Career Episode 2:

CE 1 Robotic Cane for Visually Impaired

CE 1.1 Introduction

This project was accomplished as a part of Graduation Degree. I started working on it in September 2010 and finished it in February 2011. It was the Final Year Project for ***Bachelors of Engineering in Mechatronics Engineering*** degree from ***National University of Modern Languages***, Islamabad, Pakistan. It was carried out under the joint supervision of Professor Abdul Aleem Rind and Asst. Professor Mr Shoaib Hameedi.

CE 1.2 Background

CE 1.2.1

This project aimed at improving student's knowledge in circuits and mechatronics. We were a team of 3 people and the success of the project was a result of teamwork. I was selected as the team leader by the supervisors therefore I was responsible for the overall decision-making. I started by deciding the theme of the project with consultation with the team and the supervisors.

Various ideas were discussed and finally it was decided that we improve navigation of the blind people across large obstacles. We performed the task using electronic circuits.

CE 1.2.2

The main objective we wanted to accomplish through this project was to design a device to help the visually impaired people navigate. In order to achieve this, a detailed study had to be carried out on the problems faced by the blind people while moving from one place to another. Then a unique solution had to be created that was both, useful and electronically realistic. Lastly, the idea had to be converted into a functional product.

CE 1.2.3

As a requirement for all university projects, we had to perform this project inside university premises, using university library for research and university laboratories for implementation.

CE 1.2.4 Project Reporting Mechanism

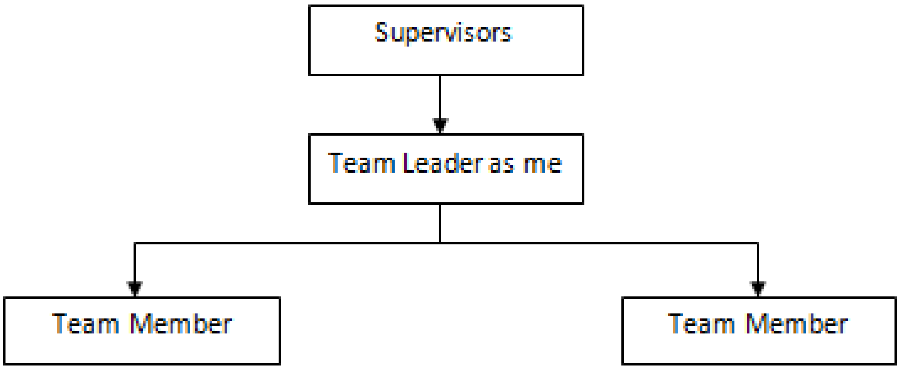

Figure 1 Project Reporting Mechanism

CE 1.2.5

I assigned tasks to each team member with the consultation of the supervisors. The responsibilities assigned to me included research and performing need analysis, designing circuit, writing the software program, mechanical modelling, carrying out testing of the prototypes and keep looking for ways and equipment to optimize our system.

CE 1.3 Personal Engineering Activity

CE 1.3.1

I started by visiting the university library and studied about the details of the hurdles a visually impaired person has to face in navigation. I already had an idea that blind people face difficulty travelling and after doing research, I discovered that moving around avoiding large objects is a great obstacle for blind people.

CE 1.3.2

I gathered my teammates and discussed the solutions for this problem. Each member including me proposed solutions. After filtering out others, consensus was reached on one solution. I then discussed with the supervisors to further improve our solution. At last the solution was finalized.

CE 1.3.3

The selected idea was based on the traditional white cane for the visually impaired, but automating it with reference to generating detection of route and obstacle avoidance. The name selected for the gadget was rightfully “Robotic Cane” since the robot was to guide blind and visually impaired users through messy and populated environments, just as a traditional white cane with the instincts of a seeing-eye dog. The user would indicate their desired motion by intuitively pushing on and twisting the handle. The robot would take this information and find a clear path using sonar sensors down a hallway or across a room in a suitable direction. The user would then follow behind the robot as it would guide the user in the desired direction by the noticeable force felt through the handle. This project is cheap alternative for guide dogs.

