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SMART TECHNOLOGY FOR DISABLE CHALLENGING PEOPLE FOR COMMUNICATION USING IoT

Project Guide
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Abstract— A smart wheelchair, sometimes called a power wheelchair, is one that incorporates various sensors, assistive technologies, and computers to provide the necessary mobility for a person with a disability, impairment, handicap, or permanent injury to move about safely and independently. Although these wheelchairs are starting to supplant conventional wheelchairs, a huge number of handicapped persons still cannot afford to buy one. Out of 70 million individuals with disabilities, barely 5 to 15% have access to wheelchairs, according to the World Health Organization (WHO). Consequently, we should supply a Smart that is both affordable and packed with capabilities, made possible by using cutting-edge components and technology. There have been a lot of nice initiatives that accomplish this goal in recent years. Some of the technologies they've embraced include AI—in the form of an autonomous wheelchair that navigates using machine learning concepts—and the Internet of Things (IoT), which allows users to operate the wheelchair using voice recognition. In this report, we will take a look at an affordable Smart Wheelchair solution that uses the Arduino Nano microcontroller and the internet of things (IoT) to help handicapped people, particularly those with lower incomes who cannot afford a costly Smart Wheelchair, carry out their daily tasks independently. Finally, this project will use an Arduino Nano, an ESP-12e module to provide Wi-Fi, an MPU6050 to detect falls and notify the user through voice messages through the IFTTT platform, a buzzer and LED to identify obstacles, a voice recognition system, and joysticks to control the wheelchair. The goal is to make the smart wheelchair affordable for a wide range of disabled people.

Keywords: smart wheelchairs, internet of things (IoT) technology, Arduino, speech recognition system, obstacle detection, and joystick.

INTRODUCTION

Technological advancements have made great strides in recent years. The term "smart" has replaced the more common practice of referring to many commonplace household and everyday items simply by their name. Traditional wheelchairs, smartphones, smart televisions, smart homes, and even the software and hardware that make up modern smart wheelchairs all have some roots with this term. Over the last fifteen years, several efforts have been made in this field, beginning with George Klein's invention of the first power wheelchair and progressing to smart wheelchairs including autonomous, intelligent, and robotic models. A variety of technologies, such as the Internet of Things, have been integrated into smart wheelchairs.

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(IoT) and AI technology to enhance users' mobility, allowing them to move freely and securely without assistance. But they're too pricey, and their hardware is cumbersome, so the software system isn't responsive enough. Affluence and prosperity are the dreams of the vast majority of people on Earth. On the other hand, there are those who would rather have a mundane, comfortable existence. This dream proved unachievable, at least for them, because of sickness, vehicle accidents, disability, and old age. The number of persons without access to appropriate wheelchairs is rising in tandem with the number of people living with the impairments listed above. People with disabilities often suffer falls and injuries, and for days afterward, no one knows what happened.

Literature Review

Regardless, a lot of work is being done on smart wheelchair technology. No intelligent wheelchair could ever be affordable, particularly for those with moderate to high incomes. Because of this, they have no choice but to use the conventional wheelchair, which need the assistance of others, which isn't always available, particularly for those who live alone and don't have family nearby. Every individual is entitled to have a typical life. In order to understand the difficulties researchers encountered while developing this kind of intelligent wheelchair, this section provides a critical analysis of relevant publications.

In their work [13], they showcased a smart wheelchair design that is both affordable and functional, allowing users to move about freely and securely while still doing their therapist-recommended tasks independently. The primary target audience for this wheelchair was those with disabilities affecting either the lower or upper extremities. In terms of the system's control, it relied on an Arduino board coupled with ITEAD joysticks to allow for manual movement control. A speech recognition tool is used and linked to the Arduino for those with a permanent upper limb. A Bluetooth module (HC-05), a Serial Port Protocol for wireless connection configuration, and an Android phone are the parts of this utility. Using the phone's microphone, an Android device may take voice commands to move in a preset direction (right, left, front, forward, or backward) that have been set up in an app. One of the design elements is a PING sensor, whose primary purpose is to identify and avoid obstructions.

