Robocon Report 2012

IIT Roorkee

This Report includes the details of ROBOCON 2012 which is the International Robotic competition in which Team from IIT Roorkee successfully participated In the month of March. The report also gives details of design and work done for it throughout last academic year. It also bring forth the generous efforts of IIT Roorkee Alumnus to add another feather to their ALMA MATER's beautiful crown. We heartily thank our Faculty Advisor Prof. P.M. Pathak, the entire alumnus and our seniors for their serious efforts to make this successful.

Aug 2011- March 2012

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Robocon 2012

ABU Robocon is an annual **Asia-Pacific level robotics competition organized** by broadcasting units of Asia including **Doordarshan** from India. Various countries like China, Japan and India participate in this robotic extravaganza to prove their technological supremacy. Each country is represented by a single team (2 in case of host country) which consists of **undergraduate students** of a premier technical institute of that country. The team which will represent its country is decided by the national level of Robocon, whose problem statement is same as the international one. In India, this event takes place in the month of March in Pune which is judged by the renowned faculty members of various technical institutions.

In this competition, we are required to build three Robots to perform certain task in stipulated time of 3 min with certain sequence and coordination. This tests the designing skills and automations capabilities of the undergraduate students. It started in India almost a decade ago; we started it at IIT Roorkee in year 2008. Since then we have improved a lot in every terms, whether it is designing, equipment selection, and other engineering aspects which is evident from our bots.

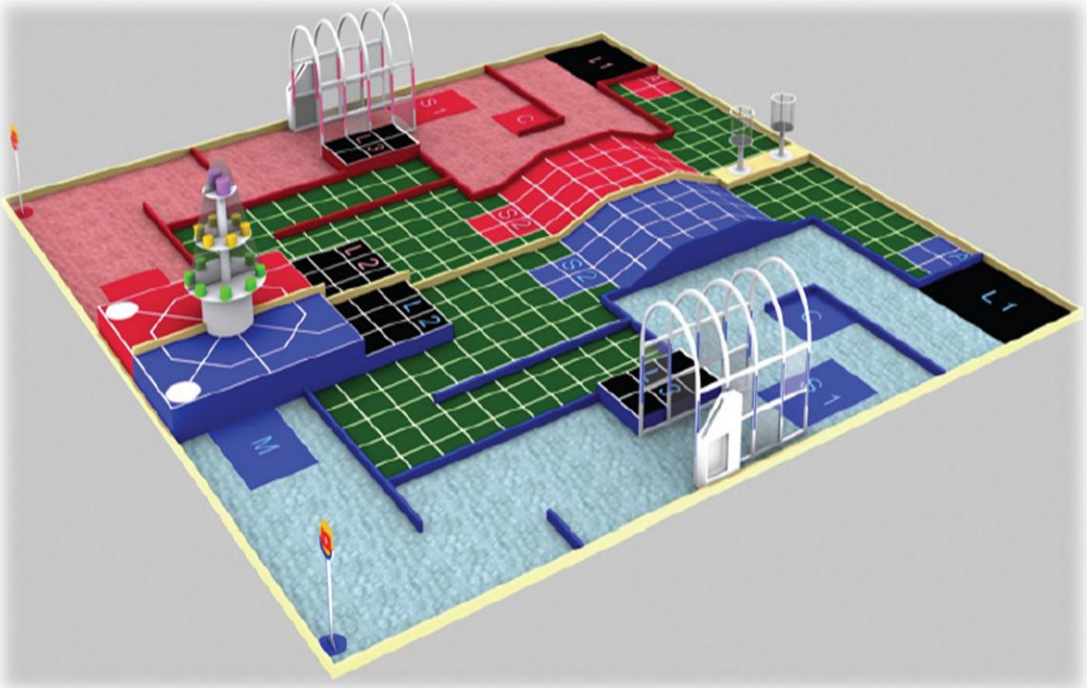
This year theme is explained in following chapter.

1.1.0 Introduction to Theme

"Peng On Dai Gat", means peace and prosperity. It is what the people try to achieve by collecting buns in the traditional bun collecting contest held during the "Cheung Chau Jiao-festival" in Hong Kong. The bun collecting contest being the most important event of this festival it is also called the "Bun Mountain Festival".

Some components of this festival will be adapted for the function of a robot-a real challenge to young contestants' creativity and innovation. We had to build intelligent robots performing in *dynamic environment.* The task of the robots involved picking and placing objects in three dimensions and simultaneously having collaboration between opponent teams. The key objective of this event which is: "One who wins over himself and wins over others is the all-time winner."

Actual Arena

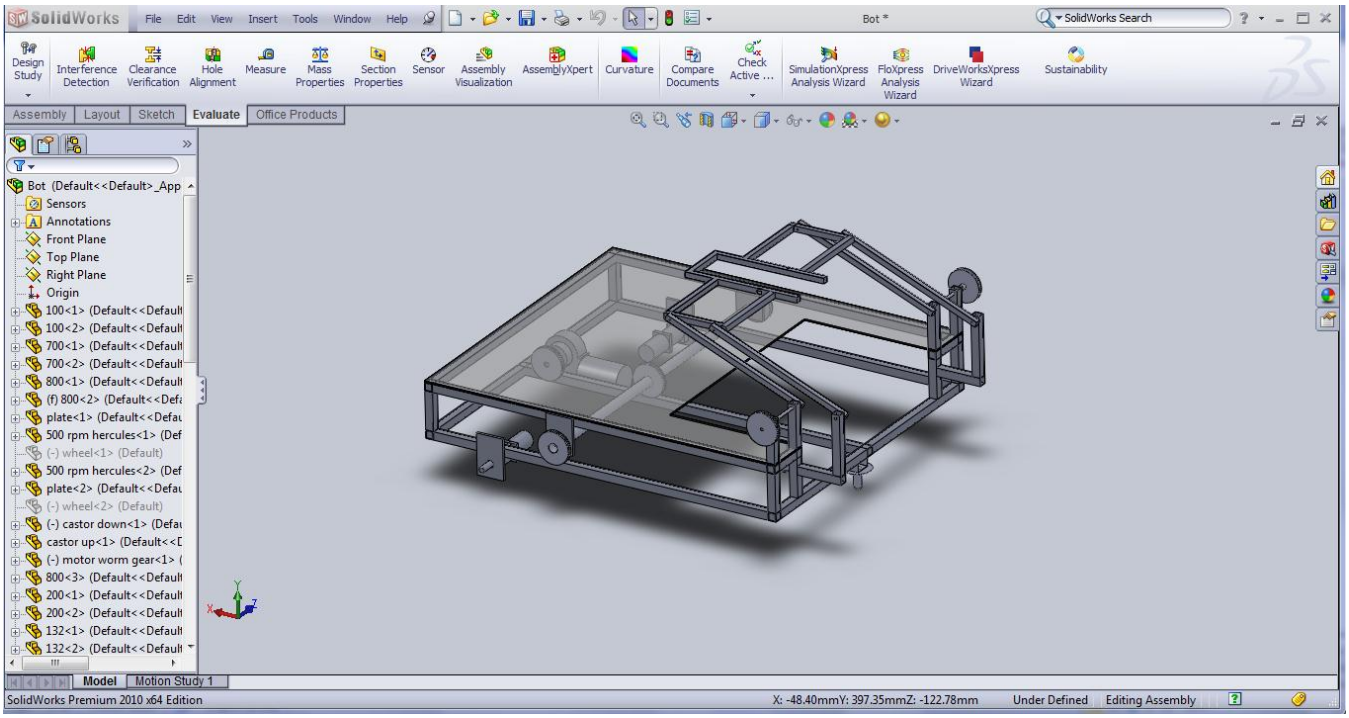


Solidworks Arena

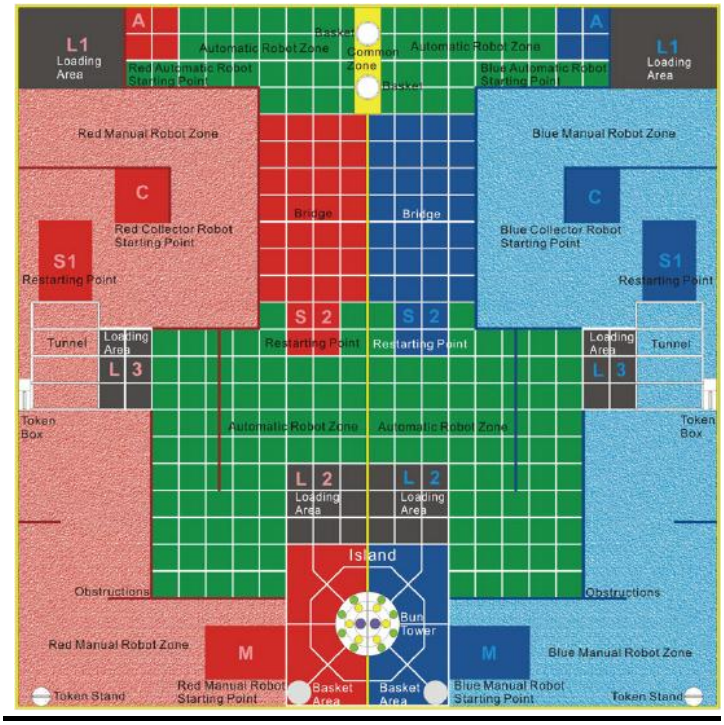
MECHANICAL HARDWARE

1.0.0 Our Approach

First the theme was studied and required functions of all three machines were enlisted. For satisfying these functional requirements mechanisms were developed and stimulated on different CAD softwares like SOLIDWORKS, ANSYS etc. After successful testing, individual components were fabricated. The quality products were selected and arranged by month long hard work. After fabrication, bots were tested in practice arena that we fabricated in out model section.



