CS684 Project Prototype Report

To sort objects based on Color and Size using Firebird V robot

Team 4

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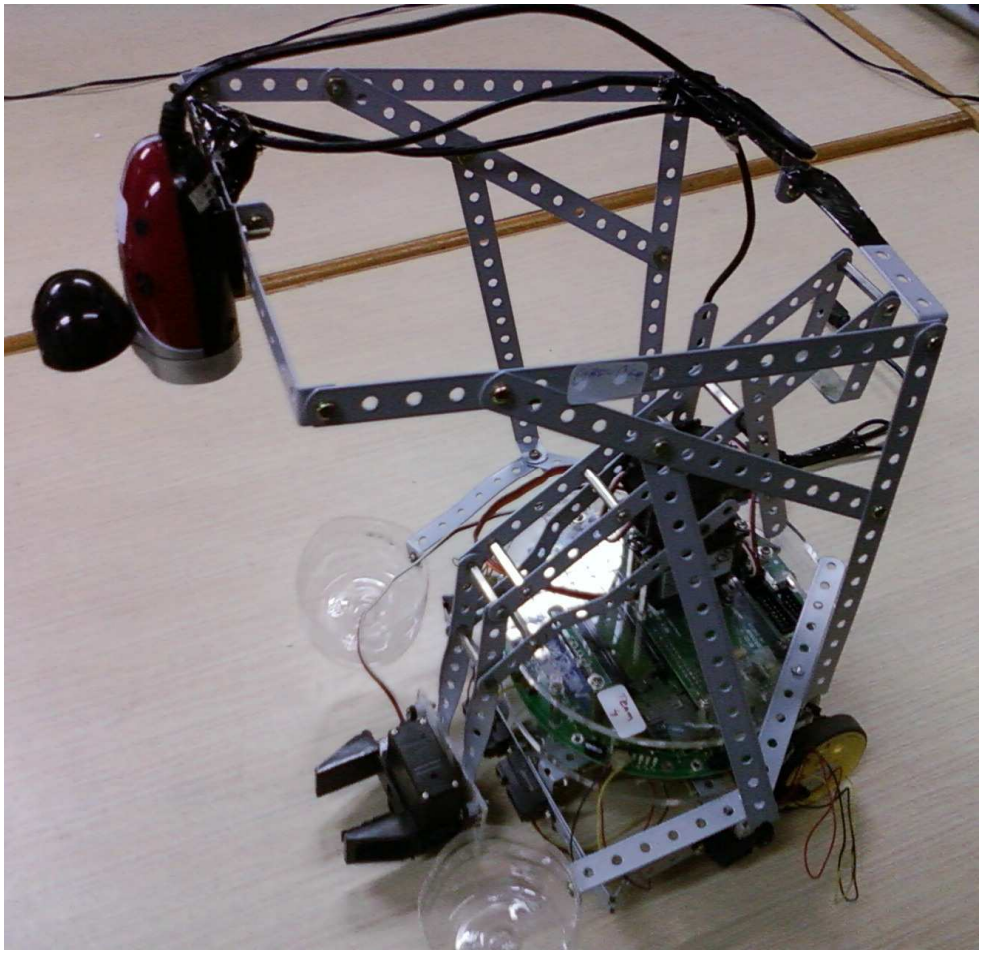


1. Introduction

1.1 Problem statement

The objective is to develop a robot to automatically detect and pick objects as per specifications. It will sort the objects based on color and size, and place them separately.

1.2 Requirements Specification

Following were the requirements for the project:

(a) 1 Firebird V robot

(b) 4 IR sharp sensors of type DP2D12

(c) Zigbee communication module

(d) Robotic arm with gripper (with 3 servo motors)

(e) Web camera (USB, 2 megapixel)

1.3 System Design

The following flow-chart explains the working principle:

