Micro-Controller Based Intelligent Wheelchair Design

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ABSTRACT **–** This work deals with a design of an Intelligent Powered Wheelchair (IPW). The usage of robotic and intelligent systems technologies helps to overcome the challenges faced by physically challenged person. To monitor and control the system a microcontroller has been employed. The obstacle detection and avoidance is done by Sensor Unit. In the age of automation this is seemingly major application area of service robots in the near future. Many people with mobility impairments who require the use of powered wheelchairs will surely benefit from this application. Previous work of Intelligent Wheelchair lacked automation within them. This project uses an interactive system which overcomes the difficulties of manual systems.

Keywords - Intelligent, Obstacle detection, Voice recognition, Sensor Unit, Microcontroller.

I. INTRODUCTION

Wheelchair becomes an integral part of the physically and visually challenged. These are extensively used in many public gatherings, especially in hospitals. Powered wheelchairs, i.e. joystick controlled wheelchairs is now common among many high class hospitals [1]. These electrically powered wheelchairs face a threat of obstacles. Moreover, maneuvering is a tedious process, which requires loads of training under supervision.

When combining this equipment with the sensors it becomes an Intelligent Wheelchair (IW) [2]. This advancement in technology led to detection of obstacles in its path and alarming the user. Further advancement in this technology led to detection of highly specialized sensors such as Global Positioning System (GPS) for outdoor navigations [3]. But this system cannot be used for indoor navigation.

Many forms of IW have been developed such as voice controlled [4] and lip movement controlled IWs using microphones and cameras respectively [5]. Both these systems have a fatal problem of unnecessary movements due to conversations. A recent design in this field is the use of Wi-Fi technology for indoor navigation [6]; but Wi-Fi cannot be expected in all places.

Certain designs include combining voice and joystick control for the navigation, switching between them whenever necessary [7]. In addition, works have been done in controlling the IW using face gestures by placing a webcam in front of the user [8]. Design of Iris controlled IW is steered by the movement of the eyes in a specified manner [9].

In IPW, a design for controlling of IW using joystick, voice, and a Graphical User Interface (GUI) design for maneuvering and a specific algorithm for obstacle detection and automatically guiding the IW away from it is devised.

II. PROPOSED MODEL

The proposed model shown in the Fig.1 includes the elements of the intelligent wheelchair, starting from microcontroller which is the brain of the design. The next input units' microphone and a keypad for motion control. Microphone is used to get the voice commands from the user and convert those into electric signals. This electric signal is given as the input to the HM2007P IC which is voice recognition, recording and comparing chip. A keypad is used for manual maneuvering of the IW in a traditional way.

The microcontroller calculates the distance and angle from the input and steer the system in the necessary direction before moving further. Sensors of

Ultrasonic rays are provided for detecting the obstacles. If any obstacle is detected, an interrupt is provided, which in turn runs a special algorithm for collision avoidance and following a new course. The final unit is the motoring part consists of the driver circuit for the motor which is a stepper motor.

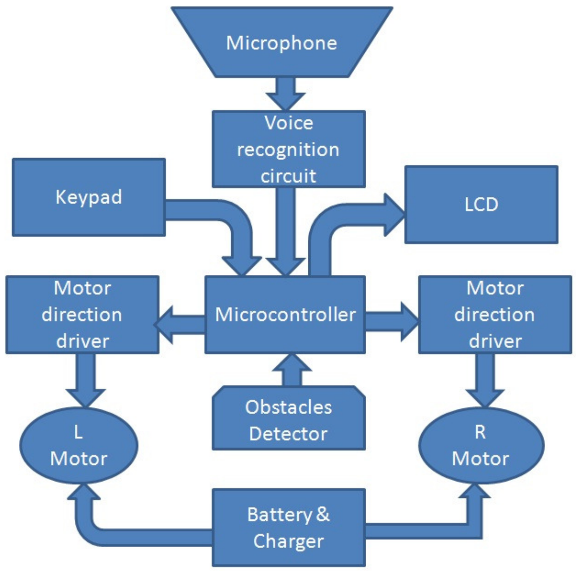
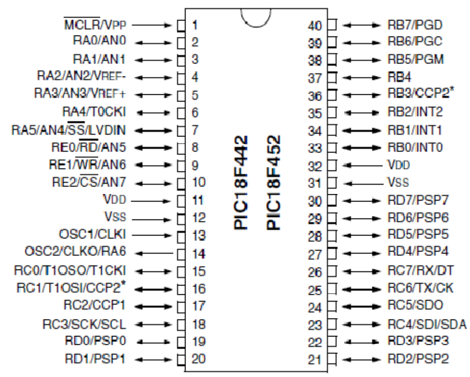


Figure - 1 Block Diagram

A.Microcontroller unit

The microcontroller used in this design is a Peripheral Interface Controller (PIC) series of 18F452. It interfaces the motoring unit, input devices and sensors together. The controller has 40 pins with five I/O ports, ten bit A/D convertor, a Pulse Width Modulation generator with four timers. It controls the motors, voice recognition unit and obstacle sensing dodging.



