Idea Lab Project Report

DEVELOPMENT OF A SMART WHEELCHAIR FOR THE DISABLED

Submitted By

Snigdha Purohit (12BEE039)

ELECTRICAL ENGINEERING DEPARTMENT

INSTITUTE OF TECHNOLOGY

NIRMA UNIVERSITY

AHMEDABAD-382481

MAY - 2016

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Under the mentorship of

Prof. P.N. Kapil

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Declaration

We do hereby declare that the technical project report submitted is original, and is the outcome of the independent investigations/research carried out by us and contains no plagiarism. The research is leading to the discovery of new facts/techniques/correlation of scientific facts already known. This work has not been submitted to or supported by any other University or funding agency.

We do hereby further declare that the text, diagrams or any other material taken from other sources (including but not limited to books, journals and web) have been acknowledged, referred and cited to the best of our knowledge and understanding.

Date:

Place:

Signature of Student	Signature of Mentor
12BEE039	Prof. P.N. Kapil

NIRMA UNIVERSITY

INSTITUTE OF TECHNOLOGY

IDEA LAB

ELECTRICAL ENGINEERING DEPARTMENT

Annual/Final Report of the work done on the Idea Lab Project. (Report to be submitted within 3 weeks after completion of the project)

1. Idea Lab Project ID: IDEA-2015-EE-01

2. Project Title: To prepare a proto type of a smart wheelchair for disabled and aged people".

3. Period of Project: July 30, 2014 to November 25, 2015

4. (a) Name of Student (Roll No.): Snigdha Purohit (12BEE039)
   Department: Electrical Engineering Department

   (b) Name of Mentor: Prof. P.N. Kapil

5. Project Start Date: July 30, 2014

6. (a) Total Amount Approved: Rs. 15000/-

   (b) Total Expenditure: Rs. 2940/-

   (c) Report of the work done:

   i. Brief objective of the project: This project aims to design a wheelchair which offers ease of control for the disabled people who cannot drive wheelchair with their limbs.

   ii. Work done:

Two approaches of smart control , namely, "Computer Vision based control" and "Darlington Pair Amplifier based control", have been presented. A robotic model of a wheelchair was prepared employing the Darlington pair amplifier based control was prepared.

iii. Results achieved from the work (Give details of the papers and names of the journals in which it has been published or accepted for publication and also about project competition won):

Project completed

iv. Has all the objectives been achieved as per plan. If not, state reasons.

Yes

v. Please indicate the technical difficulties, if any, experienced in implementing the project

No

vi. If the project has been completed, please enclose a summary of the findings of the study

A finger touch button based wheelchair can be developed using Darlington Pair Amplifiers. This method provides a cost effective method of control for a wheelchair.

Signature of Student

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Contents

Declaration iii

Final Report iv

1.1 Introduction 1
1.2 Literature Survey 1
1.3 Major Objectives Proposed 4
1.4 Objectives Achieved 4
1.5 Objectives Not Achieved 4
1.6 Experimental Setup and Results 5
1.7 Budget Analysis 13
1.8 Conclusion and Future Work 14

References 15

Appendix 16

1.1 Introduction

This project aims to design a wheelchair which offers ease of control for the disabled people who cannot drive wheelchair with their limbs. Two approaches of smart control, namely, “Computer Vision based control” and “Darlington Pair Amplifier based control”, have been presented. Both the approaches have been studied and their feasibility of implementation has been checked.

1.2 Literature Survey

1.2.1 The MS Kinect Sensor

Kinect is a line of motion sensing input devices by Microsoft for Xbox 360 and Xbox One video game consoles and Windows PCs. Based around a webcam-style add-on peripheral, it enables users to control and interact with their console/computer without the need for a game controller, through a natural user interface using gestures and spoken commands.

Figure 1: Kinect Xbox 360 sensor

There's a trio of hardware innovations working together within the Kinect sensor:

- **Colour VGA video camera** - This video camera aids in facial recognition and other detection features by detecting three colour components: red, green and blue. Microsoft calls this an "RGB camera" referring to the colour components it detects.

- **Depth sensor** - An infrared projector and a monochrome CMOS (complimentary metal-oxide semiconductor) sensor work together to "see" the room in 3-D regardless of the lighting conditions.

- **Multi-array microphone** - This is an array of four microphones that can isolate the voices of the players from the noise in the room. This allows the player to be a few feet away from the microphone and still use voice controls. [1]

1.2.2 Block Diagram and Operation of the Proposed Scheme

The computer vision system described below enables driving the wheelchair with a minimum number of finger commands. The user hand is detected and segmented with the use of a kinect camera, and fingertips are extracted from depth information, and used as wheelchair commands. The kinect is used to gather depth information for hand segmentation and finger detection.

