incorporation of sensory feedback mechanisms, such as haptic feedback or auditory cues.

Keywords – *Voice-controlled wheelchair, assistive technology, voice recognition, assistive devices, quadriplegia.*

INTRODUCTION

Wheelchairs have been a boon for people with physical impairments, but they may not be suitable for individuals with a combination of physical and cognitive or perceptual disabilities. While manual wheelchairs require more physical effort, powered wheelchairs require cognitive and physical skills that not everyone possesses.[1,2]

To address these challenges, researchers conducted a study and devised a solution. They created a device using readily available and affordable materials and developed a voice-controlled wheelchair for disabled individuals who cannot operate powered wheelchairs.

The general objective of this study was to develop a voice-controlled wheelchair for physically impaired individuals. Specifically, this study aimed to (a) design and construct the circuitry of the device; (b) modify a standard wheelchair; (c) integrate the Easy VR 3 shield, ultrasonic sensor, microcontroller, 12V wiper motor, and standard wheelchair for the device; (d) develop a program for the device; (e) test and evaluate the performance of the system through pilot testing; and (f) determine the cost of the developed system.

The wheelchair could be used by people who suffer from mobility disabilities, which include cerebral palsy, spinal cord injury, stroke, Parkinson's disease, arthritis, muscular dystrophy, multiple sclerosis, amputation, polio, or other conditions resulting in paralysis, muscle weakness, nerve damage, stiffness of the joints, strength and endurance, short stature, conditions like Osteogenesis Imperfecta ("brittle bones"), or lack of balance or coordination.[3–7] This device is also best for quadriplegic individuals who are paralyzed in both arms and both legs.[8]

The design project primarily focuses on recognizing a limited set of voice commands for direction control – five (5) in total - and two (2) voice commands for trigger and standby. It is not intended to perform any other tasks.

To evaluate the system's effectiveness, final testing was conducted involving 30 participants, including 25 individuals who underwent testing in a simulated environment and 5 people with mobility disabilities. The assessment measured the system's ability and responsiveness to execute commands accurately. The testing was carried out over two (2) weeks in Indang, Cavite, Philippines.

METHODS

This section outlines the important specifications of the materials utilized in the design project and the steps taken to create the voice-controlled wheelchair. Each material was carefully selected based on its functionality and compatibility with the other components.

The voice-controlled wheelchair comprises a standard wheelchair, DC motor, voice recognition module, sensors, motor driver, microcontroller, and battery. The standard wheelchair used is an alloy-type wheelchair that weighs only 13.1 kgs compared to a standard wheelchair that weighs up to 16 kgs. It is certified by Japan International Standards, with a JIS sticker labeled JIS T 9201:2006, specifying standards for manually propelled wheelchairs.

The motors used in the project were wiper motors. Compared to other DC motors, wiper motors are cheaper and provide high torque and low speed, making them ideal for wheelchair use. The voice recognition module that was used was an EasyVR version 3 shield. Anjum and Seetha[9] conducted a similar method where EasyVR version 3 shield was used as a voice-activated system for disabled people. Unlike voice recognition modules that only support speaker-dependent features, the EasyVR module supports speaker-dependent and speaker-independent features. Ultrasonic sensors were used because they are the only type of sensor that doesn't depend on lighting. These sensors use ultrasonic frequency to detect objects

The main component used in the motor driver was a PNP-NPN Darlington pair transistor. This fast-switching device can operate up to 10A, making it a better option than relays that cannot operate above 4Hz. The transistor can be easily controlled using pulse width modulation techniques. The microcontroller used in this project was a Gizduino V4.1. Arboleda et al.[10] used Gizduino AtMega644 for smart wheelchairs using touchpad and Android device. Compared to the Arduino Uno and Gizduino AtMega644, the Gizduino V4.1 is cheaper and more user-friendly, which was used in this design. Finally, the battery used was a 12V 17Ah lead acid battery. This battery is lightweight and cheap yet provides a high capacity.

Design of the Voice-Controlled Wheelchair

The microphone was placed slightly to one side of the mouth (Figure 1) and will then convert the voice signal to an electric signal. It was covered with a sponge to suppress echo and noise and compress the input voice.

FIGURE 1. The microphone is placed slightly to one side of the mouth.

