Project Report

CS 308 Project

Embedded Systems Lab

MINI GOLF ROBOT

Team 6

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Introduction:

The purpose of this document is to present a detailed description of the Mini Golf Robot. It will explain the purpose and features of the system, the interfaces of the system, what the system will do, the constraints under which it must operate and how the system will react to external stimuli. This document is intended for the developers of the system.

Aim of the Project:

The aim of the project is to design a golf playing robot.

Given a hole (marked by a flag) and a red coloured foosball (instead of the ping pong ball) on a platform made of wooden ply (preferably covered with green velvet), our robot will try to hit the ball towards the hole as accurately as possible. There are many extensions possible for this project, which are given here.

Brief Description:

The Bot will first look for a red coloured ball by rotating in a circle. It keeps on rotating until the ball is in centre of the frame. Once the ball is in centre of the frame, it stops rotating and moves towards the ball in a straight line. Bot stops at a specified distance from the ball using the sharp sensor. This distance is important in the implementation. Let's call it X for future discussion.

After finding the ball, the camera on the top moves through 90 degrees(say to the right) and then the bot also moves 90 in the opposite direction(correspondingly to the left) as of camera so as to keep ball in the centre of the frame. The bot rotates around the ball in a circle in search of a blue flag.

As soon as blue flag comes in the centre of the frame, the bot and camera revert back to their original position by moving 90 degree in the direction opposite to earlier movement. Now the bot, ball and flag are collinear. Depending on the distance of the ball from the flag, the angle of inclination of aluminium angle is varied with the help of a servo motor. Now we pick up the ball and roll it down the angle. If ball has entered the hole then it stops after rotating 360 degree otherwise the whole procedure is followed again.

Hardware Requirements:

1. Firebird V ATMEGA2560 (Cost=Rs.16,875.00) as the basic skeleton on which we will implement the golf-playing bot.

- IR sharp sensors already attached to Firebird.

2. Zig-bee (XBee 802.15.4 OEM RF module 2.4GHZ) is used for communicating between the firebird and the PC (Cost = Rs.1665).

3. Wireless camera is used for taking snapshots. As part of this TV tuner card is alsoused (for connecting to PC) (Cost=Rs.1500 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

4. 2 Servo motors:

- To rotate the camera
- To provide variable angle to the incline.

5. Inclined Plane to move ball by a variable distance. This consists of an aluminium angle that can be inclined at a variable angle to the horizontal plane by using servo motors.

6. Platform made of plywood (4 ft X 4 ft) with a hole at one of the corners. The entire platform is covered with green velvet to provide friction to the ball.

Software Requirements:

- AVR Studio 4
- Matlab for Image Processing.
- X-CTU for Zigbee configuration

Tasks specifications:

1. Locate the Ball

2. Move towards the Ball

3. Rotate camera 90 degree to the right and bot 90 degree to the left .

4. Rotate in a circle around the ball trying to locate the flag.

5. Again revert back to original position i.e rotate camera 90 degree to the left and the bot 90 degrees to the right.

6. Calculate angle of inclination from the height of the flag returned by image processing function.

7. Set servo angle accordingly.

8. Pick the ball and place it at the top of the incline for it to roll down freely.

9. Testing the model for various testcases.

Project Plan:

There were a number of new software and firebird functionalities in the project which were not previously done in the labs. We planned to get a basic knowledge about all of them to test the feasibility of the project and divide up the work accordingly.

We divided the project into modules and started on the easier tasks first. The plan was to complete the project by 5th April and start on the documentation of the project. We had the following dates scheduled:

Tasks 2-5	by 28th
Hardware along with Task 1and 6	by 3rd
Task 6-9	by 5th

Dates of completion:

Tasks	Date of Completion	Contributors
1,2,3,4	1st April	Arup, Neeraj and Shrikant
Hardware	4th April	Vaibhav Gupta
5,6,7,8	9th April	Arup, Neeraj and Shrikant
9	10th April	Everyone

Critical Tasks :

1) Calculate distance of the flag from the firebird
2) Communicate through the Zigbee
3) Hardware to hit the ball
4) Achieve accuracy

Innovation and Challenges:

1) Accurate hitting of the ball was achieved using Image Processing which was never tried before.
2) Algorithm is independent of the size of arena. Using flag for locating the hole helps achieve this.

