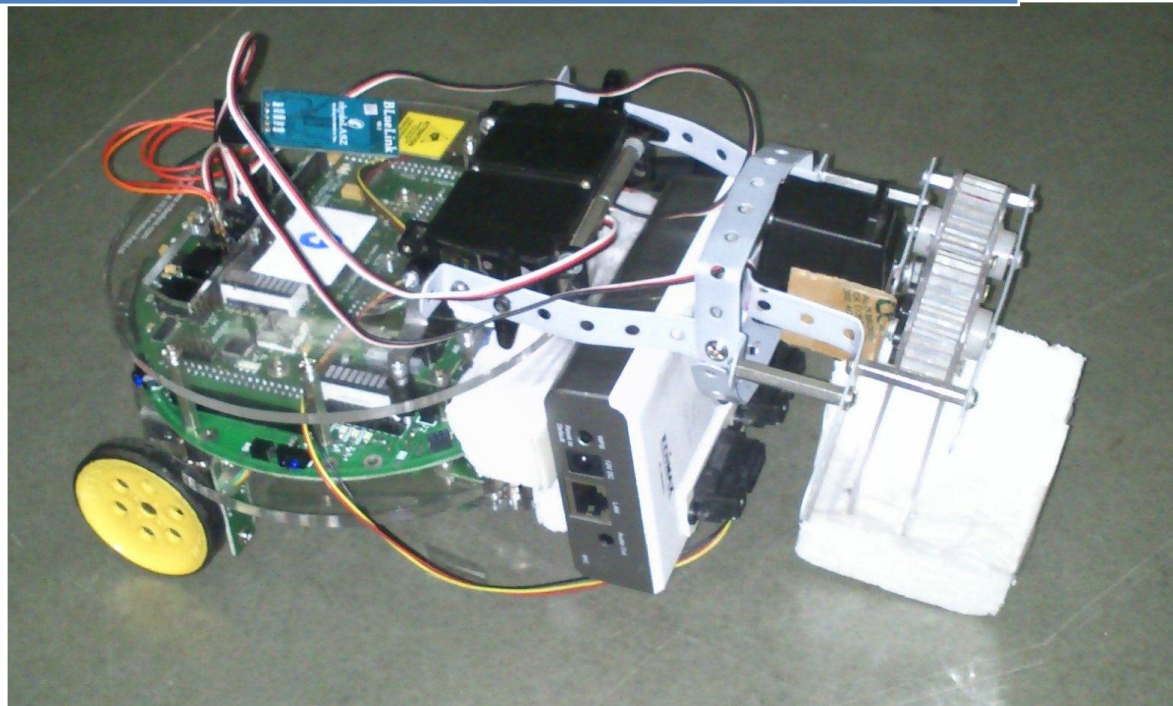


ERTS Lab,  
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# Android Based Remote Tennis Ball Collector



*Team 14*

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Our Firebird functions as a tennis ball collector. It sends the video stream of environment in front of it via an IP Camera fixed in front of it. Android mobile downloads the video from the IP Address of camera and processes it for the presence of tennis ball. Then it sends appropriate signal to the bot via Bluetooth communication module.

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## 1 Introduction

### 1.1 Overall Description

Our project aims at building a completely remote controlled firebird controller using android mobile. In that direction we implemented a Tennis Ball Collector which utilizes the processing power of Android mobile for image processing.

### 1.2 Definitions

S.No.	Name	Definition
1.	Mobile	Sony MT11i (Xperai Neo V)
2.	Android	Mobile operating system (sometimes used as 'mobile')
3.	Camera	IP Camera
4.	Bot	Firebird V
5.	PC	Computer, which acts as router in our case
6.	Wi-Fi/ Bluetooth	Communication Protocols
7.	Sensor	Sharp sensors connected to firebird
8.	Gripper Arm	Mechanical arm mounted on Firebird

### 1.3 Requirement Specification

- Environment Capture using Camera
- Transmission of media from Camera via Wi-Fi
- Processing the media received
- Sending appropriate signals to the bot
- Analyzing the received signal
- Responding accordingly