The user hand is segmented with the help of two planes that define the minimum and maximum thresholds of the extracted depth array. After hand segmentation the fingertips are extracted using the k-curvature algorithm. The index finger is used to control the forward movement and turning left or right (Figure 2 - a, b, c) and the thumb control the lateral displacement to the left or right (Figure 2 - e, f). Movement to the rear is controlled with two fingers in 'V' (Figure 2 - d). Closed hand is the stop command. [2]

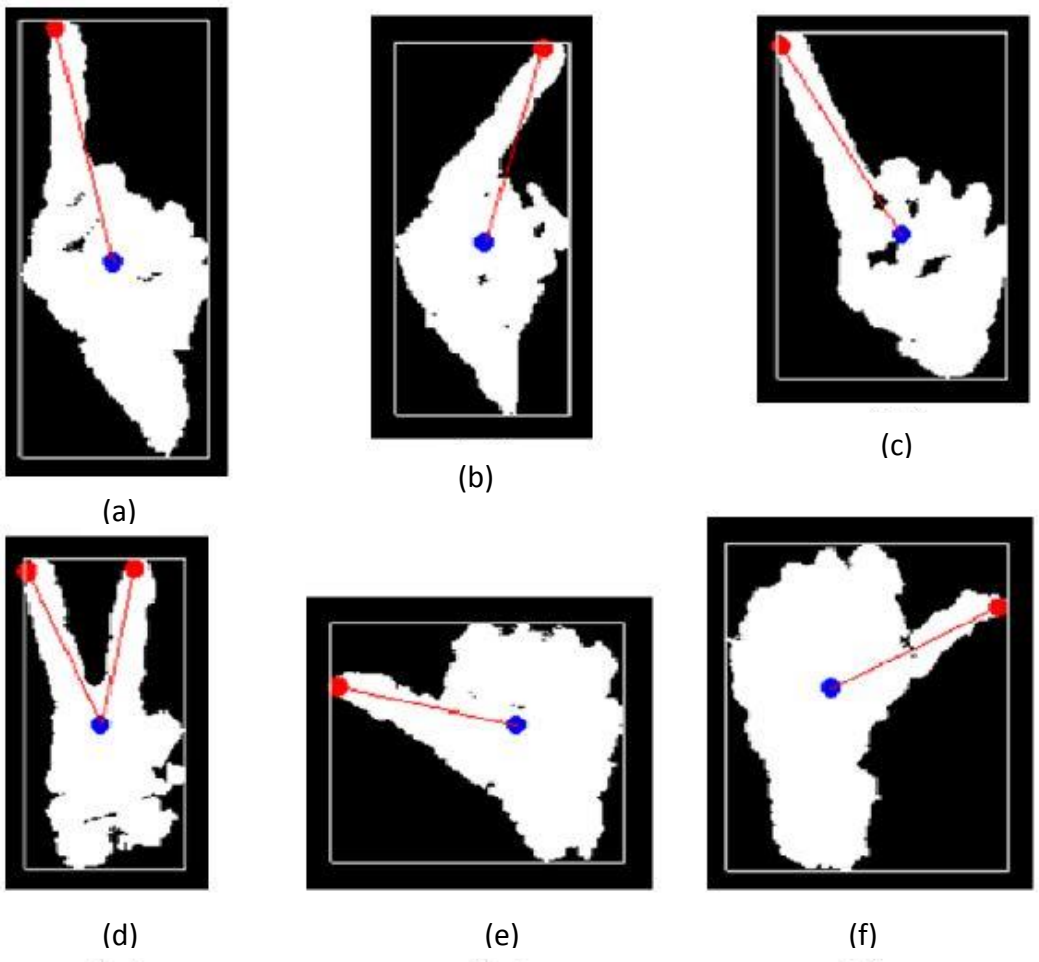

Figure 2: Finger commands used to control the wheelchair. (a) move forward, (b) turn right, (c) turn left, (d) move backwards, (e) move left, (f) move right

A. Hand segmentation

In order to segment the hand region, the nearest point to the camera is calculated on each frame. For each time t, the closest point on the depth image is calculated. Using this value, two parallel planes are defined to extract the hand blob from which the contour is calculated. The hand contour is then used to detect fingertips using the k-curvature algorithm.

B. K-Curvature Algorithm

The k-curvature algorithm is an algorithm that attempts to find pixels that represent hand peak and valley points. [2] Presents a detailed algorithm to find out hand peak and valley points from the segmented image.

[3] and [4] present different algorithms for gesture identification.

C. Signal to the controller

Based upon the pattern of hand peak and valley points, suitable signals are sent to the controller to actuate the operation of the motors causing movements such as left, right, forward and backward.

Figure 3 shows the steps involved in vision based control of the wheelchair.

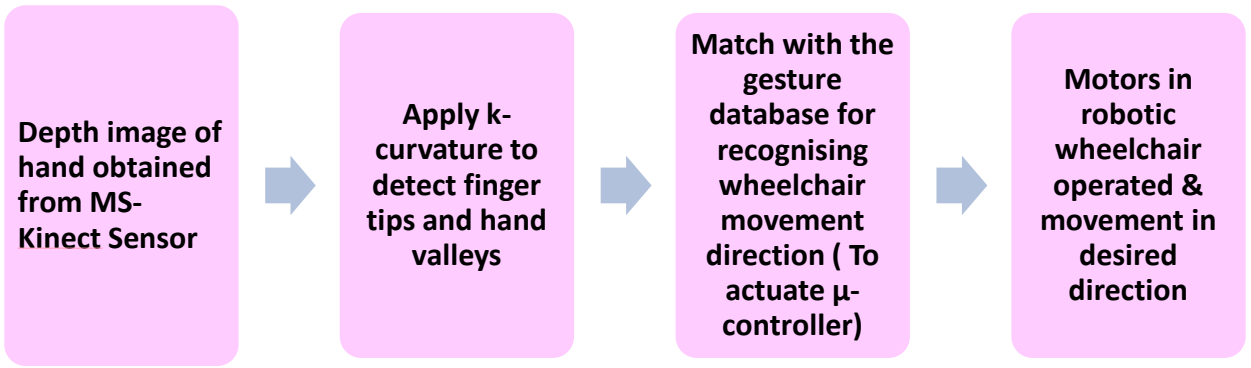

Figure 3: Steps in Vision Based Control

1.3 Major Objectives Proposed

The major objective is the development of a smart technique to control a wheelchair. A strategy of control which helps the disabled to control a wheelchair with minimum effort and effectiveness needs to be designed. A finger touch based strategy of control has been proposed and the same is taken up for implementation.