The motor driver used was transistor-based. It has a high-current and voltage NPN and PNP Darlington pair. This provides faster switching capabilities compared to relays (8). It was connected to the back wheel and responded according to the given command of the microcontroller. Wiper motors were also used to provide mobility in the wheelchair. Using a chain, the wiper motors lead the direction of the back wheel, as shown in Figure 2. Through the use of a chain drive, the motor torque was increased. The wiper motor was not directly attached to the back wheel.

FIGURE 2. The chain used to connect the wiper and back wheel.

The sensors used were HC-SR04 ultrasonic sensors.[11] Compared to infrared and proximity sensors, this provides accurate readings on solid objects, even in dark or bright rooms. The sensors were placed on the front and rear of the wheelchair, and the wheelchair automatically stops when the sensor detects a drop in terrain ahead (e.g., stairs) or an obstacle. Specifically, two ultrasonic sensors were placed at the front: 1 facing the floor (to detect approaching stairs) and 1 below the wheelchair (to detect approaching obstacles in the lower left front area), both within 1–200 cm, as shown in Figure 3. Lastly, two were placed at the back: 1 facing the floor (to detect approaching stairs) and 1 below the wheelchair (to detect approaching obstacles in the lower back area) as shown in Figure 4.

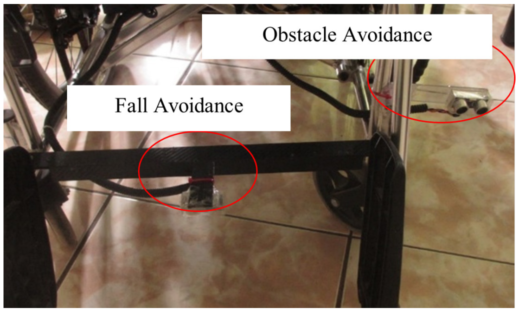

FIGURE 3. Attachment of front sensors.

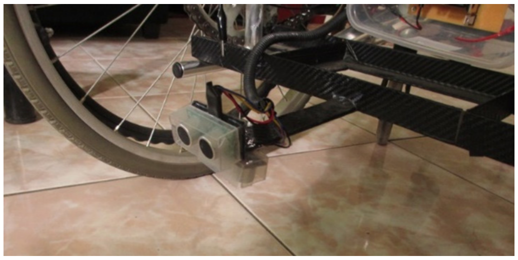

FIGURE 4. Attachment of back sensors.

Modifying a Standard Wheelchair

A standard wheelchair was used in the study. This provides a control unit, a battery, and a driver unit. These components were attached and transformed the wheelchair into a voice-controlled wheelchair. The control unit includes the microphone, rocker switch, and light-emitting diode (LED) indicator. The microphone was placed slightly on one side of the user's mouth. The LED indicators, shown in Figure 5, and the rocker switch were placed on the right armrest of the wheelchair. A fiberglass and sticker were used to cover the LED indicator. The EasyVR 3, microcontroller, and battery were placed on the flat bar and plastic casing below the wheelchair. Figure 6 shows the flat bar attached to the wiper motors and battery. Flat bars were added on the lower front of the wheelchair where the sensors are attached. The plastic casing for the shields and motor driver was placed on the lower part of the wheelchair. The driver unit includes a motor driver circuit and 2 wiper motors. The wiper motor and the back wheel of the wheelchair were welded into a sprocket in a machine shop. A chain connected the sprockets found on the wipers and back wheels. This provides easier maneuvering of the wheelchair.

FIGURE 5. LED Indicators placed on the right armrest.

FIGURE 6. Flat bar attachment for wiper motors, battery, and ultrasonic sensor.

Integrating the EasyVR 3, Ultrasonic Sensor, Microcontroller, 12V Wiper Motor, and Standard Wheelchair for the Device

The user drives the wheelchair by giving voice commands converted to electric signals by the microphone and processed by the voice recognition module. The voice command is stored in memory and converted into digital signals using Analog-to-Digital Converters (ADC). The microcontroller receives the digital input, which then outputs a signal to the motor driving circuit, switching the motor accordingly. The ultrasonic sensor senses obstacle with a fall detection system and sends a signal to microcontroller to stop the chair. The block diagram of the voice-controlled wheelchair system is indicated in Figure 7.

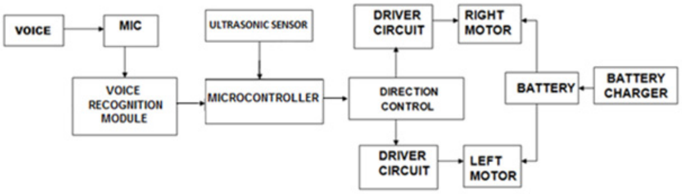

FIGURE 7. Voice-controlled wheelchair system block diagram.