## 1.4 References

- Our project is an extension of
  1. Tennis Ball Collector using ATmega 2560 Robot  
<http://www.e-yantra.org/home/projects-wiki/item/131-tennis-ball-collector-using-atmega-2560-robot>
  2. Controlling Firebird V using an Android based phone via Bluetooth Controlling FirebirdV ATmega2560  
<http://www.e-yantra.org/home/projects-wiki/item/140-controlling-firebird-v-using-an-android-based-phone-via-bluetooth-controlling-firebirdv-atmega2560>
- OpenCV + Android setup
  3. Using Android binary package with Eclipse  
[http://opencv.itseez.com/doc/tutorials/introduction/android\\_binary\\_package/android\\_binary\\_package.html](http://opencv.itseez.com/doc/tutorials/introduction/android_binary_package/android_binary_package.html)
  4. OpenCV in Android  
[http://www.stanford.edu/~zxwang/android\\_opencv.html](http://www.stanford.edu/~zxwang/android_opencv.html)

## 1.5 Developer Responsibilities

## 2 Implementation

### 2.1 Product Perspective

### 2.2 Product Functions Overview

### 2.3 User Flowchart & System Design

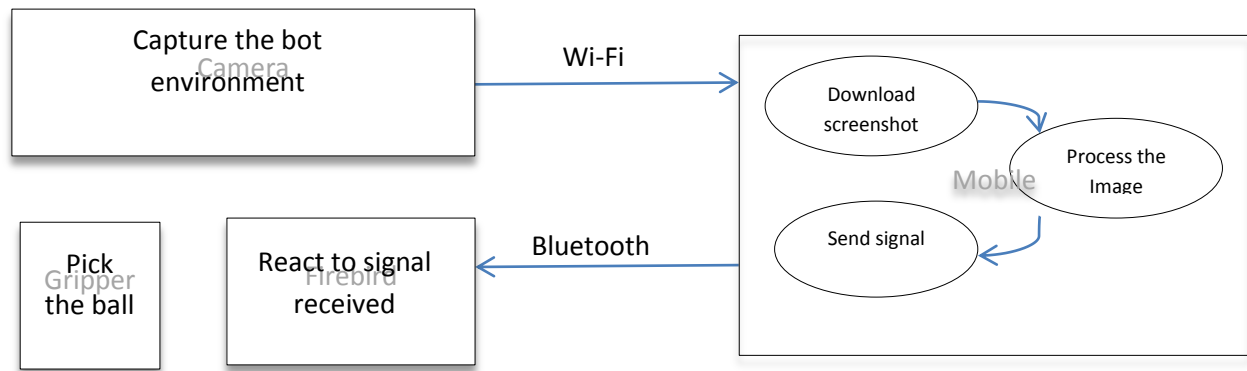


Fig 2.1.Flow Chart Diagram

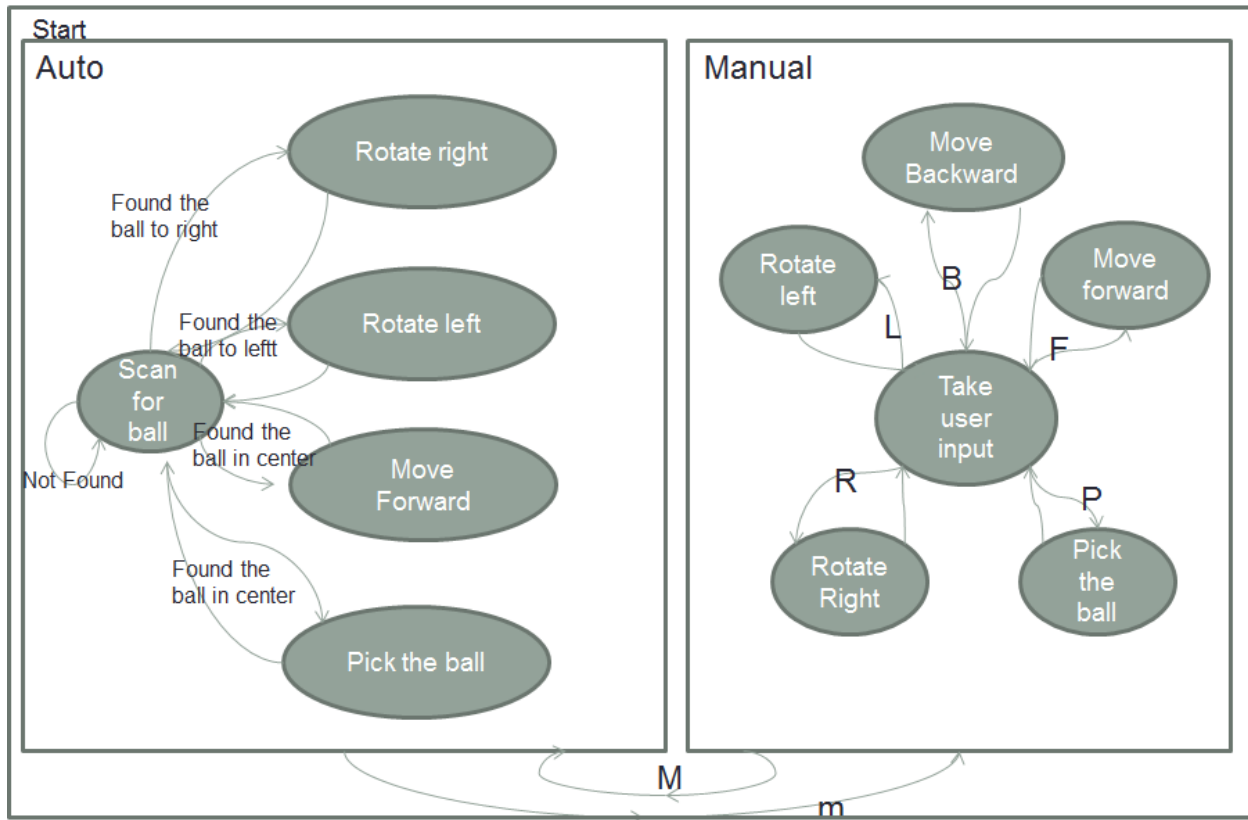


Fig 2.2. State Chart Diagram

## 2.4 User Characteristics

Here user is the person handling the mobile. He should have an idea of controls on UI (they are very much intuitive). While the application is running in Autonomous mode there is no user involvement as the mobile processes and sends the signals automatically.

## 2.5 General constraints and assumptions

- The only orange coloured objects present in the arena are TT balls. This is necessary for the algorithm used to work as it is based on colour detection.
- Only one ball will be present in the arena at any particular instant of time. Though the image processing algorithm can distinguish and identify one of the balls as object of interest, this can be tricky sometimes as android as no means of knowing which of the balls is close by.