1.1.0 Manual Bot



The key features required in the manual robot were:

- In Manual Robot Starting Point, Manual Robot must have its dimension no larger than 1.5M in length, 1M in width and 1.5M in height. Manual Robot can expand, stretch or extend without any limits.
- It should be able to place the token in token stand so that autonomous bot could start working.
- It should pick up the collector bot and place it on autonomous bot from loading area 1. It should pick the basket (placed in manual zone by autonomous bot)and place on the island.

1.1.1 Mechanical Structure

The base of the machine was made using profiled aluminium channel. The thickness and the cross-section of the channel were decided after doing stress analysis using ANSYS. Aluminium was chosen as base material for its light weight and higher strength is to weight ratio. The base was made up of different sized aluminium channel joined together using connectors and 6mm Allen key bolts. The dimension of the base was 60cm (length)*70cm (wide).

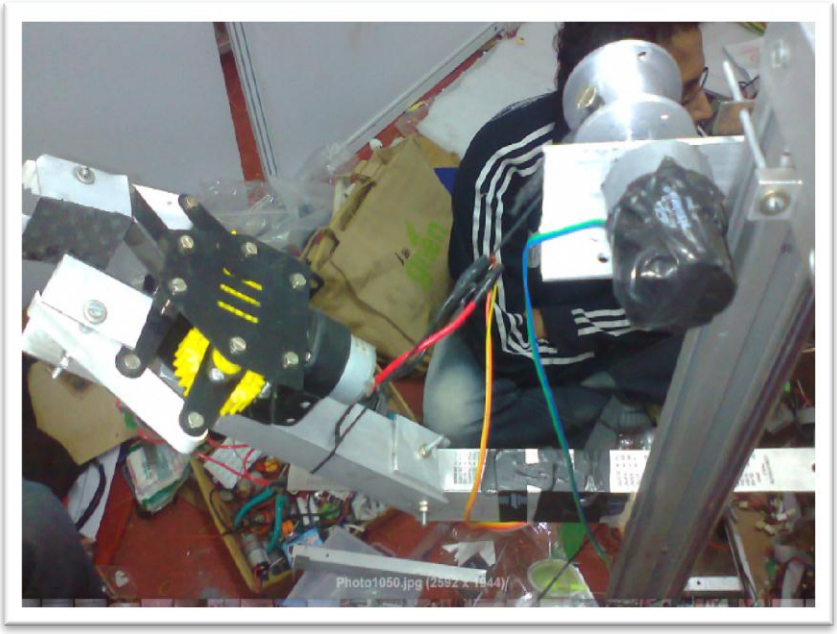
DIMENSION: 60cm X 80cm X 120cm

1.1.2 Drive Mechanism

The drive mechanism consists of 2 driven wheels in the rear and 2 castors in the front. Rear wheels were driven by DC motors from electric scooter(2500 rpm ,100 watt).Chain sprocket link is used to transmit power to the wheels from the motor's shaft. The shaft of the wheels rested on bearings. The speed of the machine can be changed by increasing or decreasing the percentage PWM given to the motors of rear wheels.

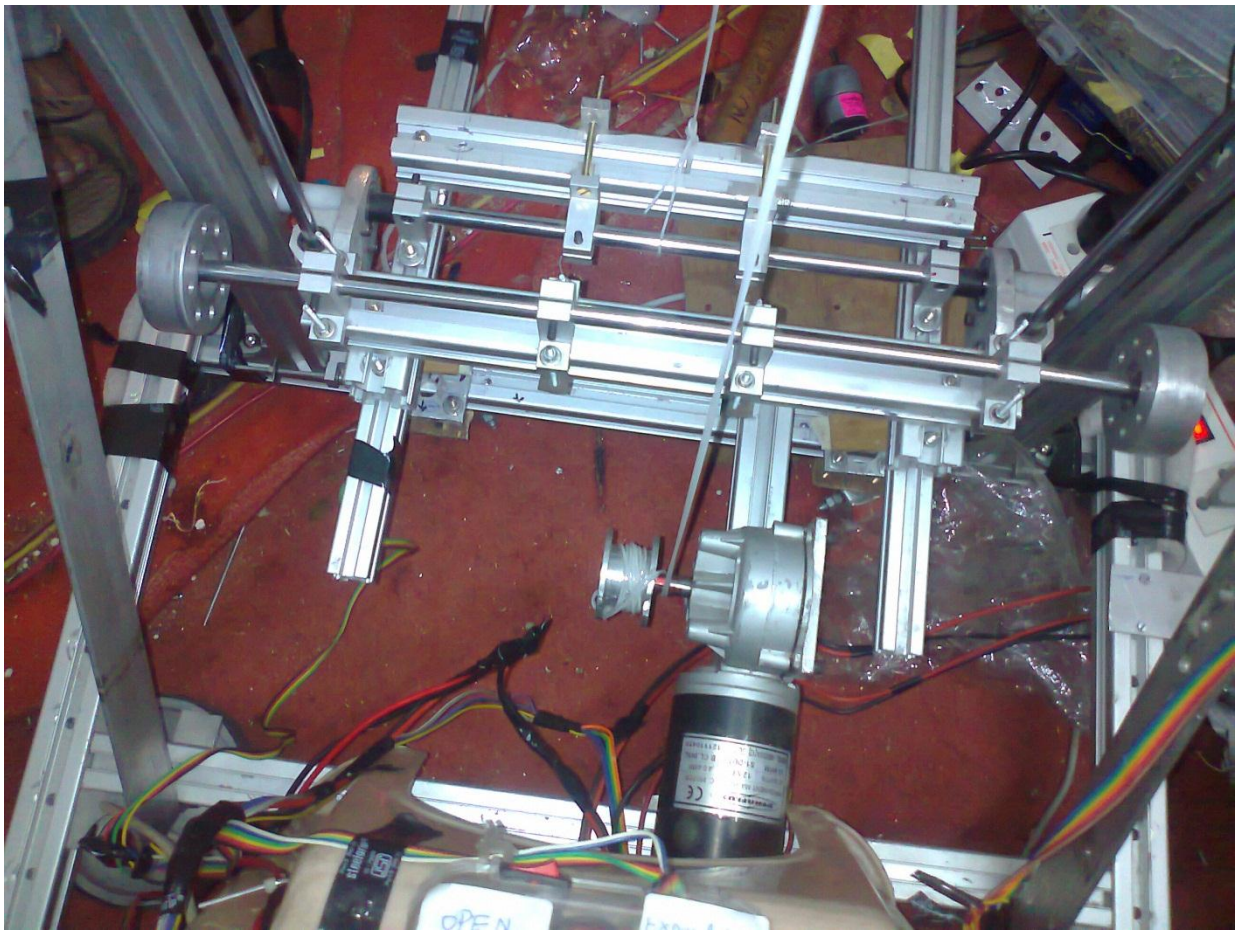
1.1.3 Token Gripping Mechanism

The mechanism for gripping the token has 3 degrees of freedom. It consists of a ready-made gripper wherein, a single motor activates two arms with 4 bar link to move forward and come closer to each other as well by means of a worm gear and two spur gears. This gripper is mounted on an L-channel that rotates freely (by means of pulley thread activated by 60 rpm dc motor) about another L- channel fixed to the bot's vertical girder. This entire mechanism could be fixed on either side of bot depending on the side of arena allotted.

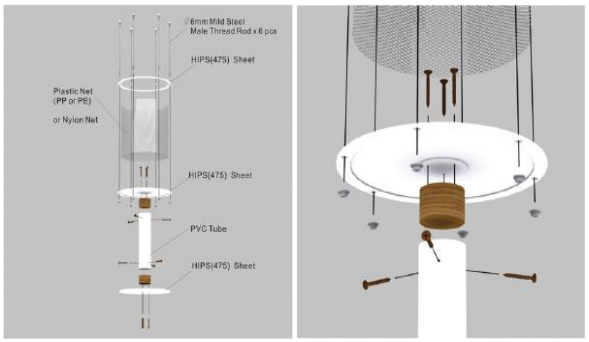


1.1.4 Lifting Mechanism

The lifting mechanism consisted of a fork made up of two profiled aluminium channels (cross-section: 2cmx2cm, length protruding outside the body=700cm and central distance between two channels of the fork= 28 cm). This fork was connected using a cylindrical ss rod through bearings to two plates which had sliding blocks connected to them, which used to slide on the cylindrical ss industrial sliders. This fork mechanism rested on the vertical channels through rolling wheels in front and back of the channels connected though bearings by ss rods. This whole fork mechanism was pulled up and down by pulley-string mechanism powered by dynaflux motor.



