المؤتمر العلمي الدولي الثالث للهندسة و العلوم
The 3RD Scientific International Conference in Engineering & Science

http://bwu.edu.ly/icse2024
Received 25/07/2024 Revised 18/08/2024 Published 10/09/2024
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Design and Implementation of smart wheelchair

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Abstract: This paper is devoted to speech controlled wheelchair for physically disabled person is developed which can be used for different languages.
The main objective of the proposed system is to design a smart, motorized, and voice-controlled wheelchair using an embedded system to assist physically disabled and elderly people who have difficulty moving. The system design incorporates a voice activation system that allows the user to control the movement of the wheelchair through voice commands. The voice command is given through a Bluetooth-enabled cellular device, and the command is then transferred and converted to a string by the BT Voice Control for Arduino, which is then transferred to the Bluetooth module connected to the Arduino board to control the wheelchair. For example, when the user says "Go," the chair will move in the forward direction, "Back" for the backward direction, "Left" and "Right" for rotating the chair, and "Stop" to stop the wheelchair. This system is designed and developed to save cost, time, and energy, and reduce the dependence on others for the movements of the wheelchair-using physically handicapped person. Additionally, the design incorporates an ultrasonic sensor to detect obstacles and prevent collisions,

Keywords: (Arduino, AR-Voice Control, mobile robot, smart-wheelchair).

Introduction

Wheelchairs have become an essential tool for individuals with limited mobility, providing them with the freedom to move independently (Nadjib et al., 2021). In particular, the growing population of elderly individuals and those with disabilities highlights the increasing demand for innovative wheelchair solutions that enhance mobility and accessibility (Ozcelikors et al., 2014). Additionally, advances in technology have paved the way for the development of smart wheelchairs, which incorporate various sensors and automated systems, allowing for more intuitive and effective navigation in complex environments (Ozcelikors et al., 2014). Recent studies have demonstrated the feasibility of integrating voice recognition technologies and low-cost sensors into wheelchair designs, enabling users to control their movement and interact, thereby increasing independence and improving quality of life for users with severe disabilities.An Arduino Uno board is used to acquire the control signal from Bluetooth shield and give it to DC motor driver circuit which intern results in the motion of wheelchair in desired direction.

The voice inputs such as forward, back, left, right and stop acquired from the user and then the motion of the wheelchair made according to the respective command. Android phone handling the wheelchair system using voice-recognition system the wheelchair System is recommended to control a wheelchair by using the android application. The main idea began the mobile device and voice- recognition system this project or application is to facilitate and increase the mobility of handicapped and old aged people who are not able to move well because of their disabilities of organs. Using this wheelchair will allow handicapped people to live a life independently without depending on others for their movement as a daily need.

I. ARDUINO:

a) Types of Arduino Boards:

There are many types of Arduino boards depend on the use and some of the capacity specification, afford the power, numbers and kinds of inputs and outputs even the size.

We can mention some of these types as follows:

1. Arduino UNO.
2. Arduino Mega.
3. Arduino Nano.
4. Arduino Micro.
5. Arduino Lily pad.

b) Arduino UNO:

Arduino UNO is the most popular boardsfor Arduino, and more useful and it is specifically ba onATmega328P microcontroller.

We can show the Arduino UNO board as in the figure:

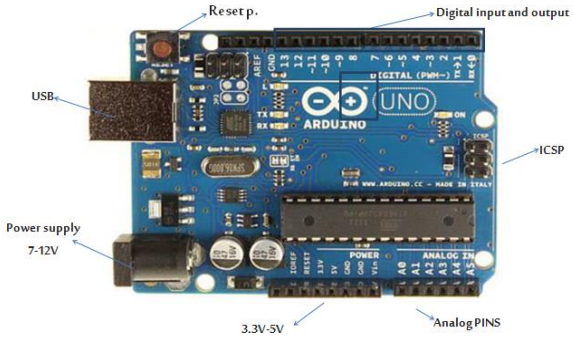


Fig.1: Arduino uno board

II. System Components :

In this chapter, we must clarify several basic things depend on access to good result.

These basic elements can be taken as follows:

1. Drive motor:

At this basic point, we are working on choosing the appropriate motors that determine what we would like to use on this subject.

We can determine it as follows:

1.1) To determine the operating condition:-

It is an easy to select and can be describe as a specific standard that of it's examples as follows:

1.1.1 Robot Mass:

It is the first point which is based on other several specifications, if it was ignored, it leads to getting away from the result to be accessed.

