Group 12

CS-684 Project Report

On

# “Pick ‘n’ Place Robot”


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# 1. Introduction

The objective of this project is to pick and place objects of similar color at base. The snapshots are taken from an overhead camera and based on some interesting properties objects are picked. The picked object is then placed at the base where objects of same kind are placed. The snapshots/images are taken from overhead camera which is interfaced with MATLAB where Image Processing is done and it will pick the object of minimum distance with the help of an Arm assembly. Robot then places the objects at base.

## 1.1 Definitions, Acronyms and Abbreviations

- **Fire Bird V:** Fifth generation Robot developed at ERTS Lab IIT Bombay.
- **Base:** Pre specified area to place the objects.
- **Threshold Distance:** It is the distance between robot and object in order to pick the object firmly.
- **Gripper Arm:** Assembly which is required to pick the objects from arena and place them at base.
- **Interesting Properties:** min (d1,d2,...,dn) where di : is the distance of ith object from robot in that snapshot.

## 1.2 Assumptions

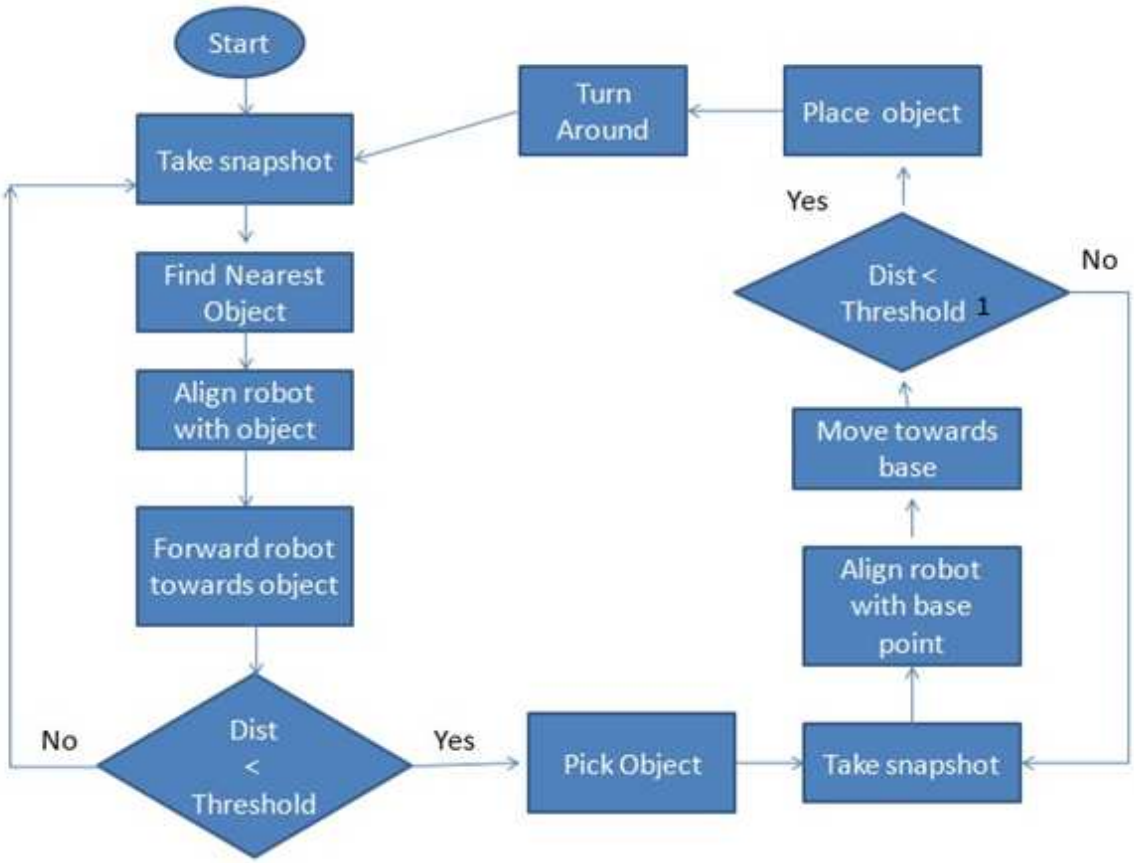
- All objects are of same dimensions, because servo angle for picking is fixed.
- Area of arena is small because of low resolution of overhead camera.
- Arena/Background colour is taken as black due to uniformity and minimum reflection.