The voice recognition module was soldered into a shield to provide an easy connection with the microcontroller. To connect the voice recognition module and microcontroller, the soldered voice recognition shield was attached to the Gizduino. A motor driver shield must be present since a motor cannot be directly connected to the microcontroller. This is an H-Bridge circuit that allows the microcontroller to control high-current motors. 4 input pins (2N222A transistor base in series with a 10KΩ resistor) were connected to the digital pins D5, D5, D9, and D10 of the microcontroller. The schematic of the motor driver and its physical connections are shown in Figures 8 and 9, respectively.

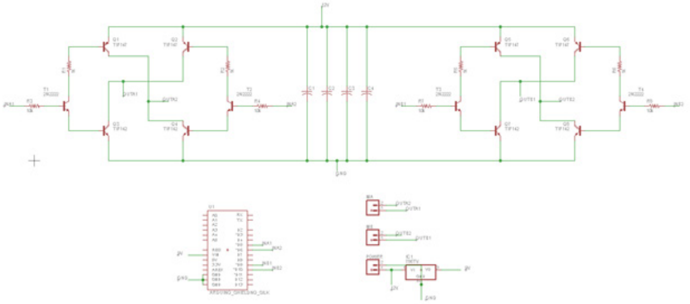

FIGURE 8. Motor driver schematic diagram.

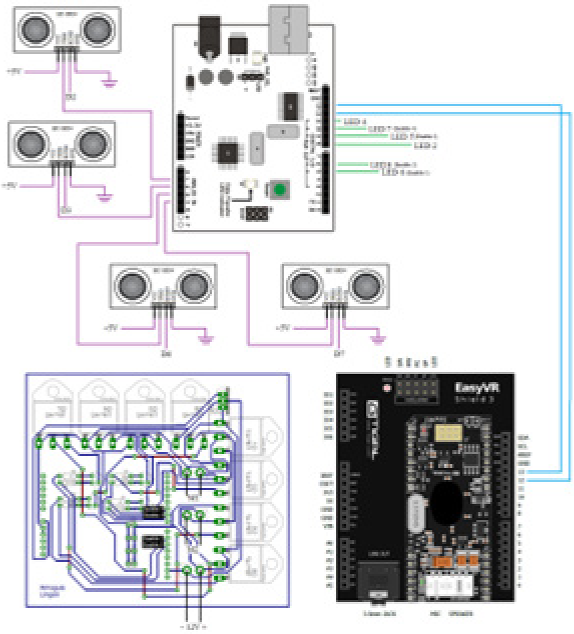

FIGURE 9. Physical connections of the device.

After connecting the EasyVR 3, ultrasonic sensors, microcontroller, and 12V wiper motor, the motors were attached to the flat bar between the front and back wheels. This was done in a machine shop. Lastly, the sensors, microcontroller, motor driver circuit, and voice recognition module were mounted below the wheelchair. A plastic casing was used in the final casing of the voice-controlled wheelchair circuitry. This way, the voice recognition module, ultrasonic sensors, microcontroller, motors, and wheelchair were integrated.

Developing the Program for the Voice-Controlled Wheelchair

The Arduino ATmega 328 microcontroller was programmed using C / C ++ language. This language was used to develop the software to control the wheelchair based on the data received from the voice recognition module. A predefined list of words controls the application with only a modest amount of RAM and program memory. The word list was created with the Arduino library. The Arduino is a PC-based program that lets users select and implement the user interface vocabulary. Those settings were recorded in memory. This memory was not lost even with the power off. The Voice Recognition Library provides an audio interface to a user's application program, allowing the user to control the application by uttering discrete words in a predefined word library. The words chosen for the library are relevant to the interaction between the application program and the user.

A word spoken through a microphone connected to the voice recognition module was analyzed on a frame-by-frame basis and quantized into feature vectors of sound characteristics against a vector codebook. The quantized feature vectors were then examined to determine which word they most closely match. The binary outputs were generated from the voice recognition module, which were set as a parameters for the program. The microcontroller received the converted voice from the voice recognition module. The application program takes appropriate action based on the parameters set by the developed program. However, once the obstacle and fall detection is active, the motors will automatically place the wheelchair in a safer place (Figures 10 and 11).

