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Design and Development of Wheel Chair Using Voice Recognition for Physically Challenged Persons

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ABSTRACT: This paper is based on the design and implementation of a wheelchair that can be actuated using voice command of the user. A voice activated wheelchair is one which receives the user's voice command as input and gives an output by moving in a specified direction corresponding to the input command. The implementation process is based on building a voice activated wheelchair that can be controlled using microcontroller and voice recognition module so as to facilitate the movement of the disabled as well as elderly people who are unable to move well. Voice recognition technology is the key which provides human-machine interaction. The design has been realized using the microphone as an intermediary. Interface has also been designed to develop the program in Arduino platform to recognize voice command as input and produce an output to control the directional motion of the wheelchair. The wheelchair was designed and constructed using ELECHOUSE voice recognition module V3 interfaced with Arduino Uno AVR ATMega328p microcontroller circuit and Direct Current (D.C) motors to actuate its movement. The programming was achieved using C programming language in Arduino platform. Also, ultrasonic sensors are used for obstacle detection thereby making the wheelchair more reliable and safer while in use by avoiding collision with obstacle along its path. The wheelchair works with seven voice commands and move accordingly in the direction of the commands. The conditions of the wheelchair motion are; moving forward, moving backward, turning to the right, turning to the left, light on, light off and stop condition. The wheelchair can be used in homes or hospitals by the physically challenged people that can talk audibly but have no legs and upper limbs to drive a motorized wheelchair or by the aged people who do not have the strength to drive a manually operated wheelchair.

KEYWORDS: Wheelchair, Voice commands, Arduino Uno, Voice recognition module

I. INTRODUCTION

Speech is the primary means of communication between people. For reasons ranging from technological curiosity about the mechanisms for mechanical realization of human speech capabilities, to the desire to automate simple tasks inherently requiring human-machine interactions, research in automatic speech recognition and speech synthesis by machine has attracted a great deal of attention over the past five decades (Juang and Lawrence, 2014).

The field of automatic speech recognition has witnessed a number of significant advancement in the past five to ten years, spurred on by advances in signal processing, algorithms, computational architectures and hardware. These advances include the widespread adoption of a statistical pattern recognition paradigm, a data driven approach which makes use of a rich set of speech utterances from a large population of speakers, the use of stochastic acoustic and language modeling, and the use of dynamic programming based search methods (Sadaoki, 2000).

Electric power wheelchairs have become increasingly important as assistive technology and rehabilitation device and the number of users has grown considerably. Wheelchairs are mostly designed with joystick control; however this may not be suitable for some disabled people. In modern technology, the Human-Machine Interface (HMI) based techniques include joystick controller, finger movement, voice recognition, eye-gaze tracking, electro-myography, etc. (Asgar et al., 2013).

II. PROBLEMS STATEMENT

In order to live a successful life, people with locomotive disabilities need a wheelchair to perform functions that require them to move around. This can be achieved manually by either assigning somebody to be doing the job for them or by pushing the wheelchair with their hands. However, for somebody to be engaged in pushing them, that person must, in most cases, be a close relative and so dedicated that he/she can forfeit most of his/her commitments so as to assist in pushing the handicapped person on the wheelchair. This however leads to disappointment and inconvenience from both parties. This challenge makes it necessary for the disabled person to look for the possible way of doing the job themselves. However many individuals have weak upper limbs or find the manual mode of operating too tiring. Hence it is desirable to provide them with a voice activated intelligent wheelchair that can be controlled through the user's voice commands.

III. RELATED WORKS

Rachna and Saxena (2011) discussed the design and implementation of voice controlled mobile robot which takes speech input as commands and performs some navigation task through a distinct Human Machine Interaction (HMI). The system is trained in such a way that it recognizes defined commands and the designed robot navigates based on the instruction through the speech commands.

Reshme et al. (2014) designed a voice operated wheelchair for the physically challenged. The wheelchair can be driven to the preferred direction with the user's voice command, to be identified by the voice recognition module and sends the voice signal to a programmed microcontroller sends finally to the L293D motor driver for the directional motion of the wheelchair.

Shraddha (2013) worked on speech recognition for robotic control. The work is based on introducing hearing sensors and speech synthesis to the mobile robot such that it can be able to interact with human through spoken natural language The speech recognition system is trained in such a way that it recognizes defined commands and the designedrobot will navigate based on the instruction through the speech commands.

Abhyudayet al. (2014)developed a voice operated wheelchair which can be easily understood and operated by people of all age groups without the need of any additional help. The system uses HM2007 voice recognition module, Atmel At89S51 microcontroller and a joy stick. The wheelchair uses an onboard power supply which can be charged while the wheelchair is not in use.

Anoop et al. (2014), a voice controlled wheelchair incorporated with home automation was implemented using 16F877A microcontroller with 16MHz crystal oscillator and HM2007 voice recognition processor. The design supports voice activation system for severely disabled persons incorporating manual operation with switch.