1.1.2 Speed:

The speed of the robot works.

1.1.3 Voltage.

1.1.4 Wheel diameter:

Which by of it can account for the rest of the points that lead the robot to work correctly.

1.2 Cost: It is most of the designs form a large difference between quality, mastery and the importance of the function that performed compare to the cost of its design.

1.3 Mobile Robot locomotion:-

It can be identified and defined as the number of points of axis wheels, if we accept that the following shapes can be represented by a fake straight lines to see how many conventions point to determine how much it has.

The symbol of it is ICR.

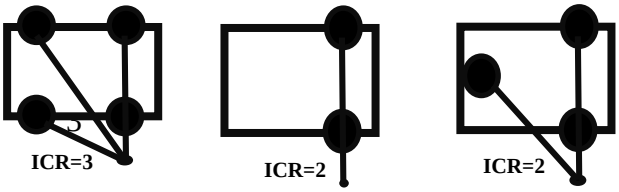


Fig.2: Explain how to determine ICR

1.4 Degree of Mobility:-

It can be defined as the number of degrees of the freedom which the robot has to determine the directions of the motion and implementation it and calculated with number of ICR which the robot has ICR=2 so, the degree of the mobility is the second degree and its symbol is δm.

1.5 Degree of Steer ability:

The number of centered orient able wheels that can be steered independtly in order to steer the robot and its symbol is δs.

1.6 Degree of Maneuverability:-

The overall degrees of freedom that robot can manipulate.

$$\frac{m * Rw}{NW} * E * Sf \quad \ldots\ldots\ldots\ldots (2)$$

$\delta m = \delta m + \delta s$ .....(1)

2. Determine the type of driving (steering):-

It is very important of how to determine the above mentioned points and also to determine what must have accounts to take for the motor torque.

It can bedefined in short it is a motion property, for example (car drive, catrabiller) and in this type we will use different drive.

III. Determine Torque:-

Selecting the right and save torque is leading to choose the suitable motor and gearing.It is the one of the most important basic points that the design of robot based on it.

Choosing the torque is depending on a set of accounting the determined with particular rule, where we can divided to rules for two basic components or two important stages it called a (Red's rule), it can be show as follows:

Determine the torque is very important for design because it determines the weight for the wheelchair can be load.

Which in turn determines the appropriate specifications for the motor used.The (Red's rule) that says that amount of wheels cannot pull the robot is enough to pull it completely without any problems or difficulties.Here is a disadvantage, which makes a robot works even if a motors stops working.

We can divide a torque account into two parts as follows:

Firstly, The Flat Surfaces:First at design, the number of wheels used in the design must be determined.

For example, if we impose that the number of wheels that used is (2) as in the wheelchair.

It is calculation is by = number of wheels.

The general rule to account the value of torque in a flat surfaces is:

T=

T is the torque.

M is the total mass.

Rwis the wheel radius.

Nw is the number of wheel.

E is the Efficiency.

Sf is the Safety Factor.

And,

Tf=Tm*RG*EG ..... (3)

Where:

Tf is the Final torque.

Tm is Torque motor.

RG is the Gear Ratio.

EG is the Gear Efficiency.

Power = T*S .....(4)

Where S is the speed.

- Secondly, The Slipping Surfaces:-

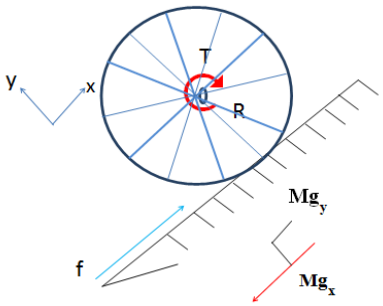


Fig.3: DC slipping surface.

It is very important to work because of the change of the working environment and therefore we must take into account and can calculate the value of the torque according to the equation of the following:

Where:

a is Acceleration,

G is the Gravity,

ɵis the slope angle,

Nw is the number of the wheel.

In the next figure will explain the relationship between the torque and rotation speed.

Where is the torque is zero then the rotation speed will be max, and at maximum torque the rotation speed will be zero then we can control the speed of the DC motor by controlling the input voltage to the motor.