## 1.3 Set-Up implemented

We have attached a robotic gripper arm on a FireBirdV for picking objects. This arm is made of 2 servo motors where one motor provides vertical motion and other helps us in picking objects.

## 2. Overall Description

### 2.1 Flow Chart




where Threshold1 is distance of Robot from base.

### 2.2 Hardware Requirements

| Name | Description | Approximate Cost(in rupees) |
|---|---|---|
| Arm Assembly | For picking and placing of objects | 2000 |
| Overhead Camera | To take snapshot of arena | 1500 (2 MP) |
| XBEE modules | Wireless communication | 1665 x 2 |
| STK200 | Programmer | 1500 |
| Firebird V ATMEGA 2560 | Robotic Platform used to build our application | 15000 |

## 2.3 Software Requirements

- MATLAB
- AVR Studio 4.16 or above
- Camera drivers

## 2.4 Communication Interface

The communication between PC and robot will be done using XBEE modules. MATLAB program sends control commands to robot in order to align with objects, pick and place the objects. Robot sends the acknowledgment once it performs a task.

# 3. Design and Implementation

We have used MATLAB for image processing while robot navigation is implemented in C language. The design steps are as follows

### 3.1 Design Steps

- First we detected different colors using image processing tool of MATLAB.
- Wrote code for pick and place mechanism using robotic arm.
- We tested zigbee modules using small codes for moving robot in different directions, picking and placing objects.
- Image processing is done using MATLAB. To know the direction of robot, we used two pasted two different color tags on robot.
- Then we identified objects and calculated distance between objects and robot center.
- Wrote code to identify nearest object and aligning robot with object.
- Then we integrated and tested all modules.

### 3.2 Design Constraints

- Motion of the robot can be inaccurate because of *unbalance wheels.
- Low resolution camera may leads to imprecise color detection of objects.
- Threshold distance may not be accurately achieved due to unbalanced wheels.

- We used overhead camera instead the onboard camera because, the former gives a 2D view of the field, which is easy to process while the later, may give a 3D view.

*unbalanced wheels:- Two wheels do not move in same proportion

- Robot wheels are unbalanced which could lead to inaccurate alignment of robot with objects. To overcome this problem, we took continuous snapshots after each operation to track current position of robot with respect to desired alignment.

## 3.4 Implementation Challenges

- As we are using overhead camera, light reflected from smooth black chart paper even appear white.
- Image properties depend on the light intensity so we had to revise the image processing program on each run.
- As we had to use multiple colors, it was difficult to differentiate between colors with low resolution camera. To overcome this problem, we used basic colors like green, white, and red.

## 3.5 Code Structure

The program is divided in 2 main modules i.e. main.c which burn onto micro-controller and imageprocessing.m which runs on PC using MATLAB. Descriptions of these modules are as follows.

- **main.c :**

  This is written in C language. It works as back end and performs the tasks specified by MATLAB program. It has functions for basic movements of robot, picking and placing mechanisms.

- **imageprocessing.m**:

  This is written in MATLAB and works as front end. It opens a serial port to communicate with robot through zigbee module. It takes snapshot and identifies objects of different colors. Two different color tags are used to know the direction of robot. It identifies objects and finds the nearest one. Then it calculates the angle between center of robot and center of nearest object, also the direction of movement. It sends this information to robot and wait for acknowledgment. It repeats this task until it reaches threshold. Threshold is the distance between robot and object which lets it pick the object firmly. Then it sends command to robot to pick the object and wait for acknowledgement. After getting acknowledgement, it again takes snapshot and sends angle and direction to robot for reaching base station and placing the object.

