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Design and Development of Voice Controllable Wheelchair

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Abstract-**In this work a voice controlled wheelchair is made for physically challenged peoples or patients whose hind limbs are not in working condition. Hence, he or she can control the wheelchair by own voice commands or of the family members. To accomplish the task Arduino microcontroller board is used which receives the voice commands either from Bluetooth module via smartphone or from voice recognition module from microphone attached to it. Further matching it with preloaded voice commands and develop movement accordingly. In the subsequent sections of the paper give more concentration on further objectives to achieve reduction in motor speed smooth movement of vehicle by two motors and the wheels as per the command. The main objective of current work is to make it as simple as possible. Certain theoretical results are also obtained by formulation and design calculation.**

Keywords- Arduino, Bluetooth module, microcontroller, voice controlled wheelchair, voice recognition module

I. INTRODUCTION

Many researchers have performed inspiring and good work to make the lives of patients as much easy and self-independent can be. The voice controlled wheelchair has been developed in span of many numbers of years by coalescing knowledge from different arenas. Their notable works are presented here, Mazo et al. developed the voice controlled wheelchair equipped with ultrasonic and infrared sensors for allowing autonomous driving [1]. Murai et al. developed the functional voice activated wheelchair having two major functions. Collision avoidance function to avoid wall and obstacles and robust elevator entry/exit function [2]. Prathyusha et al. designed the motorized wheel chair for handicapped persons using voice and touch screen technology. The methodology adopted was based on grouping a microcontroller with a speech recognition system and touch screen [3]. Suryawanshi et al. developed motor-powered wheelchair consisting of drive system and ARM Processor (LPC2138) to overcome the limitations of Powered wheelchairs with the standard joystick [4]. Sibai et al. reviewed the contemporary studies on smart wheelchair systems. Aimed for evaluating the current available technologies and to discuss new future directions [5].

Lodhi et al. described the design of smart, motorized, voice controlled wheelchair using embedded system. The methodology proposed was to give voice commands through a cellular device having Bluetooth [6]. Apsana et al. described design of smart, motorized, voice controlled wheelchair using embedded system. Arduino microcontroller and speaker dependent voice recognition processor used to support the navigation of the wheelchair [7]. Memon et al. developed a robotic vehicle which was proposed as assistive robots for people with disabilities and for industrial applications as work robots [8]. Chikhale et al. had developed the Voice controlled robotic system equipped with Arduino to control it via android device so that it can work in areas unachievable to human [9]. Zope et al. had designed a robotic vehicle to control by voice commands by use of microcontroller (ATMEGA32) and Bluetooth device to control the speed of the motor via Android application. The sensing and sharing of information were done with phone about the direction and distance of the robot from the nearest obstacle [10]. Randive et al. developed a voice controlled robot (VSR) and controlled by specific voice commands. The project was aimed for home automation system so that physically disabled persons may be beneficial [11]. Mirin et al. developed smart wheelchair controllable by voice commands and touch controlled. Having two modes voice recognition or touch mode. Arduino Uno, MD30C motor driver and HC05 Bluetooth module were used [12]. Babu et al. had developed voice-based system to control a mobile robot. Paper described the development of voice control wheelchair. An interface designed to develop program for recognizing voice for controlling the wheelchair [13]. Aktar et al. developed the voice recognition based intelligent wheelchair with GPS module to track and send location of patient to smartphone application via Firebase [14]. Muneera et al. recommended the Voice controlled wheelchair. Proposed system had to include therapy unit for assisting limbs of user to prevent numbness due to continuous rest [15]. Gaikwad et al. proposed a wheelchair using image processing. Eye control device based on image processing proposed to use as an intelligent mobility aid for paralyzed patients [16].

However, despite of all the developments there are certain areas in voice controllable wheelchair which need further study and development. According to the current technology requirement it can equipped with gear reduction system. For providing range of speeds to users which was more or less missing in previous works. Can made to carry peoples having different weights by attaching high power and torque motors.

