Voice Controlled Guided System for Wheelchair with Collision Detection and Avoidance

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Abstract. Many people are suffering from temporary or permanent disabilities due to accidents or any pre-illness that may introduce a wheelchair for the person as essential. The use of a wheelchair independently can be derived from the severity of the disability. But in the case of severe situations when a person relies on somebody else to handle the movement of a wheelchair. This paper aims to provide a solution to this problem by using voice command to guide the wheelchair eliminating the reliability of another person.

1. Introduction

In recent times, the aged person and physically disabled people whose daily routine depends on a wheelchair are increasing. Due to the increased possibility of a heavy accident or due to any chronic illness people are losing the ability to walk and they need a wheelchair to commute between one point to another. However, only two types of wheelchairs are used widely. The one which requires muscle strength to move and requires certain skills to control the direction is widely used. The other one which is also now used in day by day operation is one where a person can control the movement using a joystick. But the controls using joystick require calibration and need some type of skills to operate. The problem is that it’s quite difficult for a handicapped and old person to use the system as far as interface is concerned.

The possibility of other human feature to control the movement of wheelchair can be voice [2], [1] movement of facial muscles [4], movement of palm, eye glance [3], pressure sensor based on tongue pressure with wireless connectivity, and processed derived from a gesture of hands are suggested. By using these processes, the ease of doing movement becomes easy for users with a disability to control the wheelchair’s movement.

Human eye movement and face movement cannot be synchronized with the control of a wheelchair as a person moves eyes and face unconsciously and without any reason or due to some reaction. Operation by these methods can be dangerous and may cause unintentional damage to the person. The same can be applied for the control through pressure of the tongue as it may vary by the use unconsciously. contrarily, the human voice is a way of transmitting information naturally, and voice is one of the easy interfaces and it can also support multilingual.

The research develops a voice-command-controlled wheelchair system with collision detection and avoidance which processes the voice command from the user as the linking. The fundamental ways of wheelchair are 1) waiting for the command for the user, 2) accepting and verifying the given command 3) applying that command to motors of wheelchair and doing rotation, moving forward and backward based on command 4) detecting obstacle near the person in between movement and avoiding collision by stopping the wheelchair.
2. **Voice controlled wheelchair**

The person will use human voice instructions to control the movement of a wheelchair. The voice command consists of five commands. The mode of transmission from the person’s voice to the wheelchair will be Bluetooth. Due to the recent advancements, now smart watches also carry the availability of Bluetooth connectivity. The voice commands consist of the basic movement of a wheelchair in terms of direction and movement. Table 1 shows the commands and its response. These are fixed set of commands and the multilingual support can be used by the mobile application which can use a text translator to translate the given command and send it over Bluetooth to the system.

The fixed set of commands can be changed but it will require flashing of the microcontroller and this can damage the chip so in the future the app which takes command can provide a solution to customize the commands.

| Command | Movement                                           |
|---------|----------------------------------------------------|
| Forward | Move wheelchair forward direction                  |
| Reverse | Move wheelchair in a reverse direction              |
| Left    | Move wheelchair in a left direction                 |
| Right   | Move wheelchair in the right direction              |
| Stop    | Stop the movement of wheelchair                    |

3. **Collision detection and avoidance**

The movement of the wheelchair is controlled by the voice sent over by the Bluetooth connectivity. But sometimes there may be some chances of the user not able to give the input at the predefined time to avoid the collision so the system itself can detect the distance between the next object take control from the user to avoid collision and stop the wheelchair. Figure 2 shows the logical representation of this system.
When a user is using a wheelchair, the ultrasonic sensor will constantly monitor the distance between the wheelchair and the upfront object. The aim of doing so is to detect any collision that may happen due to the ongoing movement of the wheelchair and upcoming objects in front. The ultrasonic sensor will emit ultrasound at 40kHz frequency in the front direction. The signal will travel through the air and if there is any object in front of it the signal will bounce back to the sensor. Considering the travel time and speed of sound the distance is calculated. This how collision detection works. Once the collision is detected using the ultrasonic sensor which tells the microcontroller that the upfront object is near then the predefined minimum distance which can be considered as safe distance, the microcontroller then will trigger the collision avoidance block and will send a command to the motor driver IC to stop motor wheels.

