THE ROBOCON DIARY 2010-2011

Indian Institute of Technology, Delhi

April 15th, 2011

PREFACE :

The most important focus of this diary is the National Robocon, 2011. It provides you with an insight into the details of each robot, new technologies used and further improvements. The year 2003 saw IIT Delhi's first active participation in Robocon, an annual **ROBO**tics **CON**test. So far IIT Delhi has become champion once (in 2007), reached semi-finals four times (in 2003, 2004, 2006, 2008), and was in quarter-finals twice (in 2005 as well as in 2009). Over the years we have improved in terms of the quality of robots that we make, the components that we use and the techniques we implement. "Robocon" is not just about competing and winning. We learn a lot, not only in the field of robotics but also about project management, time management and most importantly, about team work. Apart from Robocon, the robotics club, IIT Delhi made its presence felt all across the campus and in technical festivals of various other universities. This was possible only with the sincere efforts of Prof. S.K. Saha and help from the Robocon team.

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This diary has been compiled by Shubhada Agrawal

ACKNOWLEDGEMENT:

The team members of ROBOCON 2011 sincerely acknowledge the financial and logistic support provided by Prof. Surendra Prasad, Director of IIT Delhi, and his complete administrative and moral support; without whose blessings we would not be able to participate year after year in ROBOCON. The support of Prof. Shashi Mathur, Dean of Students, Prof. S.K. Saha (Associate Dean of students) and Prof. Aditya Mittal, BRCA President, in helping us getting funds from IIT's account to purchase the components required for fabricating the robots and also in allowing us to work in the Robotics Room of SAC is highly acknowledged. The Robocon team members would also like to thank Prof. S.K. Saha, the team mentor and Faculty-in-Charge and Prof. Kolin Paul for their guidance. Assistant Registrars of the Accounts and Stores and Purchase Sections are also thanked for speedy actions on Robocon matters. The team and the institute would like to thank IFM Electronic for providing 5 photo sensors worth Rs. 20,000 for use in Automatic robots. There is an endless list of people from different departments and sections of this institute; without whose supports and blessings the participation in DD-MIT-Robocon 2011 would not have been possible.

ABU ROBOCON 2011 , PUNE , INDIA

"One who wins over himself and wins over others is the all-time winner"

- Fourth in the Leagues from the 58 teams registered.

THE TEAM-2011:

Prof. S.K. Saha (Team mentor and faculty in-charge)

- Himanshu Gupta (Electrical)-(Team Coordinator and Leader)
- Kamlesh Suwarnkar (Mechanical)-(Mechanical Coordinator)
- Sanjeev Kumar (Electrical)-(Electrical Coordinator)
- Ravi Kant Mittal (Electrical)–(Electrical Coordinator)
- Manas Paldhe (Engineering-Physics)-(Electrical Coordinator)
- Mohit Sharma (Mechanical)- (Mechanical Coordinator)
- Rohit Taneja (Electrical)

- Kartik Maheshwari (Computer Science)-(Manual Operator)
- Avnish Kumar (Electrical)
- Dhruv Agrawal (Electrical)
- Nirupam Gupta (Electrical)
- Shubhada Agrawal (Mathematics and Computing)
- Saruchi (Mathematics and Computing)
- Tanya Raghuvanshi (Electrical)
- Ankit Laddha (Electrical)
- Ankit Nayan (Electrical)
- Rohit Kumar (Electrical)
- Siddhartha Das (Electrical)
- Mukul Sajnani (Chemical)
- Shikhar Khanna (Mechanical)
- Dhruv Gelda (Mechanical)
- Areesh Mittal (Mechanical)

- Viplove Arora (Mechanical)
- Ankit Goel (Electrical)

❖ THIRD YEARITES: 7
❖ SECOND YEARITES: 15
❖ FIRST YEARITES: 2

Above students have worked for DD-MAE-Robocon-2011, held in Balewadi Stadium, Pune (2nd-5th March,2011) after working on the design, fabrication and testing of the robots for the Robocon competition since September,2010 when the game plan was declared in www.aburobocon2011.com.

CONTENTS

THE CONTEST THEME:

"LOY KRATHONG , LIGHTING HAPPINESS WITH FRIENDSHIP"

-Another step towards future

"Loy Krathong" is a traditional Thai ceremony to honor the Goddess of the river. This vibrant activity is held in Thailand on the full moon night in November every year. A "krathong" is a small boat usually made of cut banana stems and leaves. Loy Krathong revelers put flowers, candles and joss sticks on their tiny boats before releasing them into a river and leaving them to float downstream. One of the objectives of Loy Krathong is to seek forgiveness from the Goddess of the river for having polluted waterways. Before releasing the small and elaborate boat into the river, one may make wishes for a better future, prosperity or happiness. Loy Krathong is also a symbol of discarding one's grudges, anger and defilements so that one can start life afresh. On this day, many beautifully-crafted "krathong" are put on display for a contest to be followed by their release into the water when dusk falls. As the sun disappears from the horizon, the moon gradually lifts itself up and shines with full brightness. The lunar reflection on the water, a blessing to one's eyes, prompts revelers to head for nearby waterways to celebrate the Loy Krathong festival. Before releasing a small boat into the river, one usually asks for forgiveness from the Goddess of the river for having polluted the waterways as well as makes a wish for future happiness.

RULES:

Outline of the contest: Each team consists of no more than three robots: one manual and one or two automatic robots. The manual robot must complete the first task by picking up three Joss Stick Pots and placing them at Common Zone before performing other tasks. After that, the manual robot will bring a Candle Base and place it at Decoration Point located on Sala. The manual robot will collect Joss Sticks from the Common Zone to be used again during Krathong assembly. The automatic robots will collect Krathong Petals and Flowers and place them at Preparation Points. The automatic robots will decorate Krathong by stacking one Krathong Petal and then one Flower on the Candle Base located on Sala. After completing this task, the manual robot will then place three Joss Sticks into the decorated Krathong. The automatic robots will carry the completed Krathong and drop it on River Surface of its own side. No part of any robots can touch or contact the River Surface. Lastly, only one of the automatic robots will bring and drop a Candle Light Flame on top of the Candle in the completed Krathong floating on the River Surface. No part of any robots can touch or contact the River Surface or the completed Krathong. The first team that drops the Candle Light Flame successfully is the winner of the match. This type of winning is called "Loy Krathong".

Game Field: Structure

- The field consists of a Game Area measuring 12,000 mm x 12,000 mm, surrounded by a wooden fence of height 100 mm and a thickness of 50 mm. The game field is divided equally for two teams (Red and Blue).
- White lines with a width of 30 mm are drawn on the floor of the Game Area.
- The Game Area consists of a Common Zone, a Sala, a River Surface, Start Zones, Preparation Points and Storage Points.