Challenges:

1) The ball had a seam which caused the ball to deviate from the path towards the hole.
2) The distance of the flag could not be calculated precisely and had to be converted into another notation for usage.
3) The firebird had issues with the motor and sharp sensor for which a lot of time was used up which was unnecessary.
4) We needed the bot to go straight ahead towards the ball, only when the ball is in the centre of frame. Due to communication delay, bot rotated once more before stopping. To overcome this, we stopped one frame early. This made the bot move directly towards the bot.

Tasks Completed:

1. **Locate the Ball**:

We used Image processing through Matlab for this task. We ensured that the bot receives a signal to stop rotating and move toward the ball only when the ball is in the centre of the frame.

2. **Move towards the Ball**:

Simple motion of the firebird was used for this task. We used ADC Sharp sensor 11 to stop the firebird while at a safe distance from the ball to rotate around the ball. One could have also used ADC sensors 10 and 12 for more precision.

3. **Rotate camera 90 degree to the right and bot 90 degree to the left**:

We needed to keep the camera stable for image processing. Adding the rotating feature to the camera could have made it unstable . So, we used servo motors which locked the camera's position. Wireless camera added to the stability.

Simple motion control of the firebird was used for rotating the bot.Also, a wireless camera was mounted on a servo motor on top of the firebird . We used the servo motor to rotate the camera.

4. **Rotate in a circle around the ball trying to locate the flag**:

The firebird searched for the blue flag while rotating around the ball. We used Matlab Image processing to accomplish this task. As soon as it locates the flag, the bot stops rotating around the flag.

The major concern was to orient the bot so as to able to hit the ball towards the goal. So, we ensured that the flag was a certain distance to the right of center of the frame. This offset value depends on the width of the firebird and also the distance of the flag from the robot. We took only the width of the firebird into account. A picture of this state can be seen here.

5. **Again revert back to original position** i.e. rotate camera 90 degree to the left and the bot 90 degrees to the right.

The robot uses the servo motor to rotate back the camera to initial position (0 degree) and simple motion control to rotate bot by 90 degrees to face the ball and the flag.

6. **Calculate angle of inclination from the height of the flag returned by image processing function**:

We wanted to hit the ball with variable force depending upon the distance of the flag from the robot. To estimate this distance, we used Image Processing. The Matlab code returns values between 3- 9 which signifies distances of 10 cm to 90cms. With this estimate values, we change the angle of inclination using a servo motor attached to the incline.

The major problem was that signal processing in firebird can receive only one character at a time, this forced us to code distances into single digit values. Also, we needed to calibrate the angles for precision. This is completely dependent on the ball used and the arena. We made efforts to make it universal.

7. **Set servo angle accordingly**:

The servo is initially at angle of 90 at which the incline is straight. One needs to set a lower value than 90 to hit the ball towards the flag. We also kept a threshold angle of 45, so that the ball does not jump off after hitting the floor.

8. **Pick the ball and place it at the top of the incline for it to roll down freely**:

One has to keep the ball at the very end of the incline. A picture of this state can be seen here.

9. **Testing the model for various testcases**.

The motion was simple to implement but to fine tune the movement we had to overcome a few problems. One of the motors of firebird was not working correctly. We even replaced the motor, but the problem persisted. We finally, calibrated values to achieve straight forward motion and rotating the bot in a circle.

Review, Test Plan/Cases:

a) Test Cases:

a. Ball not in the Arena : The firebird rotated 360 degrees and stops displaying Ball in Hole on L.C.D
b. Ball and flag straight ahead of bot : Seeing the ball, the bot rotates towards the ball. It rotates 90 degrees and rotates camera also. It locates the flag immediately and re-aligns itself. The ball misses the hole by a small margin.
c. Blue flag not in the arena : The bot after rotating around the ball for some time, stops and displays Flag not Found on L.C.D
d. Ball was collinear to the flag and the bot. Distance between the ball and flag varied. The incline rose to a greater angle when the ball was near to the bot.

b) Performance Metrics:

a) Communication delay was adjusted for moving towards the ball. In case the delay changes, the bot will not be directly towards the ball. This would affect accuracy in a sense because we keep the flag at a certain distance from the center in the frame. Also, the bot may hit the ball.
b) We need to calculate the height of the flag. For this , the camera needs to detect the entire flag and not some part of it. If there was a difference in intensity of light, only some part of the flag was detected. This resulted in the wrong angle of incline. So, we performed under a flash light to adjust for varying intensity.

