CS684 REPORT

CS684 – 2010 Project

GROUP 17

Project: TENNIS BALLCOLLECTOR ROBOT

The objective of this document is to help someone else run the code that is delivered as part of this project.

Project Title: TENNIS BALL COLLECTOR ROBOT

Students:

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PROJECT OBJECTIVE

The aim of the project is to program the firebird to collect tennis balls scattered in a court.

REQUIREMENT SPECIFICATION

The main function of this robot is to collect balls of orange colour scattered in an arena and place it in a basket which is blue coloured. The robot will collect one ball at a time place it in basket and then scan for more balls.

HARDWARE PLATFORM

1. Firebird V ATMEGA2560 (Cost=Rs.16,875.00)
2. Zig-bee (XBee 802.15.4 OEM RF module 2.4GHZ) is used for communicating between the firebird and PC (Cost = Rs.1665).
3. Wireless camera is used for taking snapshots. As part of this TV tuner card is also used (for connecting to PC) (Cost=Rs1500 for camera + Rs 2800 for tuner card).

   Specification:

   - Image Pickup device - 1/3 1/4 inch CMOS
   - TV system - PAL /CCIR NTSC/EIA
   - Definition - 380 TV lines
   - Scan frequency - PAL/CCIR:50Hz NTSC/EIA:60Hz
   - Min illumination - 3 LUX
   - Output power - 50mW 200mW
   - Output frequency - 900MHz 1200MHz
   - Power supply - DC 6V – 12V

SOFTWARE

1. AVR Studio 4
2. Matlab used for image processing.

EXTENSIONS USED

1. A gripper is attached to the firebird for collecting the ball. Three servo motors are used for this. Two servo motors are used for upward and downward movement of the gripper and one is used for opening and closing the arms of the gripper.

2. Thermocol attachment is placed in front of the robot to place camera and the two sharp IR sensors used.

CODE DESCRIPTION

CODE FILES

Filename	Purpose	Executes on
Zigbeegp17	Main Program	Robot
matlabgrp17.m	Program that processes image to detect the ball.	PC
LCD.c	Handles the display functions of LCD screen.	Robot

PROJECT FILES

Filename	Contains	
C-code.rar	SourceCode of programs to be burnt on Robot. Contains documentation of the code as well.	
PC-interface.rar	Contains Matlab files.	
Documents.rar	Contains Project related doc files.	