- Common Zone: Rectangular in shape (500 mm x 3500 mm) painted in light green color. Six Poles with a gap of 500mm are located at the middle line of the Common Zone for placing Joss Stick Pots. Each team can collect at most of nine Joss Sticks from the Common Zone for Krathong assembly.
- Sala: A lifted platform (5000mm x 4000mm x 300mm). It is divided equally for Red and Blue teams. Each part consists of a Decoration Point, a circular shape (diameter 510 mm) surrounded by a wooden fence (height 10 mm and thickness of 10 mm). Two ramps (length 1,000 mm each) are built at two sides of the Sala to facilitate the automatic robots for moving up.
- River Surface: Located in the middle of the Sala. It can be swung by Krathong gravity during dropping

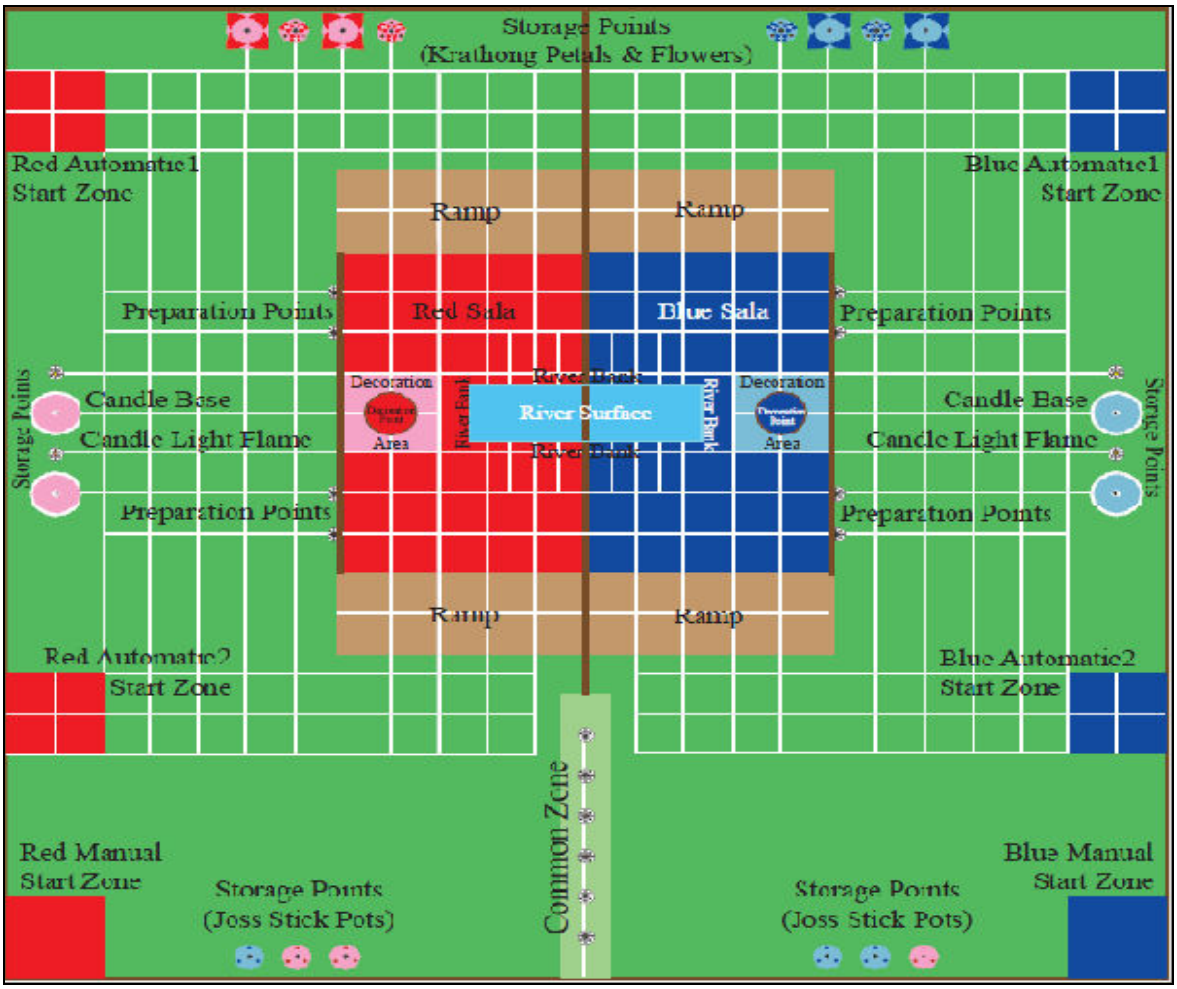


FIGURE 1: FIELD INFORMATION

- River Surface is a platform made of wood with a thickness of 4 mm, a width of 700 mm, a length of 2,400 mm. It is suspended at a level of 280 mm measured from the Sala to the lower surface of the platform by four wires made of stainless steel each with a diameter of 1.5 mm and a length of 350 mm. All parts and mechanisms which form the River Surface are considered as River Surface. They cannot be locked or touched by any robots.

- Start Zones: Each team has 3 Start Zones: two Automatic and one Manual Start Zone. Each Start Zone is a square (1,000 mm each side). Start Zones of Red team are in red color, Start Zones of Blue team are in blue color.

- Storage Points and Preparation Points: made of wood, steel, or other rigid metal are Poles used to store or place some contest tools. Each Pole of the Storage Points and Preparation Points consists of two sections; lower (cylindrical in shape with a diameter of 100 mm and a height of 800 mm) and upper (height of 100 mm). Top part of the upper section has a conical shape with the diameter varying from 40 mm measured at the topmost position until 60 mm measured at the distance of 30mm from the topmost position. The bottom part of the upper section has a cylindrical shape (diameter-60 mm). However the upper section of each Pole of the Storage Points of Candle Light Flame has only a cylindrical shape (diameter-60 mm, height-35 mm).

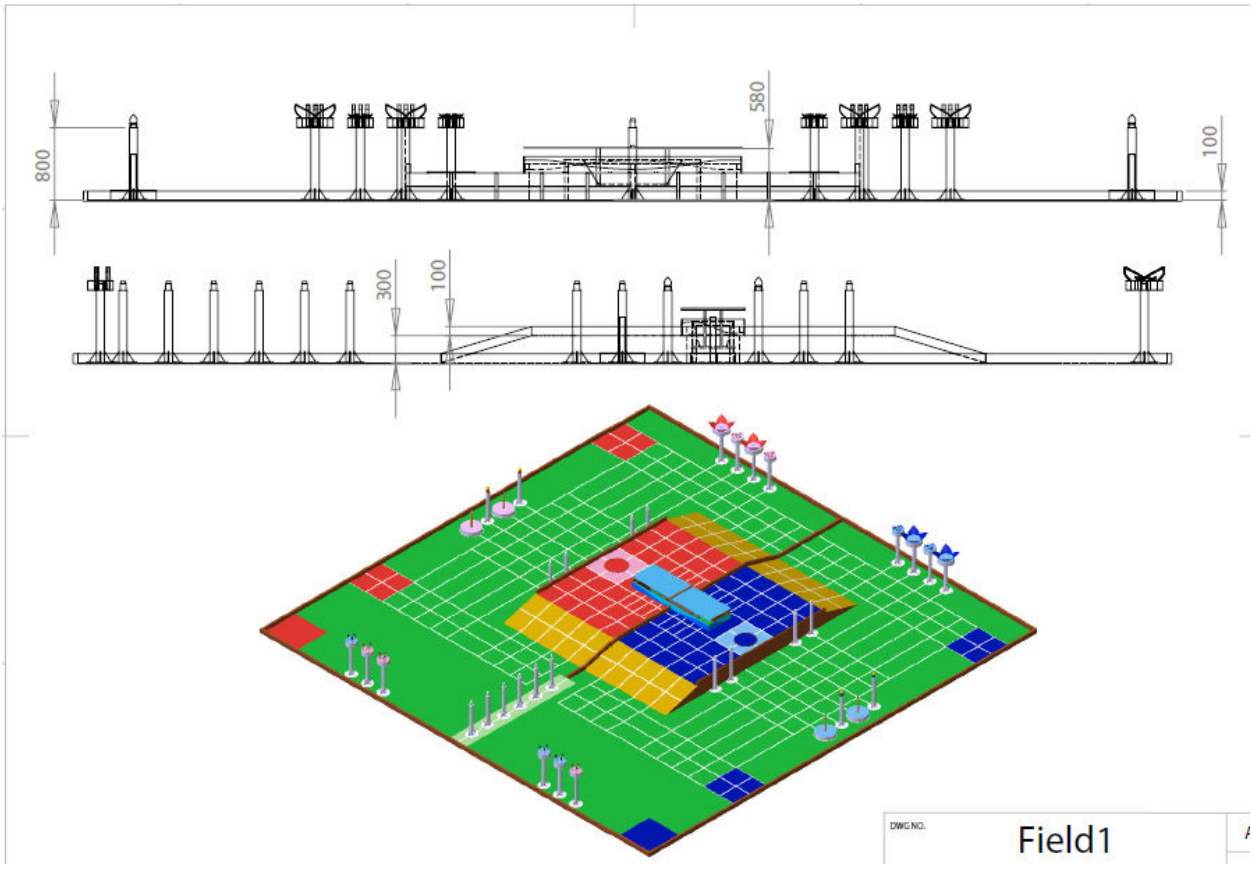


FIGURE 2: ISOMETRIC VIEW

Points For Each Task And Deciding the Winner:

