Raspberry Pi based Multi-optional Wireless Wheelchair Control and Gesture Recognized Home Assist System

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Abstract. Smart Wheelchair is a controlled device designed with the help of the user command to have self-mobility. It reduces the human effort of the user and encourages wheelchair riding. In fact, it also provides an opportunity for physically impaired people to move from one location to another. The main work of this paper is to gain more information, to construct a wheelchair using Raspberry Pi and RF controller to solve the difficulties faced by the physically challenged person. The device is fitted with the RF module, GSM and GPS module, servo motor, wheelchair and the whole module is controlled by wheelchair. To achieve a desire movement, the user will provide input commands to control the wheelchair and it is interfaced by RF communication and voice command. Depending upon the user convenience either RF communication or voice command can be used. Solution has also been proposed during an emergency by using an alert system. The movements received and the hand gesture shown by the visually impaired are recognized and contrasted with the models stored on the receiver. If the templates suit the templates stored then the home appliances are managed accordingly.

Keywords—Wheel chair, Accelerometer, Zigbee module, RF Controller, GSM module, Bluetooth module, Emergency alert system.

1. Introduction

Security and Safety is one of the basic necessities in our day to day life. In many countries, the physically challenged and paralyzed people increases everyday due to the accidents or genetic disorders. According to recent survey by World Health Organization (WHO) it is noticed that about 37.5 % of population were being affected by paralysis, which makes them feel worse in certain situations. These people are always dependent to do their work. So a solution is provided to this problem to make the physically challenged people to move independently from one place to another without anyone’s help. Even though they move outside like other people, safety is very important for them. So, in order to make sure of their safety emergency alert system is provided during their unexpected situation. And also hand gesture method is implemented to control the home appliances through the wireless system by operating from the same place.

This paper is based on the core processor Raspberry Pi and the goal is to achieve automatic locomotion which is obtained by using various interfaces as follows. Disabled people can control wheelchair by simply pressing push buttons that can shift in any direction they choose. Likewise, wheelchairs can be operated by using android Voice Commands. The wheelchair circuit consists of an RF and Bluetooth receiver which are used to receive these commands and then control the wheelchair motors to achieve the desired motion. It helps the disabled person to comfortably control the wheelchair and another person to operate the wheelchair from a distance of 3-4 metres. Therefore, using the Raspberry Pi-based wheelchair the system is taken to a new level through the use of automation and security by the user [1].
The aim of this design is to assist the visually challenged people to independently control the home appliances. Using a Micro electromechanical system (MEMS) accelerometer, a hand in motion accelerometer is sensed in three perpendicular directions (x, y and z) and transmitted via Zigbee to the wireless protocol. The models for the gesture code are already located at the receiver segment in the microcontroller. The movements received and the hand gesture shown by the visually impaired are recognized and contrasted with the models stored on the receiver. If the templates suit the templates stored then the home appliances are managed accordingly.

Independent mobility is essential for physically disabled people to develop physical, cognitive, communicative and social skills. The electric wheelchairs are highly priced. Hence, this model aims to build a more complex control scheme for electric wheelchairs. The main problem of the wheelchair is that the disabled person cannot use it, so the type of mechanical assistance that a disabled person needs to move around depends largely on the extent of his or her disability. So, there's no need to manage behind the seat to let another person drive it [2].

Literature Survey is an essential stage in the system expansion cycle as it is used to gather and it helps to analyze the important information needed for this aspect. A literature review is a detailed description of the thesis related to a specific topic and field. Earlier wheelchair motion can be controlled by physical actions, but electrical wheelchair would drive the wheelchair by using electrical and electronics components. Here there is no external force for motion. Mobility of the differently able or the Paralysed people a major problem of society. This paper focuses on designing a mobility aid to travel from one place to another for the physically challenged persons. Joystick mobility aid wheelchair based controller that has been designed for all possible direction of motions such as left, right, forward and back. In addition, the DC geared motors are used for wheel movement for the purpose of lower chair speed movement which is useful for the physically disabled [3]. Since the wheelchair is called a smart wheelchair, this paper uses the power of the lead acid batteries that are rechargeable, harmless and weightless compared to other batteries available. It also focuses on the integration of the GPS and GSM system which is used for the localization task and also a mobile application was designed for the convenience of the caretaker with the aid of the MIT application developer to know the person’s location in the wheelchair through Google maps [4].