SYSTEM DESIGN

STATE CHART DIAGRAM

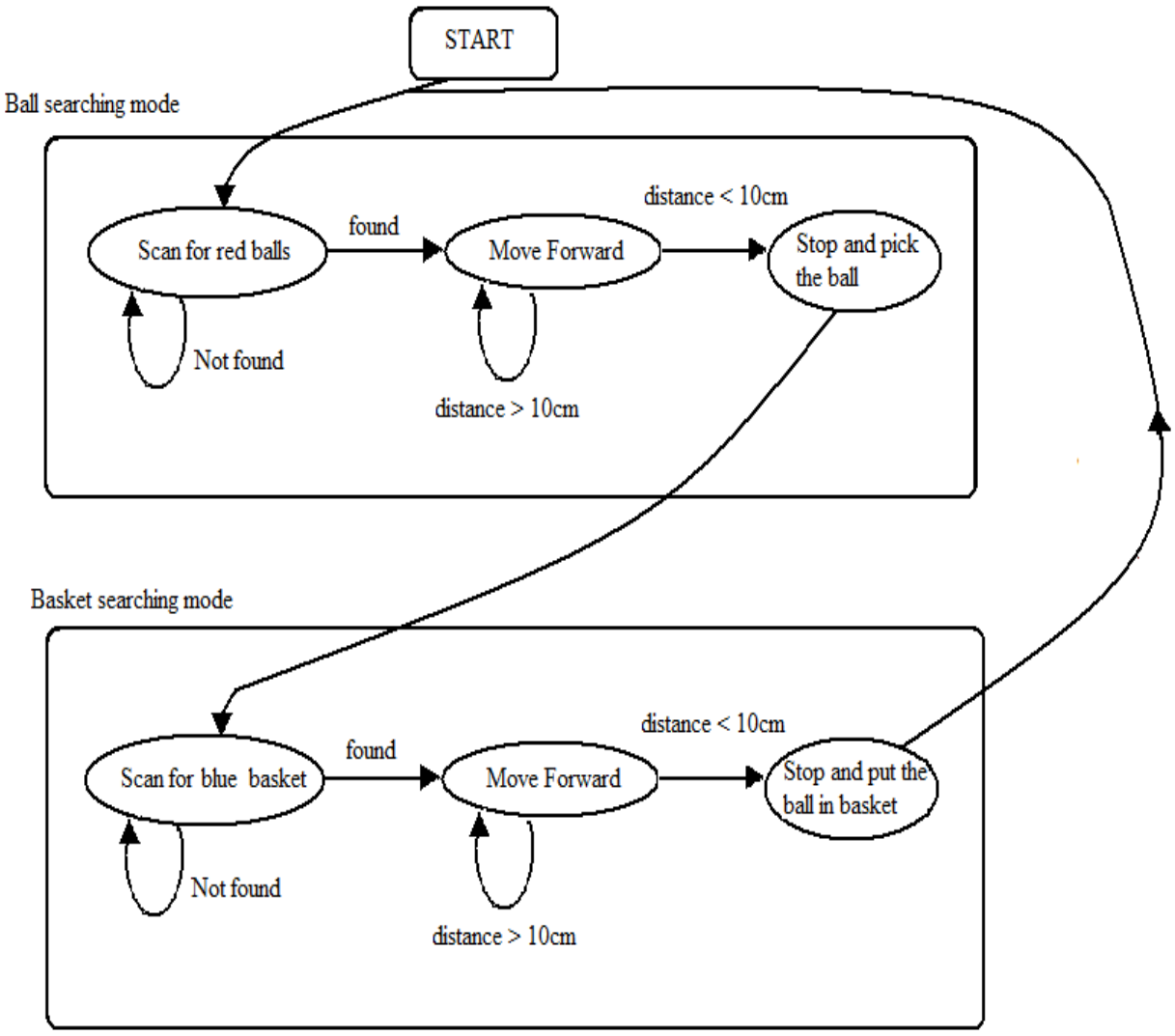


Fig. State Chart of the tennis ball collector robot

The robot works in two main states: the ball searching mode and the basket searching mode. The state chart given above describes the working of the tennis ball collector robot. In

the ball searching mode, the robot searches for red coloured balls. If not found, it keeps on searching for balls. If ball is found, it goes towards it and picks it up. Then the robot switches to basket search mode where it searches for blue coloured basket. If not found, it keeps on searching for it. If a basket of blue colour is found then it goes towards it and drops it. After that it goes back to the ball searching state.

ASSUMPTIONS AND LIMITATIONS

1. Balls to be collected are orange coloured.
2. There is no other object of reddish colour.
3. Basket is of blue colour.
4. There is no other blue coloured object in the arena.
5. The Sharp IR sensor has got a blind spot of certain distance (about 10cm). The ball should not be kept in this region.

SETUP AND EXTENSIONS ON THE ROBOT

The gripper is a small attachment made of plastic, thermocol and servo motors for gripping the ball. The image of the gripper is shown in the figure below.

Materials required for making gripper are:

- Two toothed gear wheels.
- Plastic strips.
- Thermocol.
- Metal strips for holding the two wheels together.
- Three servo motors.

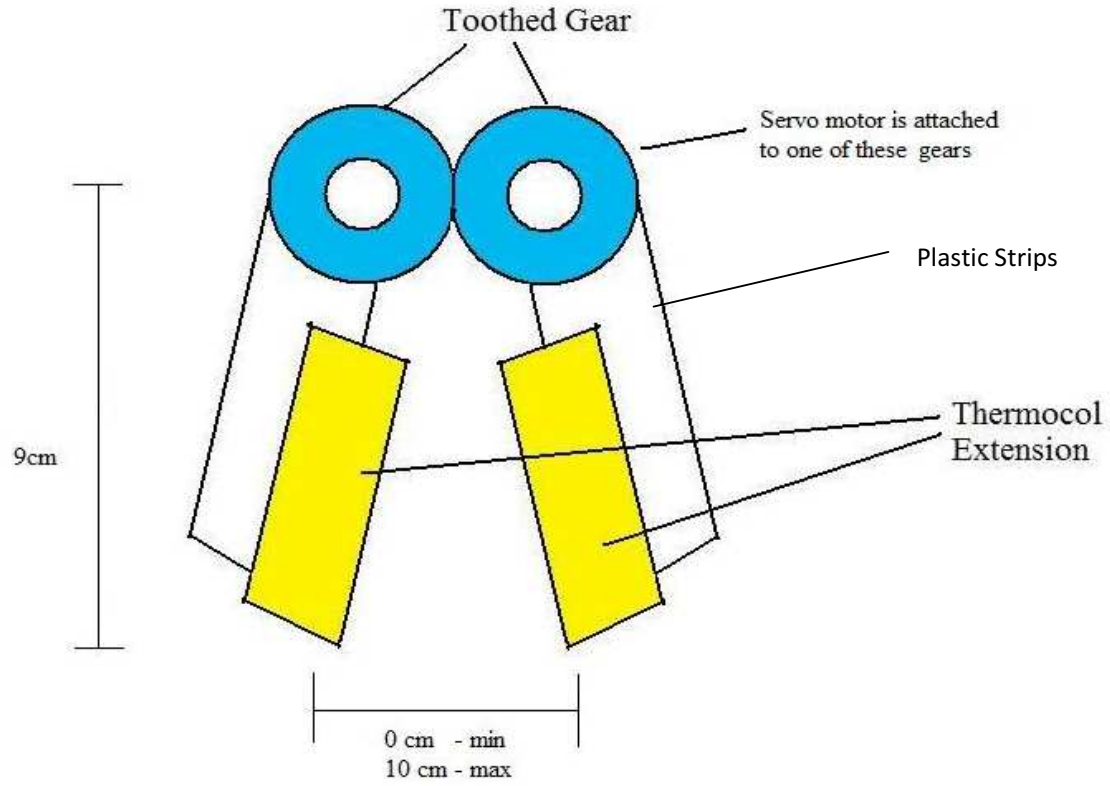


Fig. Diagram of gripper.