IV. MATERIALS AND METHODS

A. The following materials are used

- Voice recognition module V3 with microphone
- Arduino board with AVR ATMega328p microcontroller
- D.C motors
- Motor drivers
- Power supply (12 V rechargeable battery)
- Ultrasonic sensors
- Arduino IDE software
- Livewire circuit design software.

B. Voice Recognition Module

This is the device used for receiving the input voice commands. The module used in this work (ELECHOUSE voice recognition module V3) is Arduino compatible. It has an inbuilt microphone which used for detecting and receiving the voice commands. It is a speaker dependent voice recognition module and has the capability of storing up to 80 voice commands of which 7 commands can be used at a time.

Fig. 1: Voice Recognition Module V3 with Connectors and Microphone.

C. Arduino board

The Arduino Uno is a single microcontroller circuit development board that provides an easier for the design of electronic circuits. It has a 32 KB flash memory, fourteen digital input/output pins of which six can be used as Pulse Width Modulation (PWM) outputs and six

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analog input pins. It is used to perform a wide range of operations using the software kit provided with it. It can be used to convert ultrasonic sensor signal into vibrator signal.

Fig. 2: Arduino Uno Development Board with ATMega328p Microcontroller.

D. Microcontroller

The AVR ATMega328p is an 8-bit high performance microcontroller of the Atmel's Mega AVR family with low power consumption. It is based on enhanced RISC (Reduced Instruction Set Computing) architecture. Most of the instructions can be executed in one machine cycle. It can work on a maximum frequency of 16 MHz and has a 32 KB programmable flash memory, a static RAM of 2 KB and an EEPROM of 1 KB. The endurance cycle of the flash memory and the EEPROM are 10,000 and 100,000 cycles, respectively.

Fig.3: ATMega328p

E. D.C motors

These constitute the most important components when it comes to the motion of the wheelchair. Motors with high power consumption may cause inefficiency and waste the limited power supplied by the battery, while motors with low power demand may have low torque to drive the wheelchair. The optimal rotation speed and the available speed range of the motor must also be taken into consideration.

Since the typical power supply for the wheelchair is a D.C battery, then D.C motors will be chosen, as they are commonly used for low power demanding projects.

Fig.4: D.C Motor for Wheelchair Drive.

The speed of the motor measured in rpm can be determined using (1)

$$N = \frac{Em - ImRm}{K\Phi} \quad \text{(rpm)} \qquad \ldots(1)$$

Where N is the motor speed in revolution per minute (rpm), E_m is the motor voltage source in volt (V), I_m is the motor current in Ampere (A), R_m is the motor resistance in Ohm (Ω), K_Φ is a constant which depends on design factor.

For the motor used, E_m = 12 V, I_m = 14.4 A, R_m = 0.8 Ω and $K_\Phi = 6 \times 10^{-3}$

Therefore $N = \frac{Em - ImRm}{K\Phi}$

$$= \frac{12 - 14.4 \text{ x } 0.8}{0.006}$$

$$= \frac{0.48}{0.006}$$

= 80 rpm

The angular velocity, ω in radian per second (rad/s) can be determined by (2).

$$\omega = \frac{2\pi N}{60} \qquad \ldots (2$$

$$= \frac{2 \text{ x } 3.142 \text{ x } 80}{60}$$

= 8.379 rad/s

The expected power in Watt (W) to be supplied by the motor can be calculated using (3)

$$P = \tau\omega \text{ (W)} \qquad \ldots (3)$$

Where τ is the torque in Newton-metre (Nm) and ω is the angular velocity in radian per second (rad/s) of the motor. For the motor used, τ = 45 Kg-cm = 4.4145 Nm

Therefore P = 4.4145 x 8.379

= 36.989 W

F. Motor driver

This unit consists of the H-bridge L298 relay drivers, as shown in figure 5. It requires 12 V supply to control the motors for the bidirectional motion of the wheelchair, as it enables the current to flow in both directions. Free welling diode can be used to protect the relay contact and prevent damage to the transistor when the relay switches off. An intermediate stage between the control signal and motors consists of a combination of component relays, transistors, diodes, capacitors and resistors used to protect parallel port against any expected damage.

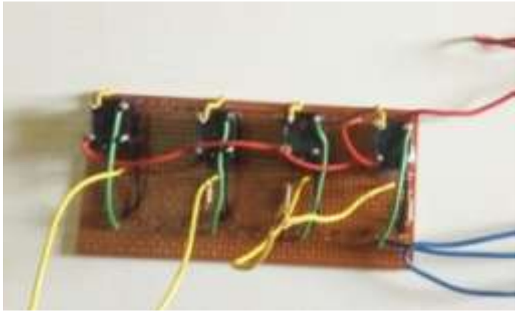

Fig.5: H-bridge Motor Driver Circuit.