1.4 Objectives Achieved

The approach of "Darlington Pair Amplifier based control" was taken up for the implementation of smart control. It was found to be more suitable and feasible than the "Computer Vision based" approach. It gives us a finger touch based control. When the finger is placed on the touch buttons, the wheelchair successfully shows movement in the desired direction. The response of the system is also found to be excellent. As soon as the finger is withdrawn from the touch buttons, it stops immediately. As per the MikroC program in the PIC controller, suitable PWM pulses cause the wheelchair to move forward and backward with a higher speed than when it is turning left or right.

This approach gives an excellent response in terms of sensitivity and operation. It provides smart control of wheelchair in a cost-effective manner.

1.5 Objectives Not Achieved

The first approach proposed based on Computer Vision involved the concepts of digital image and video processing and many complex algorithms and codes which became abstruse to understand and hence difficult to implement within the timeframe of the project. Also, this scheme was costlier to implement as the MS Kinect Sensor involved a high cost which conflicted with the aim to develop a low cost control strategy.

1.6 Experimental Setup and Results

1.6.1 Block Diagram and Operation of "Darlington Pair Amplifier based" scheme

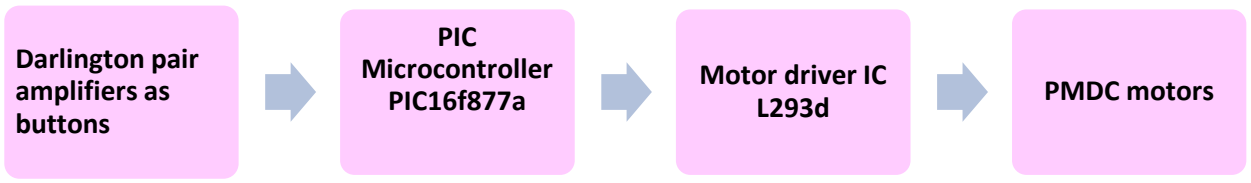

Figure 4: Block Diagram of the Darlington Pair Amplifier based scheme

- The touch based control board consists of four Darlington pair amplifiers as touch buttons. The small current passing through the finger acts as base current to the amplifier which gives a higher current as its amplified output. This output current is then given to the input pins of PIC microcontroller.

- The PIC controller takes input from the touch based control board. The controller is then programmed in such a way that according the touch button activated, it gives output to the two terminals of two PMDC motors. The controller is programmed to give PWM voltage pulse output at the output port pins. The wheelchair is intended to move slower while turning left or right whereas a faster movement is desired for forward or backward movement. Hence, lesser PWM pulses are given to the motor when the touch button for left/right turn is touched. Similarly, more PWM pulses are given when the touch buttons corresponding to forward and backward movement are touched.

- The output at the pins of the PIC microcontroller is 5 volts which is insufficient to operate the motors rated for 12 volts. Hence, the motor driver IC L293d is used in between to convert the 5 volt pulses at output pins of PIC to 12 volt pulses to be given to the PMDC motors for desired operation.

- The two motors rotate in anti-clockwise or clockwise direction and produce the basic four movements: left and right turn; and forward and backward movement.