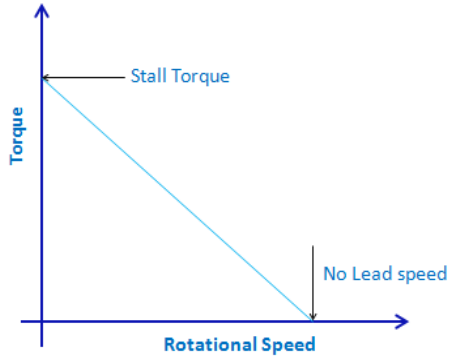
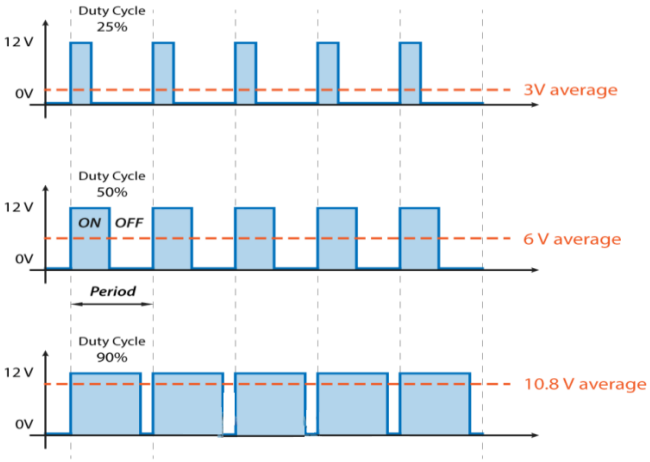


Fig.4: DC Motor Torque/Speed Curve.

1) PULSE WIDTH MODULATOR:



Its symbol by PWM, PWM is a technique to define the continuous time before to going to the electronic boards by turning on and off the power at a fast rate.

$$T = \frac{a + G * \sin(ɵ) * m * Rw}{Nw} * E * Sf \quad \text{.....(4)}$$

Theory of this work is worked in a manner that is similar to the electric key opens and closes according to a specific time selection. The amount of time is called (duty cycle) as well known the full frequency of the analysis for the analog signal depends on total time of the signal which is called (Time period).Hence, the total time "T" is a total "T on" with "T off "

From this sense we can say that the "T off" increases then "T on" will decrease and the opposite is true.

Fig.5: Pulse width modulation.

Figure No. (5) will show PWM and how determined the average voltage of it.Regarding the work of the motors and control it through PWM it changes be the change of duty cycle which is duty cycle "zero" then the motor will not work and when the duty cycle is 100% the motor will work with a maximum speed of rotation (RPM).

While we must alert the motors need a fix voltage and this voltage is called "threshold voltage" .

2) Ultrasonic sensor

This device depends on the measure of distance by using velocity law, where it is has two parts and receive signal.We can explain working theory for ULTRASONIC sensor as:

The module automatically sends eight 40 KHZ and

detect whether here is pulse signal back.

If the back signal through high level time of high output duration is the time from sending ultrasonic to returning

Test distance = high level time × velocity of sound

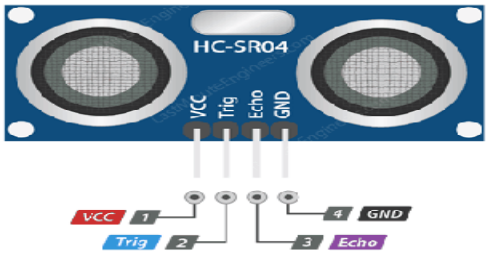


Fig.6: the ultrasonic sensor Hc-SR04

V_{cc} is connected to the 5v pin on the arduino.

$Tig.$ pin is used to trigger the ultrasonic sound pulses .

Echo. Pin produces a pulse when the reflected signal is received.

GND should be connected to the ground of arduino.

The ultrasonic produces a pulse whose varies between 150µs to 25 ms depending on time it to for the signal to be received show figure(6).

3) System description:-

In system description for this project consiststwo parts software and he hardware. The hardware depend on the arduino uno board ,Bluetooth module, motor drive and system phone (android) the communication between the android phone and the arduino board is done by a Bluetooth module.

That means the voice command given to the android phone. The user speaks the desired command to the BT Voice Control for Arduino voice (ArduinoVoice control Application) software application installed in the android phone that is connected through Bluetooth with Bluetooth Module HC-05.

The voice command is converted to an array of string and the string is passed to Arduino Uno connected to it.