The system provides the avoidance and collision system provides the safety of the person who is riding the wheelchair.
4. System Configuration

Our system is based on the commercially available microcontroller and sensors which are available in the market widely. Our system uses an Arduino microcontroller the other components are shown in table 2.

| Component Name            | Quantity |
|---------------------------|----------|
| Arduino Uno               | 1        |
| HC-05 Bluetooth Module    | 1        |
| Ultrasonic Sensor         | 1        |
| Motor Driver IC           | 1        |
| Wheelchair                | 1        |
| Buzzer                    | 1        |
| Wheels                    | 4        |

The microcontroller operates on the 5V power supply and the motors need 12V power supply to rotate. Our system uses DC motors whose polarity can be used to control the movement and the rotation can be obtained by turning on and off the single motor from both motor A and B. This way the system is capable enough to direct the wheelchair in the proper direction. Figure 3 shows the complete block diagram of both modules combined into a single system.

The Bluetooth module works on the frequency of the 2.4 GHz band. The ultrasonic sensor works on a frequency of 20 kHz. Motor driver IC is part of the range L293 series. The one which is used in the project is L293D and it has 16 pins. They are composed of 4 ground pins, 4 Input pins, 4 Output pins, 2 Enable pins, and 2 Voltage pins. The buzzer has two points one which is positive and negative. The operating voltage of the buzzer is 4-8 DC and the resonant frequency is 2300 Hz.

Once the command is received upon the validation the rotation of the back motors drives the direction of the wheelchair. The clockwise direction of motor A drives the right direction and the clockwise direction of motor B drives the left direction of the wheelchair. The clockwise movement of both motors at the same time drives the motor in a straight direction. The anticlockwise direction of both motors at the same time drives the reverse direction. The common power supply has the voltage regulators to cut the power 5V for the microcontroller. Buzzer, Bluetooth module, and Ultrasonic sensors are connected with Microcontroller. The Motor driver IC fetches power from the main power supply and drives the motors for the movement. Motor driver IC gets the signal from the microcontroller based on the voice command or if there is the possibility of a collision then the microcontroller sends the stop command to the motor, driver, IC and the buzzer is used to notify a user about the avoidance of collision.
To control the wheelchair by voice command the person has to enter data into the mobile application through voice and that command is translated and sent over by the mobile through the Bluetooth medium. The command received is processed by the microcontroller and if passed then the command is given to the motor driver IC to control the movement. The ultrasonic sensor senses the distance at the delay of half second and if the distance is less than what advises the microcontroller stops the motors and plays the buzzer.

The buzzer flag is used here to avoid the unnecessary use of ultrasonic and buzzer sound the flag makes sure that the buzzer is only played once till the next command is received through Bluetooth, figure 5 shows the control diagram. The control algorithm follows two parallel processes each process follows the below instructions.

1. Person inputs command
2. Command is transmitted over Bluetooth
3. Command is received by the microcontroller
4. Command is validated
5. Command is executed
6. Buzzer flag is set

The second process follows below instructions
1. Check for buzzer flag
2. Check for distance
3. If less than minimum
4. Stop the motors
5. Play buzzer
6. Unset buzzer flag

**Figure 4.** Block diagram of System
6. **Future Scope**

The manual control of the system can be interfaced by using a joystick. The joystick is an input device consisting of a stick that reports its angle and direction to the microcontroller. Based on the angle and direction, the microcontroller will send inputs to the motor driver IC to control the movement of the motors. The direction of the joystick can be used to control the directional movement of the wheelchair.

The speed of motors running wheelchair can be controlled by varying its input voltage. PWM (Pulse width modulation) can be used to achieve this. PWM is a technique where the average value of input voltage is adjusted by sending series of ON/OFF pulses. The duty cycle which is known as the average proportional to the width of pulses can be used to set the speed of motors. The higher the duty cycle, the greater voltage being applied to motors. Some commands e.g., “half-speed”, “full speed” can be programmed to set different duty cycles. In the case of manual control, the angle of the joystick reported to the microcontroller can be used to control the speed of motors; the more the angle is inclined, the duty cycle of the PWM signals will increase which will result in an increase of speed in motors.
7. Conclusion
This research paper proposed and developed a voice-command-controlled wheelchair. Five different commands to control, Collision detection using ultrasonic sensor and alarming using buzzer. The model experimented on the different commands, the motor moved as per the voice commands. This will help the differently able person to direct the wheelchair without any physical support from the other individuals.

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