1.6.2 Hardware implementation of wheelchair

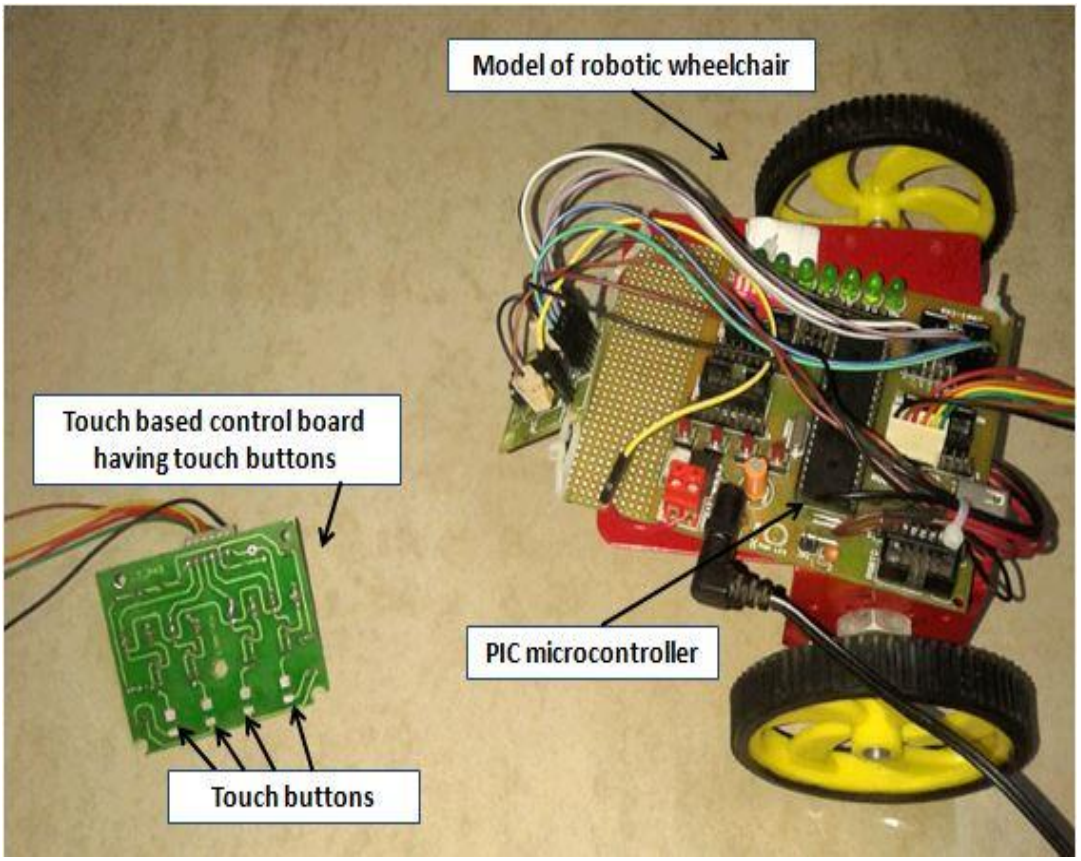

Figure 5: Overall view of the proposed scheme

Figure 5 depicts the overall view of the proposed scheme. The robotic wheelchair body consists of a metallic frame having circular slots for attaching motors and wheels. It has a tricycle type structure wherein there are two wheels on the back end and a rotating ball is kept on the front end. As per the rotation given to the motor, the wheels move in the specified direction (clockwise or anti-clockwise) and the rotating ball helps in the smooth rotation about its centre of gravity.

There are four touch buttons embedded on the PCB board on the left. They are used to provide touch-based control of the wheelchair. The PIC microcontroller development board and PCB containing motor driver IC L293d have been fixed on the wheelchair body.

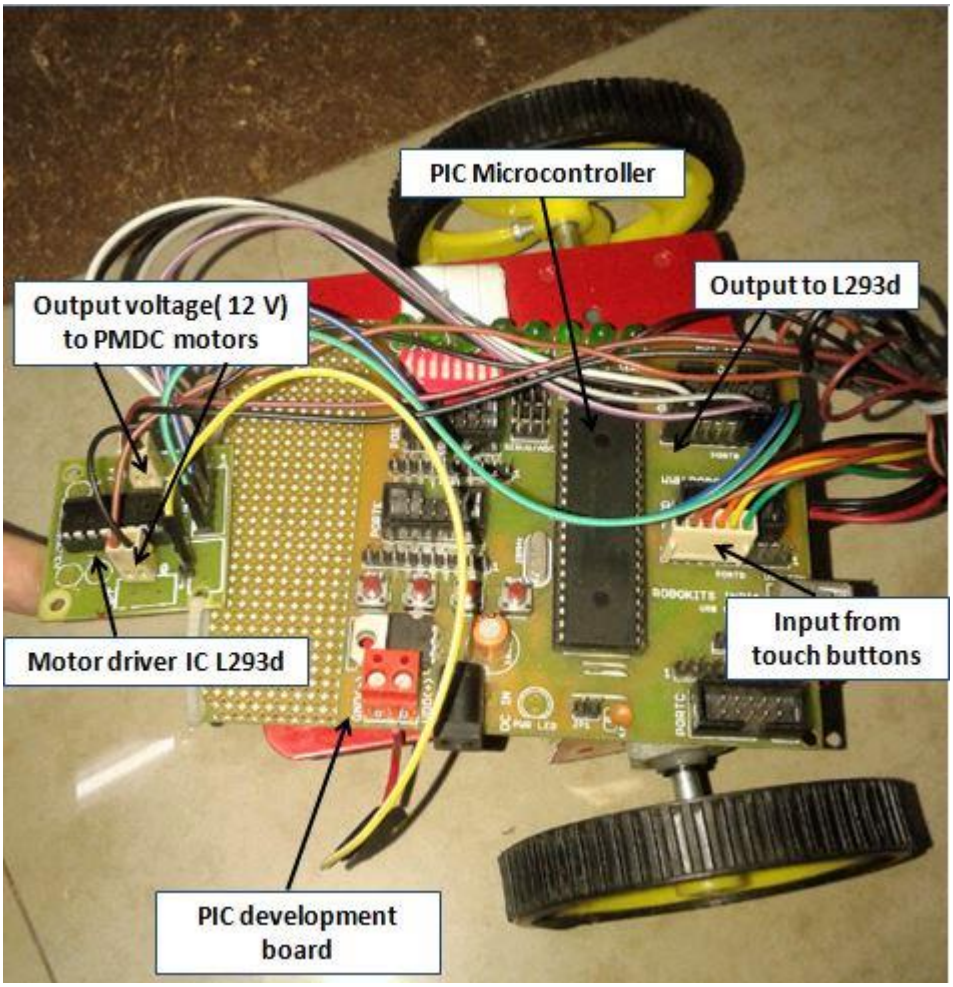

Figure 6: Connection scheme of PIC controller and motors

Figure 6 depicts the connection scheme of PIC controller and motors. It can be clearly observed that the input from touch buttons is given to one of the ports of PIC controller. The pins of the output port are given to the PCB of Motor driver IC L293d. The motor driver IC amplifies the 5 volts output voltage from PIC controller to 12 volts to be given to the two motors. The connection of two terminals of each motor can be seen on the PCB of motor driver IC.

Figure 7 shows the view of the wheelchair model from underneath. There are two PMDC motors of rating 12 volt, 60 rpm. They are fixed on two sides of the robotic model. We get a tripod structure on incorporating the metallic ball. The metallic ball helps in achieving a smooth turning operation as well as it provides support to the robotic structure.