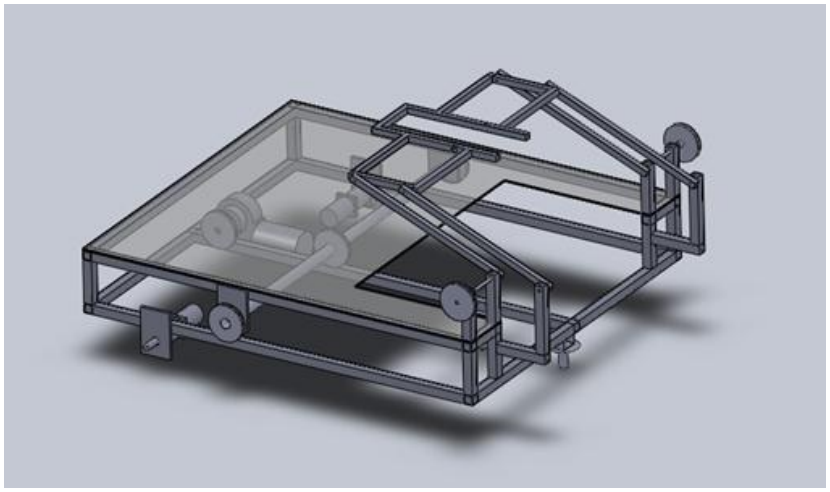
1.2.0 Autonomous Bot



The key features required in the autonomous carrier robot were:

- In Automatic Robot Starting Point (A), Automatic Robot must have its dimension no larger than 1M in length, 1M in width, and 1M in height. Automatic Robot can expand, stretch or extend within a cylinder of 1.5M in diameter considered from top view. No stretch up in height is allowed.
- It should be able to pick up the basket from common zone and place it anywhere in manual bot zone.
- Later it has to carry the collector bot on it from auto starting point to the loading area 2 passing over the ramp in the path.
- It has to communicate with the collector bot to unload it ,once it reaches loading area 2.
- It must perform its tasks automatically after it is started by a team member.

1.2.1 Mechanical Structure



The base of the machine was made using aluminium channel with square cross section. The thickness and the cross-section of the channel were decided after doing stress analysis using ANSYS and Solid Works. Aluminium was chosen as base material for its light weight and higher strength is to weight ratio.

The base was made up of different sized aluminium channels welded together. The base is rectangular with dimensions of 70x80cm. There is a square channel of 80cm in centre for strength. There is a raised platform of Al channel on which card board is placed, for the collector bot to be kept on it . Two L-shaped projections outwards are present on the front on which the parallelogram mechanism rests. Motors were mounted with help of aluminium plates and wheels are mounted onto the shaft of driving motors with help of a slot and key.

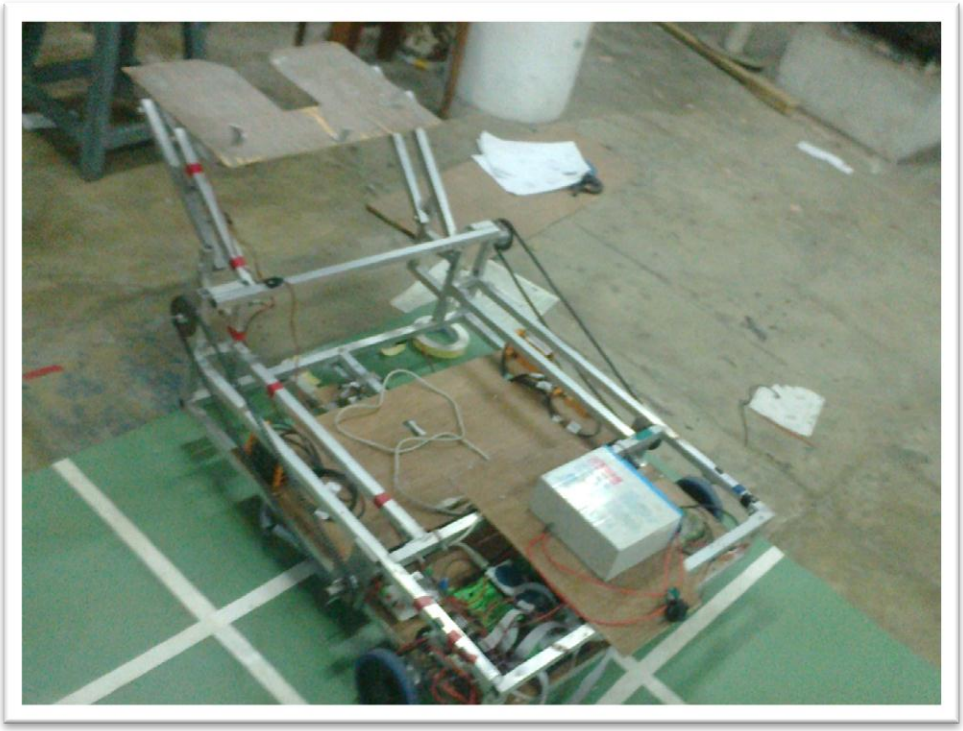
1.2.2 Drive Mechanism

The machines were driven by two rear wheels and use differential drive mechanism for turning purpose. There was a single castor on the front. The rear wheels always rotate at same speed at PWM supplied by the microcontroller. All wheels are powered by geared brushless DC Motors (12V, 500rpm). The rear wheel motors gets signals from microcontroller based on feedback from line sensor. The differential drive keeps turning the machine till it is aligned with the white line. The speed of the machine can be changed by increasing or decreasing the percentage PWM given to the motors of rear wheels.

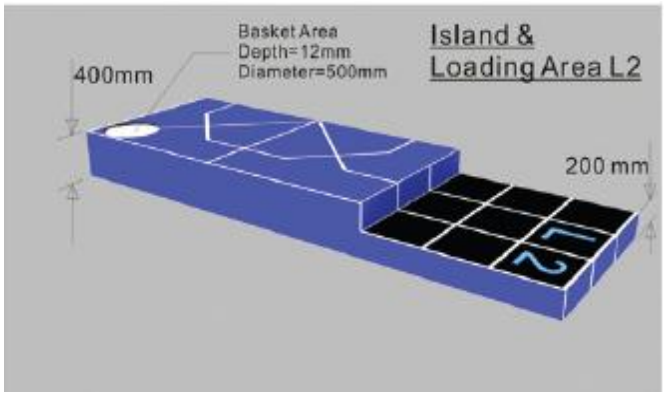
1.2.3 Lifting Mechanism

The mechanism for picking and placing the basket was based on parallelogram linkage mechanism. The power to this mechanism was transmitted from a worm geared high torque motor (dynaflux) using chain and sprocket linkage. This motor being quiet heavy, was placed in the back to avoid toppling after lifting basket. The mechanism was designed such that the bot lifts the basket and places it on itself before carrying it to the destination. By using this parallelogram linkage we avoided the use of two motors (on for lifting vertically and other for taking in horizontally).

The parallelogram link was built with three square channels and resting on the two vertical channels in the main chassis which acted as frame of the linkage. These were connected by passing an ϕ11mm Al shaft through a hole on both and locking them with the help of pins. Two such parallelogram mechanisms' top horizontal links were connected by Al channels on which a cardboard with a suitable shape to hold the basket from below, was placed. The driving link's bottom connection is joined to the shaft coupled with a sprocket. These front sprockets are driven by a chain from back sprockets whose hollow steel shaft is in turn driven by a chain sprocket link from the shaft of the motor. A suitable gear reduction is also achieved by lower radii sprockets in back from motor to higher radii ones in the front. This improved the torque and reduced the angular velocity in the mechanism as desired.