In this paper Raspberry Pi is used to construct the prototype of the wheelchair and home automation is also done using gestures. Section 2 describes about the modeling and design of the prototype. Section 3 presents the results and discussion of the wheelchair prototype. Finally, Section 4 presents the conclusion of this paper.

2. Modelling and Design of the Prototype of the Wheelchair

2.1. Block diagram of the prototype of the wheelchair: A handicapped person needs a wheelchair to perform functions that allow him or her to travel about. It is therefore important to provide them with a motorized wheelchair which can be operated either by pushing a joystick or by voice commands. All of this should be accomplished at a rate that is affordable to people with disabilities and also to organizations assisting them [5-35]. In emergency time there are no facilities for them to communicate with their colleagues, family or their friends. This would be very useful for paralysed people when they meet some difficulties. But it is not proposed in any existing model.

The components required for building this prototype is tabulated below

| Sl.No | COMPONENTS | RANGE  | ROLE                      |
|-------|------------|--------|---------------------------|
| 1.    | Raspberry pi | 4.75-5.25V | Core of project           |
| 2.    | Pic 16F877 | 2.0-5.5V | Controlling Zigbee        |
| 3.    | Four channel relay | 4.5-36V | Send supply to motor      |
| 4.    | RF Transmitter and Receiver (8-bit) | 5V | Transmit and receive signals |
| 5.    | Zigbee Transmitter and Receiver | 2.7-3.6V | For home automation       |
|   | Component                     | Voltage | Description                          |
|---|-------------------------------|---------|--------------------------------------|
| 6. | Accelerometer                | 2.5V    | Sensing element                      |
| 7. | LCD Display                  | 12V     | Showing commands or instructions     |
| 8. | DC Motor                     | 12V     | For movement                         |
| 9. | Battery                      | 12V     | Power source                         |
| 10.| Bluetooth module (HC-05)     | 5V      | For voice mode                       |
| 11.| SPDT toggle switch           | 5A      | Shifting modes                       |
| 12.| Transformer                  | 12V, 1A | For stepdown voltage                 |
| 13.| Single channel Solid State Relay | 12V | Control home appliances               |
| 14.| GPS Module                   | 5V      | For emergency mode                   |
| 15.| LM 7085                      | 7-35V   | Motor control                        |
| 16.| Tactile push button          | -       | For input commanding                 |
| 17.| SPDT Rocker switch           | -       | On/Off switch                        |

The raspberry pi is the core of the project and is connected with RF receiver. The raspberry pi is connected with RF receiver which can receive a signal that can be transmitted from the RF transmitter. The input commands can be given to the raspberry pi by pressing the tactile push button. The input commands given by the user can be sent to the raspberry pi through the RF transmitter.

The voice mode can be obtained by using the Bluetooth module and through mic. The Bluetooth module can receive the signal from mic which can be located on the smartphone. The Bluetooth module is connected to the raspberry pi. According to commands given by the user, the raspberry pi drives the motor.

The emergency alert system can be achieved with the help of the GSM module. The GSM module is connected to the Raspberry pi. When the user presses the emergency button, the GSM module locates the signal and sends the location to the contacts that can be saved in the Raspberry pi.

PIC16F877 is used to control the home appliances. It is connected with the accelerometer and ZIGBEE transmitter. The home appliances can be connected with the ZIGBEE receiver. The overall power supply can be supplied with the two 12V DC battery which can be connected in series.