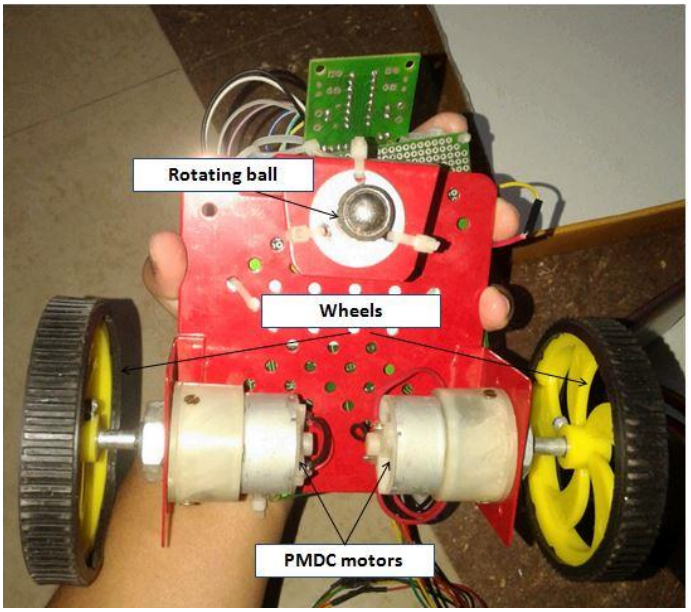

Figure 7: View from underneath the wheelchair

1.6.3 Darlington Pair Amplifier in Touch-based Buttons

There are four touch-based buttons on the control board of the wheelchair (as in Figure 9) to produce the following movements: a) Left turn, b) Forward, c) Backward and d) Right turn, respectively.

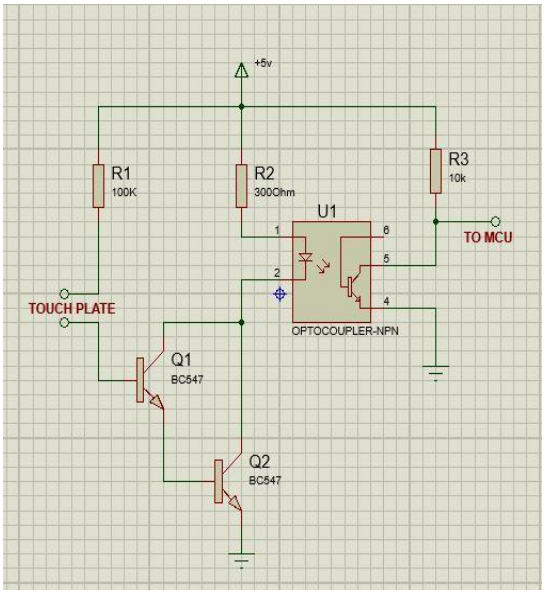

Figure 8: Circuit diagram of Touch based Switch

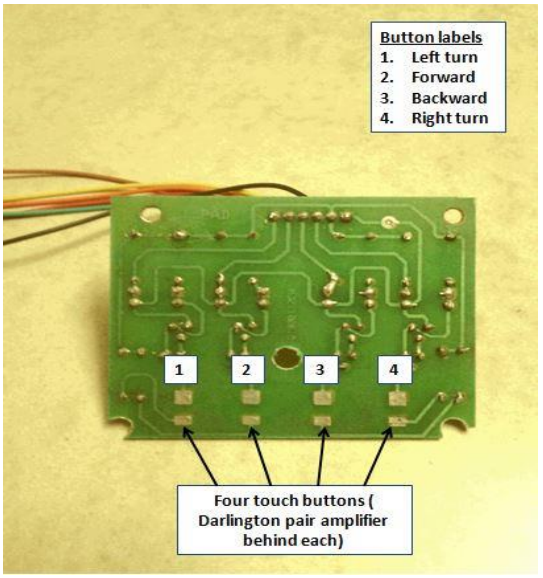

Figure 9: Four touch buttons for wheelchair control

Each button is a finger touch-activated button and has a Darlington pair amplifier embedded in it (as in Figure 8). Whenever a finger is placed on the button, a very small current, of the order of μA, passes through it. This current is given to the Darlington pair amplifier which amplifies it suitably to provide signal to the microcontroller.

This scheme provides operation of the robotic wheelchair with the touch of a finger. It is based on the fact that a Darlington pair amplifier possesses a very large current gain. Even a small current at the base of input transistor gives a very high current at the output. Hence, the arrangement of this scheme is such that on placing a finger, a small current passes through it which becomes the base current of the pair amplifier and we get output current of higher value suitable to be given to the PIC controller which further gives signals to drive the two motors of the wheelchair.

The current output from Darlington pair amplifier is observed to be higher than the current limit of the PIC controller. So, an optocoupler is kept as an intermediate device which the higher magnitude of current to that suitable for giving input to PIC controller. Hence, depending on the button touched, corresponding input pin of PIC controller gets activated and according to the PIC program, motors of the robotic wheelchair are driven to cause left, right, forward and backward movement. Figure 10 depicts the arrangement of Darlington pair amplifiers and optocouplers in the hardware circuit.