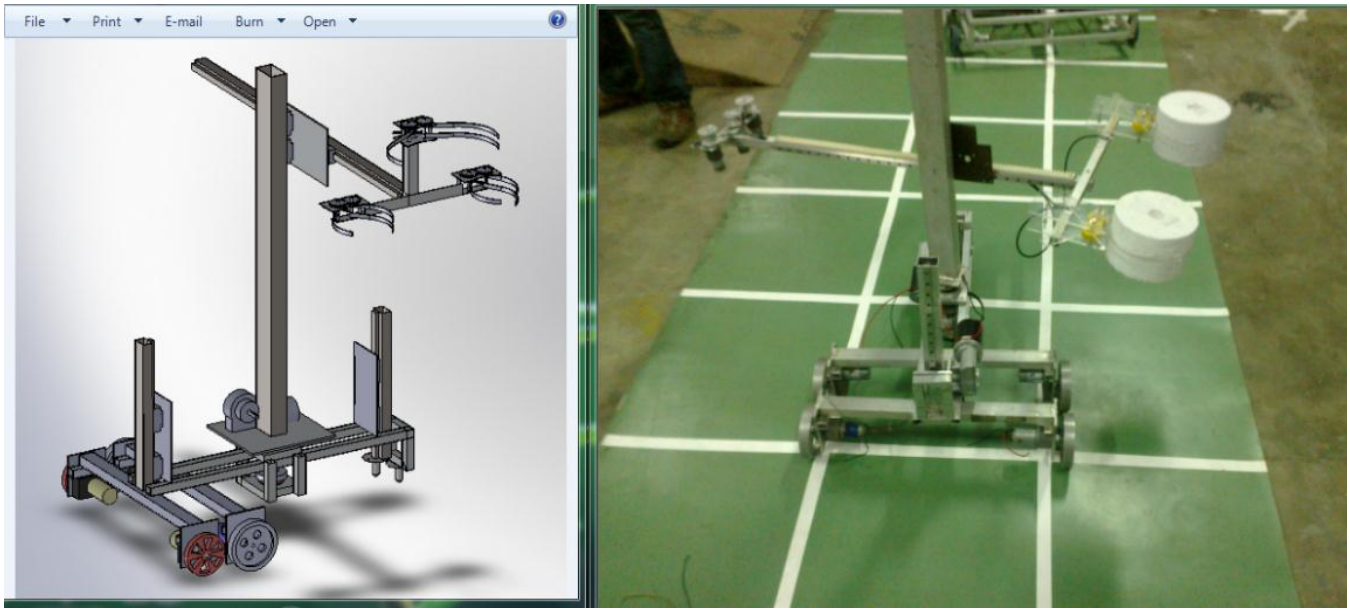
1.3.0 Collector Bot



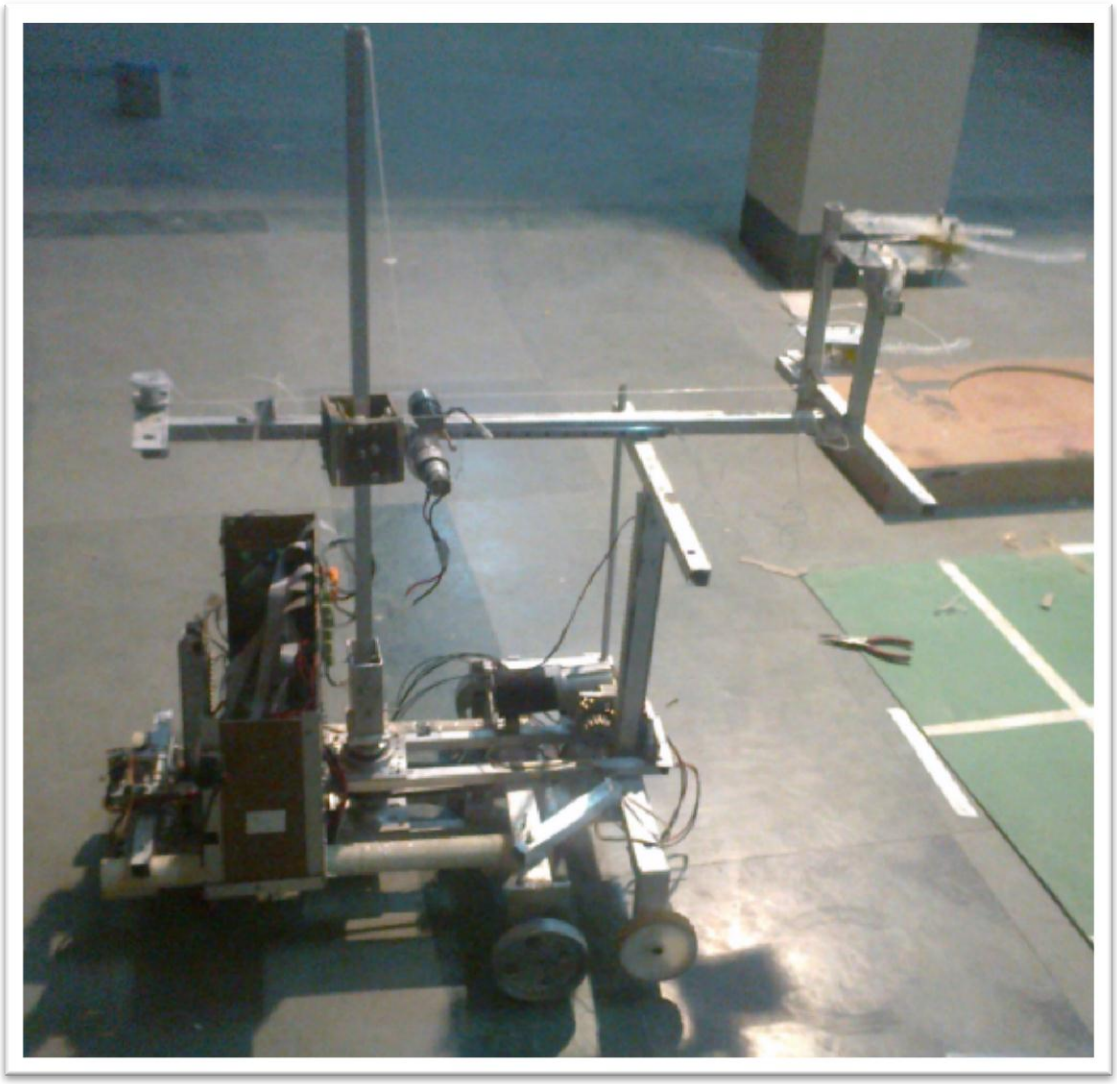
The Task of this robot was to unload itself onto the loading area-2 upon communication with autonomous bot climb a stair onto the top level of island and collect atleast one each of green and yellow buns and drop them in the basket .Then it has to collect the topmost violet bun with manual's assistance and drop it in the basket.

The key features required in the autonomous carrier robot were:

- In Collector Robot Starting Point (C), Collector Robot must have its dimension no larger than 1M in length, 1M in width and 1.3M in height. The robot can expand, stretch or extend within a cylinder of 2M in diameter considered from top view. It's fully extended total height must not exceed 1.3 M.



1.3.1 Mechanical Structure



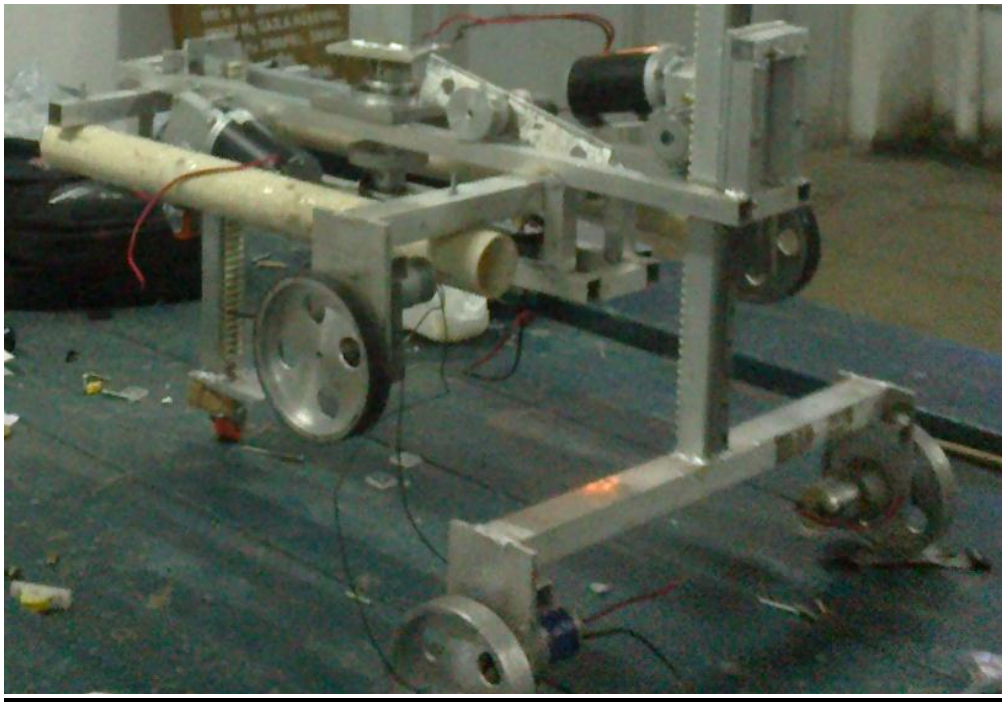
The base of the machine was made using aluminium channel with square shaped cross section. The thickness and the cross-section of the channel were decided after doing stress analysis using ANSYS and Solid Works. Aluminium was chosen as base material for its light weight and higher strength is to weight ratio. The base was made up of different sized aluminium channels joined together with gas welding. The dimension of the base was 70cm (length)*55cm (wide).Mounting channels were also used to mount sliders having the lifting mechanism, rotating base and the gripping mechanism.

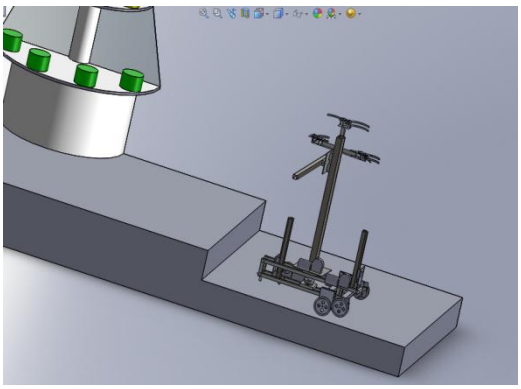
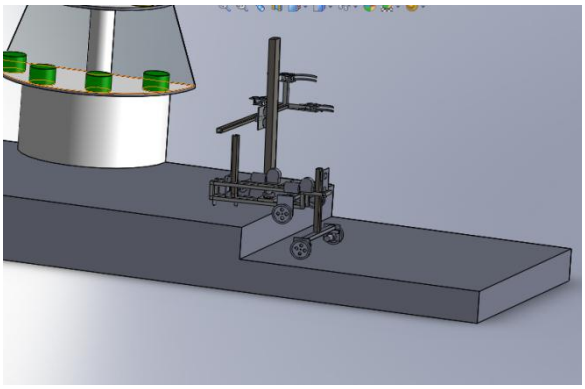
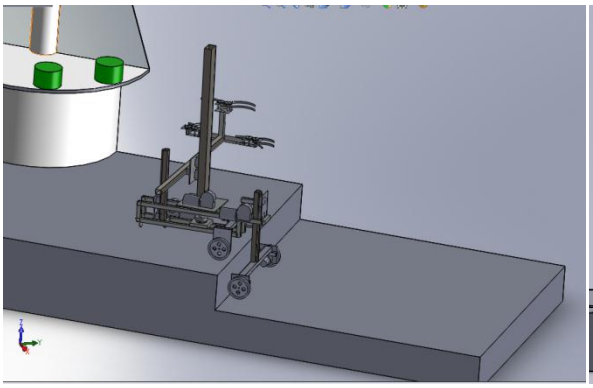
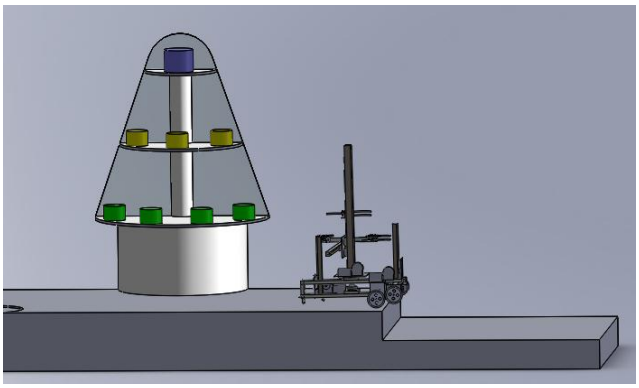
1.3.2 Drive Mechanism

It was a 2WD (for both auxiliary and main) using differential mechanism. All the wheels always rotate at same speed at PWM supplied by the microcontroller. All wheels are powered by geared brushless DC Motors (12V, 150rpm). The rear wheel motors gets signals from microcontroller based on feedback from a magnetometer.