Unlike the system that was described and used by [4]. Although several treatment facilities were described in reference [13], they did not include any cutting-edge technology into their system. Although it lacked therapeutic capabilities, [4] made advantage of cutting-edge AI to develop a smart wheelchair that was both affordable and easy to use. The two articles worked toward the same goal of developing an affordable Smart Wheelchair with supplementary capabilities. Based on the outcomes of both projects, it seems that [4] were able to successfully provide a smart wheelchair for just $252. Even if the price was not specified in [13]. Since the PING sensor's reaction time is longer than that of the Sonar sensor, I think the Sonar sensor is superior to the PING sensor employed by [13] for detecting obstructions, as more than [4] have done. The wheelchair described in [4] is capable of supporting a heavier user than the one described in [13], as the latter's maximum weight is 43 kilograms, which is below the recommended maximum.

Their study [14] shows how a smart wheelchair may be programmed to drive itself using the April fusion tags approach and computer vision. When navigating between the parking lot and the rooms, the offered autonomous wheelchair can do it all on its own. The computer vision has a fast processing time and great precision, which is great for real-time performance at the framerate of roughly 16 frames per second. It has many other benefits as well. In addition, the project's success is dependent on the computer-fusion-related April tags, so if the robot is unable to identify the tags, the connected camera will continue to rotate in search of them. The project's restrictions also include its indoor usage and its inability to transfer patients between rooms on demand.

The authors of the work in question [17] used a machine learning approach to create a wheelchair that is anonymous and accessible to those with disabilities. Their project has two modes:

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automatic and manual, and it is based on the raspberry model. Presented here is a project that utilizes cutting-edge technology in a cost-effective manner, allowing individuals with impairments, particularly handicaps, to live independently and move about freely with the aid they need. Another perk of the project is that it has two modes of operation: automatic and manual. The project that was shown, however, is only suitable for use indoors.

The idea behind the project that was described in reference [3] is that it has two modes of operation: autonomous and manual. Raspberry Pi and ROS, an open-source operating system for robot implementation, are the foundation of this project and allow for the connectivity of all components and sensors. When utilizing the manual mode, the speech recognition system is triggered and put into action by connecting to Google's Speech to Text engine, which is also known as the SR module. The author's voice recognition system differs from the work of the aforementioned authors in that it includes additional commands in addition to the standard left, right, front, and backward ones. For example, the stop command can be used to break the wheelchair's momentum, and the go-to-kitchen command can be linked to the autonomous navigation system that the wheelchair has.

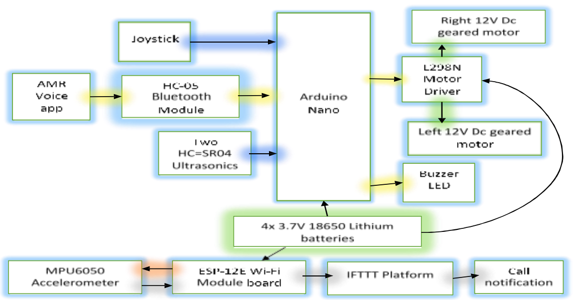

Fig. 1. The block diagram of IoT-based Smart Wheelchair for Disabled People.

together with other directives. Since the author claimed that an RGB-D camera alone would not be sufficient, they used a map developed utilizing both a camera to scan the area and an infrared sensor to identify obstructions when in autonomous mode. Unlike the previous article, which relied on a single obstacle sensor, the authors of [3] surrounded the wheelchair from all sides with four units of infrared sensors; the direction of the wheelchair dictates which of these four sensors is engaged. For people with heart issues who are unable to walk permanently, Jayakody and other writers have developed a project that includes a health monitoring system. This system will primarily include a temperature sensor to detect the patient's temperature and a heart rate sensor to allow medical personnel quickly follow the patient's state. The output values will be sent to them. It takes around two to three seconds for the system to identify the voice, which is longer than the results acquired by the speech recognition system in [17], as shown in [3]. With the assistance of cutting-edge technology, such as a RoS system, the authors of article [3] have created a smart wheelchair that enables those with impairments to move about securely and independently. Nevertheless, there is an issue with the speech recognition system's reaction time that requires fixing. The project will be too costly due to the components utilized, which means it won't be accessible to many consumers.

I. The Design and Implementation of the System

I. Block schematic of the system

The block diagram for the Internet of Things (IoT) Smart Wheelchair shows all the parts needed to show the project. This block diagram lays out the project's basic operation and the steps needed to effectively showcase it.

A. **System Methodlogy and Implemntion:**

This Smart Wheelchair can work in two modes, automatic mode, and manual mode. In automatic mode, voice recognition is activated. The user can make the wheelchair move by using AMR Voice app that linked to Arduino Nano using the HC-05 Bluetooth module and says the specific command stored in the IoT Cloud system such as, right, left, front, backward, and stop.