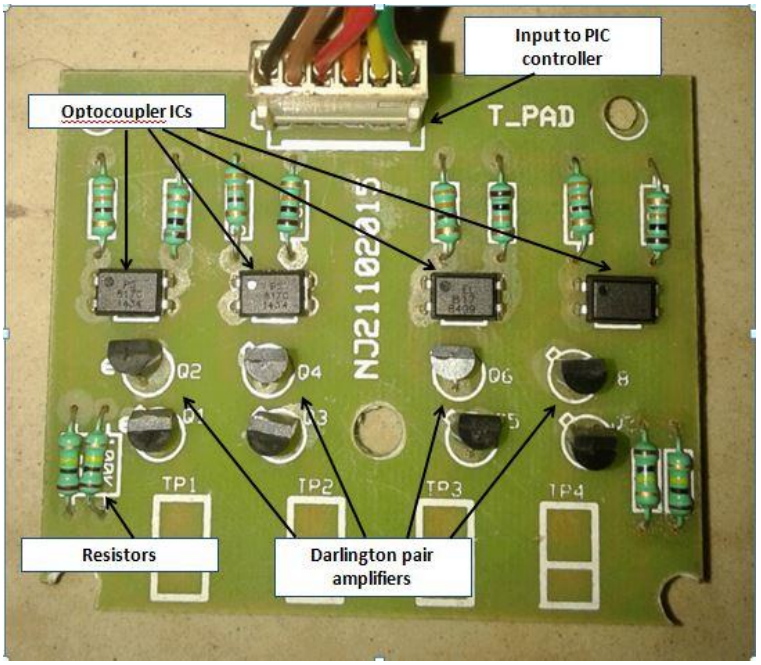

Figure 10: Arrangement of Darlington pair amplifiers and optocouplers

1.6.4 Programming Methodology in Microcontroller

The microcontroller used here is PIC16f877a and Mikro C is the software used to program this IC.

Four pins of the input port of the controller are connected with the four touch buttons via Optocoupler IC 4N35. For example, if Port D is declared as input port and Port B as output port, the output current signal from the four buttons is given to pins D0, D1, D2 and D3. The microcontroller processes the above inputs according to the program dumped in it and gives suitable polarity output on the output pins.

If suppose, B0, B1, B2 and B3 are the output pins of the microcontroller, B0 and B1 may be given as the input to Motor 1 and B2 and B3 to Motor 2. The output from these pins B0 to B3 is then given to motor driver IC L293D. The input to the motors is based on PWM pulse technique. For forward and backward movement, the ON time is kept more for each time period so that this operation is faster. For right and left turn, the ON time is kept less since right and left turn is intended to be slower. Figure 11 explains the concept of PWM excitation. In context of the project, 80% duty cycle is suitable for faster forward and backward movement and 50 % duty cycle is appropriate for a relatively slower left and right turn.

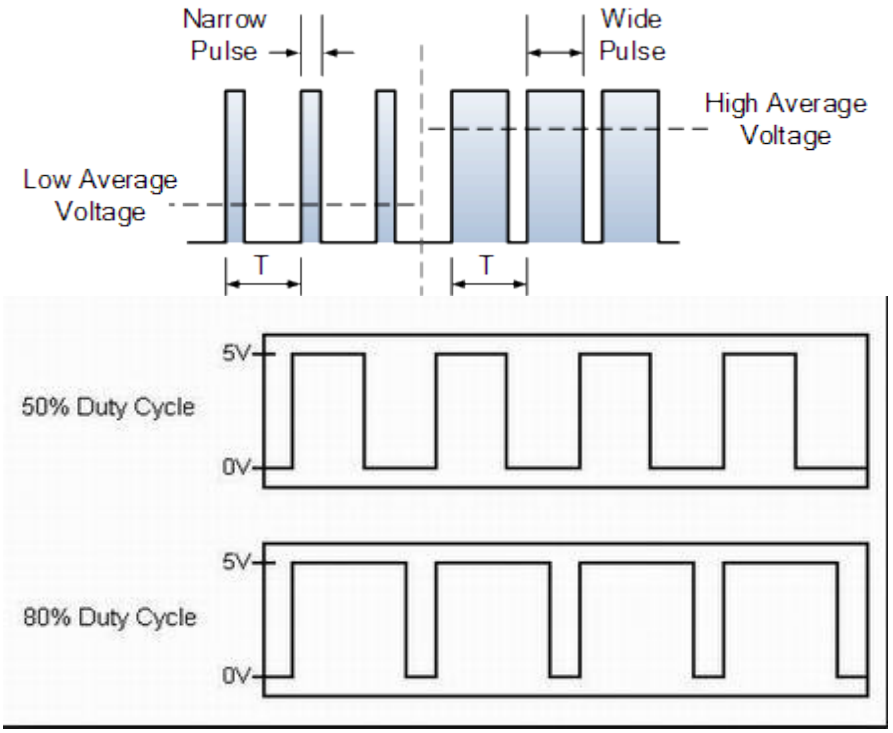

Figure 11: Concept of PWM pulse excitation

1.6.5 Motor driver IC L293d

The motor driver IC performs the task of converting the +5 volt signal from microcontroller to +12 volt signal which is the suitable voltage to be given as input to the motor. The 5 volt PWM pulses from the output pins of the PIC controller are converted to 12 volt pulses. The two motors rotate clockwise or anti-clockwise according to the program to produce the desired movements: left, right, forward and backward. The faster or slower rotation is the result of more or less PWM pulses.

The motors used in the wheelchair model are permanent magnet DC motors in order to give better torque and compactness. The right/left turn is carried out at a speed lesser than when the wheelchair is moving forward or backward.