Two arms of the gripper are attached together using a gear arrangement. A servo motor is connected to one of the gear wheel. When this servo motor rotates, both the arms move due to the presence of gear wheels. A thermocol attachment is provided on the gripper for better catch. Actual photo of the gripper is shown below.

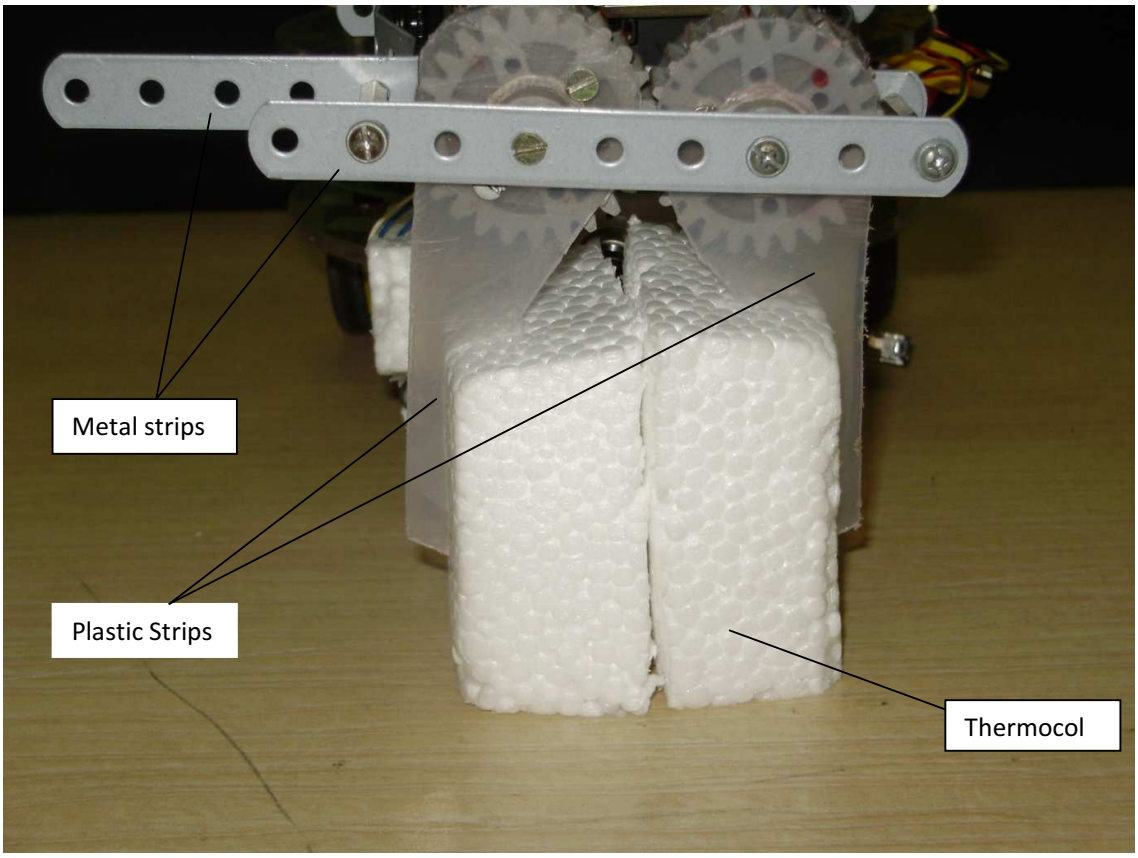


Fig. Photograph of gripper.

Then a thermocol attachment is fixed on the front of the firebird for holding the camera and the Sharp IR sensors. Two Sharp IR sensors are used for better accuracy (the two wheels may not move by equal distance on forward movement. So these two sensors take care of the sideward movement up to certain extend).

Placing the camera at this height gives better view of the arena. The camera is placed just above the IR sensors. The diagram of the robot with all the attachment is shown below.