Since the user would be holding the robotic cane in their hand, it would be easier for them to use it just like a normal cane, the only difference being the user would not only be *feeling* their way around, but actually *seeing* it through the cane’s eye.

I began my equipment research by keeping in mind the available equipment in the local market. I suggested using Maxsonar Ez1 sonar sensor because it can easily sense any object for up to 6.45 meters, has 3 types of outputs and is cost-effective. For the microcontroller, I suggested that we use ATmega32 because of its low cost, availability, simple programming, built-in timers and ADC (Analogue to Digital Convertor). Two types of motors were suggested by me for the robot: 1) unipolar stepper motor for sensors and 2) DC motors for the movement of the robot. I suggested using a joystick which would helpful in turning, moving or stopping the robot as per the user’s desire.

After the supervisors’ approval, I created the block diagram as shown in Figure 2.

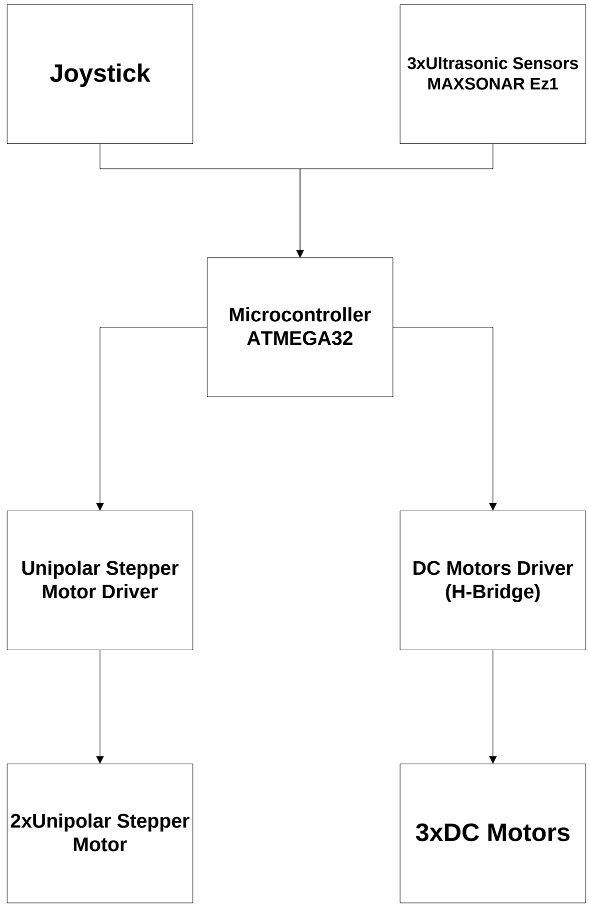

Figure 2 Main Block Diagram for Robotic Cane

CE 1.3.4

Next phase was the writing of the software program. I started by making a detailed flowchart of the algorithm. Figure 3 displays the flowchart