Once the Bluetoothmodule receives the message, the command sent will be extracted and executed by the microcontroller attached to it and depending on the commands fed to the Motor Driver, the motors will function accordingly.

The system will interpret the commands and control the Wheelchair accordingly via android application.

Blockdigram:-

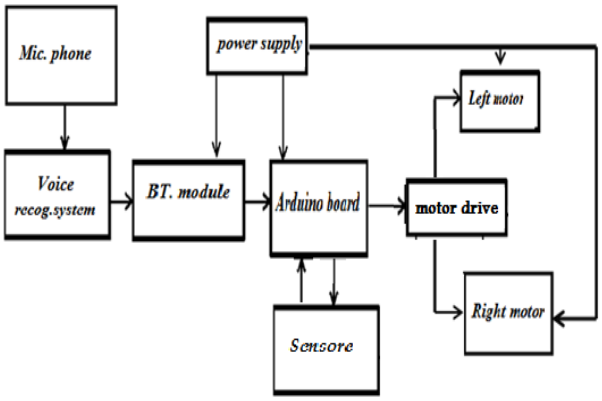


Fig.7: Block diagram system.

4) Requirements:-

- Arduino UNO.
- Bluetooth Module HC-05.
- 2 Ultrasonic sensors
- L298D Motor Shield.
- Wheel chair chassis.
- Battery 9 volts or 12V.
- 2 DC Motors (12 V 200 rpm).
- Android phone.
- Power supply.

III. Implementation:-

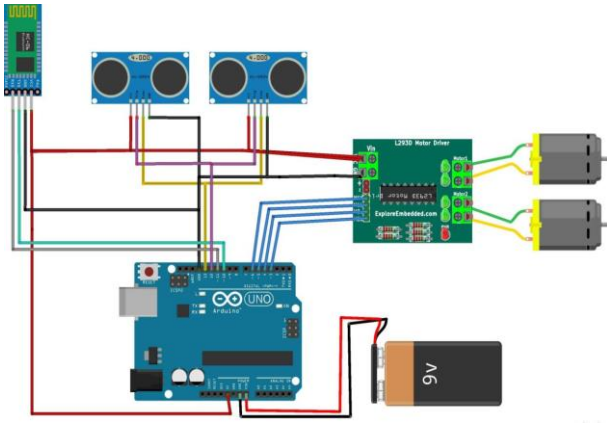


Fig.8: Connect the system circuit.

IV. Flowchart of project:-

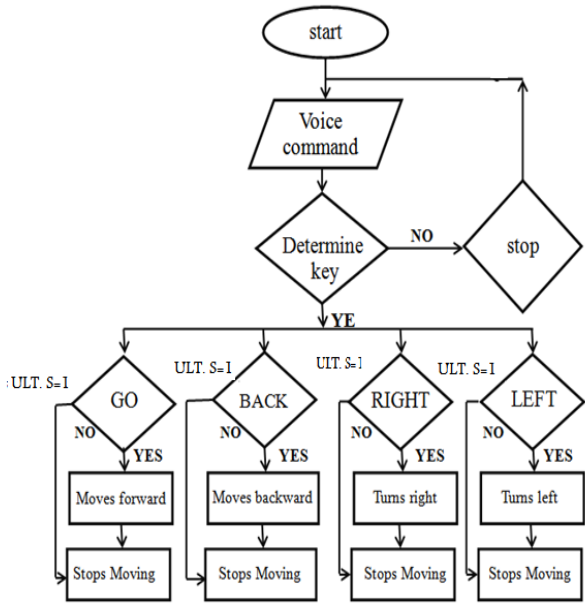


Fig.9: flow chart of the Project

IV. Results and discussion

a) Drive motor

The first part in this capture we account the details of complete design including the specification of the motor parameters depending on the collection weight of user with the mechanical parts to gather.

With reference to the equation NO.(5) define the power and torque of motor as the following:

Firstly must be known the maximum weight of user is 125Kg and the weight of mechanical design is 55Kg then the total weight is 180Kg.And the diameter of wheels is 0.7 m ,and two DC Motor 12V– 20 RPM.