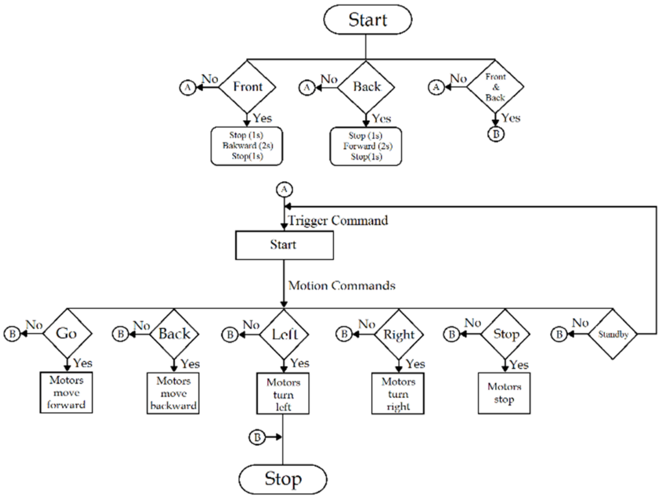

FIGURE 10. Software Flowchart for Speaker Dependent.

Project Testing

Before evaluating the wheelchair, the researchers pilot-tested the project. The project was tested in the Engineering Science Building, College of Engineering and Information Technology (CEIT), Cavite State University, Indang, Cavite, Philippines. The motors, voice recognition, and sensors were tested by giving different voice commands.

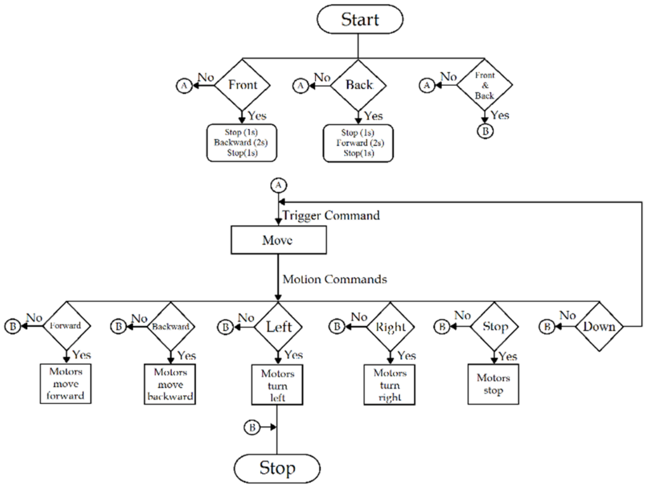

FIGURE 11. Software Flowchart for Speaker Independent.

Project Evaluation

The researchers evaluated the system's functionality in technical evaluation. This is done to identify if the operations that can be run on the wheelchair are attained. This includes tests for each sensor and motor integrated with the wheelchair. This way, the wheelchair is placed and tested in a quiet room with obstacles like chairs, walls, tables, and stairs. The second is placing the wheelchair in a room filled with random noise. All of these tests were repeated twice; the first is for speaker-independent, and the second is for speaker-dependent. The researchers identified which of these two features is more efficient.

In the acceptability test, the respondents conducted a final test on the device to evaluate usability, correctness, control, reliability, safety, and comfort by giving any desired voice command. This was done by gathering data from the respondents that used the device. The sampling method employed was opportunity sampling, whereby individuals from the target population who were available and willing to participate were selected to evaluate the device.[12] This includes a total of 30 respondents, which include 25 students selected from a sample of students at the CEIT and 5 persons who suffer from mobility disability. The respondents evaluated the device in a simulated environment. Each respondent was tied up in the simulated environment while using the device. To implement this, a hand and foot strap was provided on the wheelchair.

A clearance was sought first from the Ethics Review Board to ensure that the device was ready for Persons with Disabilities' (PWD) evaluation. They also gave any desired voice commands on the wheelchair.

The evaluation results are analyzed using statistical parameters like mean method and standard deviation analysis. Tables are used to present and discuss the results gathered.

Ethical Considerations

Prior to using the wheelchair, the researchers provided a detailed explanation of how it is operated. During the evaluation, no harm was done to any of the patients. A physical therapist also accompanied the researchers to provide medical assistance if needed. An informative document/manual was attached to the questionnaire to ensure the user was seated properly. The following parameters were taken into consideration: (a) The user is sitting upright in the chair; (b) The pelvic/seat belt is secured firmly; (c) The feet are placed flat on the ground; (d) The knees are aligned with the hips; (e) The trunk and pelvis are centered; (f) The head is centered with the chin slightly tucked; (g) The elbows are bent at a 90-degree angle; and (h) The chest is lifted.