G. Ultrasonic sensors

For the detection of obstacle, the wheelchair uses ultrasonic sensors. These are sensors that use ultrasound for sensing objects, pits and any obstacle located on the path of the wheelchair. They operate based on the phenomenon of transmission and reflection and calculate the distance using the time taken between each transmission and reflection. The test distance can be calculated using (4).

$$\text{Test distance} = \frac{\text{High level time (s)x Velocity of sound in air (340 m/s)}}{2} \text{ (m)} \quad \ldots(4)$$

For this design, High level time = 2.5 ms

$$\text{Therefore Test distance} = \frac{0.0025 \text{x} 340}{2}$$

$= 0.425$ m

$= 42.5$ cm

Fig. 6: Ultrasonic Sensor for Obstacle Detection.

H. Sets of chain drive and sprockets

This is a mechanism in which power is transmitted from the engine to the wheels of the wheelchair by means of a moving chain. In a chaindriven system, the rear wheel isdriven by a chain running from the gear at the point of transmission to the gear on the rear wheel.

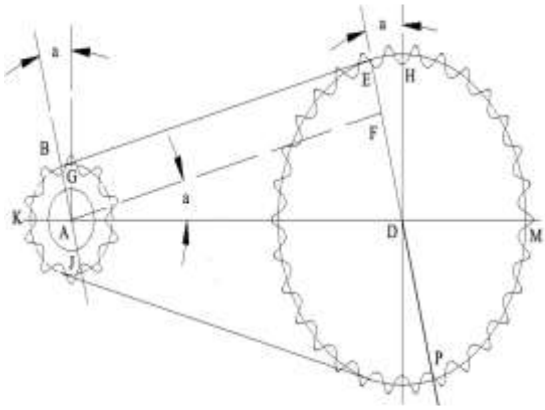

Fig. 7: Chain Drive and Sprockets

The velocity ratio, V.R of the chain drive is expressed in (5).

$$\text{V.R} = \frac{T2}{T1} \quad \ldots(5)$$

Where T_1 = Number of teeth of smaller sprocket and

T_2 = Number of teeth of larger sprocket

For this design, $T_1 = 14$ and $T_2 = 22$

Therefore V.R = $\frac{22}{14}$ = 1.571

The sprocket pitch diameter, D (m) is determined using (6).

$$D = \frac{p}{\text{Sin}\left(\frac{180}{N}\right)} \text{ (m)} \quad \ldots(6)$$

Where p = Chain pitch (m)

N = Number of teeth on the sprocket

Considering the driving sprocket p = 12.7 mm = 0.0127 m and N = 22

$$\text{Therefore, } D = \frac{0.0127}{\text{Sin}\left(\frac{180}{22}\right)}$$

$$= \frac{0.0127}{\text{Sin } 8.182}$$

$$= \frac{0.0127}{\text{Sin } 8.182} = \frac{0.0127}{0.1423}$$

$= 0.089$ m

Hence the sprocket pitch diameter, D = 8.9 cm

The average velocity, v of the chain is expressed in (7).

$$v = \frac{\pi DN}{60} = \frac{TpN}{60} \quad \ldots(7)$$

Where D = Sprocket pitch diameter (m)

p = Pitch of the chain (m)
But D = 0.089 m and N = 22
Therefore $v = \frac{3.142 \times 0.089 \times 22}{60} = 0.1025$ m/s

V. RESULTS

A. Testing of the Electronic Circuit on Prototype Board

The connection of the circuit is shown in figure 8. The voice recognition module was connected to the Arduino Uno development board, which consists of the ATMega328p microcontroller with a 16 MHz crystal oscillator and the ultrasonic sensor, which serve as obstacle detector. The voice recognition module receives voice command through the microphone and sent it to the microcontroller for processing. It then sends the processed command to the motors for the motion of the wheelchair in compliance with the said command.

Fig. 8: Circuit Connection on Prototype Board

The response of the motors is shown by light emitting diodes (LEDs) on the prototype board, in which four LEDs were used, as shown in figure 9. For forward and backward commands, two adjacent LEDs turn on based on the command while for left and right commands, two adjacent LEDs turn on accordingly. All the four LEDs turn off for the stop command and when an obstacle is brought 40 cm in front of the ultrasonic sensor.

Fig. 9: Circuit Connection on Prototype Board Showing the Motor Response to Voice Commands

VI. CONCLUSION

At the end of this research work, the objectives have been achieved as a standard adult size wheelchair has been designed and implemented. The wheelchair has two batteries connected in parallel as its power supply. It has two ultrasonic sensors one from the front and the other from the back for the detection of obstacle while in motion. For the lighting section, two torch-lights are used and connected in parallel so as to receive the command at the same time and function as a single entity.

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