- The first team that an Automatic Robot successfully drops a Candle Light Flame on the completed Krathong floating on the River Surface is the winner of the game and the match ends. This is the achievement of the game goal and so called "Loy Krathong".
- If neither team achieves "Loy Krathong" at the end of the 3 minutes match, the winner is decided based on the earning scores. The team that earns higher score is the winner. The score of each task is described as follows:
- Manual Robot successfully picks 3 Joss Stick Pots and places them at 3 Poles in the Common Zone. **[18 points]** (2 points for each Joss Stick).
- Manual Robot successfully places a Candle Base at the Decoration Point. **[12 points]**
- Automatic robots successfully collect 2 Krathong Petals and 2 Flowers and place them at 4 Preparation Points. **[40 points]** (10 points for each object)
- Automatic Robots successfully stack a Krathong Petal from the Preparation Point on the Candle at the Decoration Point. **[10 points]**
- Automatic Robots successfully stack a Flower from the Preparation Point on the Krathong Petal at the Decoration Point. **[10 points]**
- Manual robot successfully places 3 Joss Sticks into the holes of the decorated Krathong at the Decoration Point. **[30 points]** (10 points for each Joss Stick)
- Automatic Robots successfully drop the completed Krathong on the River Surface. **[30 points]**
- An Automatic Robot successfully brings Candle Light Flame and drops it on top of the Candle in the completed Krathong floating on the River Surface. **[50 points]**

- The Match will end when
    - End of 3 minutes.
    - One of the teams is disqualified.
    - One of the teams achieves the goal, “Loy Krathong”.
- A total score of **300** is given to the team that achieves “Loy Krathong”.
- Before achieving “Loy Krathong”, more than one set of Krathong can be made and dropped.

Violations:

If a violation occurs, 20 points will be immediately deducted and if the violation still continues, 20 points will be deducted for every 3 seconds. Each time of deduction is considered as the number of violations. The team with three violations in a match will be disqualified. The violations are categorized as follows:

- Any parts of any robots or the objects held by any robots move out of the game field or the space above it.
- Any parts of any robots or the objects held by any robots enter the opposing team area or the space above it.
- Any parts of the Manual Robot or the objects held by the Manual Robot enter the River Surface or the space above it.
- Any parts of the Manual Robot physically touch any Automatic Robots either directly or indirectly.
- Any parts of any robots or the objects held by the robots cause obstruction in the Common Zone.

- The operator of the Manual Robot uses the Manual Robot to hinder or cause difficulty for the opponent team while placing Joss Stick Pots in the Common Zone.
- Any parts of any Automatic Robots physically touch the River Surface, especially during dropping the completed Krathong, either directly or indirectly.
- Any parts of any Automatic Robots physically touch any parts of the Krathong floating in the River Surface, especially during placing a Candle Light Flame, either directly or indirectly.
- The Automatic Robot holds any Candle Light Flames and the completed Krathong at the same time.
- The Automatic Robot places any Krathong Petals or Flowers to the Preparation Points while it is on the Sala.

Disqualification:

- The team damages or tries to damage the field, facilities, equipments or opponent's robots.
- The team performs any acts that are not in the spirit of fair play.
- The team fails to obey instructions or warnings issued by the referees.
- The team has made a false start for three times in the same match.
- The team has made three violations in the same match.

PROBLEMS FACED BEFORE GOING TO PUNE

Mechanical :

The mechanical designs at first on the papers looked totally the ones which would have given a cakewalk during the fabricating part. But the day we started our fabrication part the tides of problems just never settled down a bit.

- **Failure of the igus sliders:** The feature previously made us to think that sliding motion would not give any problems of jamming, locking etc. because when we first went to see the prototype at 'Pragati Maidan', their motion seemed to be very swift and controlled. But these sliders turned out to be a mere disappointment. Even after paying so much we still had the same problem as in the conventional sliders - difficulty in maintaining the parallel configuration of the two sliders, jamming while coming down and ultimately providing us with an extra degree of freedom causing vibrations in the robot while traversing and during their downward motion.

- **Maintaining the Four Wheel Drive** : persisted throughout the preparation as well as competition. This was attempted the very first time by our Club and since there were no whereabouts of the existing technology, it depended totally on us .The general idea of maintaining a four point contact involves the use of suspensions but in a system as small as our bots, the conventional system of suspensions could not be applied as such.

- **Late designing of the joss stick grippers:** It go through much mechanical iterations. It was a very simple mechanism in terms of design wasn't so effective either. It was designed to pick all the three joss sticks in one go and the three grippers for the joss sticks were rigidly connected and so could not be operated independently. This caused a lot of problem to the manual operator in order to

maintain the perfect 120 degree configuration as present in the placed joss spot to pick up the joss sticks.

- Regular breaking of the ropes attached to all the grippers to move them up and down. The rope material wasn't strong enough and caused a lot of problem throughout the practice.

Most of the mechanical problems were associated with Manual and Auto 2. Auto 1 was very sound mechanically, right since the beginning. The only problem was the seldom damage to the telescopic channels attached at the two ends and the slipping of wheels at various position in the field due to poor condition of the grip. These were the major problems that made it difficult rest if any were taken care of very easily.

Electrical:

It was the month of January and we were all busy with the preparations of Robocon. Work was progressing on all the three robots, Auto1, Auto2 as well as the manual bot. Even though, each of the respective sub-groups was aiming for the best performance and actuation but still, there were some difficulties that were plaguing this process from electrical point of view:

- Taking the manual robot into account, there was the issue of Arduino boards repeatedly blowing up. The problem was the absence of proper voltage reversal protection mechanisms in the form of diodes etc. Hence, apart from the act of buying supplementary boards more than the required + spare amount, we also took care to not mistakenly connect arbitrary voltage level batteries.

- There was also an issue of motor drivers of Sabertooth which were repeatedly blowing up, but more so due to our own mistakes than internal faults as Sabertooth drivers have been quite reliable during our practice for quite many years in the past. Hence, definitely good amount of care was being taken during the last days to ensure no problems with any of the Sabertooth drivers.

- Similar was the problem with our handling of IFM sensors, more than 4 sensors went faulty initially, again more due to our little mistakes rather than actual hardware troubles. But once they were installed, there was hardly any problem. So, **they must be installed by someone with prior experience**.
- We also purchased 5 colour contrast sensors from a different brand. They were definitely more costly than these as well as possessed better functioning and reliability. But buying them was not a good decision as it was too late by the time we got them.
- Then came the problems specific to Auto2. Firstly, the circuit boards (PCBs) that we had designed last year were being used and hence quite a few connections in those had been burned out and the traces been removed etc. Hence, we tested 2 old ones and got them ready for preliminary testing, besides obtaining a couple of fresh copies of the same.
- Secondly, we did not have any sensors which could easily calibrate on red surface. So till the end we struggled on the red field with auto-2.
- Then came the wiring issue. Actually due to repeated changing, re-welding etc of the gripper arm of this robot, we used to frequently connect and disconnect the complete circuit wiring. Hence neat and efficient wiring for this one happened quite late almost in the last month of practice, thereby delaying the debugging process too in between.
- These problems actually signify quite a large portion of our future learning areas and potential where we can improve upon.