1.3.3 Stair Climbing Mechanism

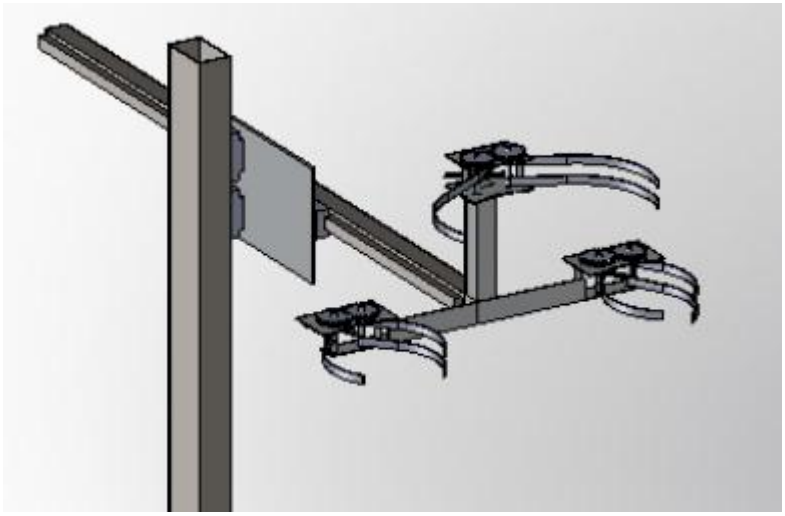
For stair climbing the robot lifts its base on auxiliary wheels, then it moves forward and Successively lifts its auxiliary wheels and uses the main wheels for support.



1.3.4 Bun Gripping Mechanism

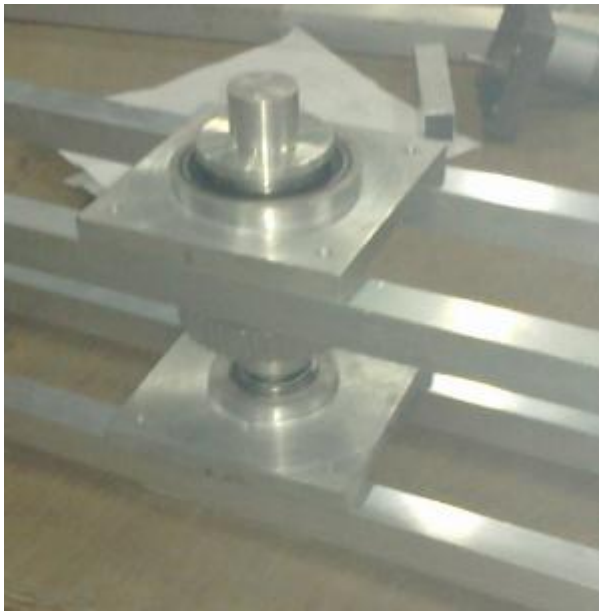
It has wisely been said that “symmetry leads to stability”. So we tried to introduce symmetry in all three robots so that our game plan gets stabilized. We used to grip three buns, one from the middle layer and two from the lower layer. This allowed us to use same mechanism for both the sides (red and blue).



To pick up the buns and put it in the basket gripper was opened using thread wounded on motor and closed by rubber band as the thread unwound. It was lifted to the height of basket top point by rail and block slider.

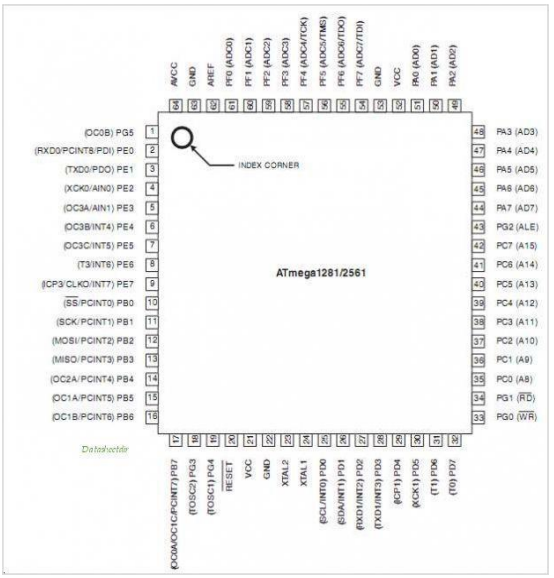
1.3.5 Rotating Base

The vertical rectangular channel, onto which horizontal gripper channel was mounted, was able to rotate by the rotating base which included shaft and bearing assembly actuated by high torque 10 rpm motor using a belt and controlled by potentiometer.



2. Electronics

2.1.0 Our Approach



Due to requirement of more general input/output pins as per the problem statement we upgraded to a more flexible and better interfaced atmega 2560 based board.

Moving from breadboards to much more reliable pcbs was also one of the new and important changes in this year's design. This helped reduce debugging times as well as make sure shot solid connections b/w components used.

Apart from many new hardware implementations, we also have used more sophisticated control algorithms and intelligent calibration methods which have improved machine robustness and adaptability.

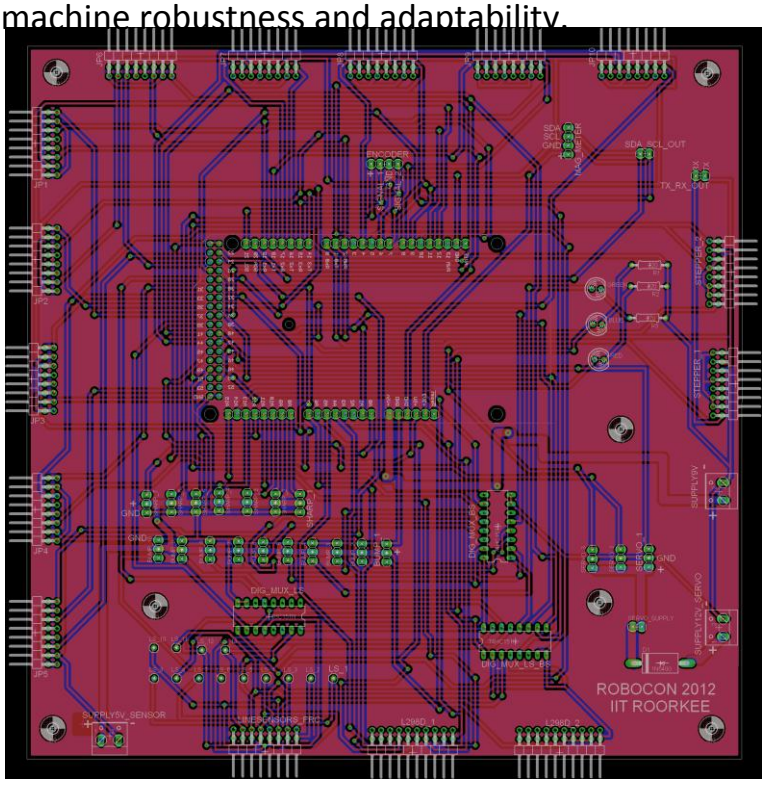


Image of PCB used generated from EAGLE Software

2.2.0 Electronics Hardware description

2.2.1 Microcontroller Board

The Arduino duemilanove's ATmega2560 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega 2560achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed. It also possesses a large 256 kb of flash and 83 data lines which played a key role in driving many peripherals like motor drivers ,sensors etc.

2.2.2 Line Sensor - OJ5044

Line sensor is uses to differentiate white line from its background of different color.Specifications of the sensor we used are

Bright red light source for visual indication of beam alignment
- Programmable for application flexibility
- Remote adjustment available with fourth wire
- Miniture housing (45*24*11 mm) for application with limited mounting space
- Range 0.015 - 0.4 m
- Switching frequency - 1000 Hz
- Operating voltage - 10-30 volts
- Maximum load - 200 mA
- Supply Current - 25 mA
- Voltage drop - 2.5 Volts

2.2.3 H Bridge Motor Driver

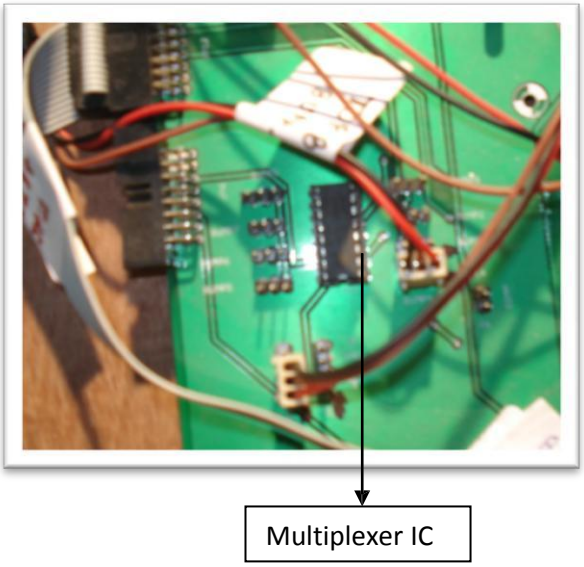
An **H-bridge** is an electronic circuit which enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forwards an backwards.