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So ,in this work a humble approach and efforts have been made and tried to combine features such as Arduino compatible ultrasonic sensors for detecting obstacles ,voice recognition module with microphone for easy control of it by patients ,driver circuit to control two sets of DC motor for each wheel and to use a mechanism for speed reduction of motors.

Robots have the ability to perform in the extreme kinds of environments, chemical as well as nuclear. They can work in such kind of environments where humans not only can't work but also can't survive. The main objective of this project is to build a wheel chair that work as robotic vehicle and could be controlled using voice commands. Such systems are known as Speech Controlled Automation Systems (SCAS). Present system will be a prototype of the same. The main purpose is to develop a machine or a robot controlled by human, where the control is done by the voice command. At its grass root level speech recognition allows the user to perform many tasks at the same time, while continuing to work with the appliance.

It will able to perform these basic and important tasks as follows,

1. Move forward
2. Move backward
3. Turn left
4. Turn right
5. Stop

II. SOCIAL BENEFITS

It is mainly beneficial to the people devoid of movements especially hands. People suffering from various hind limbs related diseases, are devoid of bipedal motion. Also, they are not capable of operating normal wheelchair due to paralysis. Since it is aimed to facilitate movement of handicapped people on their own, it reduce need of family members to support these handicapped peoples. Independent mobility increases many educational opportunities, promotes feelings of self-reliance. The system is also able to sense the obstacles, which is not present in ordinary wheelchairs. The implemented device helps to improve the lifestyle of the physically disabled peoples and lead them to keep pace with others in the society.

This concept of voice controlled wheelchair will be of great utility for less dependency on family members and to live with dignity. Therefore, voice controlled wheelchair will be a potential device for such requirement for better life and society.

III. METHODOLOGY OF OPERATIONS

There are certain parts in the wheelchair which are dependent on each other. Functioning or command will be transferred to each part after it will be processed in the other part electrically or mechanically or both. The dependency or working functions of the main parts are described as below,

1. Common wheelchair
2. Arduino uno
   ATmega328P, Operating voltage (5 volts)
3. Driver circuit
   Model (L298), current (600 mA), voltage(3-35v)
4. DC motors
   120 W, 12 volts and 2500 rpm
5. Gears
   Made of Nylon
6. Shaft – diameter (1.5 cm)
7. Smartphone and Bluetooth module (Hc05)
8. Voice recognition module
   Voltage (4.5-5.5V), current < 40 mA
9. Gear drive / Chain drive – made of mild steel
10. Battery (for power supply) – 12 volts

1. First, the audio or voice input is taken from the user through the android application using Smartphone or microphone. Then this input voice command is sent to the Arduino UNO board through the HC-05 Bluetooth module or voice recognition module.
2. Voice commands are recorded, stored and trained in English for convenience. Commands used along with their explanations are mentioned. "Forward" will drive the device forward; "Right" will turn the device right; "Left" will turn the device left; "Backward" will move the device in opposite direction; "Stop" command will stop the device from moving.
3. Arduino UNO checks all the data coming from the Bluetooth module. If the voice commands are matched, then it sends an activation signal to the motor driver circuit for controlling the movement of the motor according to the pre-loaded code and thus we get the desired direction of the device according to the input command.
4. Any unmatched command will be ignored by Arduino.

A. Command and Action sequence

What user or patient give the voice input and after receiving appropriate voice command what wheelchair will do or perform is presented below in the tabular form,

TABLE I. LIST OF TASKS WHEELCHAIR PERFORM BY VOICE COMMANDS

Serial no.	Input (what speakers will speak)	Output (what wheelchair will perform)
1	Left	Moves left
2	Right	Moves right
3	Forward	Moves forward
4	Backward	Moves backward
5	Stop	Stop moving