ITERATIONS IN THE MECHANICAL DESIGN OF THE BOTS

Majority of mechanical iterations were made in Auto-2. The Candle Base gripper of the manual robot didn't involve any iteration while the grippers of Auto1 went through a couple of iteration so as to achieve decent grip to prevent the objects from falling.

- **Igus Slider:** Iterations in Auto-2 and were based mainly on getting the right parallel configurations of the two Igus sliders. They were firstly joined with the help of a flat faces at the ends of a straight aluminum pipe which were then bolted into the carriage of the slider but they still didn't serve the purpose. We couldn't replace them with the telescopic channels as they couldn’t withstand such high loads. So instead of running AUTO 2 with the rotating arm mounted on a single slider, the numbers of carriages were increased to bear the excessive load.

- **The gripper for Auto-2:** It had two arms, one each for picking Flower and the Petal, and lifting them together. But we later realized that they interfered with the placed poles. So the gripper was completely changed to one arm which accounted for the difference in the sizes of the two objects by placing an additional gripper within the larger one and was mounted on the front channel instead of the middle one.

- **The Double pulley mechanism:** It was realized sometime later that by loosening the carriages, it was possible to change the clearance between the slider and the carriage which could make the motion as smooth as required. The gripper in Auto 2 was very eccentrically loaded and still had many vibrations even after the above iterations which reduced the accuracy a lot, therefore double pulley mechanisms was employed which helped in reducing the dynamic forces on the bots.

- **Driving motors of Auto2:** The motors earlier ordered for traversing were not able to move the bot up the incline and so motors with higher gear ratio were ordered which solved the problem but their rpm was reduced.
- **Igus sliders of AUTO 1**: Replaced by the conventional telescopic channels and they worked fine and smooth.
- **Nylon Ropes:** Clutch wires had high friction and their unwinding wasn't as smooth as expected, so they were replaced with nylon ropes but they had their separate problem of breaking frequently but this problem wasn't solved.
- **Four Point Contact:** For maintaining the four point contact in manual, the holes on one of the plates for mounting the motors, were made in the form of slots with the help of which their position could be adjusted and the contact could be established. This was helpful and the bot didn't slip at all in the main field.
- The joss stick gripper was made such that it was able to pick all the three joss stick in one go and was rigidly attached so it was necessary that it had high dimensional accuracy and so was made after quite iterations.

FINAL DESIGNS

MANUAL ROBOT

Role of the manual robot : As has been the case with the Robocon problem statements for the last few years, this time too the performance of any team at Robocon was too heavily depend on the design and performance of its manual machine. The main reason for this being, unlike earlier in Robocon, the dependence of the autonomous machine(s) on the manual robot. As per the problem statement, the manual robot was required to perform the following tasks:

- Picking up three Joss-Stick Pots and placing them at Common Zone before performing other tasks. The autonomous machine(s) were allowed to operate only after the completion of the first task.
- After that, the manual robot was required to bring a Candle Base and place it at Decoration Point located on Sala.
- The manual robot would then collect Joss Sticks from the Common Zone to be used again during Krathong assembly.

Mechanical Design:

- The chassis consisted of a low base aluminium structure augmented with a four wheel drive implemented by us for the first time.
- *For the first task:* For lifting the joss stick pots, we implemented a simple yet efficient and reliable lifting mechanism using sliders. The unique feature of the design was that we could lift and transfer the three joss-stick pots simultaneously yet not restricting ourselves by a mere possibility of non-availability of three simultaneous spots for placing them in the common zone. This was done by a gripper arrangement that could stack one joss-stick pot over the other.

- *For the second task:* For lifting the candle-base, we used a gripping mechanism to grip the object from its cylindrical base and lift it using a high-torque motor.
- *For the third task:* For picking up the joss sticks, we implemented a simple design using two motors. One motor for vertical motion on the sliders and the other for gripping the joss sticks. Other key feature was that it used spring action to keep the joss sticks in grip.

Manual robot

CAD Model of Manual Robot

Electrical Aspects:

- PS2 Remote
- Arduino Platform
- We could control any number of motors by using combinations of buttons when we ran out of buttons.
- It had front mode and back mode for easy maneuvering from both sides of the bot. (as we were using both the sides of the robot in different parts of the game).

- Had numerous speed modes depending on the level of control and speed we required.
    - Individual motor control: pressing R1 and L1 allows the joystick control each of the four motors individually.
    - Fast Speed Control: pressing R2 and using right joy stick we could make the robot move straight, back, left and right at speed ranging from 0 to maximum speed of the motors.
    - Slow Speed Control: pressing L2 and using right joy stick we could make the robot move straight, back, left and right at speed ranging from 0 to around half the maximum speed of the motors.
    - Super Slow Speed Control: pressing R2 and L2 together and using Left joy stick we could make the robot move straight, back, left and right at speed ranging from 0 to around tenth of the maximum speed of the motors (vital for lifting and placing mechanism of joss sticks).
    - VibrateBot Function: Given the narrow clearances between objects and we made a function which made the robot vibrate and whenever there were some difficulties in placing joss pots and getting the gripper down we used it and it worked wonderfully.

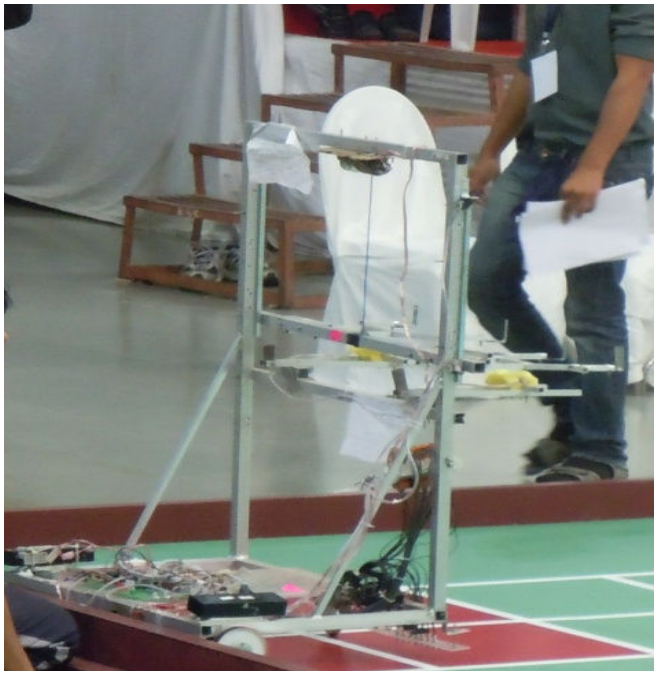
As you can see the level of control we had on our robot made the life of manual operator much less tedious and with proper practice we were averaging descent timing in our tasks. But all this would not have been possible without a proper microcontroller. Interfacing PS2 controller was a piece of cake as we had the luxury of arduino microcontroller. We used last year's boards for using relays. We could not only use the relay part of the board but also switch to PIC if needed. Thus utilization of already available sources was made.

AUTONOMOUS ROBOT-1

Role of the Auto-1 Robot: Auto1 was assigned to carry the petals and flowers from their storage point to the preparation points, it was of worth 40 points and the whole task of auto 2 was dependent on it. So as it had to be reliable and robust thus we designed to keep it simply in both aspects mechanically as well as electrically.

Mechanical Features:

- Aluminium channels for the basic robot structure.
- Use of Mechtex PMDC motors for driving the robot.
- Simple PMDC geared motor for lifting purpose.
- Telescopic sliders for lifting the grippers.