The two motor drivers used by us are

1) HERCULES
- 6-16 Volts
- 20 A max load
- 20 KHz PWM

2) L298
- Dual motor driver
- Can driver 4 motors at a time
- 18 volts
- 2 A

2.2.4 MULTIPLEXERS



Because we had to access many sensors & drives, we found it best to use multiplexers in our pcbs. This made our number of read strobes vastly increase.

ICs used were

1>4067 analogue multiplexer (16 channel to 1)

2> 75hc15n digital multiplexer (8 channel to 1)

2.2.5 Batteries

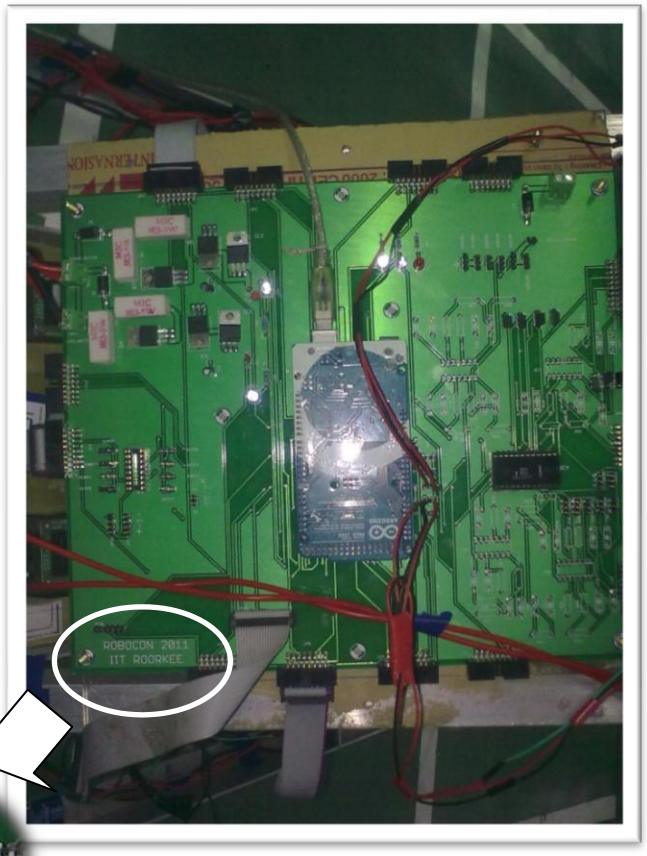
High discharge lithium batteries were used extensively to provide the large current requirements of the many motor drive systems. also they are light weight and have internal protection mechanisms. Various regulation circuits were used to power the cmos components as well as the sensors.(on pcb)

Lithium Polymer Batteries

2.2.6 PCB s

With advanced cad software's like eagle ,we designed dual layer PTH PCBs which were carefully optimised to provide maximum scalability and interconnects as well as good overall workmanship. because of pcbs , one of our major problems i.e. poor interconnects was avoided totally.

Our pcbs had many features like on pcb voltage regulation and over voltage protection circuit's .high quality professional manufacturers were approached to manufacture the custom pcbs.



2.2.7 SENSORS

Since we had to perform many challenging tasks involving pole detection, accurate turning , motion detection etc we used sharp sensors, bump sensors and a mems gyroscope.

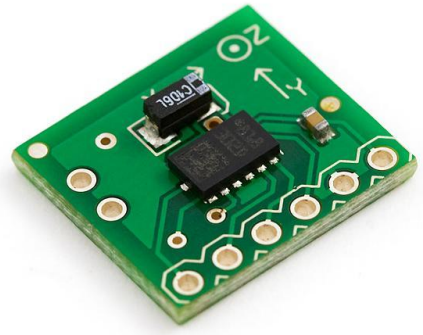
- **Sharp sensors**

These advanced proximity sensors are used to detect objects nearby on the basis of IR reflection and an onboard dsp converts the distance into an analog signal read by our microcontroller

- **Bump sensors**

these are basically tactile switches which we used to detect nearby approaching objects. used mostly in closed loop movement.

- **Accelerometer**



An accelerometer measures weight per unit of (test) mass also known as g-force and using this it calculates the accleration in two perpendicular axis

2.3.0 MANUAL MOVING & BUILDING ROBOT

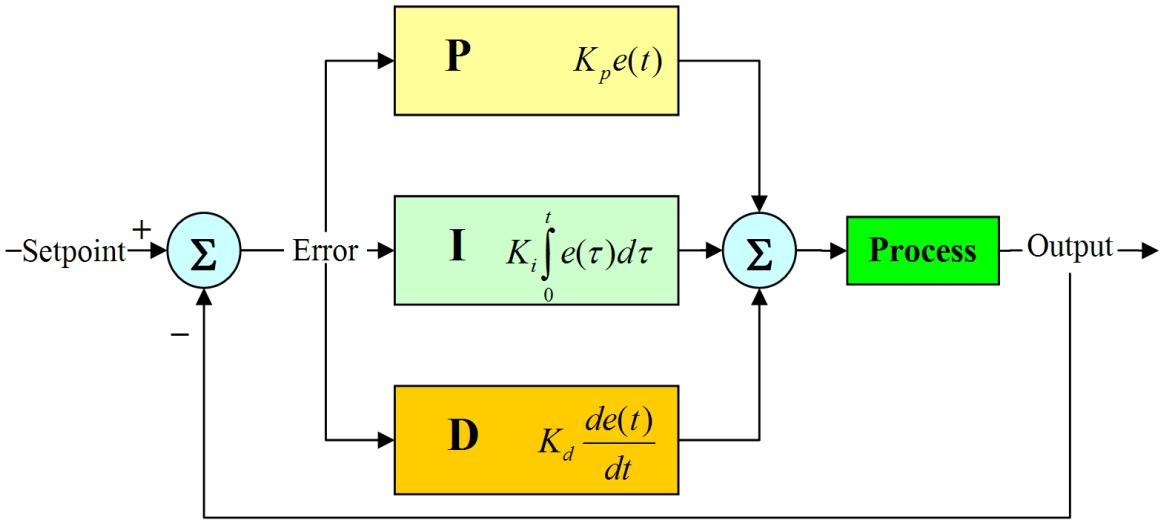
2.3.1 OPERATION

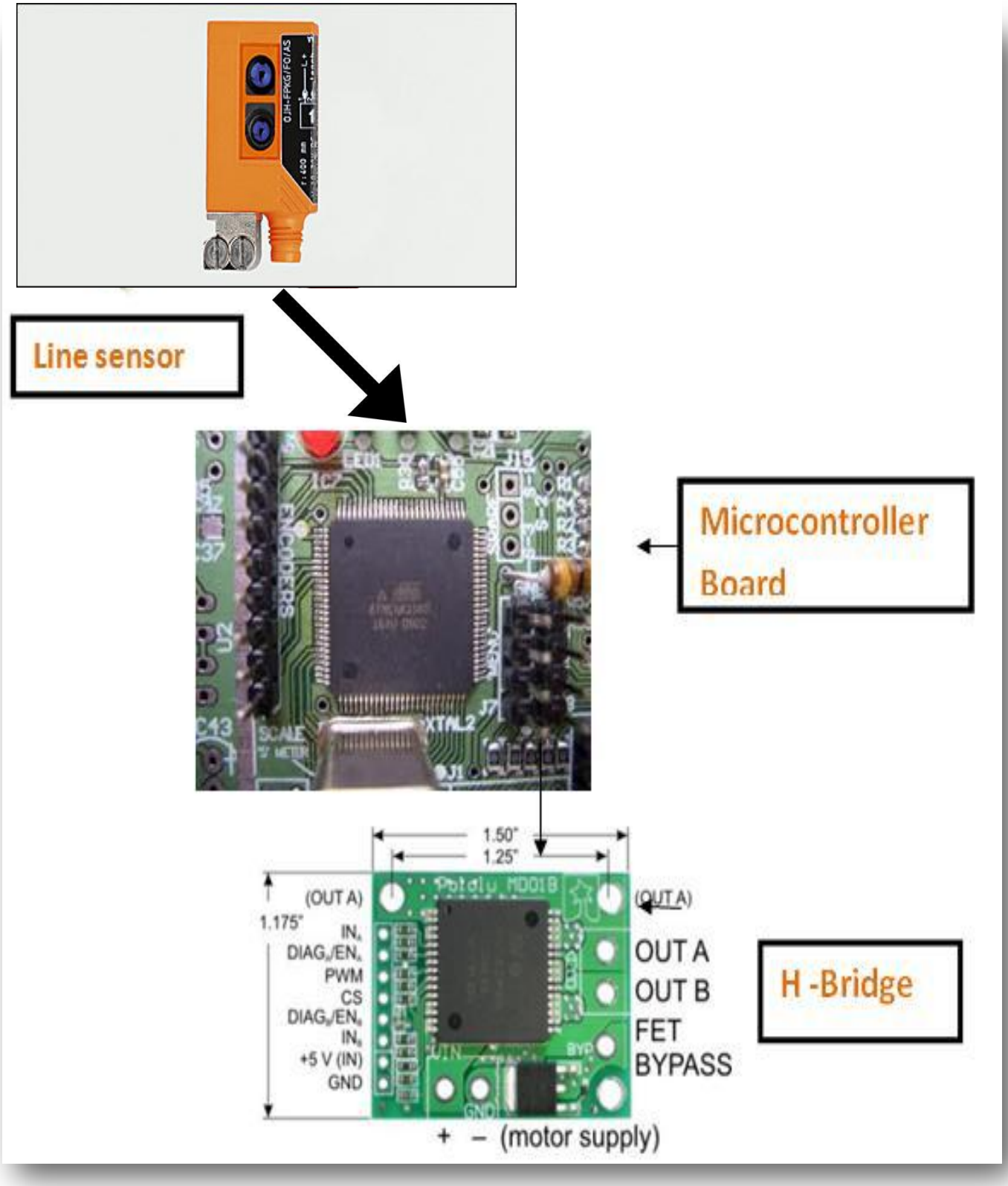
Manual bot had to pick up a token and then drop it in a box. It then had to pick up the collector bot and place it on the autonomous. Also it had to pick up the basket and place it on island and in the last one minute it was free to pick up buns and lift collector bot to pick up the top bun. It had to do this all while carrying the operator on it. It too used arduino 2560 to control its speed and was controlled by a handmade remote control.