Figure–2 Microcontroller Pin Diagram

B.Obstacle Detection Unit

The obstacle detection is performed by five GH-311 ultrasonic sensors. The GH-311 sensors detect objects by emitting a short ultrasonic wave (40 kHz) and receiving the reflected echo. Receiving this echo from particular sensor will invoke a particular algorithm which dodges the obstacle in pre – programmed path according to the position of the obstacle after dodging. The obstacle detection and inputs from the sensors and wheelchair's corresponding dodging direction is given in the Table-1.

Direction	Inputs from port A
Left	02, 03, 05, 06, 07, 0F, 0A
Right	04, 08, 0C, 0E, 14, 18, 1C, 1E
Backward left	09, 0D, 0B
Backward right	12, 16, 14
Full stop	13, 15, 17, 19, 1B, 1D, 1E
Soft left	01

Soft right	10
Straight	11

Table-1 Obstacle Bypassing

Each unit senses any obstacle in the range of 2 centimeters to 3 meters with sensing angles confined to 15 degrees. The unit considers water and wet surfaces also as the obstacle thus avoiding any hazardous environments. The units detect all types of movable obstacles such as humans, pet animals, etc and immovable obstacles such as wall, furniture, etc in the size greater than 2 centimeters.

C. Stepper Motor Driver Circuit

Four stepper motors are used for movement of the wheelchair. Continuous movement of the wheelchair is achieved by operating the motor in multi-stepping operation. The unipolar stepper motors are directly controlled by the PIC 18F452 microcontroller through the motor driver IC ULN2003A. The movement of the wheelchair is controlled by either individual or combined action of all four motors. It is provided in the Table-2.

Movement	Left	Right
Forward	ON	ON
Turn Right	ON	OFF
Turn Left	OFF	ON

Table -2 Direction control

D.Voice recognition unit

This unit consists of a microphone and a HM2007P chip which is a Large Scale Integration (LSI) circuit with analog front end and control system embedded in a single chip Complementary Metal Oxide Semiconductor (CMOS). Along with this an external memory (HM6264A IC) of 64K external RAM is used by the HM2007P IC for storing the commands to be utilized during the operation. It operates at 95% accuracy with dependent recognition mode. This board also consists of membrane keypad, HM6264A Static Random Access Memory (SRAM).

E.Membrane Keypad

A set of six keys are provided to the system for its operation. Three keys are directly connected to the interrupts of the microcontroller. One for choosing the keypad control motion of the system, second interrupt for switching over to voice control system, final interrupt for turning on Touring Guide mode of the system.

The other three keys are for movement control of the system. The Wheelchair moves in the direction according to the key pressed either forward, left or right. Backward movement of the wheelchair is achieved by pressing both the left and right keys at the same time.

Another nine set of keys arranged in matrix form is provided in a default manner to the HM2007P project board and is used for recording and voice command trainings.

F.Inputs to The system

As discussed in the previous block, keypad is used for hand controlled movement of wheelchair and selection of wheelchair operating mode. A microphone is used to receive the voice commands from the user. Ultrasonic sensors are used to detect the obstacles on the path of the wheelchair. Another ultraviolet sensor is used which is embedded in the microphone. The system follows this sensor wherever the user moves. This is achieved in touring guide mode.

III. WORK DESCRIPTION

All the described circuits are assembled together in one board which is the motherboard of the wheelchair. It includes the PIC 18F452 microcontroller which is interfaced with HM2007P board, key pad. LCD, obstacle sensors and stepper motors through port B (B0-B7), port E (E0-E2 and

B0-B2), port C (C0-C7), port A (A0-A4) and port D (D0-D7) respectively.

Port B receives an eight bit Binary Coded Decimal (BCD) number from the voice recognition kit. Each number represents a voice command as described in the HM2007P IC it lies between 1 and 40. The mismatch in voice recognition is represented by specific numbers 55, 66, and 77 which represents short word, long word and mismatch respectively.