Confidentiality and Informed Consent

Maintaining the participant's anonymity was also observed. They were not required to give their name or share personal information with the researchers. Moreover, the participants were given informed consent so that they could decide whether to participate or not.

PWDs' Evaluation Location and Compensation

Those participants who suffer from mobility disabilities were visited at General Emilio Aguinaldo Medical Hospital, Trece Martires, Cavite, Philippines. They were given compensation like a pack of assorted fruits. In answering the questionnaire, the patients were assisted by the researchers and his/her guardians.

RESULTS

Through this, the researchers could identify which voice recognition feature, speaker-dependent and speaker-independent, was more responsive. Moreover, as a possible strategy to reduce noise, the effect of wearing a helmet was also evaluated for both features.

The motors and sensors were found to be 100% functional. This was done by giving 10 trials per command and recording whether the voice was recognized successfully or not. The number of trials was based on the study titled "Design and Development of Voice Controllable Wheelchair," which also corresponds to the number of trial testing of the wheelchair's functionality.[13] The device's accuracy was proven good for speaker-dependent, while for speaker-independent, the accuracy was excellent. Table 1 shows the calculated rating for each word spoken through the EasyVR using the speaker-dependent feature. It has a low recognition rating for noisy environments, showing that the EasyVR is susceptible to noise.

TABLE 1. Functionality and Responsiveness Calculations Using Speaker-Dependent

	Noisy Environment	Quiet Environment
Spoken Word	No. of Correct Recognized Word	No. of Correct Recognized Word
Start	10	10
Go	4	10
Back	1	10
Left	1	10
Right	0	10
Stop	1	9
Standby	0	7
Average	24.29	94.29
Total Average	59.29	

Table 2 shows the calculated rating for each word spoken through the EasyVR using the speaker-independent feature. Comparing the results from Table 1, it can be shown that the EasyVR is less susceptible to noise using speaker independent.

TABLE 2. Functionality and Responsiveness Calculations Using Speaker-Independent

	Noisy Environment	Quiet Environment
Spoken Word	No. of Correct Recognized Word	No. of Correct Recognized Word
Start	9	10
Go	8	10
Back	6	10
Left	6	10
Right	5	10
Stop	7	10
Standby	7	10
Average	68.57	100
Total Average	84.29	

Table 3 shows the calculated rating for each word spoken through the EasyVR while wearing a helmet for both features. Comparing the results from Tables 1 and 2, it can be shown that the EasyVR is less susceptible to noise while wearing a helmet for speaker-dependent and speaker-independent.

TABLE 3. Functionality and Responsiveness Calculations while Wearing a Helmet

Speaker Dependent		Speaker Independent	
Spoken Word	No. of Correct Recognized Word	Spoken Word	No. of Correct Recognized Word
Start	10	Move	10
Go	6	Forward	9
Back	1	Backward	6
Left	2	Left	7
Right	1	Right	7
Stop	3	Stop	8
Standby	1	Down	7
Average	34.29	Average	77.14

Table 4 shows that the percent error of a well-trained speaker dependent is two times greater than the speaker-independent speech recognition. The error percentage was reduced by 10% when wearing a helmet for both features. The table suggests that the most effective feature is speaker-independent.

$$\text{Percent Error} = \frac{\textit{Words to be recognized} - \textit{Words recognized}}{\textit{Words to be recognized}}\ x\ 100$$

TABLE 4. Comparison of Speaker Dependent and Speaker Independent

	Speaker Dependent	Speaker Independent
Software	The software learns the characteristics of the user's voice through training	It does not require training in the software
User	Works only to the trained user to recognize commands	Able to recognize commands by different users
Accuracy (% error)Noisy Environment	75.71%	31.43%
Accuracy (% error)Quiet Environment	5.71%	0 %
Reducing noise in wearing a helmet(% error)	65.71%	22.86%

The wheelchair's speed was calculated by dividing the distance travelled over time. It was determined that the wheelchair has an average speed of 0.2m/s with a person weighing 46 kilograms. The maximum weight capacity was determined by letting users with different weights, specifically, 46 kgs, 53 kgs, 61 kgs, 68 kgs, 72 kgs, and 80 kgs, sit on the wheelchair. With a user weighing 80 kgs, a noticeable decrease on the wheelchair's speed was observed. Figure 11 shows the effect of the user's weight on the wheelchair's speed.