1.6.6 Flowchart of Algorithm of PIC Controller Program

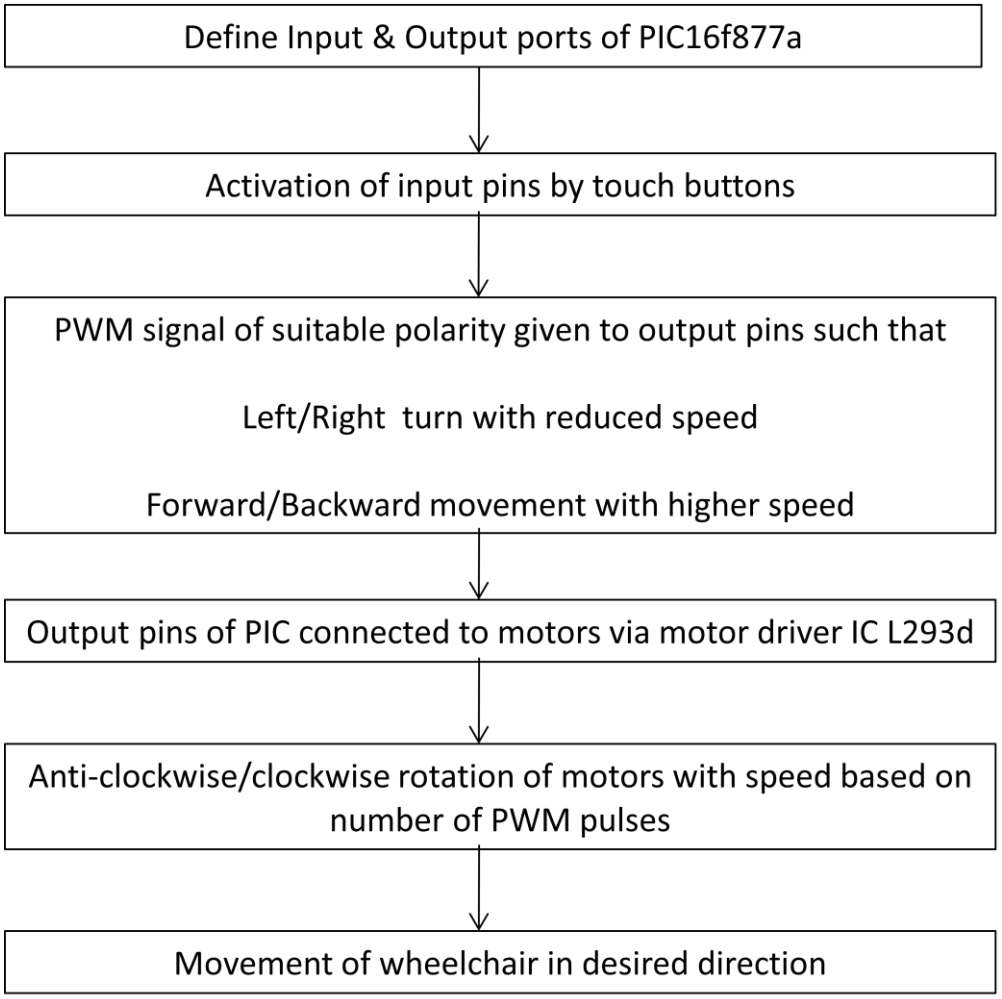

Figure 12: Algorithm of Mikro C program

Figure 12 presents the flowchart of the algorithm of Mikro C program put into PIC controller. First of all, the input and output ports of the PIC controller are declared. Thereafter the signal received from the finger-touch board is given to the input pins. Accordingly, suitable output pins are activated by giving PWM pulses in order to rotate the two motors in such a way that they perform forward, backward, left or right movement.

While turning left or right, lesser PWM pulses are given to the motors so that the wheelchair rotates at a slower speed. In contrast to this, more PWM pulses are given for faster forward or backward movement of wheelchair.

1.7 Budget Analysis

1. Budget Sanctioned: Rs. 15000/-

2. Budget Utilized: Rs. 7057/-

Serial No.	Name of Product	Amount	Bill No.	Date	Consumable/ Nonconsumable	Dead Stock Number (if any)
1	PIC Controller	238.09	085/FY16	24-Dec-2015	Nonconsumable	-
2	PIC PCB Boards	952.38	085/FY16	24-Dec-2015	Nonconsumable	-
3	Wire Connectors	323.68	085/FY16	24-Dec-2015	Nonconsumable	-
4	Adapter (AC to DC), 12V	190.47	085/FY16	24-Dec-2015	Nonconsumable	-
5	Body of Wheelchair	666.66	085/FY16	24-Dec-2015	Nonconsumable	-
6	Rotating Metal Ball	66.66	085/FY16	24-Dec-2015	Nonconsumable	-
7	Wheels	285.70	085/FY16	24-Dec-2015	Nonconsumable	-
8	Opto-Coupler PC 817	76.16	085/FY16	24-Dec-2015	Nonconsumable	-

3. Budget Unutilized: Rs. 7943/-

1.8 Conclusion and Future Work

Hence, it can be concluded that the new approach of wheelchair control, namely, the "Darlington pair amplifier based control" is suitable and feasible to implement for the smart control of the wheelchair. When the finger is placed on the touch buttons, the wheelchair successfully shows movement in the desired direction. The response of the system is also found to be excellent. As soon as the finger is withdrawn from the touch buttons, it stops immediately. As per the MikroC program in the PIC controller, suitable PWM pulses cause the wheelchair to move forward and backward with a higher speed than when it is turning left or right.