- After every fresh setup, sensor values are to be re-calibrated as they seem to change with environment and from one-to-another.
- Hardware, Android:
  - armv7 processor is recommended, because of have a floating point preprocessor (Open CV).



- Touch enabled – by design
  - Bluetooth and Wi-Fi capability – most smart phones have it
- Though initially planned during our SRS, we couldn't implement dropping of ball in basket after picking it up, due to lack of time.
- No packets are lost in transmission

## 2.6 Additional Hardware

- Bluetooth Module – 5V Serial UART ( Rs. 2000)
- IP Camera – Edimax IC3030Wn
- Gripper Arm – mechanical parts
- Android mobile – Sony MT11i

## 3 Functional Requirements

### 3.1 each feature e.g. Bluetooth>

## 4 Implementation of Functional Requirements

Working - explain with diagrams

### 4.1 Sub-parts and explain code )

## 5 External Interface Requirements

### 5.1 Android Application

### 5.2 Embedded Systems

### 5.3 Hardware

Describe the implementation and reproduction of various hardware/mechanical parts used

explain with diagrams

## 6 Usage Settings

Various settings which are to be made to use the project

## 7 Development

### 7.1 Settings & Configuration

say for communication e.g. serial, Bluetooth, Wi-Fi

#### 7.1.1 Environment

1. ***FB5***
2. ***Android***

#### 7.1.2 Project (adjustable)

### 7.2 Utilities

#### 7.2.1 Hardware

#### 7.2.2 Software

### 7.3 Code Description

Just copy paste the commented code here

#### 7.3.1 Description of Image Processing Algorithm

### 7.4 Instruction Execution

## 8 Performance Characteristics

Performance depends on the

- speed of Wi-Fi connection
- whether the network is shared with WLAN used.
- Mobile Processing power
- Distance between bot and mobile (Bluetooth communication)

## 9 Design Constraints

(These constraints can be overcome)

- Only one ball in bots view.
- Connects only to one hardcoded Bluetooth module
- Picks only one ball in auto mode and then stops.