Re-usability Features:

a) In-code and adherence to standards

The code is written mostly using functions and thereby is easy to work on. It also presents a working of the bot which is machine independent. The contents of the functions are to be changed on changing the underlying hardware

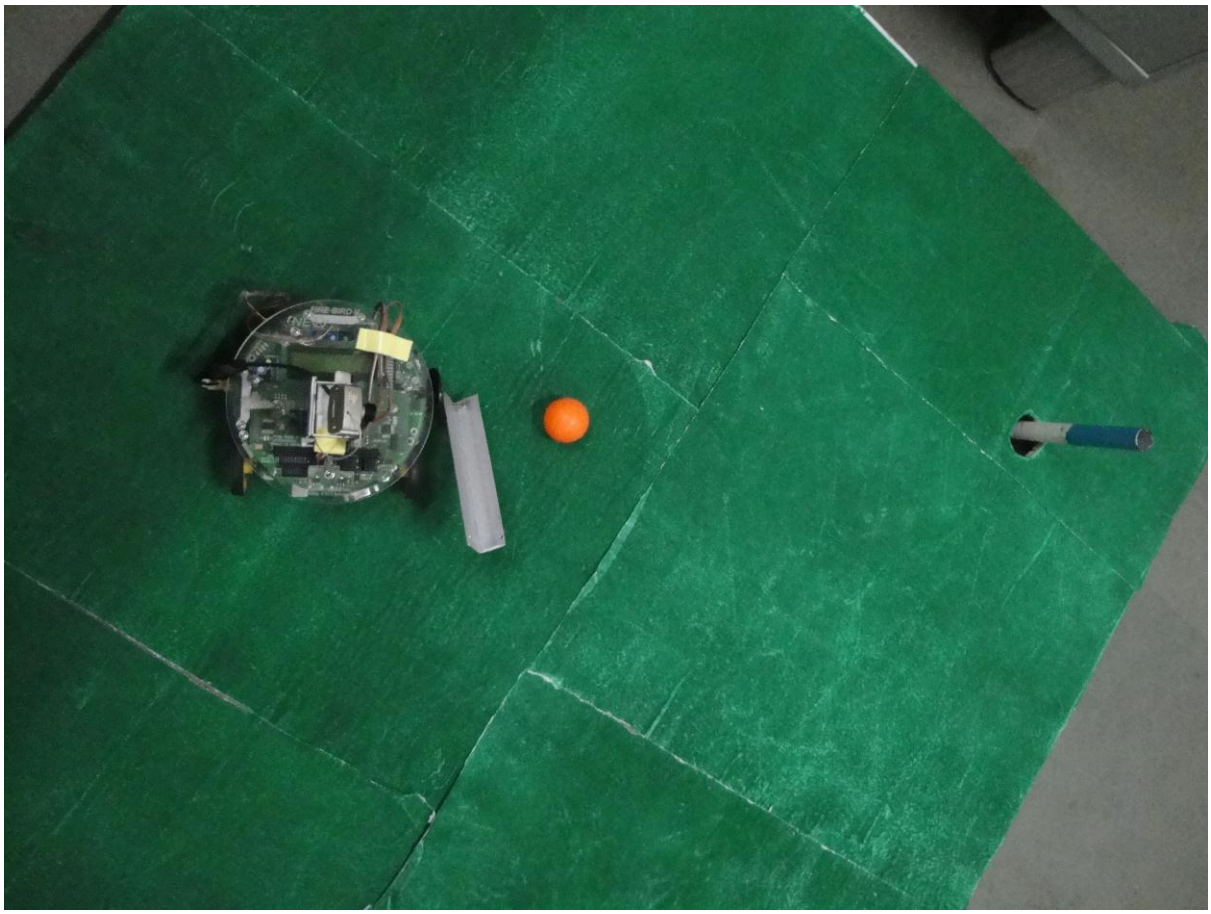
b) Image Processing Module

The image processing code can be used for detecting any coloured object. Only a few parameters are to be changed to get desired output.