The future scope lies in devising other ways for smart control. The approaches which could be worked upon are capacitive touch pad based control, hand gesture based control, etc. With the advent of the field of brain machine interface, control of a wheelchair by using signals from brain nerves would be also prove as a novel technique for the disabled with complete paralysis.

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Appendix

A.1 Motor driver IC L293D

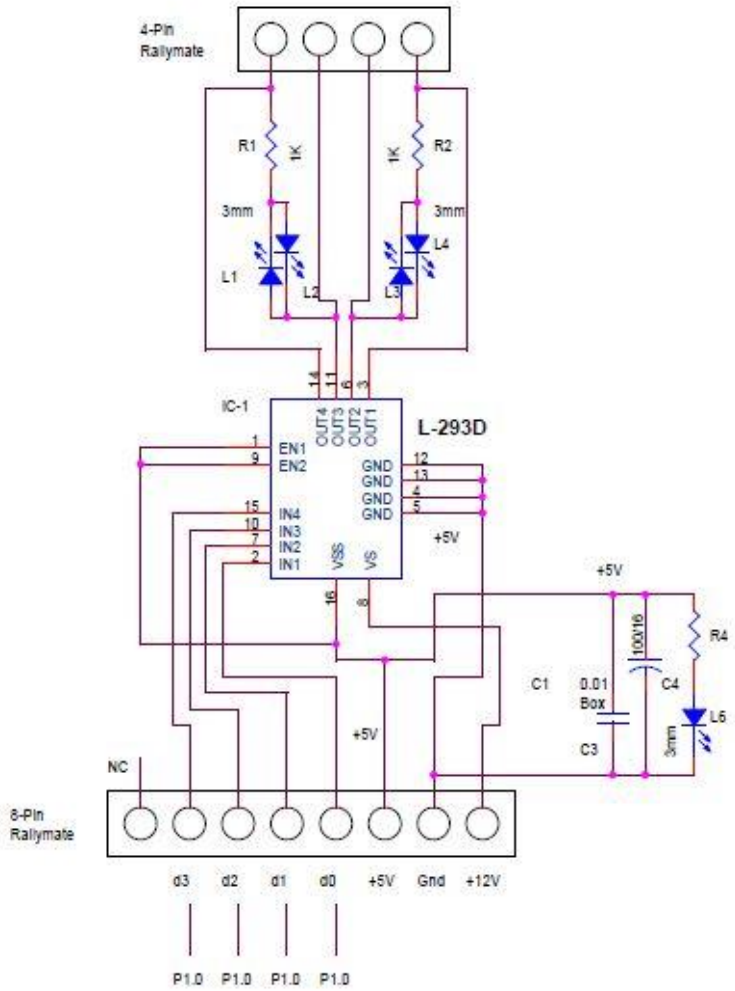

Figure 13: Schematic diagram of motor driver IC L239D

Figure 13 shows the schematic diagram of motor driver IC L239D. This driver IC is used to convert the +5 volt output of the microcontroller to the input of +12 volt to the motor so that they can be suitably operated.

A.2 IC 4N35 Optocoupler

4N35 is an optocoupler integrated circuit in which an infrared emitter diode drives a phototransistor. They are also known as opto-isolators since they separate two circuits optically. These are used to couple two circuits without any ohmic contact. They allow one of the circuits to switch another one while they are completely separate. The first circuit is connected to IR diode while the other circuit with the phototransistor. The isolation ensures that no damage occurs in either of the circuits while the other one has a fault.

An optocoupler is analogous to a relay which isolates two circuits magnetically. They differ with relays in the sense that they are smaller in size and allow fast operation. 4N35s are commonly used in interfacing an electronic circuit with the parallel port of a computer. Figure 14 shows the pin diagram of IC 4N35 Optocoupler.

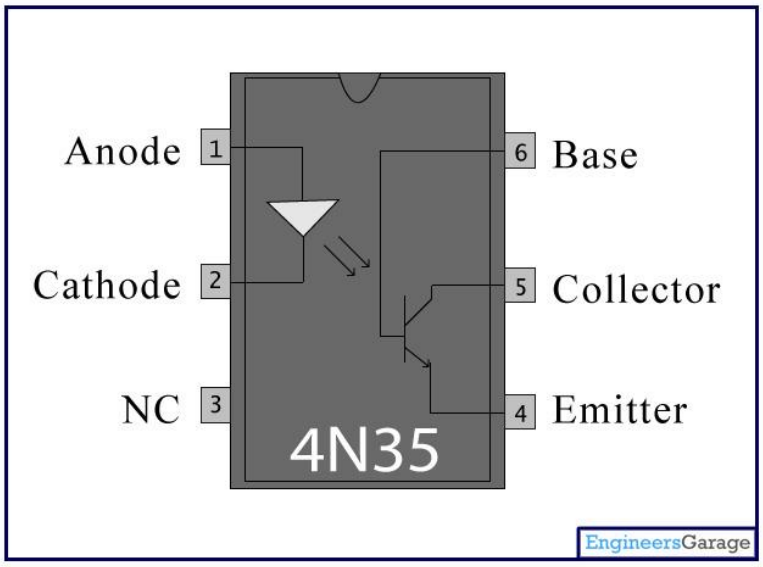

Figure 14: Pin diagram of IC 4N35 Optocoupler

Pin Description:

Pin No	Function	Name
1	IR diode's anode	Anode
2	IR diode's cathode	Cathode
3	Not connected	NC
4	Phototransistor's emitter	Emitter
5	Phototransistor's collector	Collector
6	Phototransistor's base	Base