The figure 1 shows the block diagram of electric wheelchair and hand gesture based home automation.
Figure 1: Block diagram of the prototype of the wheelchair

2.2. Design of the Experimental Setup
In this circuit, the 16F877 microcontroller is used. It consists of 40 pins, in which the 11th and 31st pin is connected with positive terminals and the 12th and 32nd pin is connected with negative terminal. Here the controller gets 5V supply from the battery. The pin 13th and 14th is connected with the crystal oscillator and also the pin 1 is connected with memory layer with the reset switch. Raspberry pi is a small CPU and it consists of 24 ports, in which 5V, GND, 4 I/P pins are connected with the RF receiver and also there are 4 O/P pins. The Bluetooth module and toggle switch is connected to the raspberry pi to change the modes of operation of wheelchair. The RF transmitter has 4 pins, port Vcc and GND is connected to the terminals of the battery and the port DATA is connected to buttons for getting input command from the user. The port 7 and port 11 of raspberry pi is connected to the relay to drive the motor.

Accelerometer sensor is an analog pin which has three dimensional values (X, Y, Z). The Vcc and GND port of the accelerometer is connected to the supply and port x out, y out, z out is connected to AN0, AN1, AN2 of pic 16F877. Through accelerometer the input command can be given to the pic and the pic microcontroller transmit the input command to ZIGBEE.

The ZIGBEE module has both transmitter and receiver. The transmitter is connected to pic 16F877 and the receiver is connected to the relay for ON/OFF circuit. GSM module is connected with the 12V supply from the battery. The GSM module is connected to the pic16F877. LCD has 3 control and 4 data pins such as (b0, b1, b2) and (b4, b5, b6, b7).

The pic 16F72A consists of 28 pins; in this 8th, 19th pins are connected to the ground. The stepdown transformer is connected with the rectifier circuit. The transformer helps to stepdown 230V AC supply to 5V AC supply. Solid state relay has two pins (CO, C1). It helps to ON/OFF the home appliances.
The figure 2 shows the circuit connection of smart wheel chair using Raspberry pi and RF controller.

Figure 2: Circuit connection of smart wheelchair using RF module

2.3. **Structure and operating modes of the wheelchair**: The operation of the electric wheelchair helps the physically challenged people to make them feel secured and convenient. The figure 3 and figure 4 shows the general modes of wheelchair and the workflow respectively.

Figure 3: General modes of wheelchair
The proposed wheelchair is designed with different types of operating modes, emergency alert system and home automation system. The wheelchair can be operated by two different modes of operation for their convenience. The different modes of operation are

- Joystick Mode
- Voice control mode

On considering the safety of the user the emergency alert system can be provided for them. The user can switch ON/OFF their home appliances with the help of an accelerometer.

The proposed wheelchair has two modes of operation. The Fig 3.9 shows the operation flow of a wheelchair. The touch mode can be achieved with the use of raspberry pi and RF controller. At first the raspberry pi recognizes the user commands. According to the commands the motor operation can be performed. For “BUTTON 1”, the motor runs forward. For “BUTTON 2”, the motor runs in the reverse direction. For “BUTTON 3”, the wheelchair turns rightward. For “BUTTON 4”, the wheelchair turns leftward.

The voice mode can be achieved with the help of android smartphone and Bluetooth module HC-05. When the voice is on, the first Bluetooth device of the phone and Bluetooth module will be paired. The Bluetooth device of smartphone will act as transmitter and Bluetooth module acts as receiver. After pairing open “Arduino voice control”, application in smartphone. Through this

![Workflow of wheelchair](image_url)
application user can give command to the wheelchair. The voice command will be transmitted to the raspberry pi. According to the commands the motor operations can be performed. For voice command “FORWARD”, the wheelchair moves forward direction. For voice command “BACKWARD”, the wheelchair moves reverse direction. For voice command “RIGHTWARD” the wheelchair turns rightward. For voice command “LEFTWARD” the wheelchair turns leftward. The wheelchair would be stopped when user instructs “STOP”.