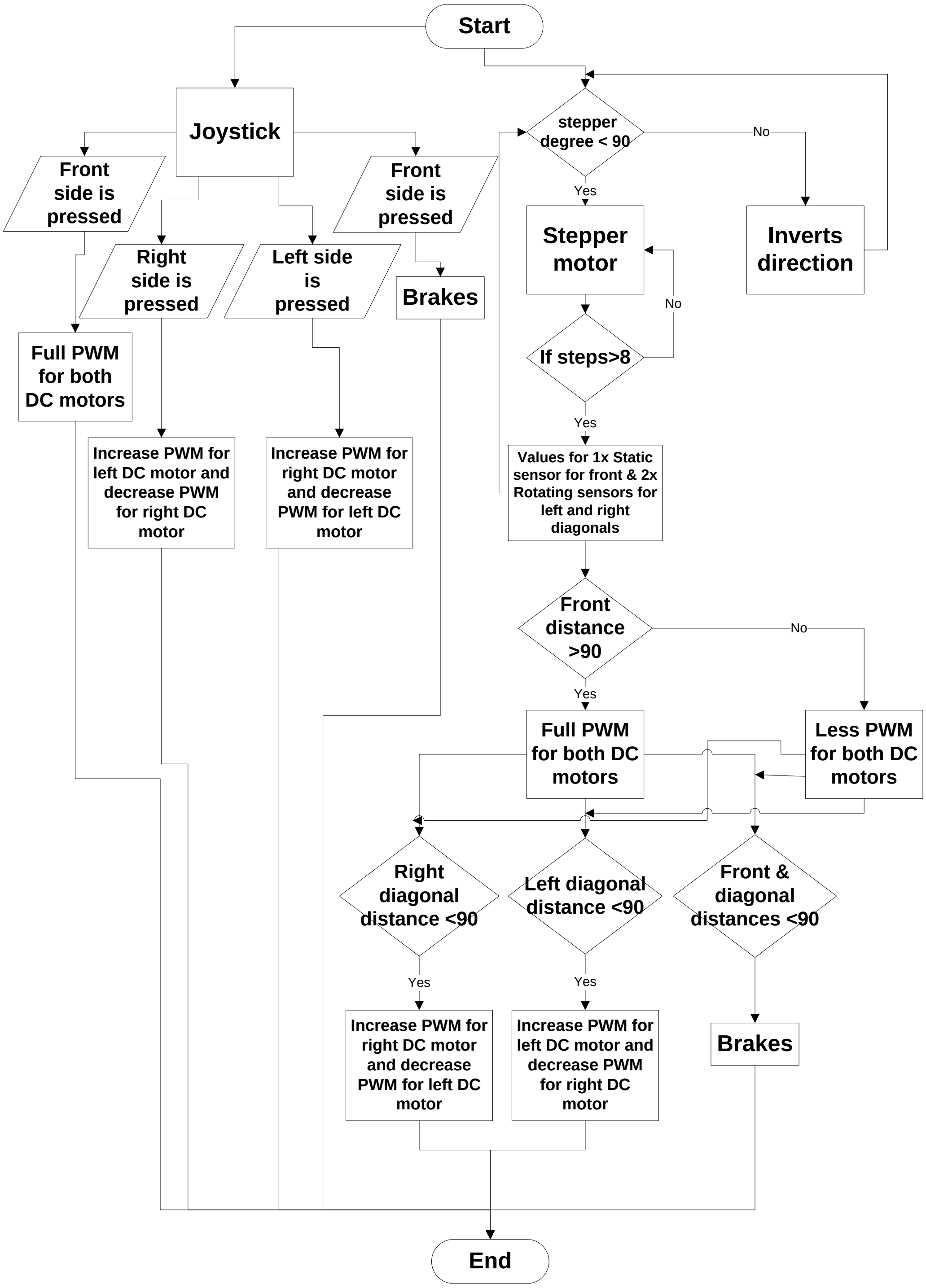

Figure 3 Flowchart for Algorithm

I used built-in timers of the AVR for controlling the stepper motor timing. The ADC of the AVR was used to convert analogue output of the sensors into digital.

Since the circuit design was also assigned to me, I took both the tasks side by side. I used C and Assembly language for programming. Whenever I wrote a module of the software, I performed test simulation to check it for correction. Therefore, circuit design and coding went hand in hand. I had to make the code that utilized the least memory and hence took the least time in execution. This required several iterations for improvement and optimization of the code. With each iteration, I made the code more compact, quickly executable and easier to understand. I used AVR Studio 4 for writing and debugging the software and Proteus 7.7 SP2 for simulations purposes.