Autonomous Robot 1

CAD Model of Autonomous 1

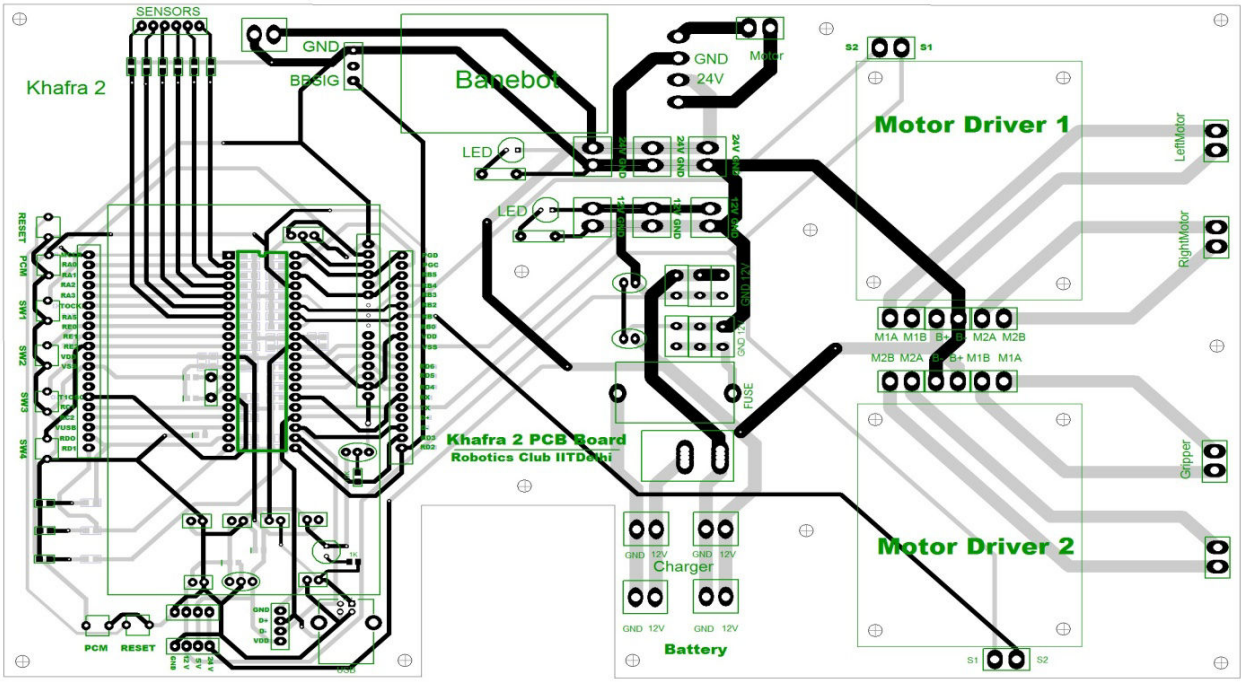
Electrical Features:

- IFM sensors for detecting the white line on the field.
- Sabertooth Motor Driver for controlling the speed and direction of the driving motor.
- Basic H-bridge for controlling the lifting motor.
- PIC microcontroller was used as the processing unit.
- Limit switches for determining the height limits of the gripper and detecting the poles.

Circuit Used:

The circuit we used in Automatic Bot-1 was of Khafra-2, one of the robots of the Robocon'11. It consists of connections for :

- 2 Sabertooth Motor Drivers
- Banebot Motor Driver.



Working :

Auto 1 had to traversal around 50 % of the field and so its task was divided into 2 parts –

- Carry the first pair of flower and petal from the poles nearer to the starting zone and keep them on the preparation points that were used by Auto2.
- Carry another pair and keep it on the second preparation point.

Both parts were of worth 20 points and the second part was only required to procure more points, although it was not mandatory. The field was printed with white lines on it so the basic function of Auto 1 was to read the lines and follow the path accordingly. It was strategically so sound that we could run it from either of the starting zones as it was programmed smarty to follow 4 paths, it saved our time in taking strategic retries. This property of auto 1 even helped us during the match when one of the path was not being traversed properly, then we switched it to a different path.

AUTONOMOUS ROBOT-2:

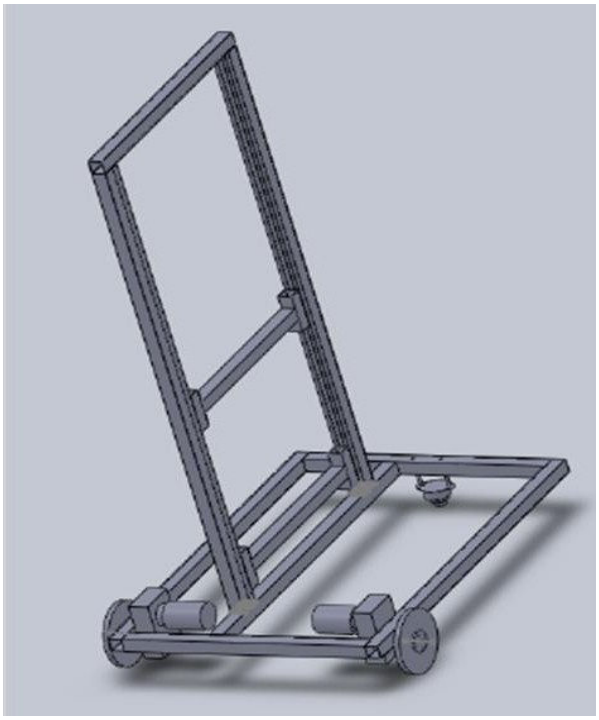
Tasks it was designed to perform:

- Climb up the Sala.
- Pick up the flower and petal from the preparation point and place them on the Candle Base.
- Pick up the Krathong and place it on the river.

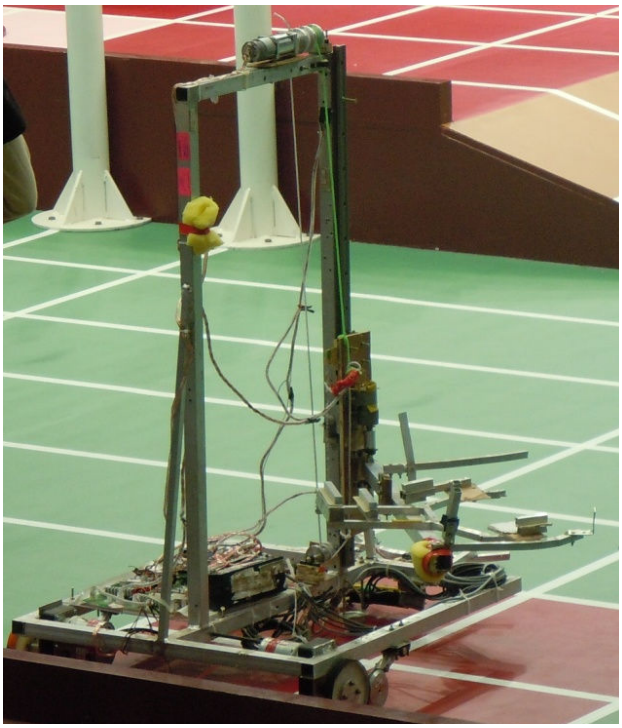
We decided that, since the theme was tough and time consuming, we will target only completing the Krathong. So no mechanism to pick and place the Krathong was designed.