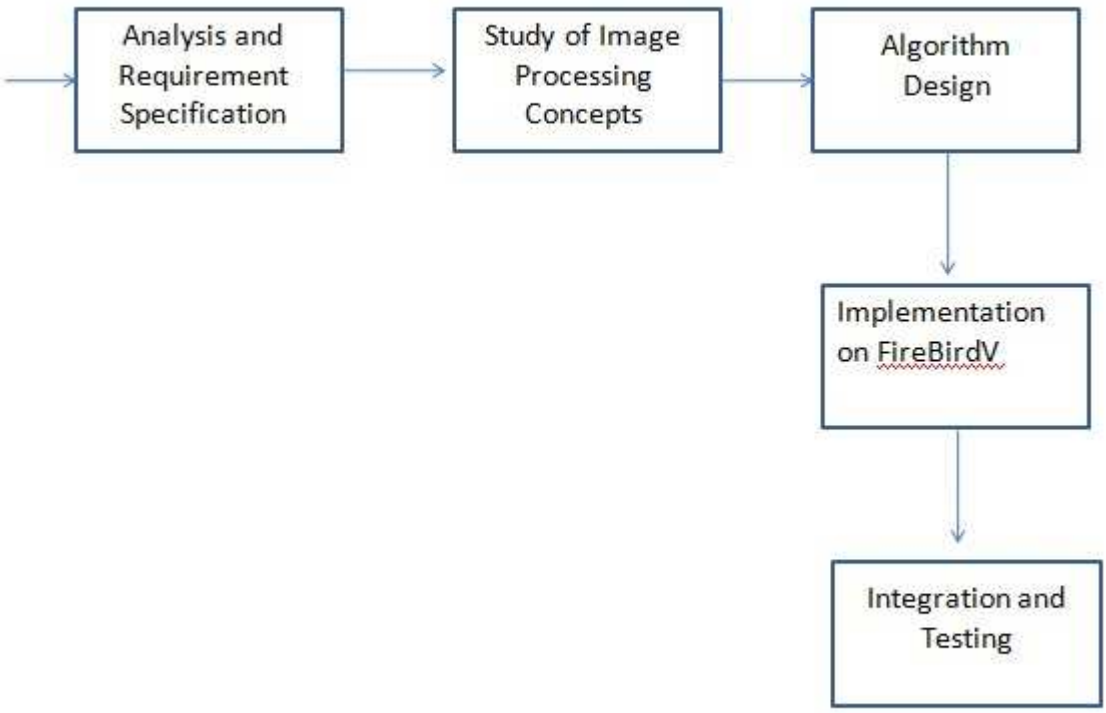
  Same process is repeated for all objects.

## 3.6 Innovation and Reusability

- We have used overhead camera which lets us identify objects precisely without roaming around in the arena.
- The algorithm used is capable of handling unbalanced wheels motion by taking continuous snapshots and sending back the acknowledgement.
- In image detection algorithm, we have identified objects based on color and area. This mechanism can be used to distinguish small and big objects.

- The code can be used in collaborative pick and place application where various robots negotiate with each other.

## 3.7 Time-Line




Time Line

| **Steps** | **Time Taken(in days)** |
|---|---|
| Analysis and Requirement Specification | 7 |
| Study of Image Processing Concepts | 7 |
| Algorithm Design | 14 |
| Implementation on FireBirdV | 13 |
| Integration and Testing | 7 |

Total time devoted by both = 192 hours(approx)

### 3.8 Milestones and Deliverables

- Serial communication to/from MATLAB and FireBirdV through Zigbee modules [ 25-30 sept].
- Color detection using MATLAB [ 01- 10 Oct].
- Implementation of servo mechanism [11-20 Oct].
- Nearest object detection algorithm and sending information to robot (angle and direction).[21-25 Oct]
- Integration of above with pick and place mechanism.[27-28 Oct]

## 4. Work Division

- Image processing is done by Dinesh.
- Implementation of servo mechanism and communication between robot and MATLAB is done by Bharat.

## 5. Testing

We have done both unit as well as integration testing. Unit testing comprises of identifying different colors, communication interface while integration testing is done by combining all modules.

**Test Plan**

- Identification of different colors.
- Rotation through appropriate angle and direction.
- Alignment with minimum distance object.
- Correct alignment with object and base.
- Testing of complete setup.

## 6. Other Related Projects

- Stacking / Arranging objects of same colour at base, where Robot pick object and place it over object of same colour at base.
- Collaborative picking and placing using multiple Robots, where Robots negotiate with each other to divide their area for picking and placing based on certain dynamics like (number of objects in certain area, distance of objects from Robots etc).
- Tennis ball collection.

## 7. Learning

- Image processing concepts using MATLAB.
- Serial communication through Zigbee modules.
- Implementation of servo mechanism on FireBirdV.

## 8. Conclusion

We have built an application where robot picks colored objects and deposit in predefined area (base).

## 9. References


- Firebird V Hardware manual
- Firebird V Software manual
- XBEE Data sheet
- Digital Image Processing by Gonzalez and Woods.
- MATLAB Help