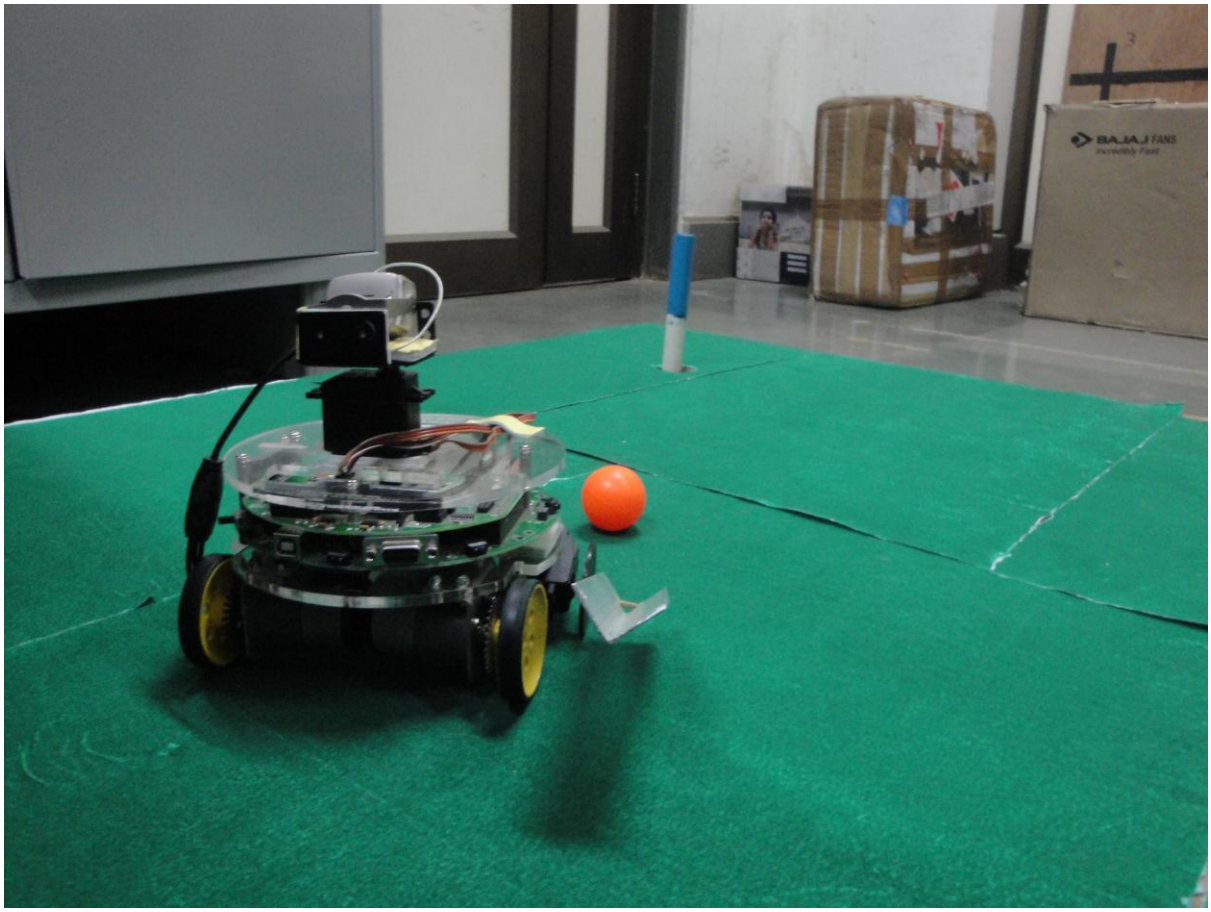
Future Enhancements:

1) One could improve upon our project and add for varying factors like sloped surface and obstacles between the ball and flag. This would involve knowing the terrain and would make the simulation very much like actually playing golf.
2) One can build a golf stick arm attachment for the firebird or a grabber to place the ball into the incline
3) To achieve higher accuracy, one can involve the distance from the flag into calculating the offset.

Camera, ball and Flag Collinear



Hitting the ball towards the hole



References:

- http://www.e-yantra.org/home/
    - For basic support for Firebird
- http://www.mathworks.in/help/techdoc/
- http://www.mathworks.in/help/pdf_doc/matlab/getstart.pdf
    - For image processing help in Matlab
- http://www.e-yantra.org/home/projects-wiki/item/131-tennis-ball-collector-using-atmega-2560-robot
    - For building on the existing code of this project