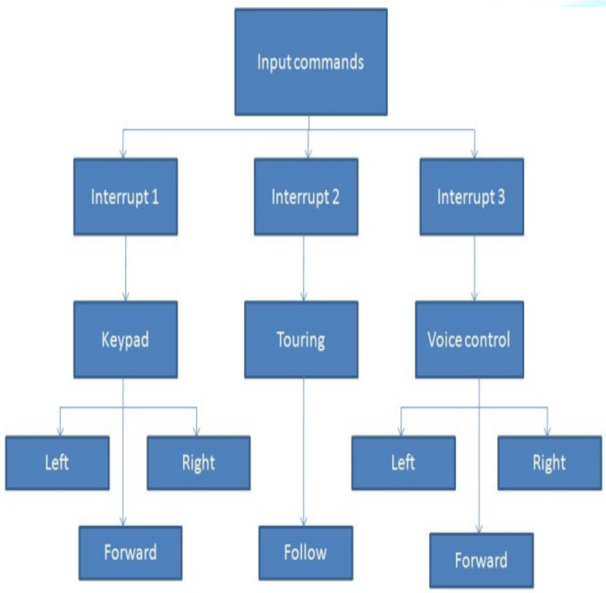


Figure-3 Program Flow

An ultraviolet sensor attached to the headphone transmits a signal which is received by a receiver in the system. A voice command is given to the HM2007P which commands the system to follow the user wherever the user moves.

The microcontroller is programmed to give the necessary command to the LCD and motor ports for each BCD received from HM2007P, to follow the guide and inputs from the keypad. The wheelchair can be operated in any of the three above mentioned ways. Each controlling way is given as an interrupt to the system. The programming methodology is given in the Figure 3.

The ultraviolet sensors are placed in the system, such a way three ultraviolet sensors are placed in front of the system for higher accuracy. Two sensors are placed at the sides of the wheelchair for sensing the obstacles, detecting walls and going through doors.

The system responds only to particular voice commands. If any other user tries for commanding the wheelchair, the system do not responds. For other users to use the system they have to go through to a voice training course.

IV. RESULT AND DISCUSSION

The keypad cum voice control gives a facilitated control over the wheelchair. Moreover, the automatic obstacle bypassing makes the system handy in runtime changing environment. The system maneuvers most of the obstacles successfully, except for some combination of inputs obtained from the port-A. For these inputs the wheelchair makes a stop and provides an error signal to the user through buzzer. These inputs corresponds to the position of obstacles such that wheelchair cannot successfully maneuver.

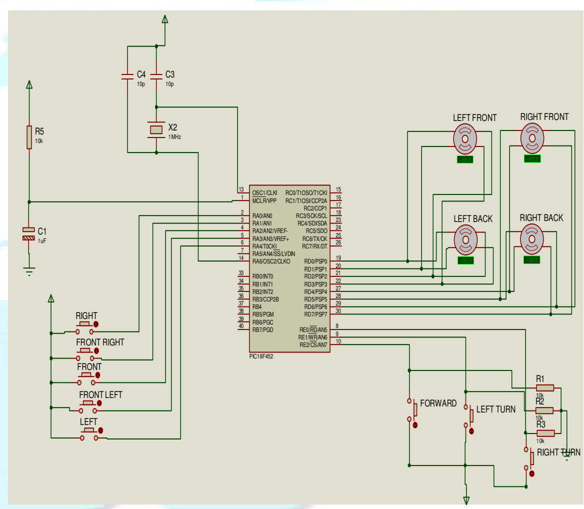


Figure-4 Simulation Model

The simulation for the obstacle detection is performed using"Proteus-8" simulation software and the results are accurate. The coding for PIC18F452 is done using PICC Compiler and Micro-Processor Lab IDE version 8.10. The programming is done in C language and converted into hex file which is then loaded into the microcontroller.

The design successfully maneuvers through the obstacles whenever detected. IW also steers around the obstacle while operating in voice control mode. The design specifications of the prototype are given in the figure-4.

V. CONCLUSION

In this paper, Intelligent Wheelchair with keypad control, voice control and Obstacle detection cum avoidance is designed and simulated using the Proteus-8. The programming for the microcontroller is performed using the PIC C Compiler, which generates the hex file for the controller. The design is cheap compared to the powered wheelchairs in the market. The disadvantage of this system is that it cannot bear a weight more than 75 kgs. It can be over came by using Pulse Width Modulation (PWM) technique for driving the motors and replacing stepper motors with Brushless DC motors.

VI. FUTURE WORK

Hardware implementation of the proposed work is to be done in the near future. Furthermore in future work to be done is to include a self map generating circuit for the wheelchair which can be used in any kind of runtime changing environment and integrate the wheelchair to a laptop or a smart phone for displaying map.

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