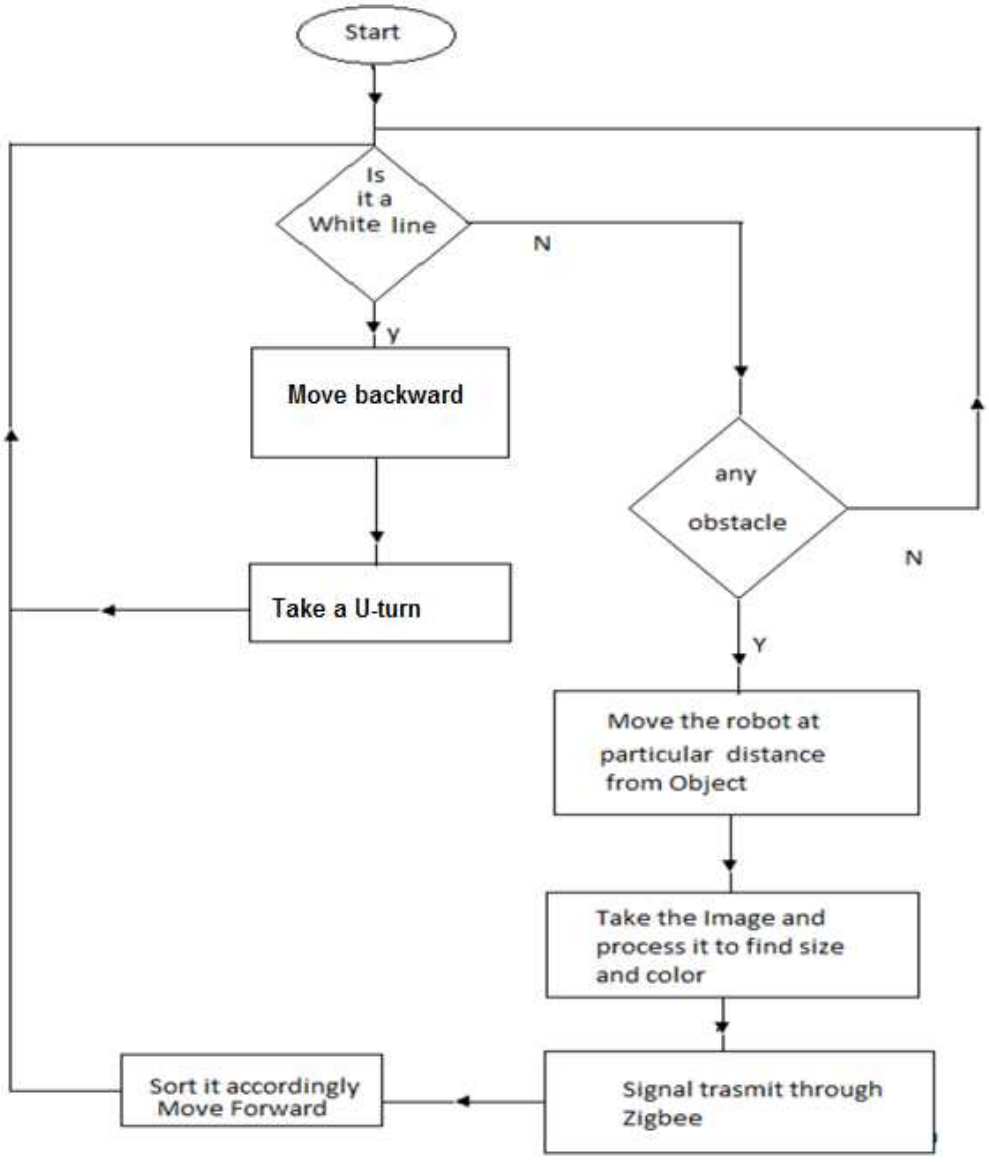


Figure 1.1 Flow chart of the system

The steps can be enumerated as follows:

(a) The field of movement of the robot is bounded by a white line strip. The robot moves according to a predetermined algorithm to cover this field. Once it reaches a white line, it makes a U-turn and go down along a parallel path.

(b) If it detects an object on any of its side sensors, it turns to align itself to face the object.

(c) It moves forward and stops at a particular distance from the object.

(d) The robot then takes a picture and sends this image to Matlab on the PC. This communication is done via Zigbee.

(e) In Matlab environment, first the color of the object is detected.

(f) If it is not of required color, it is ignored.

(g) If it is of required color, the size of the object is detected.

(h) Accordingly, Matlab sends signal to the robot whether or not to pick the object, again through Zigbee.

(I) If it is to pick up the object, the robot moves forward and picks the object using the robotic arm and places it in the respective basket.

(j) When the robot is done with an object (it can either ignore, or pick and place an object), it reverts back to its original position on the path. It then moves from there for the next object.

(k) When the robot completes covering the entire field, it comes to a stop.

1.4 Assumptions and limitations

The following assumptions and limitations had to be taken into account:

(a) The application is implemented in 2D.

(b) The arena is bounded by white line strips.

(c) Currently only two sizes of objects are considered.

(d) Color distinction involves selecting objects of only one color and ignoring those of other colors.