CE 1.3.5

Next task was of mechanical modelling. I used Autocad software to create the mechanical model of the robot. I mounted 3 sensors on the robot, out of which one was stationary (middle) and two were rotated via stepper motors (left and right). The stepper motors had the capacity of revolving the sensors approximately 90 degrees. The sensors took a reading on every 8th step of the stepper motor. The robot comprised of a 1x1 ft plastic base, having 2 wheels on each side. A DC motor was used to move a pair of wheels.

Figure 4 shows the top view of the base of the robot. Two DC motors have been used to rotate the four wheels.

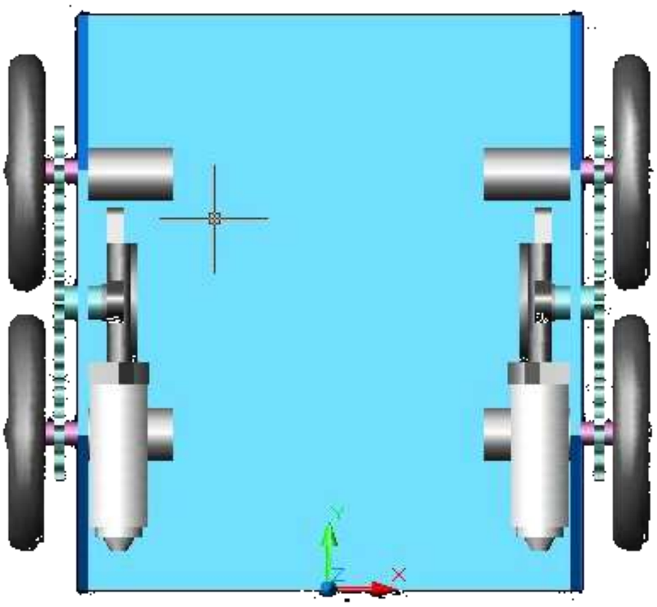

Figure 4 Top View of Robotic Base

Figure 5 shows the side view of the base of the robot. Three mechanical gears and one chain have been used on each side for controlling the rotation of the wheels.

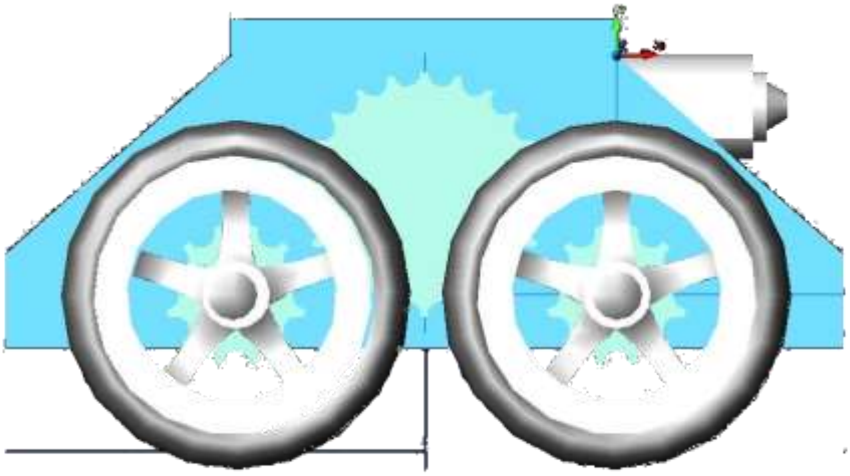

Figure 5 Side View of Robotic Base

The joystick used in the circuit was included to help the user inform the robot about the direction of movement and to start/stop it. This joystick would be attached to the cane and user would be able to use it with his/her thumb.

The circuit diagram was a detailed version of the basic controller interfacing (Figure 6). The sonar sensor first sent out sonar waves from its transmitter and when they got reflected off an obstacle and came back, the receiver caught the waves and calculated the distance and direction of the obstacle. That reading was then fed to the microcontroller's ADC and after its conversion to Digital, the controller determined the obstacle-free route. This information was then sent to the DC motors in order to move the robot in the determined route.