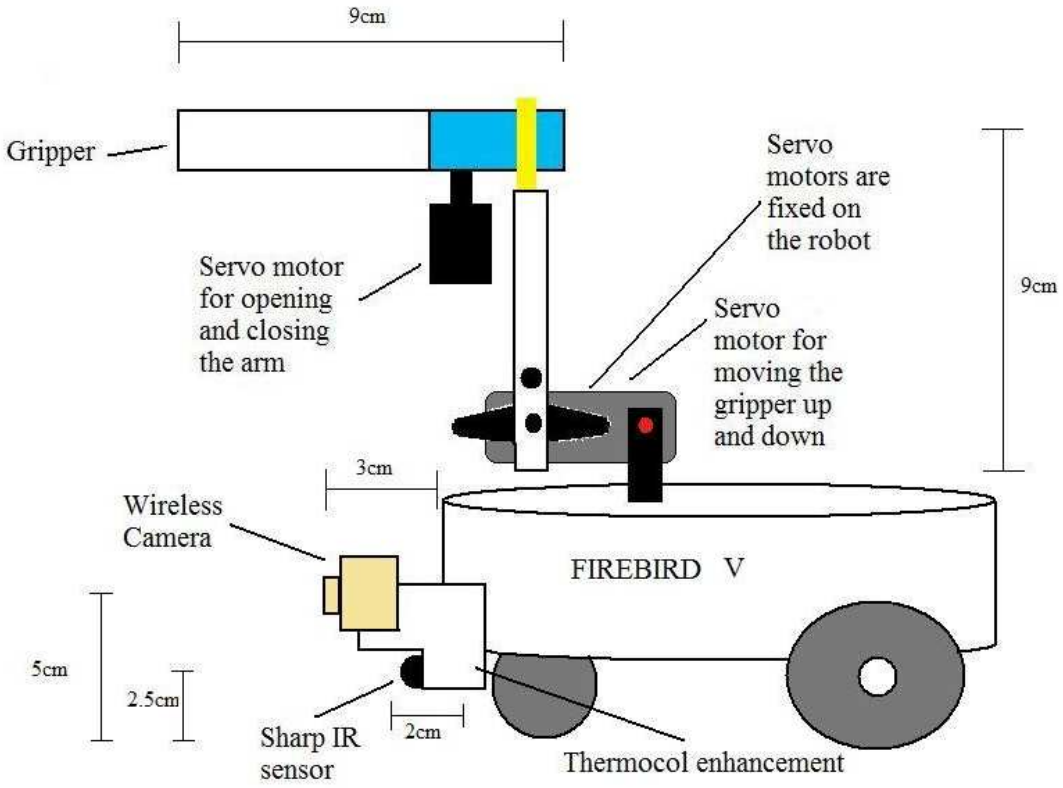


Fig. Diagram of tennis ball collector robot

The actual photo of the robot is given below.