The linear Velocity can be defined as:

$$v = 2n \times R \times N$$

$$= 2 \times 3.14 \times 0.35m$$

$$\times \frac{20}{60} \frac{m}{min} = 0.73\, {}^{m}/_{s}$$

And the acceleration can represented by assuming the time for wheel chair from o to max. velocity is 2s then:

$$a = \frac{v}{t} = \frac{0.73^{m}/_{s}}{2s} = 0.36\, {}^{m}/_{s^2}$$

The angular velocity defined by linear velocity or by RPM AS

$$\omega = \left[2n \times R \times \frac{N}{60}\right] \; OR \; [\frac{v}{R}]$$

$$\omega = \frac{0.73}{0.35} = 2.02\, {}^{rad}/_{s}$$

The force can be defined as:

$$F = M \times a$$

$$F = (M_1 + M_2) \times a$$

$$= (125 + 55) \times 0.36$$

$$= 64.8\, N$$

Then the torque of the DC motor is:

$$T = F \times R = 64.8 \times 0.35 = 22.68\, Nm$$

The power of the both DC motors is:

$$P_M = T \times \omega = 22.68 \times 2.02 = 45.8\, w$$

$$P_{\frac{M}{2}} = \frac{45.8}{2} = 22.9\, w$$

Where we use battery 12 Volt then the current must be more or equal

I= 1.9 A.

The last results without taking into account the power Efficiency ,The slope surface and the safety weighting, In the following equations we obtained that as:

$$T = \frac{M \times R_W}{N_W} \times E_f \times S_f$$

.....(5)

$$T = \frac{180 \times 0.35}{2} \times 70\% \times 1.2 = 26.46\, NM$$

Where W = 2.02 rad/s then the power is:

$$P_M = 2.02 \times 26.46 = 53.45\, w$$

$$P_{\frac{M}{2}} = \frac{53.45}{2} = 26.73\, w$$

Then I = 13.15 A

By using the Red rule ,

If we assume the maximum surface slope (θ =20°) And from equation :

$$T = \frac{GO \times G \times M \times R_w \times \sin\theta}{N_w} \times E_f \times S_f$$

.....(6)

$$T = \frac{2.02 \times 9.18 \times 180 \times 0.35 \times \sin 20}{2} \times 70\% \times 1.2 = 167.8\ Nm$$

$$P_M = T \times GO = 167.8 \times 2.02 = 338.95\ w$$

$$P_{\frac{M}{2}} = \frac{338.2}{2} = 169.5\ w$$

The current will be equal:

I=14.125 A

b) Application instruction

- Compared with the reference data by microcontroller and if the microcontroller detect"*GO#" the motor drive will be run to clockwise and the wheelchair will be moves to forward.
- When the Microphone of the phone system is attached "BACK" AR-VOICE CONTROL application sends the data in form of string "*BACK#" to Bluetooth module connected to the circuit, and the Microcontroller is detect "BACK", the motor drive will be run to un clockwise and the wheelchair will be moves to back.
- When the user says "LEFT" AR-VOICE CONTROL application sends the data in form of string in form of string "*LEFT#" to Bluetooth module connected to the circuit. When microcontroller detects "LEFT" the moves the motor attached to the wheelchair left side.
- When the user says "RIGHT" AR-VOICE CONTROL application sends the data in form of string "*RIGHT#" to Bluetooth module connected to the circuit. When microcontroller detects "RIGHT" the moves the motor attached to the wheelchair right side.
- When the user says "STOP" button which is in the Centre of remote the AR-VOICE CONTROL application sends the data in form of string "*STOP#" to the Bluetooth module connected to the circuit. When microcontroller detects "STOP" the wheelchair gets stopped.
- Click on "DISCONNECT" icon to disconnect the paired Bluetooth module.At first the voice commands can be inferred through voice recognition technology used in the Android system and motor response to rotation as in the following table:

Voice command	Condition(input1,input2)	Staring command	Left/Right motor
GO	Moves Forward(+1,+1)	*Go#	On/On Forward
BACK	Moves Backward(-1,-1)	*BACK#	On/On Backward
RIGHT	Moves Left(0,+1)	*LEFT#	Off/On Forward
LEFT	Moves Right(+1,0)	*RIGHT#	On/Off Forward
STOP	Stops(0,0)	*STOP#	Off/Off

- When the application program and verify its accuracy and performance prove that an integrated system and procedure is easily and rotation of the motors in the desired direction and appropriate resolution the system and see results from successful implementation of reliable image and can be used by the target persons of this design. And we note the source code works well and gives the users the possibility of amendment by kind words you want the programmer to use the voice recognition system that puts the system in a high degree of design and good performance.

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