In order to make this system flawless, I simulated the system numerous times on Proteus 7.7 with varying conditions and checked if the results were the same in all situations. I created test cases for quality assuring each possibility. I simulated the circuit with all type of obstacles: very big, fairly big, smaller. After confirming all the test cases several times for correct results, when I was satisfied with the system, I showed the simulation to my supervisors and then proceeded towards the next step after their approval.

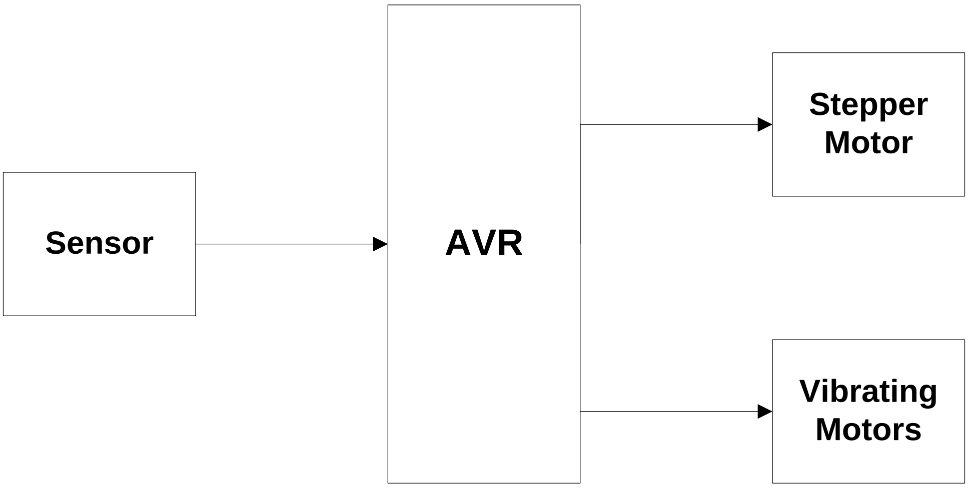

Figure 6 Controller Interfacing

CE 1.3.6

The subsequent step involved forming an implementable shape of the circuit. For that, with the help of my team members, I designed the PCB (Printed Circuit Board) of the sensors and stepper motors (Figure 7) and the PCB circuit of the DC Motors H-Bridge (Figure 8). This task was accomplished using Proteus 7.7. Finally the hardware was prepared.