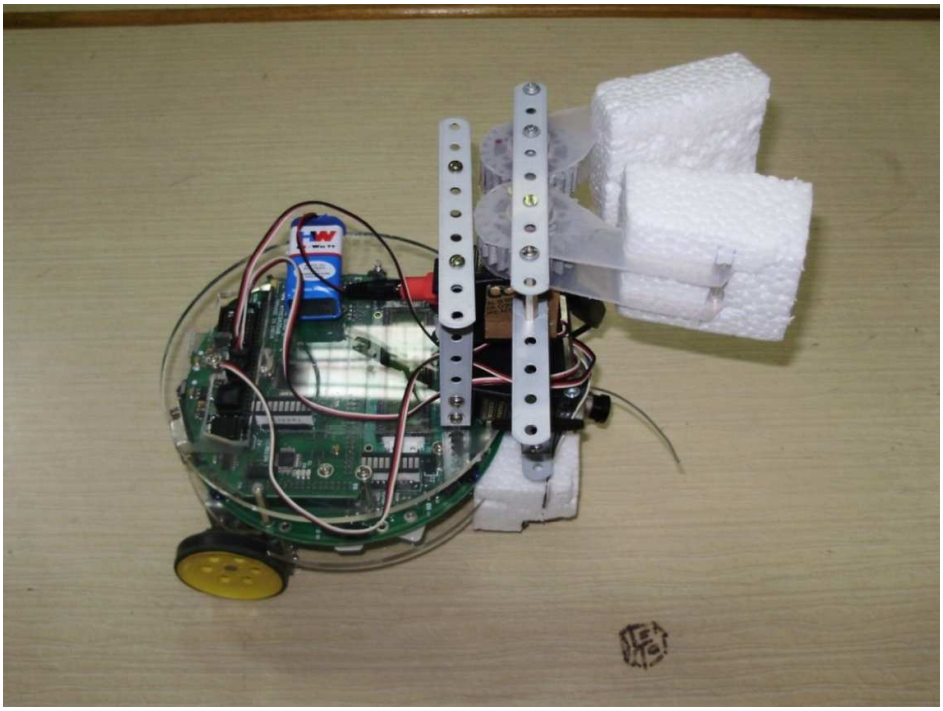


Fig. Photograph of tennis ball collector robot

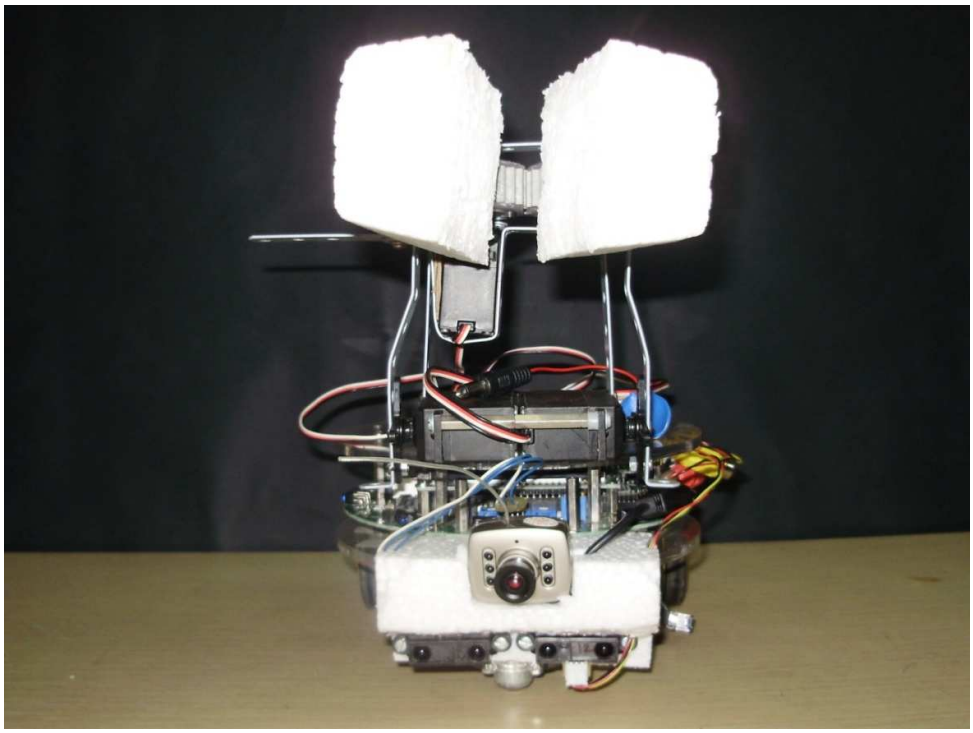


Fig. Photograph of tennis ball collector robot

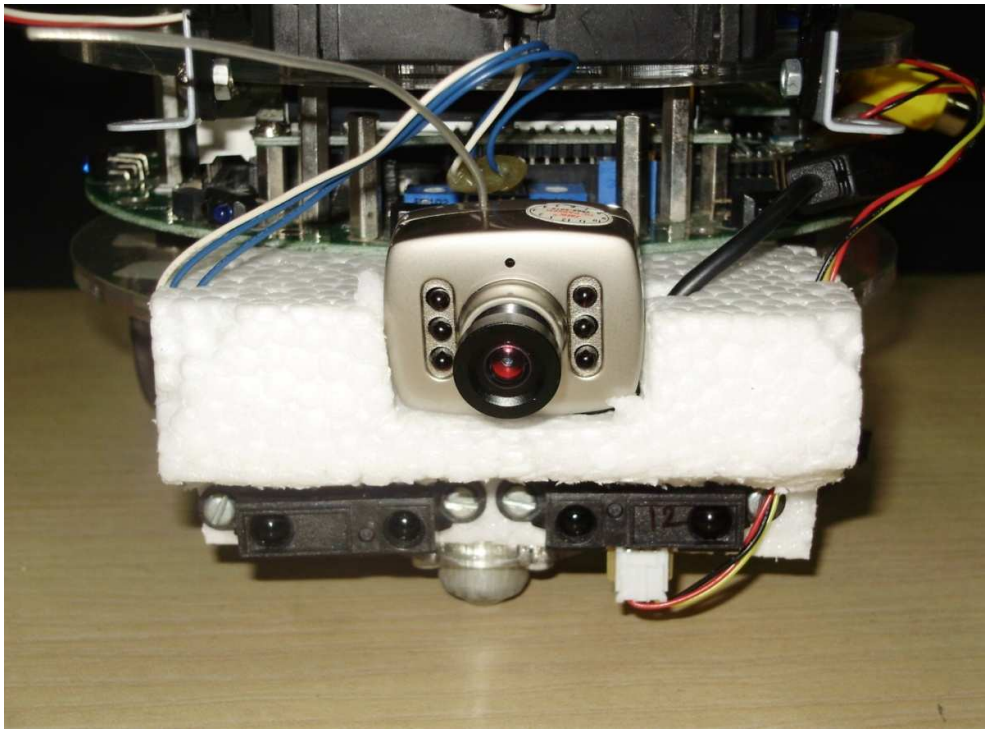


Fig. Video camera mounting

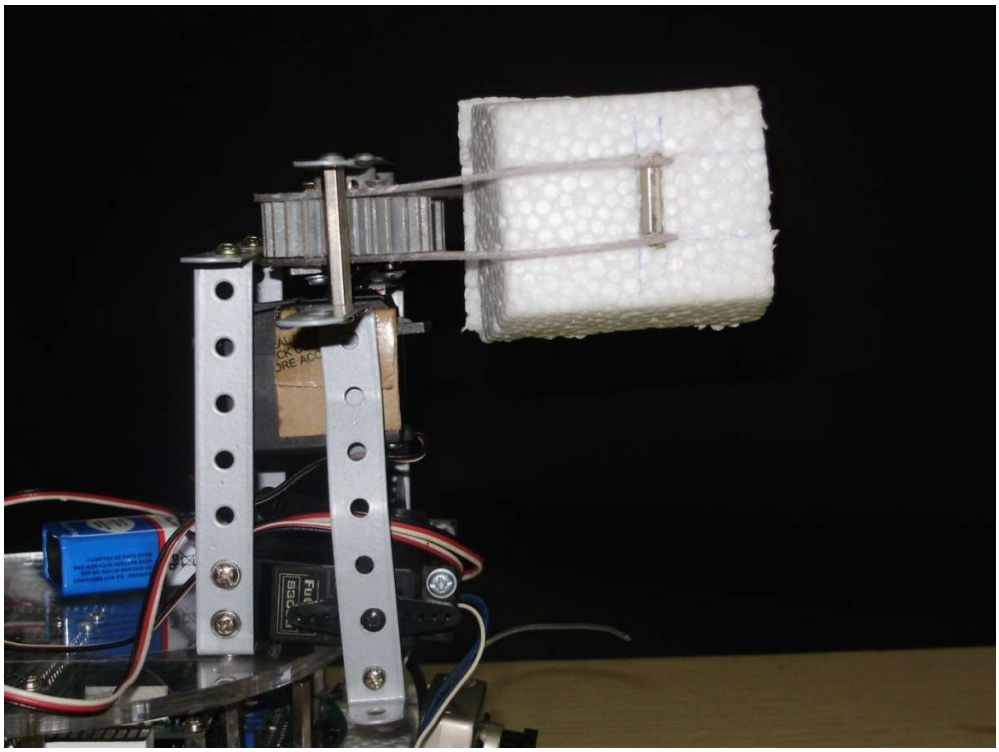


Fig. Gripper arm side view (Idle position)

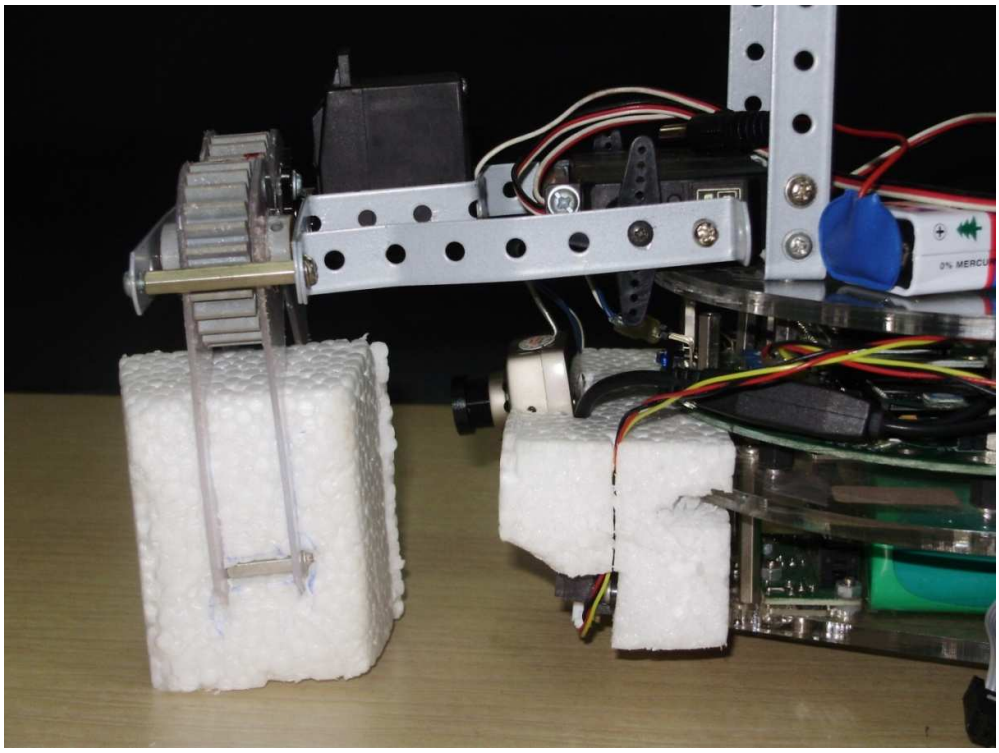


Fig. Gripper arm in picking position

EXTRA HARDWARE USED

1. Wireless Camera
2. Zigbee module
3. One additional IR sharp sensor.
4. Wireless receiver for receiving data from camera.
5. TV tuner card.

WORKING

This project is aimed at programming the firebird to act as a tennis ball collector robot. This project consists of two parts: one is the C code to be burnt into the firebird and the other is the Matlab code which runs on a PC attached with a zigbee module.

When the firebird is switched on, the robot rotates in steps of 3 degrees and scans for the ball (red coloured) in the field using a camera attached on it. The camera takes snapshots and sends it to the Matlab code running on a PC. The Matlab code processes the images and if a ball (centroid of the ball) is detected in a small band centred around the central axis of the image, the robot stops rotating and goes towards it and picks it up. Else it will continue rotation and scan the area. If a ball is detected, the robot goes towards it and while going towards it, it calculates the distance with the obstacle in the front. Since the ball was in the central band of the image, only the ball will be in front of the robot. When the distance between the ball and the robot is less than 10 cm it stops and the two servo motors drop the gripper down and the servo motor attached to the arm activates and opens up the arm of the gripper to collect the ball.

Then after collecting the ball, the robot scans for a blue coloured basket and if detected, goes towards it and drops the ball into it. After dropping the ball, it continues to scan for more balls.

The Matlab code sends a signal when a ball is detected using the zigbee module attached to the PC. The Matlab code contains the code for detecting the red objects first. Whenever a red coloured continuous area is detected, the program constructs a bounding box around it and calculates the centroid of this bounding box. This technique is followed since on calculating centriod of the continuous area directly, it may result in many centroid if the lighting is not good. A figure similar to the one shown below will be created on following this inefficient approach.