Mechanical Features:

- Aluminium channels for the basic robot structure.
- A big castor instead of small one to prevent base from touching the ramp while climbing.
- Sensors were attached to a plate fixed to different castors so that the sensors always remained parallel to the surface.
- Used Igus sliders to move the lifting arm up and down.
- Use of double pulley for lifting objects : When single pulley was used the sliders did not come down freely and there was great deal of vibration which did not allow the robot to keep the object properly as it would change the orientation of the object relative to the pole. The use of double pulley helped to bring down the arm smoothly as there were two distinct ropes used one for lifting the arm and other for bringing it down



CAD Model of Autonomous Robot 2



Autonomous Robot 2

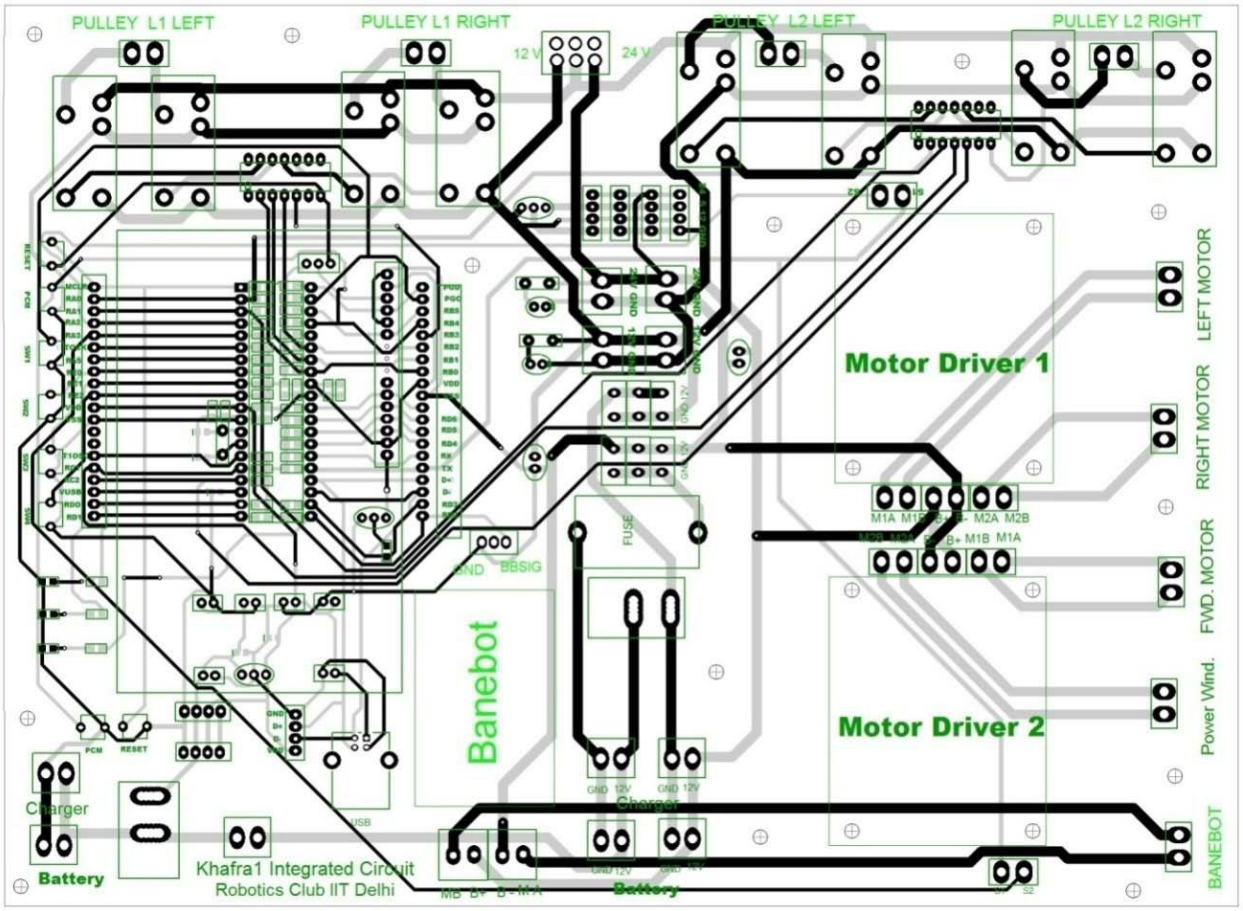
Electrical features of the robot:

- Line following using optical encoders.
- Use of high quality distance sensors and line following sensors.
- High speed.

Circuit Used :

The circuit we used in Auto-2, was of Khafra-1 (one of the robots of Robocon'10). It consists of connections for:

- 2 Sabertooth Motor Drivers (Dual 10 A channels for controlling two motors each).
- The Banebot Motor Driver Circuit.
- A series of relays for operating different motors.



The positives:

- Line following using the encoders was very efficient.
- We used really high grade colour sensors very effectively.
- The strategy was such that we never had to do any mechanical changes on this bot while switching from Red field to blue or blue to Red.

THINGS TO LEARN:

- **Team spirit** is the most important thing and a major factor too for the success of the team. At nights when other team members worked, hardly any one of us went to hostels to sleep. We used to sleep on the arena made in front of the club when it became impossible for us to keep our eyes open. This helped a lot in motivating others to keep working.

- We never realised that there was enough space on the Sala, to turn the robot, and so we instead of lifting the objects from the front (as in Auto1), decided to lift it from a side. In order to do the same, the angle of the arm had to be accurately controlled. This was among the major reasons for the failure of the bot. **It's necessary to know the field well before the designing starts.**

- We made a larger base than required (It was mainly due to avoid the Robocon'09 like disaster).

- **No Data fusion of various sensor data was done**. Encode-Line following coupling, Encoder-Distance sensor coupling would have helped increase the accuracy a lot.

- **Sensing was compromised upon**. The better the sensing, the better is the control (Nirma had used 5-6 limit switches on every slider to control the speed and position of the slider!). We compromised on the number of sensors. An encoder or a set to detect the arm position, or a set of limit switches for the BaneBot slider control would have helped.

- **More systematic work always helps.** Due to the panic situation, we somehow couldn't work on the bot systematically.

- Never compromise on the wiring. Follow colour codes. By not doing this we lost more than two hour at Pune. (A wire got burnt, and to debug the same, we had to open up and check all connections)

- We changed the design/path/control/sensing mechanics, without testing the bot enough times. (When we realized it, and started avoiding the same, the bots performance significantly improved).

NEW TECHNOLOGIES USED:

lectrical:

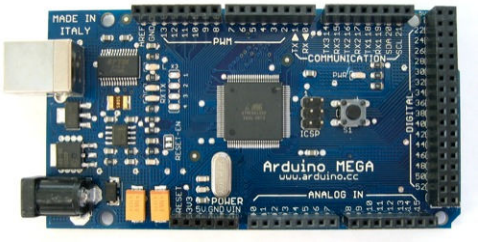
This time we successfully applied new technologies in Electrical Departments. There was a need of better controller for Manual robot and then it was required to follow line on three different colors. After doing a lot of research in these fields we were able to implement efficient yet simple solution for the same. These technologies include PS2 Remote controller, Arduino microcontroller board, and the Contrast sensors.

- We successfully used PS2 Remote Controller without changing its circuit. It improved controlling of the robot drastically. This we did by using Arduino board with ATmega2560 which is open sourced and more popular than PIC microcontroller.

- There were three different colors Blue, Red, and Green used in the field. So we used contrast sensor to solve this problem.

- **The PS2 Remote:** For the first time, we used a *PS2 controller* for operating the manual robot. This provided a better speed control and enabled us to incorporate the number of controls we needed for different mechanisms. PS2 controller came as a savior and proved to be one of the most fruitful things we did in winters from electrical point of view.