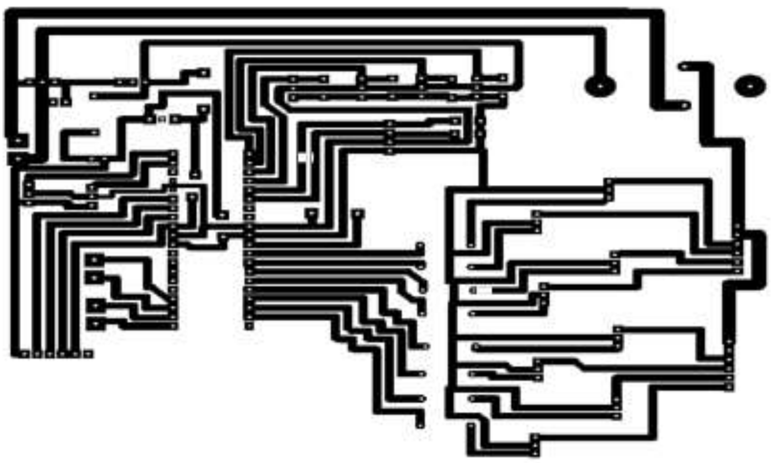

Figure 7 PCB Layout of Robot Circuit

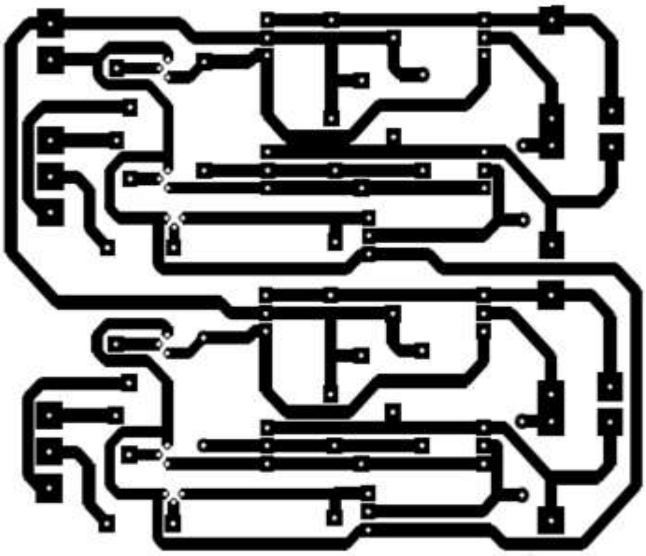

Figure 8 PCB Layout of H Bridge

CE 1.3.7

Since this project involved mechatronics and powerful hardware interfacing, I faced many challenges during testing and bug fixing. I solved each technical problem systematically and debugged each issue considering all factors for example equipment malfunction and loose connections. I also ensured proper insulation of the cane for it was the component in direct contact with the user.

I tested the final prototype several times with all the test cases before showing it to our supervisors for further assistance.

The supervisors were impressed by our efforts. Since I had created a detailed project timeline and shared it with the team, considering all the worst case scenarios in mind while working on the project, and devised a specified timeframe for each task, and since I encouraged all to work together as a team, taking responsibility of the work, there was no lingering upon a task more than the expected time.

Final hardware of the project is shown in Figure 8.

Figure 9 Robotic Cane

CE 1.3.8

As the leader of my team, I took it upon myself to keep documenting each and everything going on in the project right from the beginning till the end every day. I used Microsoft Word for the purpose. This helped me explore the areas of strengths and weaknesses to help me in future. This documentation helped me immensely in generating the final presentation of the project and writing the project thesis, as per the requirement of the university.

CE 1.4 Summary

Being the leader of a final year project, which is such an important constituent of the graduation degree, was a big responsibility. I not only had to take care of my own degree but also the two team members who were working with me. This project not only gave me an insight to circuit design and development on a product scale, but also helped me improve my leadership abilities. I always tried to help my team members in all tasks instead of ignoring their problems and just focusing on my own tasks. Since I gave every member voice his opinions and made nobody feel unimportant, I noticed difference of opinion rising within the team regarding a few matters some times. All such times, I assessed all the opinions and took them logically to find a solution that was acceptable to all, hence keeping consensus. As a leader, I took it upon myself to lead by example. Whether it was punctuality or meeting the deadlines, I always made sure my team members find in me an ideal.

This project helped me improve my skills in circuit design and analysis. I also learnt a lot about optimization from product point of view. When we implement things on hardware, optimization makes all the difference and this was the key lesson. Whether it was code writing or circuit diagram, optimization played its role in determining the usefulness of the product. I also got to learn about systematic quality assurance and testing. I generated test cases and tested our product for each case several times for consistent results. This way, the product was pretested for all expected bugs in all possible cases.

Furthermore, I took care not to stick solely to the tasks assigned to me, but also helped my team members in their tasks. This way, I got hands on experience in hardware implementation via soldering and Printed Circuit Boards. My skills in Assembly language and C programming were also immensely bettered by this project since I wrote all code myself. Moreover, I learnt how to read and use the data sheets of electrical components, use of sensors, stepper motor and its drivers, and hardware troubleshooting.

We all got 4.0/4.0 GPA in the project and in a project exhibition at our campus, the CEO of a renowned electronics company took interest in our project, encouraged us and appreciated our efforts for helping the visually impaired persons. All in all, it was a very enlightening experience for me.