1.5 Setup, modifications and extensions implemented on the robot

The project starts off with a Firebird V robot. Some changes had to be incorporated in the setup of the robot – especially the design of a rig for fitting a camera and a gripper arm assembly.

The objects that were expected to be detected by the robot are small in dimension. The IR sharp sensors at their usual level (height) in the robot were not able to detect these objects. So they needed to be mounted at a lower height.

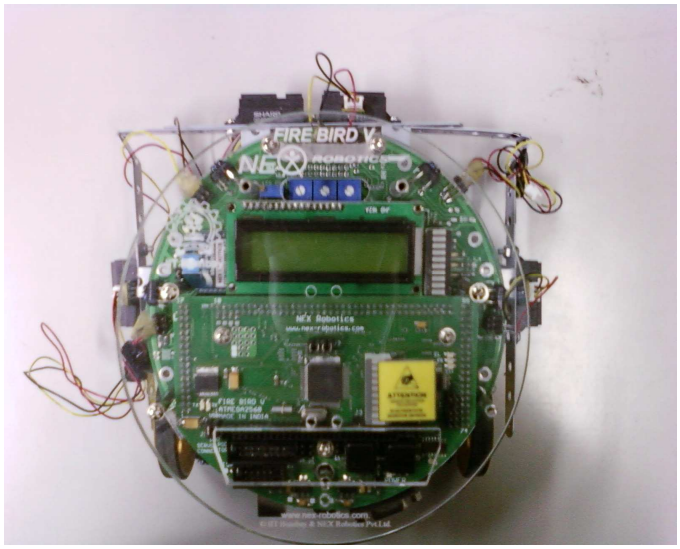
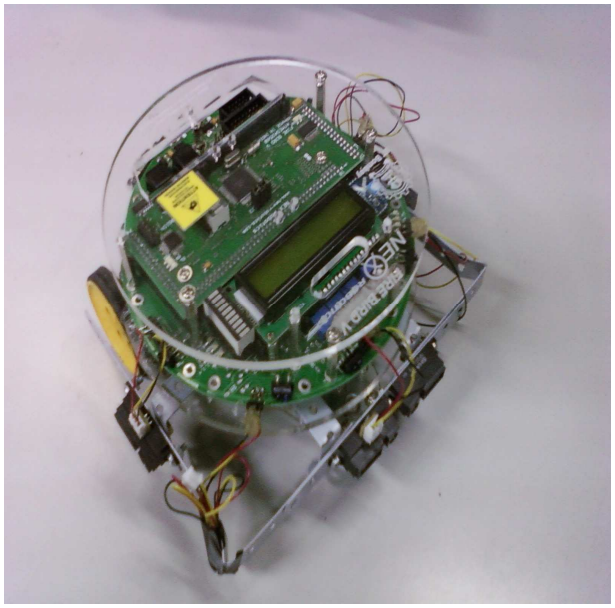
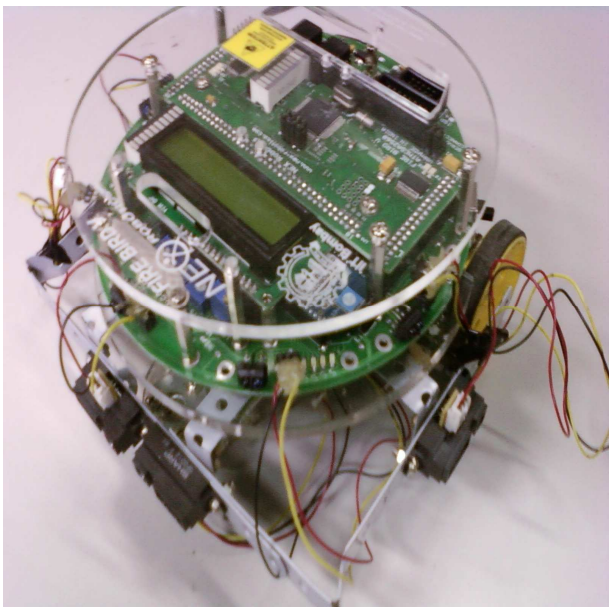


Figure 1.2 Top view of the robot with sensors attached

For achieving this, the five IR sharp sensors of the robot were taken out and four of them were mounted on metal strips specially attached for this purpose. They were mounted at a height of about 1cm from ground.