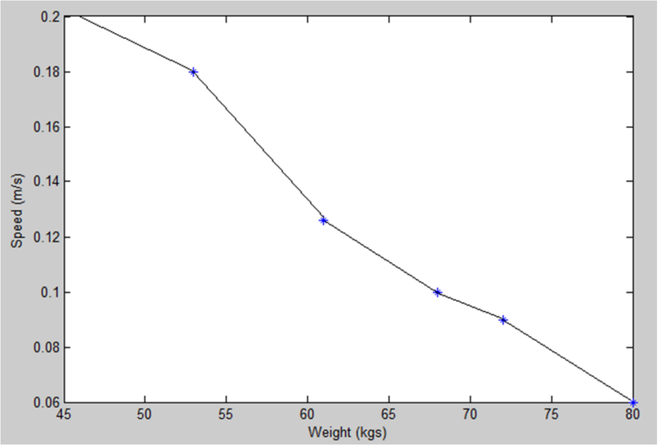

FIGURE 12. **Speed versus weight.**

The usability, correctness, control, reliability, safety, and comfort were gathered. A total of 30 respondents (25 students and 5 PWDs) were the participants who answered the questionnaire after they had used the wheelchair. Table 5 shows the user acceptability computations evaluated by 25 students at Cavite State University, Indang, Cavite, Philippines when the wheelchair was evaluated. It also shows that the usability, correctness, control, reliability, safety, and comfort of the wheelchair have low standard deviation. This means the device met the expected objective, and the system was considered efficient.

TABLE 5. User Acceptability Computations for Healthy Persons

General Qualities of the Wheelchair	Mean	Standard Deviation
Usability	4.6	0.58
Correctness	4.16	0.75
Control	4.4	0.71
Reliability	4.64	0.57
Safety	4.48	0.59
Comfort	4.84	0.47

Table 6 shows the user acceptability computations evaluated by 5 persons who suffered from mobility disability when the wheelchair was evaluated. PWDs evaluated it after the device was used by healthy persons and rated the device as acceptable. It also shows that the usability, correctness, control, reliability, safety, and comfort of the wheelchair have low standard deviation. This means that the device met the expected objective, and the system was considered efficient for persons with mobility disabilities.

TABLE 6. User Acceptability Computations for PWDs

General Qualities of the Wheelchair	Mean	Standard Deviation
Usability	4.2	0.45
Correctness	3.6	0.55
Control	4.2	0.45
Reliability	3.8	0.45
Safety	3.6	0.89
Comfort	4.6	0.55

Table 7 shows the overall user acceptability of the wheelchair. The mean and standard deviation evaluated by PWDs and students were combined.

TABLE 7. Overall User Acceptability Computations

General Qualities of the Wheelchair	Mean	Standard Deviation
Usability	4.53	0.57
Correctness	4.07	0.74
Control	4.37	0.69
Reliability	4.5	0.63
Safety	4.33	0.71
Comfort	4.8	0.48

Table 8 shows the actual cost of the voice-controlled wheelchair. This included the main parts of the device as well as the casing and screws. The unit cost was $369.48, comprising all materials essential to the device's construction.

TABLE 8. Total Cost of Device Construction

Materials	Quantity	Unit Cost (USD)	TOTAL COST (USD)
Microcontroller (gizDuino v3)	1	14	14
EasyVR Shield	1	52	52
Ultrasonic Sensor	4	5	20
12V 17Ah Lead Acid Rechargeable Battery	1	18	18
Battery Charger	1	15	15
Standard Wheelchair	1	79	79
TIP147	4	2	6
TIP142	4	1	4
2N222A	4	0.5	2
LM7809	1	0.4	0.4
Terminal Blocks	3	0.6	1.8
Resistor	8	0.035	0.28
12" × 12" Pre-sensitized Circuit Board	1	3	3
Wiper Motor	2	18	36
Chain	2	5	10
Sprocket	2	8	16
Plastic Casing	1	1	1
Labor	-	-	73
Miscellaneous Fees	-	-	18
TOTAL			$369.48

DISCUSSION

Wheelchairs are crucial for people with paralysis, muscle weakness, or any condition that limits their mobility. There are two types of wheelchairs: manual and powered. Manual wheelchairs require more physical effort, while powered wheelchairs demand cognitive and physical skills that not everyone possesses. To address this issue, researchers have developed a voice-controlled wheelchair that allows disabled individuals to move around independently. This wheelchair uses a voice recognition application connected to motors, enabling it to receive and perform voice commands given by the user. The microcontroller can be programmed to recognize a single user's voice or any voice command.