These instructions will be processed by the Arduino Nano microcontroller with the aid of the HC-05 Bluetooth module, and the resulting signal will be sent to the L289N module motor driver. Then, in response to the user's command, it will activate the wheelchair's two DC geared motors. When operating in manual mode, the wheelchair's movement may be controlled using the two-axis joystick that is connected to the Arduino Nano. Two features have been introduced that may be utilized in any mode to make the journey more enjoyable and safe. One uses two HC-SR04 ultrasonic sensors, one on each side of the chair, to identify obstacles. This sensor primarily detects obstacles by sounding waves within a 2cm to 450cm range; if an echo wave is detected from an item within this range, the associated buzzer and LED will activate as warnings. For the visually impaired, the buzzer serves as a warning, while the deaf will be alerted by the red LED, particularly as the wheelchair reverses direction. Additionally, the MPU-6050 module enables Internet of Things (IoT)-based fall detection. The core idea behind this module is to let the user program it to detect when they've fallen out of their wheelchair. Then, through the use of the IFTTT platform and the ESP12E Wi-Fi module, which connect the IoT platform to the MPU605, a voice message can be sent to the user's loved ones or the closest hospital to alert them about the user's situation. The Arduino Nano, L289N module motor driver, and ESP12E Wi-Fi-module will all be powered by a rechargeable 4 x 3.7V 18650 lithium battery.

Fig. 2. The Final Prototype of IoT Based Smart Wheelchair.

The analysis and discussion of the results
In this part, we will highlight the project's results and analyze them in depth. Seventeen individuals, ranging in age from four to sixty-six, were used to test the Smart Wheelchair, which was subjected to loads of differing weights. Also covered will be the difficulties encountered by the project.

Part A: Data Analysis.
Testing the wheelchair's weight capacity with actual children is not common practice for safety reasons. A real kid may be injured if the wheelchair was utilized because of the balance problem. Consequently, the wheelchair's efficiency was tested with a total weight of 17 Kg. Seventeen different prototypes were tested to guarantee that the Smart Wheelchair is user-friendly and straightforward.

Using either the joystick or the AMR Voice app, participants ranging in age from eighteen to thirty-one were able to control the Smart Wheelchair's orientation. In addition, the adult's parents may be alerted to any falls by the fall detection features, and the adult can be warned of obstacles by the obstacle detection features, which use two hazards—an LED light and a buzzer sound—to alert the adult. While samples between the ages of 40 and 66 have trouble controlling the wheelchair in both directions using the AMR voice software due to pronouncing the phrases backward and forth incorrectly, samples between the ages of 4 and 6 have no such issues. Because she did not grow up speaking English. Thanks to some simple punction terms like "go" (instead of "backward") and "forward" (instead of "forward"), the issue was resolved.

There have been three sorts of testing conducted on the Smart Wheelchair's control functions to ascertain the impact of age and weight on the wheelchair's mobility.

• Initial check: how quickly the motors respond before you attach them to the wheels.
• Second trial: how long it takes for the motors to react after being fastened to the wheels.
• Thirdly, we check how long it takes for the Smart wheelchair to react when we apply pressure to its

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wheels and brakes.
The testing have been conducted on both the voice and joystick controls of the smart wheelchair. The results of the tests are shown in the tables below.

TABLE 1. The Response time of the motors when using voice to control them (before attaching the motors to the wheels).

Direction string	Recognize Delay time (sec)	Execution Delay time (sec)	Total delay time (sec)
Forward	0.5	0	0.5
Backward	0.5	0	0.5
Left	0.5	0	0.5
Right	0.5	0	0.5
Stop	0.5	0	0.5

The above table represents the response time of the motors before attaching them to the wheels when using voice to control them. As it shows the time taken by the app to recognize the user's command, the time taken to execute these commands, and the sum delay time of both.

TABLE 2. The response time of the motors when using voice to control them (after attaching the motors to the wheels).

Direction string	Recognize Delay time (sec)	Execution Delay time (sec)	Total delay time (sec)
Forward	0.5	0	0.5
Backward	0.5	0	0.5
Left	0.5	0	0.5
Right	0.5	0	0.5
Stop	0.5	0	0.5

The above table represents the response time of the motors after attaching them to the wheels when using voice to control them. As it shows the time taken by the app to recognize the user's command, the time taken to execute these commands, and the sum delay time of both.

TABLE 3. The response time of the motors when using voice to control them (after putting the load on it).