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The alignment of the sensors were also a little different from the usual. The leftmost and rightmost IRs were mounted at exact right angles to the central axis. Two IR sensors were mounted in front facing forward. They were mounted to help the robot align itself to the objects. The four sensors were connected to ADC channels 9,10,11 and 13.

1.6 Additional hardware used

(a) Robotic Arm

A special robotic arm constructed for picking up the objects and placing them. Three servo motors were used for this purpose. There was also a gripper that actually caught the object.

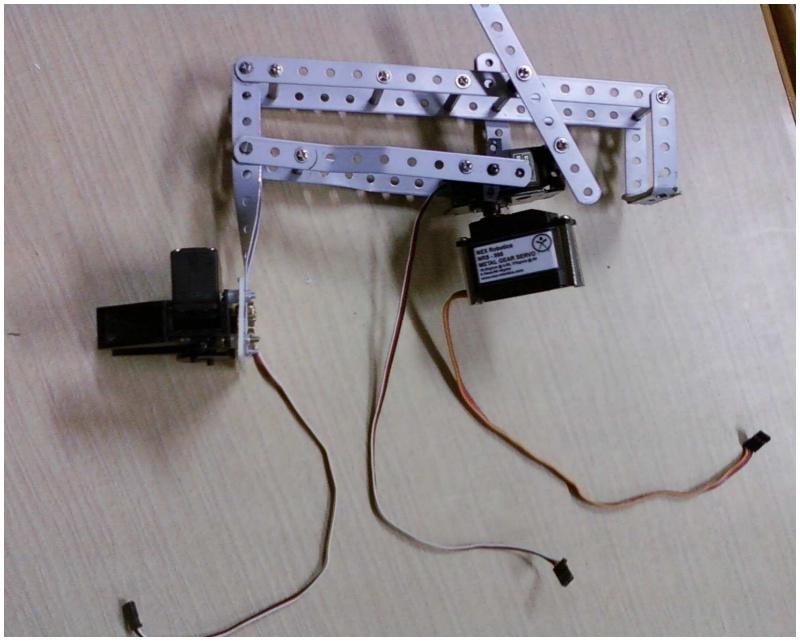

Figure 1.4
Robotic arm

The three servo motors were:

(i) The first servo motor was mounted exactly over the cover of the robot, in the center. This servo was responsible for the left- right motion of the arm.

(ii) The second servo was mounted over the first. This gave the up-down moment of the arm.

(iii) The third servo was used to control the gripper at the front.

(b) Support for camera

A separate frame was constructed to mount the camera. This was an L-shaped frame that held the camera on the top of the robot.

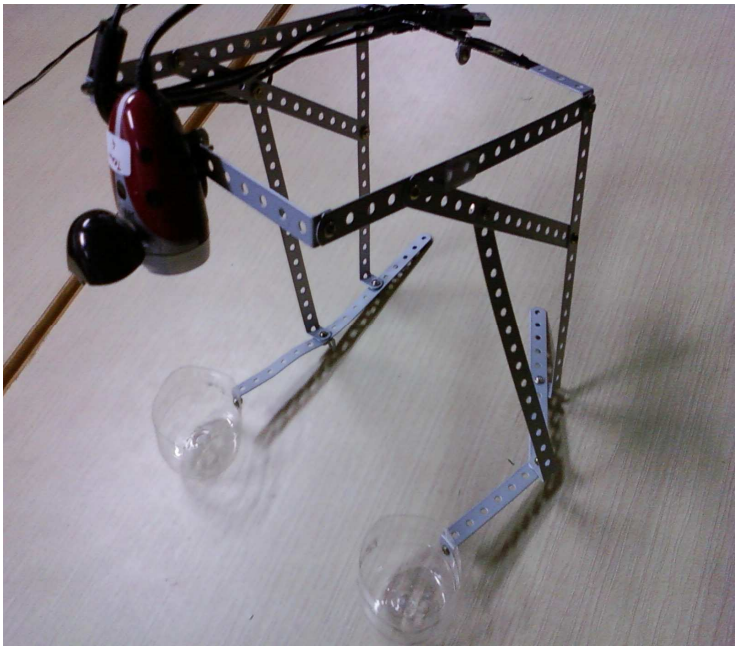

Figure 1.5 Assembly for camera and plastic bins

Thus the camera faced down and captured images of the object on the ground immediately in front of itself. Two containers were attached to this frame for collecting the sorted objects.

2. Project Status

2.1 Project time line

The project was started in the second week on Sept 2010 and finished over a period of about seven weeks. The main development and coding required about 6 weeks with a team size of 3 members. Testing was simultaneously done. The final week was devoted to fine tuning of the project and documentation.