## 10 Testing

### 10.1 Criteria

We have introduced a delay of 1s between any two communications. This is done in order to give the other end sufficient time to realize the signal sent.

Since the Android mobile has considerably much lesser resources when compared to PC, delays might be larger.

### 10.2 Results

We have practically observed that the android mobile takes about 500ms to process a single image and transmit the appropriate signal.

We have tested the bot in various environments and background views. It works fine unless there are orange objects in background and also slight variations are found in sensor values with environment.



## 11 Troubleshooting

### 11.1 Delays

We have introduced a delay of 1 second between any two consecutive communications. This is to make sure that the other end gets sufficient time to receive, analyze and respond to the signal sent.

### 11.2 Bluetooth not connected

Try restarting both the application and firebird. Wait for about 30 sec between two consecutive starts.

### 11.3 Image Download very slow

Share your local LAN with the WLAN setup in your PC.  
We don't know the reason but this works.

### 11.4 Bot tries to pick up before reaching the ball

Change the sensor thresholds where pick function is called I auto mode. The sensor values keeps changing with environment.

## 12 Individual Roles and contribution

S.No.	Name	Work done
1.	Hasan Kumar Reddy	Android application
2.	Bhanu Prakash	Firebird code
3.	Vinod Reddy	Image Processing OpenCV code
4.	Avinash T	Hardware

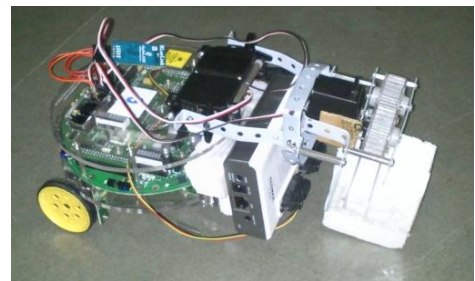
## 13 Roadmap

S.No.	Milestone	Alloted to	Completed On
1.	Project Presentation	Vinod, Hasan	7 <sup>th</sup> March
2.	Identifying modules and allotment	All	16 <sup>th</sup> March
3.	Setting up the Wi-Fi Camera	Hasan	29 <sup>th</sup> March
4.	Received our order for Bluetooth module		3 <sup>rd</sup> April
5.	Android Application	Hasan	7 <sup>th</sup> April
6.	Image Processing Code	Vinod	9 <sup>th</sup> April
7.	Firebird Application Logic	Bhanu	8 <sup>th</sup> April
8.	Fixing Arm on Bot	Avinash	9 <sup>th</sup> April
9.	Bluetooth Transmission	Avinash, Hasan	10 <sup>th</sup> April
10.	Bluetooth Receiving	Bhanu, Vinod	10 <sup>th</sup> April
11.	Project Integration	All	11 <sup>th</sup> April

## 14 Challenges and Innovation

- Android Mobile (MT11i) doesn't recognize the usual ad-hoc Wi-Fi network setup by PC. But for IP Camera to work even Mobile is to be connected to the internal network (proxy issue).
  - Rooted the mobile and tried various applications which claimed to work, but unfortunately none of them worked.
  - Finally setting a WLAN network bridge (which acted as an Interface mode Wi-Fi router) in windows worked.