The speaker (user) gives the necessary voice commands through smartphone. The voice module recognizes and checks for its validity and then send signals to the Arduino. Depending on the inputs, the Arduino controls the driver circuit of each motor using the code i.e. it indirectly control the direction of rotation of the motor according to the code. This control movement of the motors which eventually

controls the movement of wheelchair which is given below in the tabular form,

TABLE II. DIRECTION OF MOTION OF WHEELCHAIR BASED ON DIRECTION OF ROTATION OF MOTORS

Direction	Left motor	Right motor
Forward	CKW	CKW
Backward	ACKW	ACKW
Left	ACKW	CKW
Right	CKW	ACKW

CKW – Clockwise rotation, ACKW- Anticlockwise rotation

Few trials performed to understand how the wheelchair is working by receiving the voice commands. Whether it is showing any deviation in motion i.e. if not responding on true voice commands. Showing no motion for false voice commands or not. The description of the trials and results are presented in table III as follows,

Trial 1st – In this trial first forward command was given by saying word "Forward" ,and the wheelchair moved successfully according to that in the forward direction then "Backward", "Left" and "Right" commands are also given distinctly and wheelchair moved as per that for the specified time interval in the program of Arduino.

Trial 2nd – Second trial also given the same result or wheelchair moved effectively following the four mentioned commands.

Trail 3rd – In this trial first forward command was given by saying the word "Forward" and the wheelchair moved forward then "Backward" command was given by voice then wheelchair performed same task of moving backward as was told, similarly for "Left" command also result obtained successful but when "Right" command was given it didn't perform according to it but rather didn't respond to that command.

Trail 6th – In the sixth trial two errors were noted while giving the voice commands of "Forward" and "Left" individually.

Trial 10th – In few trials anomaly also occurred such as in 10th trial wheelchair moved successfully following the three voice commands of "Forward" "Backward" and "Left" commands but for the "Right" voice command wheelchair didn't move or didn't respond.

Trial 12th – In this trial wheelchair performed all the four movements or motions correctly after recognizing the specific voice command.

B. Block diagram, Testing table and Speed profile of the operation

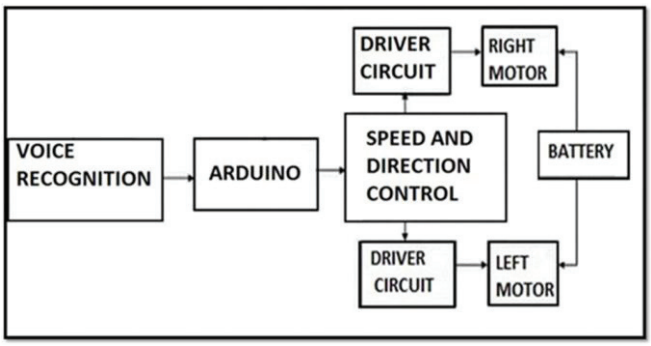

Fig. 1. Block Diagram of the system

In block diagram, it is shown how the voice command given by the user is first checked by the Arduino before transferring the signal to driver circuit. If command is matched by Arduino which is fed into it at the time of programming then it will send the required signal to driver circuit which will eventually control the direction of rotation of the motors which will drive the wheelchair as per the directed voice command by user.

Few experiments were performed to study the speed profile of the wheelchair of how it achieves its specified speed which is shown by the following figure 2 below the table.

TABLE III. TESTING AND TRIALS OF EXPERIMENTS OF THE WHEELCHAIR SYSTEM

Trials	FORWARD		BACK		RIGHT		LEFT	
	Correct	*Error*	*Correct*	*Error*	*Correct*	*Error*	*Correct*	*Error*
1	yes		Yes		yes		yes	
2	yes		Yes		yes		yes	
3	yes		Yes			yes	yes	
4	yes		Yes			yes		yes
5	yes		Yes		yes		yes	
6		yes	Yes		yes			yes
7	yes		Yes		yes		yes	
8	yes		Yes		yes		yes	
9	yes		Yes		yes		yes	
10	yes		Yes			yes	yes	
11	yes		Yes		yes		yes	
12	yes		Yes		yes		yes	