2.2 Delays and how they were overcome

The development of the extra hardware took some time which needed to be made up for later on. Obtaining servo motors and web-cam according to the specification and on time was also a challenge.

Delays were also introduced when the hardware did not always behave as expected. Some of the IR sensors stopped working after some time and needed to be replaced. The time associated with the interfacing of these led to some unproductive time.

2.3 Critical steps in the project: hardware, interfacing, algorithmic complexity, etc.

1. The most critical aspect was the calibration. The objects to be picked up were small, and the dimension of the gripper arm was also quite small. So, a lot of time had to be devoted in making the robot move by a particular distance or to move the motors by a particular angle. Quite a lot of trial and error needed to be done here to get the minor calibrations right.

2. Development of the hardware and the time associated with it was another critical step. Co-ordinating the hardware was also a challenge.

3. Working with the Zigbee module was also critical as it was found that they were unpredictable in their behavior. We required two way communication with Zigbee. Some of the modules worked well in transmitting in one direction only. This led to some problems and a lot many modules had to be checked to find out a pair that worked properly for us.

2.4 Individual roles and contributions

Work was divided more or less equally between the three members of the team. Also, as the team size was small, at least any two of the three members always worked together. However, the work division was roughly done per member as

Member 1: Communication, Coding, Calibration
Member 2: Image processing, Communication, Coding,
Member 3: Coding, Documentation, Calibration

2.5 Time devoted in man-days

A total of about 40 man-days were put into the project.

3. Innovation, Creativity and Re-usability Index

3.1 Innovations in project

1. There were a number of places where we were faced with challenges that needed innovative solutions. One of them was the design of the robotic arm. It needed quite a lot of imagination to design the arm, specially because movement of the arm in two axes were required. Our team is grateful to the lab staff for their help in this regard.

2. Another place were we faced problems was the position of the camera and the way of mounting it, so that it did not come in the way of the robotic arm. Again this called for some creative method of mounting the camera.

3. The design of the objects to be picked were also decided after lot of deliberation. As the gripper was small, it was not able to pick up a large object. Again, a small object was being overlooked by the IR sensors. So finally, a nail was put into the large objects. Thus, the object was detected by sensors, and also the gripper could lift the object by the nail.

3.2 Enhanced re-usability in project

A lot of importance has been given to make the project and its associated materials reusable in the future. For this maximal stress has been put on extensive documenting, report and snapshots of the hardware built. The code has been made as much modular as possible which comments at places that are not self-explanatory.

4. Improving the process

4.1 What can be improved in terms of project activities

Working on the project has been a very exciting and satisfying experience. However, there are a few aspects that can be improved for later on.

(a) Faster and more prompt delivery of the hardware, specially for those that are built in the lab, would definitely be appreciated.

(b) A clearer and more timely outline for the requirements in related documents could definitely have been of help.

4.2 Comments on the current schedule of events

The current schedule of events were well planned and optimally spaced out for a timely completion of the project. The reviews from time to time have definitely been helpful.

4.3 Are you satisfied with the way the course activities have gone – specially the project?

The course has been a very delightful experience. The variety of materials covered and the chance to communicate with distinguished personnel from the industry has truly enriched the experience of the course.

The course project specifically has been very exciting and educative. The hands-on with the hardware has been fun. Overall the course, as well as the project, has been very satisfying.

6. Testing

Testing was done in three steps.

(1) With objects of only one color and size
(2) With 2 objects of same color but different size
(3) With multiple objects with different color and sizes

5. Bug Report

The bugs detected during testing have been successfully removed. However, as the project was developed within a small time frame, there might be others that have been overlooked. Any report of a bug to the authors will be highly appreciated and taken care of immediately.

6. Future Scope

The project has been developed keeping in mind the need of a farm assistant robot. The prototype can be developed further to overcome the existing shortcomings. Some of the extensions that can be incorporated are

(a) Extension to a 3 dimensional space

(b) Sorting based on more specific qualities

(c) Better and more compact structure

(d) More energy efficient prototype

(e) Better image processing algorithms

The project definitely forms a platform for better work in the future.

7. Learnings

A few key areas that we gained knowledge in are

(a) Interfacing with hardware

(b) Image processing

(c) Wireless communication

Overall the course has been very exciting and satisfying. The project in particular provided us with a better understanding and insight of actual problems faced in real life and the approach to their solutions.