SI. No	Loa--ds weig ht (Kg)	Forward		Backward		Stop	
		Recog nize delay time (Sec)	*Execut ion delay time (Sec)*	*Recog nize delay time (Sec)*	*Execut ion delay time (Sec)*	*Recog nize delay time (Sec)*	*Execut ion delay time (Sec)*
1	2.5	0.5~1	0	0.5~1	0	0.5~1	0
2	5	0.5~1	0	0.5~1	0	0.5~1	0
3	10	0.5~1	0	0.5~1	0	0.5~1	0
4	12.5	0.5~1	0	0.5~1	0	0.5~1	0
5	15	0.5~1	0	0.5~1	0	0.5~1	0
6	17	0.5~1	0	0.5~1	0	0.5~1	0

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With varying weights applied to the Smart Wheelchair and voice commands applied, the following table shows the reaction time of the wheelchair. Because it displays how long it took for the program to both identify and carry out the user's orders.
Every load has an execution delay of zero, and the recognize delay varies from user to user owing to two variables: Wi-Fi connectivity and user age. There seems to be a little lag in the recognition time because to the unstable Wi-Fi connection. It took longer for the app to identify the user's speech since the Smart Wheelchair's effectiveness is age-dependent. The length of the command words causes the user, particularly those between the ages of four and six, to mispronounce them, particularly the Forward and Backward terms. Thanks to the app's speech-to-string converter, there's no need to teach the components to recognize words, unlike with a voice recognition module. Because of this, the issue was easily remedied by substituting shorter words for longer ones; for example, "Go" for "Forward" and "Back" for "Backward" so the youngster could easily pronounce them.

easily and without mistakes. Besides that, it has been observed that each time the weight of the load increase, the Smart Wheelchair's speed became slow.

TABLE 4. The response time of the motors when using a joystick to control them (before attaching the motors to the wheels).

Direction	**Execution Delay time (sec)**
Forward	0
Backward	0
Left	0
Right	0

The above table represents the response time of the motors before attaching them to the wheels when using a joystick to control them. As it shows the time taken by the motors to execute the commands provided by the joystick. Since the joystick does not require any internet connection, there almost zero delay time in the execution.

TABLE 5. The response time of the motors when using a joystick to control them (after attaching the motors to the wheels).

Direction	**Execution Delay time (sec)**
Forward	0
Backward	0
Left	0.1 (Almost zero)
Right	0.1(Almost zero)

The above table represents the response time of the motors after attaching them to the wheels when using a joystick to control them. As it shows the time taken by the motors to execute the commands provided by the joystick. Since the joystick does not require any internet connection, there almost zero delay time in the execution delay time.

TABLE 6. The response time of the motors when using the joystick to control them (after putting the load on it).

SI.No	**Loads weight (Kg)**	**Execution delay time (Sec)**		
		Forward direction	***Backward direction***	***Stop***
1	2.5	0	0	0
2	5	0	0	0
3	10	0	0	0
4	12.5	0	0	0
5	15	0	0	0

6	17	0	0	0

The above table represents the response time of the Smart Wheelchair when loads with different weights are put on the wheelchair and controls it using a joystick. As it shows the time taken by the motors to execute the commands provided by the joystick. The exaction delay time for the three directions is zero. As the motors must carry three weights, the wheels, the chair, and the loads. Each time the weight of the loads' increases, the wheelchair's speed decrease.

Another test has been done for obstacle detection to check if ultrasonic able to detect obstacles within the determined distance (20 cm and less) and out the determined range (21 and above) using HC-SR04 ultrasonic.

TABLE 7. The test of obstacle detection feature within the determined distance (0 to 20 cm).

Distance (cm)	Obstacle Detected
0-20	Yes
21 and above	No

As the above table show, the ultrasonic able to detect the obstacle within the determined distance (0~20cm). As the sound of the buzzer and the light of the LED prove this. When there is an obstacle within the determined distance (0~20 cm), the sound of the buzzer activates, and the LED turns ON. While, when there no obstacle within the determined distance (0~20 cm), the sound of the buzzer does not activate, and the LED turns stay OFF.

Furthermore, to check the efficiency of the Fall Detection feature and how much time it takes to send the notification, several attempts were done and recorded as can be seen in the below table.

TABLE 8. Fall detection attempts.