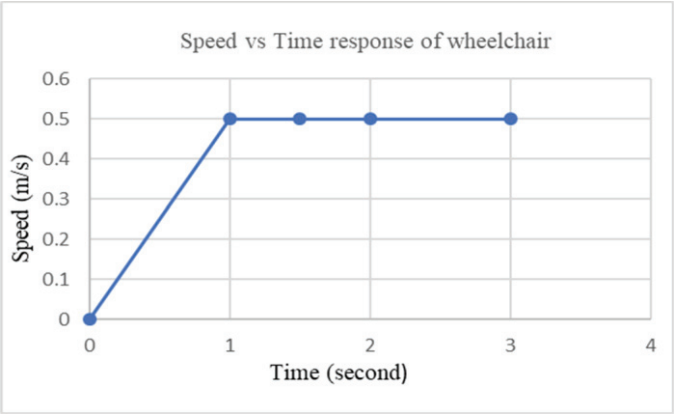

Fig. 2. Speed profile of the wheelchair

Fig. 2 is showing the speed increases linearly up to time limit of 1s and then attaining constant speed or velocity after that. Possible reason for it can be the certain time taken by motor to attain constant angular speed and effects of static and kinematic friction. After taking many trails actual average speed of wheelchair comes out to be 0.5 m/s as given above.

C. *Calculations for final speed of the wheelchair*

Angular speed of rotation (ω) of motors is very high to be of practical use for wheelchair, so speed reduction provision is provided in the form of gear train to reduce the speed of motor

up to certain value which will be transmitted to the rear wheels of the wheelchair as given below,

We know,

$$\frac{T_1}{T_2} = \frac{N_2}{N_1}$$

T_1 (No. of teeth in driving gear) = 22

T_2(No. of teeth in driven gear) = 44

N_1(RPM of driving gear) = 2500, Therefore, N_2(RPM of driven gear) = 1250

N_3 = 260 rpm,

Torque on the pulley = $\frac{p_{out}}{\omega_{out}} = \frac{120\times60}{2\pi\times260} = 4.40$ Nm ,

Considering Maximum load= 60 kg,

We want the wheel chair to attain a constant velocity of 0.5 m/s after 1s

So, Velocity of wheel chair = 0.5 m/s.

Second moment of area of wheel chair = 50 kg × 0.3^2 m^2 = 4.5 kgm^2,

The acceleration (a) of the wheel chair will be

$$a = \frac{0.5\ ms^{-1}}{1\ s} = 0.5\ ms^{-2}$$

The angular acceleration (α) of the wheelchair will be,

$$\alpha = \frac{0.5\ ms^{-2}}{0.3\ m} = 1.67\ rad/s^2$$

The torque required to move the wheel chair at the stated velocity is,

$\tau_{required}$ = 9 × 1.67/2 = 7.51Nm

Torque produced by two motor (τ_{total}) = 4.40 × 2 = 8.8 Nm

As given above produced torque is more than the required torque which is showing wheelchair can bear the specified maximum load for specified speed.

IV. Conclusion

Recent advancements in the technology are making the lives of humans easier. This work elaborates the design and construction of Voice Controllable Wheelchair. Till date wheelchair is made and tested for the credibility of speed and torque requirements with transmission from belt drive. To do it smartphone with android application is used, with microcontroller receiving signals by HC-05 Bluetooth module, though it is working efficiently and it is expected to achieve voice commands with voice recognition module with transmission from chain or gear drive. This voice operated wheelchair will give freedom to the patients to move around freely without the help of any other family member or person.

V. Future Modifications Proposed

Future planning is going on to replace smartphone and Bluetooth module specifications with voice recognition module and for that Bluetooth module have to be replaced with USB to TTL convertor. Attempts are in progress to make it obstacle efficient by use of sensors so that it will not collide with nearby objects. More innovative possibilities such as use of gearbox and many more will be searched or thought to make Voice controlled wheelchair more easier and efficient to use for patients, and to make it more effective to work in real.

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