2.4.0 AUTONOMOUS SYSTEMS

Since our game field had lines plotted to aid motion, we used line following algorithms as well as gyroscope to get about the field. positioning was done by line counting algorithms derived from low level matrix processing and comparing algorithms.

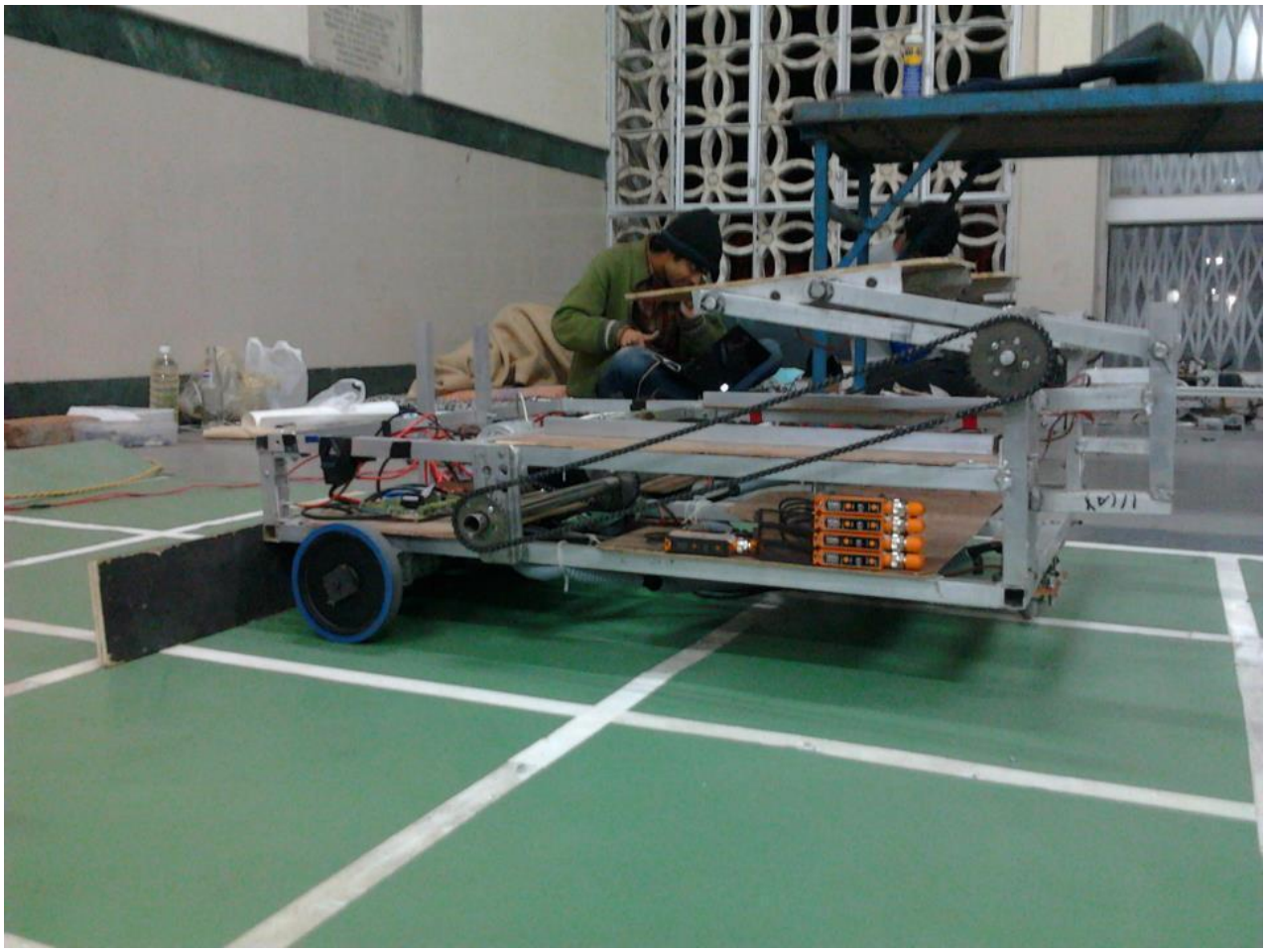
High speed and control was achieved using PID algorithms.





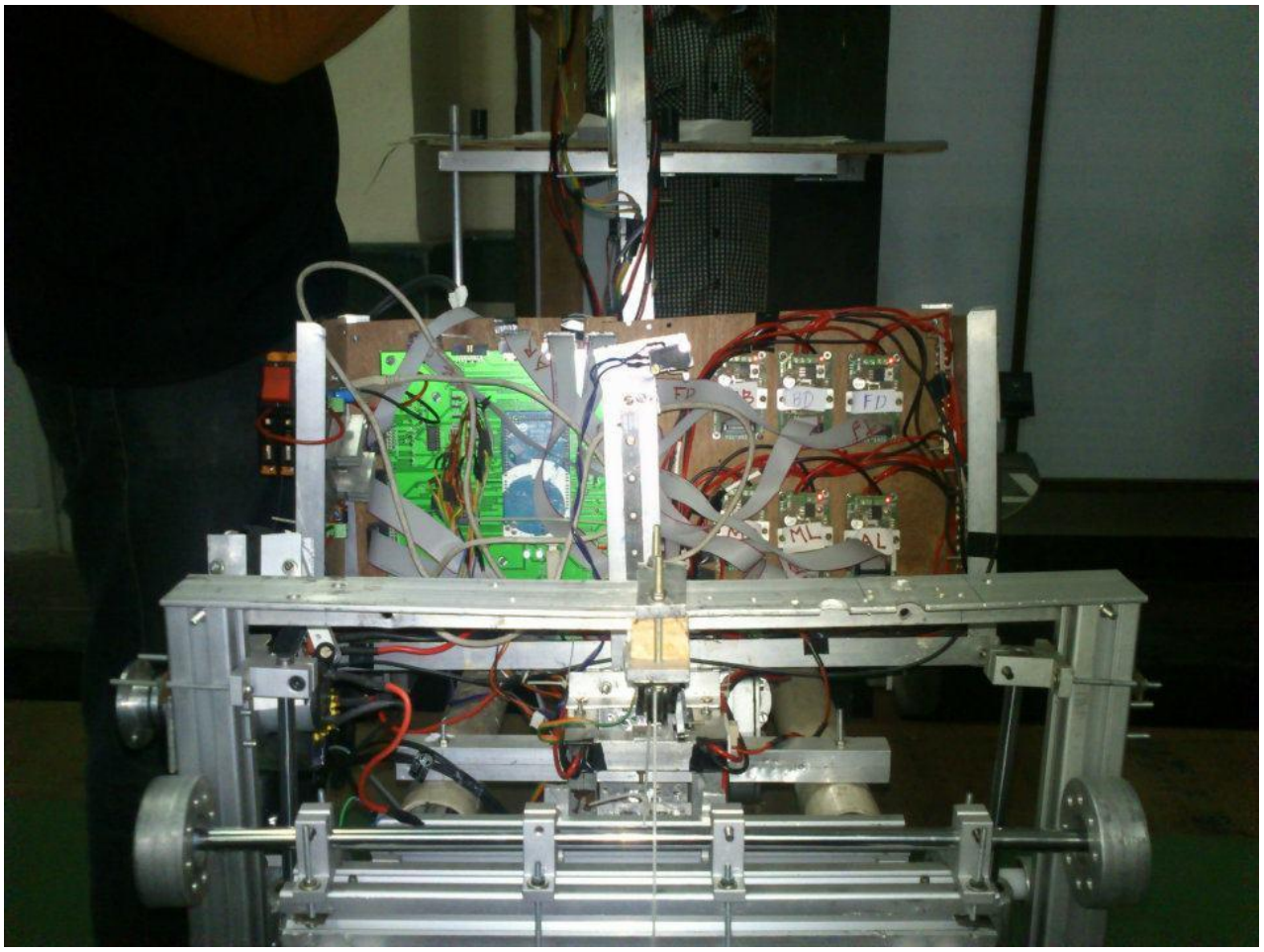
Line following hardware was as follows

3.4.1 AUTONOMOUS ROBOT



- This bots work was to pick up basket and carry collector bot to the island.
- This robot functioned on a differential drive based line following algorithm.
- It detects poles with bump sensors and picks the basket using high torque motors.
- Complex pid algorithms are used along with pre defined timings <determined by days of Debugging and testing.
- It had 4 different programs stored each performing a different function like which basket to pick up and where the restart was taken.
- Differential drive also added a quick and agile motion .neat wiring tricks and tagging was done for easy assembly and fool proof performance.
- All contacts were insulated by professional grade heat shrink pipes
  Onsite debugging was done via serial communication.