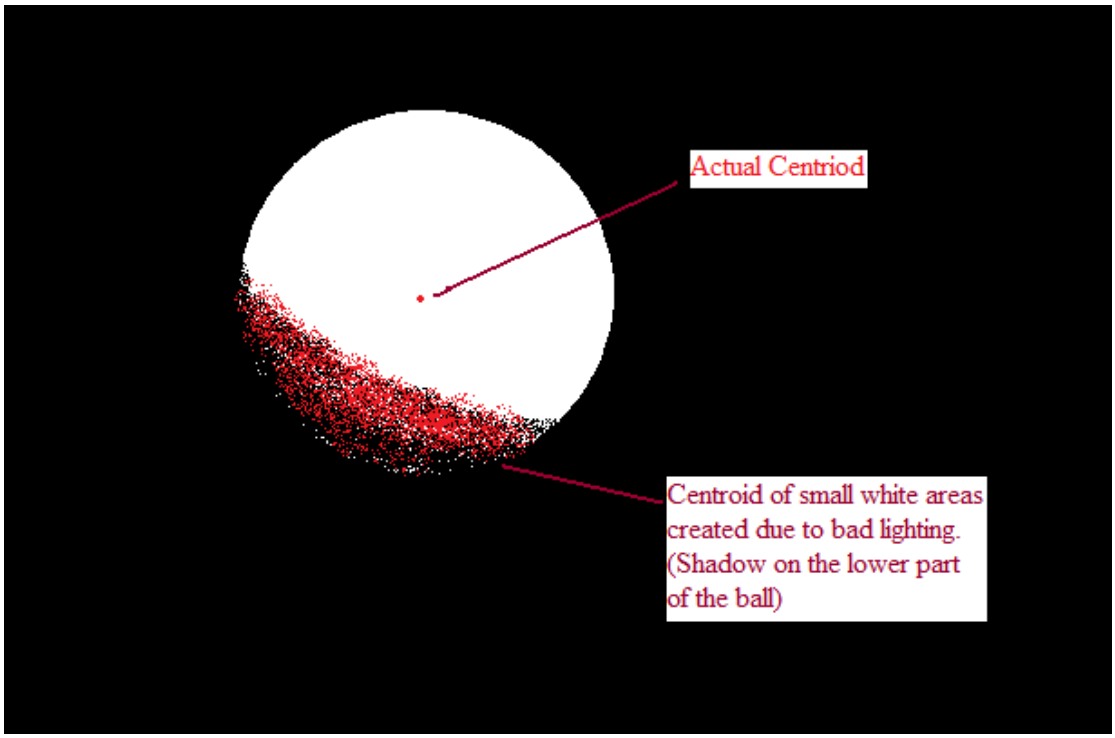
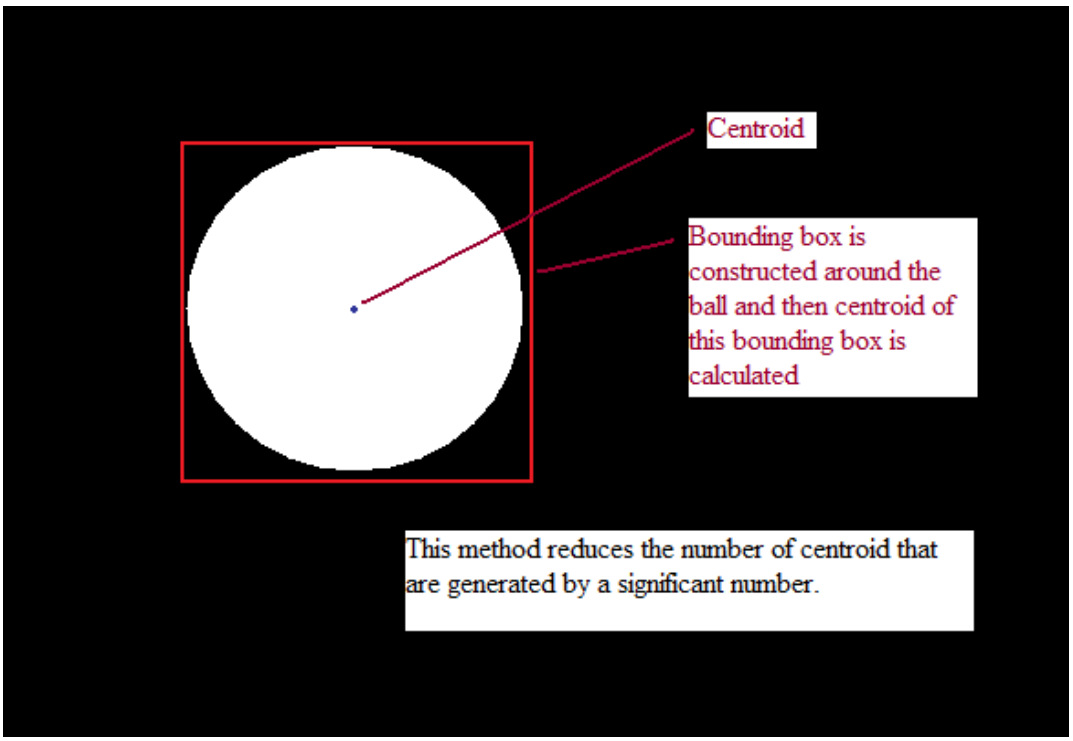


Fig. Approach used at the beginning

So it is difficult to process the image. Also due to this bad lighting, the image processing time is very high.