- **Arduino Platform**: The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. From the past experiences we were slowly getting frustrated by the redundancies, complexity and constraints we were facing with PIC MCU. So the third yearites gave us an option to use Arduino board. We learnt the basic coding of it in about a day and it took around 3 days to interface the PS2 remote control with it. One of the most precious features of the Arduino platform was that of serial monitor. Now we could read the values that the joystick was giving on our laptop and code accordingly. The code we employed was so robust and detailed that it gave a clear error if the controller was not properly connected. So we were done with the controller and as an obvious step went to interface sabertooth motor driver which was the mahout which controlled the four mammoth mechtex motors.



- **Interfacing the Sabertooth With Arduino:** Given the ease to code Arduino, we developed our own libraries for sabertooth motors. And since we were using PS2, which gave proper integers ranging from 0 to 255, it was obvious for us to use serial communication to give commands to the sabertooth. But when we drove the motors with arduino controlling the sabertooth we could not change the speed of a motor instantaneously by large amounts (i.e. we were unable to drive a motor from forward to reverse direction abruptly). So we gave up the idea of using serial

communication and moved on to another mode that sabertooth offered-Analog Input mode. In this mode an analog voltage of 2.5V corresponds to no movement. Signals above 2.5V will command a forward motion and signals below 2.5V will command a backwards motion. This kind of Analog voltage control was done superbly using PWM pins of Arduino, which was no trouble given 14 PWM pins and a one liner code for initiating a PWM at a PWM pin (A huge advantage over PIC). But due to noise the voltage we got (for keeping the motor still) was oscillating around 2.5V and due to this motor gave a humming voice. Though the speed control was nice, this was a major roadblock as motor constantly drained power and the noise was not at all good for the motors. We had to find a solution and for the first time our electrical Engineering lectures came to our rescue with the idea of RC filter. We put it between the MCU and Sabertooth. We were mesmerized by the beauty of the Low pass filter. It did not allow high frequency noise arrive at the sabertooth pins as a capacitor takes time to show a change in voltage. Everything was fine but when we drove our bot it had a very poor speed control. It was as if it had only two speeds 0 and maximum. PS2 remote was of no use. We pondered over the reason and came to a conclusion that the Capacitor was also hampering the PWM since it was keeping the charge and consequently voltage across the terminals and the high frequency PWM was not giving enough time to the capacitor to discharge. We tried different combinations of Resistors and Capacitors and all in vain. Either noise came back or speed control sucked. So we tried the Serial Mode again but with a slight change. Instead of sending an Integer, we sent a BYTE to sabertooth. To our astonishment it worked and was better than analog mode. Abrupt speed changes were possible. Speed control was awesome.

Mechanical:

- **Igus Sliders:** Moving from the conventional C channel sliders that we had been using for long we went for linear actuators from IGUS (a German company). There are many such sliders available in the market with ball bearings but the main features which separated it from the lot were the ability to come down easily by gravity and their weight. Normal sliders available in the market are very heavy and even if you find them to be light weight (a sample of light weight linear bearing is kept in the club) you will find that it does not come down by gravity and hence has to be driven. These sliders used do not have ball bearings but special plastic pads and hence do not require maintenance and lubrication.

- **Four Wheel Holonomic Drive:** The holonomic drive system basically consists of 4 omniwheels arranged in such a way that the robot can be driven in all 4 directions without having to rotate the bot. These drives can have 2-3 configurations one of which was used by us. While implementing the four wheel drive the only thing that was kept in mind that we would be able to reduce the time that we would take to place the objects. The four wheel drive lacked proper suspension system and hence required a very flat surface to have four point contact. This was a major issue as the bot did not work properly on poor fields. It is an important aspect that needs to be implemented in the coming years.

- **Mechanical Docking:** An important aspect of this year's mechanical designs was the use of mechanical docking, this was done so as to give the bot a greater deal of accuracy in attaining the required orientation and position. For more details on dock refer to the articles of Manual and Auto-2 .

CONDITIONS OF THE BOTS BEFORE LEAVING FOR PUNE:

Manual Robot: The manual robot was able to pick all the three joss pots and place them at the desired place. It was picking the candle base and placing it on the sala. The design for picking and placing joss sticks was not reliable and was also difficult to operate. The Robot was able to do the task but it was crossing the time limit of 3 minute. Four wheel drive was working fine.

Autonomous Robot 1: Auto1 was the most reliable robot. It was doing it task reliably and was tested for around a month on both the sides. It was able to pick and place both petal and flower efficiently.

Autonomous Robot 2: Auto was one robot which was not very reliable especially on red field. It was able to climb up sala, pick up the objects but placing was a problem. One Problem was with the slider mechanism and second was with placing the objects accurately.

ON REACHING PUNE……

After the long and enjoyable train journey, we finally reached up there. Half of the team reached earlier and did all the formalities regarding registration, lodging, food etc. Rest of the team reached at around 6 o' clock. Each team had its own working area in the form of a square wooden box (pit area). Everyone also seemed to be busy all around unpacking and laying out all the material and equipments. But in the evening, something happened which no one had ever anticipated. Imagine, in the month of Feb, it was raining. We had to shift all our bots and related items inside the main arena hall. Plenty of space was there, and yeah, it was a better place to work in. After that, we unpacked the robots and all other materials we brought. The actual work began at around 2 am. Along with the assembly of bots some of us worked on to arrange the circuit boards on the bots taking careful note of the wirings. A good suggestion this time was writing out the role of each pin and every connection in the circuitry to avoid any sort of confusion at the last moment.

The arrival of different teams also gave way to curiosity so many of us began to look out for their designs as well, quite a few of which were good and made us realise that maybe we were in for a surprise. With the aim of achieving success, we got down to our work of giving the final assembly to our bots so that we could start our practice.

That morning, we began our practice. The starting was not that good as the bots were bound to have some difficulties in adjusting to the new type of vinyl covering on the game area. Our manual was facing problem. It was difficult to maintain four point contact in it. It was also having difficulty in picking and placing objects and many of us were quite busy in trying to do some minor changes in it while some of us were back in our pit area, arranging the material and charging up the spare batteries.

All the teams including us were given 5 minutes as the stipulated time for grading our sensors according to the colours of the vinyl sheet employed on the main game field, on day before matches were to start. Next day, the tournament started and we were still

fighting with our Auto-2 robot. It was considered to be additive to our points to our highly constrained and conservative scoring scope.

LEAGUE MATCHES:

The matches were to begin a day after we reached there. We all were busy iterating our designs, making small changes. Our opponent teams had quite nice bots. But, luckily, it didn't matter against whom you were contesting. Ultimately, you just had to score the maximum number of points to clear to the first level. The second good thing, which we came to know, was that we didn't have any match on day-1 of the tournament which meant we could continue working on our bots. Three to four of us kept on working on Auto-2 continuously with the aim of adding some more score to our total by that out casted bot. Surprisingly after all the 3 x 3 rounds (3 teams x 3 rounds/match), our final score stood around 132 and we reached the level-2 with ***4th position!! And at the end our Auto-2 was a success (but, only on practice field…)***

THE SUPER-LEAGUES:

Since the super-league had fewer teams so naturally the pressure mounted upon us to outperform the better performing teams at that stage like IIT Bombay(TeamA and TeamB), Nirma and VIT. IIT Bombay was performing quite well with their bots giving minimum glitches and keeping almost every object except one and only The FLAME. Nirma was also doing well but was having some problems in Auto2, supposedly. They had minimum problems in covering the entire arena and with good dynamical control. This was mainly due to the highly stable design that they had employed.

We had to make good number of changes in our Auto2, if we were to show our prowess in the arena with real time optimization and complete run. Finally the problem of Auto2 was almost over and it was running successfully in complete run. We were having some

problems with the grips attached to the wheels of the bots as they were frequently coming out. So, we continuously replaced it.