2.4.2 COLLECTOR ROBOT



- This robot was primarily aim to climb a step .For this purpose it had 6 wheels, 2 in front 2 in middle and 2 at back. It climbed the step using the system of rack a pinion. It had two grippers for gripping buns and these grippers could move forward and backward plus up and down.

- Bump Switches were used to detect the buns, clicking on it sends the signal to processor.
- Potentiometer was used to regulate the rotating base.
- Magnetometer was used when the robot had to skip line and move straight and get on the line again.

3.1.0 Budget

ROBOCON 2012 has taken a total sum of Rs 3, 18,170/- expenses are shown below:-

S no.	Items	Quantity	Cost	Net Cost
1	Arduino Mega Microcontroller Board	6	3650	21,900
2	Batteries	8	2100	16,800
3	Battery chargers	4	2700	10,800
4	Motor Drivers	5	2700	13,500
5	PCB Printing	12	1125	13,500
6	Line Sensors	8	4000	32,000
7	Industrial Sliders and blocks	4	1600	6,400
8	Motors	25	1200	30,000
9	Machining Cost			12,000
10	Green PVC Sheet	17*2 sq m	405	13,770
11	Electronic consumables			25,000
12	Mechanical consumables (channels, Nut bolts etc.)			35,000
13	Team Registration Cost			14,000
14	Team members Registration Cost			49,000
15	Transportation			10,000
16	TA			15,000
			Total	**3,18,170**

Here is the progress report of Robocon 2012, which include our timeline, our sources of Help, budget etc.

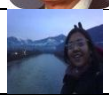
3.0.0 TIMELINE

First mail for arranging the funds send	**28 August, 2011**
Recruitment of 2nd year in the team	15 September2011
Problem Statement released	**28 September,2011**
Funds raised (INR 1,65,500)	18 October,2011 – 20 January,2012
Amount received (INR 84,000 Approx.)	**21 October,2011 - 21 March,2012**
Robot Design Period	28 September,2011- 15 October,2011
Robot Fabrication started	**25 October,2011**
First Robot Completed	15 November,2011
Second Robot Completed	**15 January,2012**
Third Robot Completed	10 February,2012
Practice Time and Debugging Time	**21-23 February,2012**
Competition	1st - 3rd March,2012

3.1.0 OFF Screen Team Members

3.1.1 The alumnus of IIT Roorkee

They played the most important role in making things possible by sending in there invaluable contribution. The alumni who helped Team Robocon IITR to successfully participate in competition are:

Name Of Alumni	Batch	Branch	Photograph
Mr. Pradeep Kumar	1966	Electrical Engg.	
Mr. Rajendra Aggarwala	1953	Electrical Engg.	
Mr. Alok Jain & Friends	1989	Civil Engg.	
Mr. Shamsher Prakash	1954	Civil Engg.	
Miss. Megha Jain	2006	B. Arch	
Mr. Ajay Tyagi	2006	B.Arch	
Mr. Sushil Kumar Goel	1984	B.Arch	
Mr. M.L.Gupta	1958	Civil Engg.	
Mr. Amit Kumar	2006	B.Arch	
Miss Parul Aggarwal	2001	Computer Science	
Mr. Punjabrao Mali	1989	Computer Science	
Ms. Purnima Gupta	1968	B.Arch	
Mr. Amit Vyas	1984	Electrical Engg.	

3.1.2 Alumni Groups

IIT Roorkee Alumni Association **Lucknow Chapter** sent in their Valuable contribution through Mr. Jeetesh for which we are greatly thankful to the association.

A Sincere Thanks to **IIT Roorkee Heritage Fund** for its huge support in gettingfinancial assistance from abroad.

3.1.3 Seniors of Team Robocon

Our seniors who passed out last year also send in their help to support us in the best possible way they could. We thank them from the deepest corner of our heart:

Name Of Senior	Batch	Branch	Photograph
Dinesh Vohra	2011	P &I	
Marut Shukla	2011	Mechanical Engg.	
Rajveer Shekhawat	2011	P&I	

- **IFM Electronics provided 10 Optical Sensors worth INR 60,000 as sponsorship.**

Apart from these contributions, team members made their own contributions to meet the budget of Rs 3.3 lac. With all the efforts from alumni, seniors and our hard work we improved significantly though were not able to transform our quality into results.

We thank everyone for supporting us in improving the technological bite of IITR and compete with the best in India.

3.2.0 On Screen Team Members

Faculty Advisor - Prof. P.M Pathak, Mechanical and Industrial Department

Team Captain – Yadwinder Paul Singh, Mechanical, 3rd year

Name	**Enrolment No.**	**Branch**	**Year**
Shashank Shekhar Agarwal	9117057	Mechanical	III
Suraj Singh	9117062	Mechanical	III
Vimanyu Aggarwal	9117066	Mechanical	III
Anshul Dhurandar	9119008	Production & Industrial	III
Gaurav Rakhecha	9119018	Mechanical	III
Rohit Goel	9115077	Electrical	III
Saurav Bhaik	9111034	Biotechnology	III

Shashank Shekhar	9115084	Electrical	III
Ajay Simha	9115007	Electrical	III
Piyush Makhija	9116033	Electronics & Communication	III
Chetan	9118033	Metallurgical And Material	III
Faiz Akram	9116020	Electronics & Communication	III
Wagh Saurabh Dilip	10411033	Geophyical Technology	II
Anant Sharma	10115015	Electrical	II
Ajit Kumar Vishwakaram	10115007	Electrical	II
Abhiyudai Nouni	10115005	Electrical	II
Abhishek Negi	10116001	Electronics & Communication	II
Yatin Sharma	10116055	Electronics & Communication	II
Saksham Jain	10116043	Electronics & Communication	II
Govind Gullbadhar	10112012	Chemical	II
Inderpreet Singh	10117026	Mechanical	II
Jitendra Singh	10117028	Mechanical	II
K Saichand	10117030	Mechanical	II
Sudhir Yadav	10117074	Mechanical	II
Sumit Saxena	10117075	Mechanical	II
Kuldeep Uttam	10119015	Production & Industrial	II

3.3.0 Sequence of Event at Pune

- Reached Pune on 27 February,2012 with practice of just 2 days
- Practiced their on 28 February,2012 with satisfactory results and justifying potential of top 5 Team
- Had the first match at 10:00 am on 1st March,2012
- Practiced till 8 in morning.
- Match started and we scored 10 points satisfactorily, suddenly manual robot stopped.
- Match continued and we weren't able to debug the problem during match, our score remained 10.
- After going into pit, we found the motor driver malfunctioned resulting into our loss.
- We had the second match on 2nd march, 2011. We scored 90 taking our total to 100.
- Wasn't able to qualify for Super 18 as the Cut-off was 110 points.

3.4.0 WAY AHEAD

Keeping the shortcomings of last year in mind and learning from our counterparts out there, we have thought of following these things to strengthen our basic and make our success long lasting.

To develop culture:

- Promoting robotic events in North India through our Techfest, Cognizance which could provide a great platform for North Indian colleges to learn from each other. This time Team Robocon is organizing 5 Robotic events.
- Promoting **entrepreneurship** in Robotic products. Need of an hour is the establishment of a firm to passage quality products from abroad. We have thought of promoting existing market strong holders in similar field to invest in these with our collaboration.
- Joining or forming the **society** solely for Robotics as it has grown itself into a vast field over a period of decade especially in India. This will also provide **autonomy** to all Robotic activities in campus
- Conducting projects and event throughout the year in the campus under the established society, to promote the first yearites.
- Slowly putting 1st yearite into Robocon Team and promoting 3rd year to start with other disciplines of Robotics such as Humanoid, Haptic etc.

To tackle slow working process

- Establishing a separate society to lessen the financial and work burden on Hobbies Club which itself has so many activities.
- Last year, we had got financial assistance quite late. We have saved some money this time in Hobbies Club account for next year work so that we can start early next year.
- Last year lot of time was wasted in understanding, how this system works, that time could be saved now.

3.5.0 Expectation from IITR Alumni & Administration

We have covered a lot of ground with your help. A huge amount is still left unexplored. Our counterparts in North, west and South have reached a level which is hard for us to imagine. But with *constant and cooperative efforts we can so wonders and surprise them all. But what is required in faith in our self, faith in each other, A Zeal (**Keera)** as Honorable Director* suggested a lot of hard work and blessings of our elder ones.

I am sure, we can see IITR leading the way for the Robotics for India in coming years, what it takes is above mentioned things and a Chemical to keep that “Keera” alive which I suppose is with our administration.

We expect everyone to work towards establishing an autonomous society for the development of robotics in IITR and all Over India