Attempt No.	Delay time (sec)
1	3.97
2	3.57
3	3.50
4	5.82
5	3.52
6	2.54
7	1.97

The above table describes the response attempts of detecting falls and send the phone voice message to the phone using MPU6050, IFTTT Platform, and ESP12E Wi-Fi module to connect between them. The delay time of the response differs due to the internet connection. The more stable the Wi-Fi connection, the less delay time is obtained. Adding to that, the features have been tested using cellular Wi-Fi, too and it shows similar results as home Wi-Fi.

The Smart Wheelchair has faced several problems. For example, selecting the suitable motors and wheels, and the wheelchair's design. At first stepper motors were used. However, they emit a lot of temperatures which leads to a decrease in their performance and eventually get damaged. Then Dc gear motors with 60 rpm were used. But, due to the bad design of the wheelchair, one motor gear broke. As the wheelchair was not distributing the force equally and all the force was centring on the motor which led to damage it. The design of the wheelchair causes other problems also. To reduce the problems that the design cause, the wheels were replaced by smaller and lighter wheels, and the motors were replaced by motors that have more rpm but less torque because the time and the materials are not enough to try another design. The wheelchair able to move but it could not carry a weight of more than 17 Kg and was not able to turn left or right.

CONCLUSION

The following is a brief summary of the outcomes of the project that was provided. Since 17 individuals weighing a combined 17 kg were used to test the Smart Wheelchair. These individuals' ages range from four to sixty-six. Three distinct kinds of testing have been conducted on the Smart Wheelchair. The motors' reaction delays were recorded before they were fastened to the wheels as the first test. The second experiment included connecting the motors to the wheels and then timing how long it took for them to respond. The Smart wheelchair's reaction time to changes in load and speed was monitored in the third test. This study found that the Smart Wheelchair's top speed decreases with increasing load weight. The features that detect falls and obstacles were also put through their paces. Two tests were conducted for the functionality that detects obstacles. In the first test, we checked to see whether the Hc-sr04 ultrasonics could identify obstacles within the specified range of 0~20 cm. The findings show that they were successful in doing so. When both the light and the buzzer go off, it means that an obstruction is within the predetermined range. As for the second test, which aimed to see if the HC-SR04 ultrasonics could identify impediments beyond the specified distance, the findings show that they cannot. Since the LED and buzzer did not activate, it may be concluded that the obstacle detection function will not display an incorrect danger to the user. Evidence suggests that the effective operation of fall detection and obstacle detection features is unaffected by age or weight gain. These features do, however, have a few limits. The wheelchair has to be redesigned since its current design can only support 17 kg of weight. If the user is blind, the obstacle detection system can sound an alarm, and if the user is deaf, the system can flash an LED to alert them. Users who are both visually impaired and aurally impaired will find it completely ineffective. Since the user may fall even while they're not at home, the fall detection features may identify when the user has fallen and notify them by voice message. In addition to not being able to foretell the user's fall position, the user's loved ones have no idea where the user really is. Above and above. The slower the wheelchair becomes, the more the rider weighs, according to observations. On top of that, there have been reports of users between the ages of 50 and 66 and between the ages of 4 and 6, who had trouble controlling the wheelchair with their voices due to pronunciation issues. Fortunately, this has been resolved.

problem has been overcome easily by just replacing the lengthy words with a short one. As the AMR Voice app that used to control the wheelchair converts the voice to a string which is already have been declared in software code. Finally, it can be declared this paper has successfully presented a Smart Wheelchair that is friendly, has the necessary features, and cost-effective price of around 66.452 and some recommendations have been provided in the recommendation/future work chapter to enhance the performance of the Smart Wheelchair.

Recommendition

The following has to be done in order to make this project friendlier. It would be more practical to develop a wheelchair that can anticipate when the user needs to shift their back position, as the majority of handicapped persons who use wheelchairs spend the majority of their time in that position. That way, the user's back won't get a workout from sitting for hours on end. Just like paralysis prevents some crippled persons from changing their posture. Those who are blind or deaf will gain from it, but not those who are both, even if two barrier dangers have been employed. Therefore, the wheelchair need to have the capability to identify and avoid obstacles on its own. While this technology has been covered in the past, it does have one major drawback: it takes too long to respond. In addition, although the fall detection notification serves its purpose—notifying the user's relatives or neighbors—it also does not account for the user's lack of relations. Unfortunately, it works best when the user is at home when they fall. Since there is a chance that the user may fall when outside his house and no one knows for sure where he fell. Consequently, the issue may be resolved by equipping these smart wheelchairs with a function similar to GPS. However, there is a risk of providing the incorrect user position if a GPS component is included, which might easily fix the issue.

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