The following table shows the direction of rotation of motor according to the command given by user.

| VOICE MODE | TOUCH MODE | INSTRUCTED COMMAND | MOTOR 1 (RIGHT) | MOTOR 2 (LEFT) |
|------------|------------|--------------------|-----------------|----------------|
| Forward    | Button 1   | Move forward       | Anticlockwise   | Anticlockwise  |
| Backward   | Button 2   | Move backward      | Clockwise       | Clockwise      |
| Rightward  | Button 3   | Turn right         | Anticlockwise   | Clockwise      |
| Leftward   | Button 4   | Turn left          | Clockwise       | Anticlockwise  |

2.4. Emergency Alert System: The Fig 5 shows process occurs when the emergency alert system is activated. The GSM module will receive the signal from the raspberry pi. After it receives the signal, the GSM module call the contact that would be imported and also sends the message that is “NEED HELP…EMERGENCY”.

2.5. Home Automation system: The process flow and algorithm of home automation are explained in section below. In this paper the proposed method is to make a wheelchair to control home appliances through ZIGBEE module. The ZIGBEE module has both transmitter and receiver. The transmitter circuit is placed on the wheelchair and the receiver circuit is placed on the main board. The input command given by the user is recognized by the accelerometer. The accelerometer is a sensor used here to analyze the hand gesture of users. The following Fig 6 shows the functional representation of home automation system.
The user gives the input command through hand gesture. The accelerometer recognizes the user commands according to their hand gesture and it sends the input signal to the ZIGBEE transmitter. The ZIGBEE transmitter transmits the signal to the ZIGBEE receiver module. According to the input command it will sends output signal to the relay. When the relay is closed the circuit will close. For switching off the home appliances the relay will be opened and there is no flow of current.

3. Results and Discussion

The following sections deals with the different stage of home automation.

3.1 Initial stage of home appliances

The home appliances can be operated with the help of hand gesture control system. Inorder to ON/OFF the different loads, we use the accelerometer sensor. Initially this Fig 7 show that the loads are in OFF state.
3.2 LOAD 1 IN OFF STATE

When the accelerometer sensor is in downward direction, then the load 1 is in off condition using a hand gesture module. The figure 8 shows that the sensor is in downward direction and load 1 is in OFF state.

![Figure 8 Load 1 in OFF state](image)

3.3 LOAD 1 IN ON STATE

When the accelerometer sensor is in upward direction, then the load 1 is in ON state using a hand gesture module. The fig 9 shows that the sensor is facing upwards and the load is in ON state.

![Figure 9 Load 1 in ON state](image)

3.4 LOAD 2 IN ON STATE

When the accelerometer sensor is in rightward direction, then the load 2 is in ON state, with the help of hand gesture module. The fig 10 shows that the sensor is in rightward direction and load 2 is in ON state.

![Figure 10 Load 2 is in ON state](image)
3.5 LOAD 2 IN OFF STATE

When the accelerometer sensor is in leftward direction then the load is in OFF state, with the help of hand gesture module. The fig 11 shows that the position of sensor when the load 2 is in OFF state.

![Image](image_url)

Figure 11: Load 2 is in OFF state

4. Conclusion

This prototype for the wheelchair is a hybrid system embedded with mechanical, electrical and communication unit. This system is beneficial to physically disabled or paralysed people, which eliminates the need of caretakers in every situation. This provides opportunity for them to overcome their difficulties by self-accessing technique integrated in the system, such as home automation, emergency alert and motion of wheel chair. For efficient communication of command signal accelerometer sensor, ZIGBEE module and RF controllers are used. Long range of communication is made possible with the help of ZIGBEE and RF controller. It enables easy access by simply pressing the respective button which then sends signal to the controller and the controller controls the operation as per the command.

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