Source: <http://www.youtube.com/watch?v=klHzMyYFGeQ>
- To display bot's environment in the mobile, we initially tried loading an image at regular intervals (less data transfer). In its implementation, we had to use the native java timers, which made the app non-responsive a few time. (Though a better approach would have been using a handler for a runnable, which calls itself after certain time after its execution.)  
So, we switched to webview, which displayed the default monitoring page of the IP Camera. The problem here is that it always displays four different camera streams, three out of which are defunct for our purpose.  
Soln: We ran a javascript on top of webview to hide all unnecessary fields.
- Open CV :
  - Installing Open CV in Windows is a challenge in itself. We had to set it up for android environment in windows. We had followed various tutorials , but all in vain. Finally got a bundle of open CV C++ files, which we had put them inside our jni folder instead of linking the Open CV library during the build time. This made the whole open CV library a part our project. Though it take a while to build for the first time, it's worth it. Your android application will still be of same size as before as eclipse is clever in linking only those object files which are referred.
  - The usual opencv cvHoughCircles, which is used to detect circles doesn't perform well in non-uniform background and is relatively slow. We came up with our own algorithm (described in 7.3.1 ) which works fine in most cases and is fast.
- Hardware:
  - Mounting the camera
    - If placed in front, will obstruct the sharp sensor and will be in the path of arm movement
    - If placed on top, will be obstructed by the gripper arm
  - Using a single sharp sensor led to missing the ball in a lot of cases, so we have decided to use two closely placed sharp sensors
  - Solution :
    - Increased the length of gripper arm
    - Placed the sensor on the camera
    - Placed the camera in front of the bot



### 14.1 Github Repo

We have maintained our github repo in an organized fashion and updated it regularly. We maintain two branches one for development and other for master and merged development to master once after every milestone is reached.

### 14.2 Bugs & Fixes

- If the Bluetooth module doesn't get connected, restart both bot and application and then try to connect again.
- Both the servo motors were out of sync initially, fixed via adjusting the rotation angles in software.
- One the ball is picked in auto mode, cannot collect any more balls. – by design
- Build your project only for Android version  $\geq 2.3$  as apparently there is but in Android 2.2 regarding BitmapFactory which makes the image download and processing very slow (around 20 times)

## 15 Bug Report

- Application seemed to crash when many other applications are running simultaneously in the background.  
Fix: Close all applications before opening this application
- Bluetooth connectivity:  
A few times Bluetooth connection doesn't get established automatically.  
Fix: Restart both the bot and application after waiting for about 30 sec.
- If the first signal sent by the application is to move either left or right, i.e, not forward or backward, the application on bots end gets stuck and will not receive any more signals.

## 16 Reusability

We have used parts of Bluetooth communication from previous batch's application code. On the similar lines we expect someone else to use our code in forth coming years.

Hence we have our code in a nice modular fashion and documented wherever necessary.

- Image Downloading
  - Image processing
  - Application code
  - Communication
- Each in a different class.

In-code standards:

have adhered to java commenting standards (javadoc), eclipse friends

We have also included a brief description on how to use Open CV for android image processing projects. This could save a lot of time for forthcoming teams.

## 17 Future Work

- Replace the Bluetooth communication with Wi-Fi shield. This make the application remotely working in real sense.
  - Resources:
    - Application using Wi-Fi shield  
<http://www.instructables.com/id/How-to-build-an-Arduino-WiFi-4x4-with-Android-Cont/>
    - Procurement site  
[http://asynclabs.com/store?page=shop.product\\_details&product\\_id=26&vmcchk=1](http://asynclabs.com/store?page=shop.product_details&product_id=26&vmcchk=1)
- Use and existing or write one openCV wrapper for android (Java)
  - <http://code.google.com/p/javacv/>
- Improve the UI control  
 Gives better control over bot and instructions are executed smoothly.
  - e.g., <http://www.instructables.com/id/JabberBot-The-Arduino-robot-with-an-ATMega-brain-/>
- Implement reliability  
 Right now we assume that all the signals sent have reached the other end. But this might not be the case in a real world example. In that case we need to acknowledge in some manner that the packet has not reached the other end.

## 18 Conclusion

During the course of the project we have learnt a lot including

- Open CV Image processing
- Interfacing Open CV with android
- Bluetooth protocols
- Configuring Bluetooth module
- Various hardware usage techniques

All which could help us even a long way after the completion of the course and are very satisfied with the project.