4th march 2011, 11am , our first match in the super-leagues! Surprisingly our Auto1(the most reliable award winner in our hearts) just didn't complete its stipulated task and we lost that match! This almost made it clear that IIT Delhi was out of the Robocon'11. Our next match was at 4p.m. and we were trying our best to first figure out the glitch in the Auto1 bot. Parallely, matches were continuing among IIT Bombay, Madras, MIT Pune etc. But alas! It was our last match. Team IIT Delhi was out of the contest. Our strategy failed in this match. On the other hand NIRMA University (our opponent) completed the Krathong! This was the end for us.

Winner : NIRMA University

SOME PERSONAL EXPERIENCES :

SOME WORDS FROM THE AUTOMATIC-1 OPERATOR-DHRUV….

The Robocon is the biggest Robotics competition in India and the anticipation of the people is quite especially when you are representing IIT Delhi. I could feel the heat before the first match, as we entered the ambient arena with huge crowd.

The pressure was huge but it was a very nice experience to operate Automatic -1 robot, although there is generally not much to do for an automatic operator but with the strategic use of retries this year, I had to stop the robot in between the match and carry it back to the start zone, as quickly as possible.

We had our first match against COE, Roorkee. It was a nice match, the Automatic-1 robot completed all the tasks, it was a confidence-booster. Expectations were raised. The second match against Nirma was a very close one, both teams scoring equally in the first two rounds, but in the final round Nirma completed the Krathong! It was then I realized " We are by no way winning this year". It was heart-breaking, when we realized our incapability to complete the tasks. On the brighter side, we did finish in the fourth place in the preliminary round amongst 58 teams, quite ironical !

The second round was marked by the "mysterious" failure of Automatic-1 robot in the main field. In both the games, it wasn't able to complete the task and that ended our story for the Robocon-2011. It was really harsh as the same robot worked perfectly well just after the match on the practice field. It was really embarrassing and disappointing, the way it ended. The sight of that match still haunts me and I keep wondering what went wrong but left clueless! Many of us were inconsolable, but the good part was, some of us took it positively and critically examined the reasons for our under-performance. The team looks really determined for the next Robocon and I really believe we will put up a winning performance next year.

SANJEEV AND SARUCHI SAY….

It all began, in October. The problem statement of Robocon 2011 was out. There was excitement in the air. We had to do well this time...and we would. The first phase began soon - problem discussion. Then the club was divided into 4 teams, and each team was supposed to come out with a design for each robot. Manual- this was the robot under limelight this year, primarily because the whole problem had to be executed sequentially, and manual was the starting key.

Our team, had 3 girls (yeah! we were the first girls in the club), Kamlesh, and RKM. Kamlesh was amazing at design, more because he was among the very few who had prior Robocon experience in the club. So hence began the discussion; where the manual and auto-1 designs were discussed in detail, auto-2 was shrugged under the carpet. Little did we imagine at that time, this is the mistake that is ultimately gonna cost us our dream.

During the Winter break, the emphasis was laid on completing small projects - PID, PS2 Controller interface, Mouse interfacing and encoders; and all were completed. Backed by the successful completion of these small projects, started the building phase. Here the club was again divided into 3 teams-one each for Manual, Auto-1 and Auto-2. We were both part of Auto-2 team, along with Shubhada, Kartik and Rohit. For the first few weeks, the work was rather smooth. All the three robots were progressing, and auto-2 was well ahead of the rest. All were happy till the first hurdle hit - the IFM sensors that we used for line following, could not be used while climbing the ramp. The field that was constructed did not project the actual space that was available for use of auto-2 on Sala. This and the fact that it was never formally discussed were the faults that auto-2 and we along with it struggled throughout the competition.

But Robocon was something more than just the bots. The feeling, that high; that we experienced to see the bots running for the first time (and after it every time it would run successfully). The stress at its every trial, it was as if not the machine, but we were the ones put to test; the time that went into making the robots, the night outs, those birthdays

which were celebrated only in club because there was no time to go out, Kartik's Krathong birthday cake and much more….

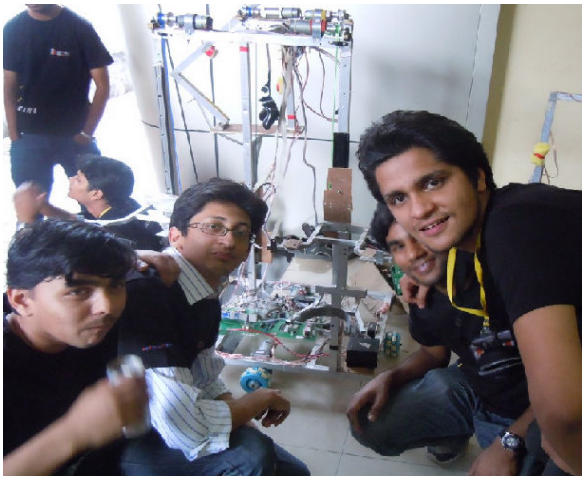
Don't ask us about the number of classes we missed to catch up with sleep or how many classes we slept through, simply because we were too tired to attend or how after a certain time the classes themselves became meaningless, club was the only important thing that was left. Even on the days when you could catch rest, we wanted to be there in club, just see the bots working, do anything, just anything, how our roomies practically disowned us after sometime because we were never in the room, always in the club. When you did, sleep (of course! it was rare) the only thing you could dream of was bots, you could feel your hands moving, you talking, frustration, it just never went away-club, the centre of your existence. It wasn't all work though, many strong friendships were built and forged right from those walls. Sac canteen, the field outside, we came to identify ourselves with all of these. And not just us, our friends shifted all of us' address to sac, well atleast mentally.

Then soon came the big night, club was packed, and we were set to go to Pune. The train experience was something worth mentioning. For once we could enjoy without worrying, because the competition was off, well off till tomorrow. Cards, crowd, yuck food, dumb-shraws, life story telling; together made our train journey worth cherishing for the rest of our lives. Come Pune, and the first day was full of drama, both internally and externally. The rain caught organisers off guard, so they had trouble handling it. And internally, were all shocked and under despair at having seen the other team bots. Couple it with the fact, that Avnish, our manual operator chickened out and then thankfully Kartik stepped up. The feeling of managing 20 odd people, bots, and your tool kit -all in a 10*10 pit is something you would have to go through to understand. The practice field offered another interesting opportunity with perpetual demand of practice slots. Here IIT spirit, all IIT's helping each other was displayed.

The first league match was tense, too many things at stake. We did well, but in the final run, rope of maunal broke, and with it hell broke off. Kartik cried and Kamlesh blasted off. The evening match against Nirma was head to head and it also meant that we went cruising into the super-league. Well we stood 4th to be precise. That night we had ice-cream -a welcome respite from the Vada-Pav, that had become out daily appetite consumed in breakfast, lunch and dinner. We were assured by the win that we would go to atleast semi's. Soon though we hit out first hit-back, and never got a chance to recover. We lost the first match of super league. That meant we were out of the competition, though we had still one more match to go. Lost, hopeless, none had any enthusiasm to work. Then Himanshu, the team leader; had a meeting in which he explained as to why it was important for us to perform, if not for us, then for the junior batch, we decided to put up a fight. None shall eat, till we shall conquer, but we never conquered. We were in the end, let down by our most reliable bot so far, Auto-1. As to why it didn't work, nobody has an answer. But the fact remains that it didn't. And so was IIT-Delhi out of the Robocon. Well we did help IIT-Bombay with sensors before going!

But the story didn't end. Next year, we will try again, and make sure the mistakes that we made this time are not carried forward the next time. For many of us, like us both this was the last Robocon that we would go to. But we had our fair share of memories, of being converted into one big unit from 22 people that originally made the team. This was Robocon, nothing matches the excitement, the pleasure of being there and watching your bots play and win.

PHOTO GALLERY :



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