After conducting a technical evaluation, it was observed that the wheelchair was prone to noise, with only 17 out of 70 spoken words being recognized correctly as speaker-dependent and 48 out of 70 as speaker-independent. However, a helmet helped reduce noise and increased the number of correctly recognized spoken words to 24/70 for speaker-dependent and 54/70 for speaker-independent. This shows that wearing a helmet can significantly improve speech recognition accuracy. Furthermore, in situations with minimal noise, 66 out of 70 spoken words were recognized correctly for speaker-dependent and all 70 for speaker-independent. Hence, the speaker-independent feature was more accurate and responsive, and the survey was conducted using this feature.

The testing and evaluation of the wheelchair showed that it met the desired objectives and limitations of the device. The motors and sensors were fully functional, and the wheelchair could move at an average speed of 0.2 m/s, carrying a weight of up to 80 kg and lifting at an angle of up to 10°. The overall acceptability of the unit was rated at an average of 4.53, with ratings of 4.53 for usability, 4.07 for correctness, 4.37 for control, 4.50 for reliability, 4.33 for safety, and 4.8 for comfort. This indicates that the unit meets the objectives.

Due to its wiper motor design, the device only responds to stored voice commands and cannot be manually controlled. Ultrasonic sensors work well for detecting obstacles and stairs but have limited detection range and angle. The front sensor only detects obstacles on the left side, and the system cannot detect objects beyond 200 cm.

Table 8 presents the cost breakdown of the developed system, including the main components of the device as well as the casing and screws. The total unit cost was $369.48, covering all the necessary materials to construct the device.

Several studies and articled were synthesized to assess the effectiveness of the device. A research study, "Design and Development of Voice Controllable Wheelchair" published in 2022, is relevant to the methods and block diagram employed in this study for the voice-controlled wheelchair.[13] The study found that the Arduino analyzed the user's voice commands before transmitting the signal to the driver circuit which is similar to the process of this study, as depicted in Figure 7. Another study titled "Voice Controlled Automatic Wheelchair" produced similar positive outcomes to this research, although it used Arduino R3 as the wheelchair's primary processing unit.[14] A similar study titled "Development of a Low-cost Electronic Wheelchair with Obstacle Avoidance Feature" shows similar findings where ultrasonic sensors for obstacle avoidance and infrared sensors were also installed and thus gave out positive results concerning the individuals involved in the testing and evaluation.[15] The researcher compared the project's overall cost with a similar study called "Design of an Arduino Based Voice-Controlled Automated Wheelchair."[16] The cost of the mentioned study was close to the cost of the wheelchair developed in this study, indicating that the cost of components and materials used to develop this project is not too high. These studies validate the efficacy of the techniques and results in this research study, which contributes to the knowledge base of voice-automated wheelchairs.

Numerous studies have shown that access to independent mobility benefits children and adults. It enhances their educational and vocational opportunities, reduces their reliance on family members and caregivers, and promotes feelings of self-reliance.

CONCLUSIONS

Upon careful observation and analysis of gathered results, the Development of a Voice-Controlled Wheelchair for Physically Impaired Individuals has successfully met all desired objectives. The wheelchair is designed to respond to voice commands, allowing users to navigate and control the device through vocal instructions. With the capability to detect obstacles and stairs, the unit can automatically halt its movement, ensuring the safety and convenience of the user. This research study has demonstrated that technological advancements, particularly in trained and reprogrammed modules, can yield significant breakthroughs in the equipment used by patients in hospital wards. With proper orientation and guidance, individuals with physical impairments can operate a low-cost wheelchair using voice commands.

Recent advancements in technology have enabled patients to move independently without relying on the assistance of hospital staff or their loved ones. By utilizing voice commands, individuals with physical impairments can effortlessly control their movement, ensuring greater independence and convenience in their daily activities.

This research serves as a foundation for future studies, allowing for integrating more advanced technologies into voice-controlled wheelchairs. Ultimately, this study has the potential to improve the quality of life for individuals with physical impairments and those who aim to enhance the lives of individuals who cannot care for themselves effectively.

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