The image after using the modified method just described is shown below.



On detecting the ball in the central band of the image, it scans for blue objects. So the code alternates between detection of ball and detection of basket.

Since only one coloured object is being detected at a time the image processing time is less compared to detecting two different coloured objects in the same frame.

EXECUTION INSTRUCTIONS

- Open the project zigbeegp17 in AVR studio 4
- Compile the code.
- Connect the firebird V programmer on to the PC in which this code exists.
- Burn this code into Firebird V.
- Connect the wireless receiver of camera to the PC via a TV tuner card.
- Run the Matlab code on a PC connected with a Zigbee module (make change to the code according to the port number to which Zigbee is connected).
- Now switch on the Firebird.
- Make sure to connect the camera on the Firebird to the 9V power supply.
- Now the Firebird will start working and will respond to the code sent by the Matlab code.

TEST CASES

- **TEST CASE 1:**

  The balls of red colour were placed at different parts in the arena.

  RESULT: Passed.

- **TEST CASE 2:**

  The balls were placed such that they form a continuous area of the ball colour.

  RESULT: Failed.

  REASON: Image processing code fails to identify individual balls as it identifies continuous area of colour

- **TEST CASE 3:**

  The balls were placed one behind the other.

  RESULT: Passed

  REASON: Used different colours for balls and basket. So this alternates properly.

- **PROBLEMS**

  Sometimes due to power fluctuation or due to power spike, the camera doesn't capture the image properly and sends an arbitrary image consisting of red, blue and green areas which will make matlab code to send the signal. This causes the robot to move forward even if ball or basket is not in front of it.

INNOVATION AND CHALLENGES

INNOVATIONS:

- One of the major features of this project is that this works in an open arena.
- Another feature is that robot can collect ball even if it is far away from the robot. There is no restriction on the area of the arena provided the camera can detect the ball.

CHALLENGES:

- One of the biggest challenges in the project was the communication between the robot and the Matlab code using zigbee. The communication is slow compared to the wired communication.
- Distinguishing between the basket and ball: Since the ball and the basket were of different colour, the matlab code needs to identify two different colours. So the code needs to be designed such that there is no much delay in image processing.
- The robot should go straight to the target. Due to the fact that the rotation of both wheels is not same, sometimes the robot misses the target. So in order to stop the ball in front of the ball, we have used two Sharp IR sensors so that a small sideward deviation problem is solved.

REUSABILITY FEATURE

- Every line of code is well commented for the user to understand what function it does.
- Each complex function is well explained in the code for the user to understand what function it does.
- Each action is implemented as function. So these functions can be reused.
- Problems encountered are well documented so that anyone using this code will not encounter the same difficulty and can extend the functionality of the project.

INDIVIDUAL ROLES AND CONTRIBUTION

TEAM MEMBER	WORK CONTRIBUTED
ANUP NAIK	Programming the firebird, Documentation
VISHNU KANTH T	Matlab code, Documentation
RAJ DEEPAK	Matlab code, Documentation

MILESTONES ACHIEVED

MILESTONE	COMPLETED ON
Completion of ball detection module using an effective method	October 22
Completion of Robot movement module	October 24
Completion of communication between Matlab and robot	October 25
Testing and debugging	October 27
Reducing delay of communication	November 2
Final testing and documentation	November 7

BUG REPORT

1. If the balls are closely placed touching each other, then the matlab code will detect it as single continuous area and will hence detect it as a single object. So it will go and pick the one which is closer in distance to it.
2. Due to fluctuations in power supply, some red and blue areas are created in the image which disturbs the normal working of the robot. If the centroid of this non-existing red or blue coloured area comes in the central band considered, then robot will move forward even if no ball is there in front.
3. Because of the problem in rotation of wheels (both the wheels do not rotate with same speed) the robot may not move correctly to the intended destination. It will move sideward and misses the target.

FUTURE ENHANCEMENT

- A basket can be attached on the top of the robot so that it can collect it in that basket. This requires some gripper enhancement.
- Including higher capacity batteries to make the robot entirely wire free
- Use of good resolution camera for image capture is another enhancement which can be done.
- Another enhancement is detecting multi-coloured balls.
- Optimal path planning to pick the ball in least time
    - Using the current system.
    - Using overhead camera.
- Design of “scoop action” bin to do away with the need for gripper.

LEARNINGS

1. Learned basics of image processing in the course of the project.
2. Communication between two programs using zigbee was also carried out.
3. Learned how to work effectively in a team, distributing the work and similar things.

CONCLUSION

We have provided in this project a basic “ball collector” system which may be used as the basis for more sophisticated systems exploring new hardware designs or more sophisticated algorithmic solutions.