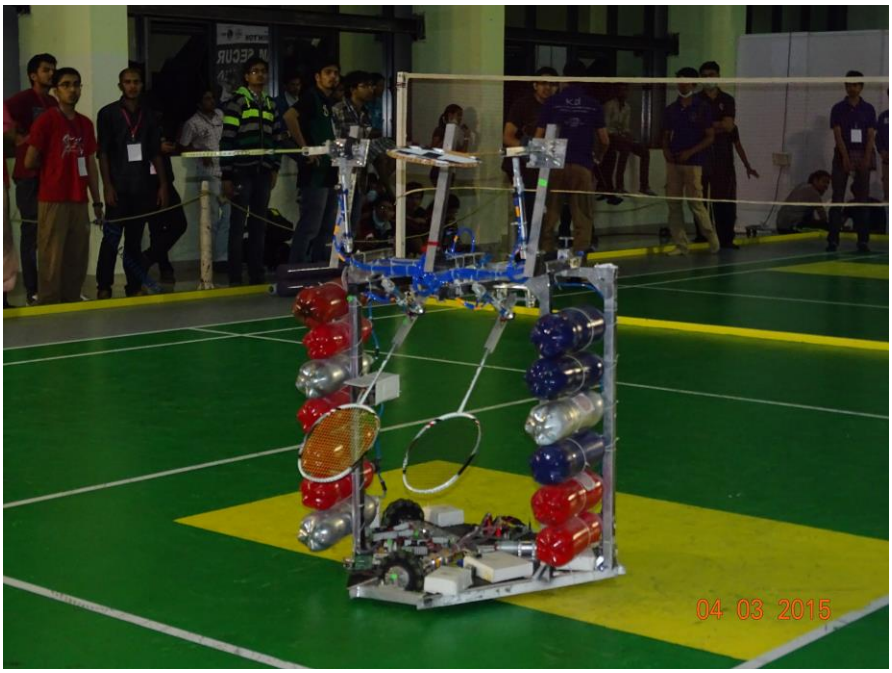
ROBODIARY 2015



The Journey To Robocon 2015

Robocon 2015 presented a new challenge to Robotics Club, IIT Delhi. This report aims to enclose the various aspects of the preparation and performance of Robotics Club, IIT Delhi in Robocon 2015 and notes in hindsight things which can be improved upon.

Robodiary 2015

THE JOURNEY TO ROBOCON 2015

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SUMMER TRAINING 2014

A summer training camp was organized for the incoming second year members in May 2014 after the culmination of majors and lasted for 40 days.

For mechanical students, the curriculum involved:

- SolidWorks CAD modelling
- Assembly and disassembly procedures via practice in Robocon 2014.

For electrical students, the curriculum involved:

- Study of electrical components.
- Assembly of electrical components in robot chassis.

The other part of the training involved multiple hands-on projects given to teams which involved designing and manufacturing of various components such as grippers and mountings. A project was also initiated in use of optical encoders in differential drives.

Note in hindsight: Even though the hands-on project was quite an educating experience, there should be more focus on learning the basics. For example: failure theories in solid mechanics, motor characteristics, designing with pneumatics, drive train designing, etc.

Also, the summer provide an excellent time for exploring with products and coming up with novel and reliable technologies. So senior members of the club should try and explore with upcoming products used industrially. This will give the club the much needed industrial exposure.

ROBOMINTON – PROBLEM STATEMENT OVERVIEW

The theme for Robocon 2015 was "Robominton". The teams had to make two robots, manual **or** automatic, which are capable of playing a doubles game of badminton. The game field was of the same size as a standard badminton court. **The service had to be specifically dropped inside a Service Drop Zone colored yellow in the opponent's court.** Each team would be awarded a point whenever the shuttle drops in the opponent's court without touching the net. **The match would end when one team scores 5 points. If a draw is reached at 4-4, then the team which scores 2 points first wins. If a draw is reached at 6-6, the judgement is made on the basis of number of returns, successful serves, less warnings and judges' discretion**.

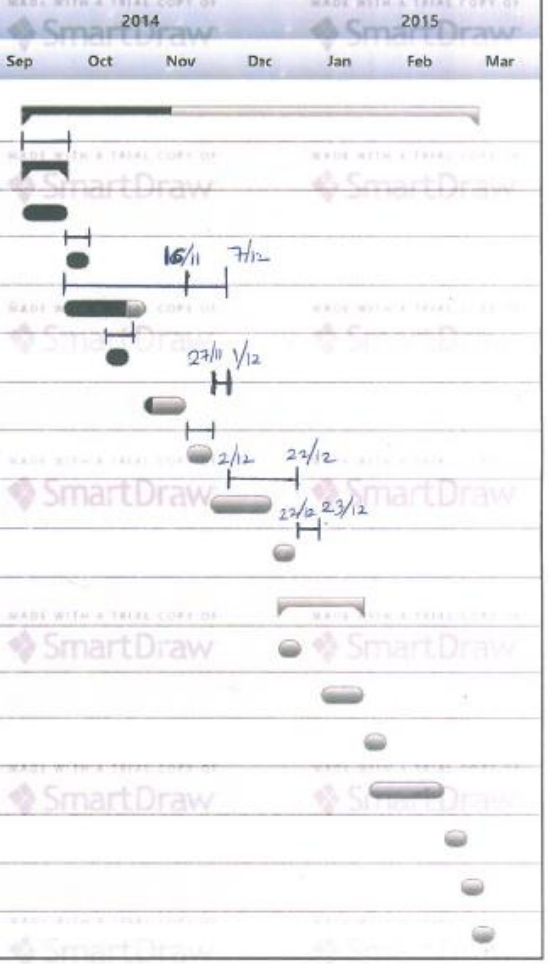
Some other constraints were:

- Maximum weight of each robot is 25kg.
- Each robot has to fit in a cylinder of maximum diameter 1200mm and maximum height 1500mm.
- Maximum potential difference in the circuit should not exceed 24V.
- Use of compressed air below 6 bar pressure is allowed.
- Racket handle can be remodeled but otherwise rackets and shuttles used should satisfy World Badminton Federation's regulations.
- 6 shuttles will be provided to the team at the beginning of the game. The team can load shuttles according to its' own accord.
- Touching the net and poles will lead to disqualification and the game would end at 5-nil.

Note in hindsight: The problem statement this year was remarkably much more competitive from the previous years, where the individual performance had paramount importance. This year teams' performances were dependent on the performance of their opponent contrary to previous years.

GANTT CHART: PROPOSED AND FOLLOWED TIMELINES

	Task	Assigned To	Start	End	Dur	%
	ROBOCON 2015		17/9/14	7/3/15	116	33
1	Designing		17/9/14	3/10/14	13	100
1.1	Design Visualization		17/9/14	3/10/14	13	100
2	Minor 2		3/10/14	11/10/14	6	100
3	Proof of Concept		2/10/14	2/11/14	21	75
4	Mid Semester Break		18/10/14	26/10/14	5	100
5	Finalization Of Design		2/11/14	17/11/14	10	20
6	Majors		18/11/14	27/11/14	7	0
7	Manufacturing		27/11/14	20/12/14	16	0
8	Assembly		21/12/14	22/12/14	1	0
9	Test Runs		23/12/14	24/1/15	21	
9.1	Iterations		23/12/14	31/12/14	6	0
9.2	Performance Enhancement		9/1/15	24/1/15	10	0
10	Republic Day		25/1/15	26/1/15	1	0
11	Practice		27/1/15	24/2/15	20	0
12	Packing		25/2/15	1/3/15	3	0
13	Off to Pune		1/3/15	2/3/15	1	0
14	Robocon		5/3/15	7/3/15	2	0



* Black Portion represents Completed percentage.
* Line represents the actual timeline followed.

DESIGNING PHASE

The designing phase commenced with the arrival of the problem statement. The methodology used was as follows:

- Four teams were made and each team had to brainstorm and come up with a rough design of robots and identify the various subsystems associated with the problem. After discussion on the various subsystems used by the different teams, **the better and the more feasible subsystems** were selected. The teams also came up with different playing strategies including whether the two robots would play side by side or front to back.

- **PROOF OF CONCEPT:** In this phase, the prototypes of ideas selected in the previous stage were manufactured and were **approved by the faculty** themselves. **This ensured lesser iterations in the design later.** New teams were made for this phase. The various subsystems were:

    - **Shuttle hitting mechanism:** A mechanism based on pneumatic pistons was manufactured in the club itself. Its target range was 7m.

    - **Shuttle detection:** Ultrasonic and Laser based detection systems were proposed for this subsystem. The detection for the dropping service shuttle was done quite easily by both designs and ultrasonic was used for this finally. However, the detection for any incoming shuttle was quite difficult and both designs could not be done up to the mark till the end.

    - **Shuttle dropping mechanism:** Cam-shaft design and Gun barrel Design were two designs proposed for this subsystem. However, Cam Shaft design proved unreliable and Gun barrel design was used.

    - **Holonomic drive:** The Three Wheel Holonomic Drive was unanimously chosen by all teams because it could run without changing its orientation and did not have the problem loss of contact. A design made in the summer training was used as the initial design for the base of the drive. The drive was manufactured by Sardarji.

- **OVERALL DESIGN AND CAD:** The various subsystems which proved reliable in the proof of concept phase were assembled onto a chassis. Also, front to back strategy was chosen as then the 2 robots have lesser probability of collision. The chassis had the same base as the design of the holonomic drive base and the design for the above was decided on the basis of:

    - **For Front robot:** The front robot, which was also the serving robot, had 5 rackets. Its design had to incorporate higher number of bottles and shuttle dropping mechanism for service. **4 Separate bottles which were not connected to the other bottles were used for the serving racket because successful service was quintessential for winning and the pressure had to remain same for at least 6 services.** Also, maxon motors were used for this robot as it had to move faster.

    - **For Back Robot:** The back robot had 5 rackets. It had more bottles per racket as compared to the non-serving rackets of the front robot because it needed larger range. The design for this robot was comparatively simpler and had more space.

Note in Hindsight:

The **Proof of concept** phase was quite helpful in the long run. It was not used in the previous years and entire designs were made with technologies which failed later. This led to iterations in many later stages and proved harmful. The proof of concept phase ensured that all critical subsystems used were tested before the designing part.

The front robot later exceeded the 25kgs limit for weight. During the design phase, stricter limits should be used as the exact weight cannot be formulated easily right then as some parts used are subject to change.

The manufacturing of the robot commenced after the end of majors. It continued for the entire winter break including the assembly of the robots. Many teams were formed corresponding to multiple subsystems and manufacturers used. The various manufacturers used were:

- **Sardarji**: He shows versatility in manufacturing and is the only manufacturer with the infrastructure of aluminum welding. Also, he has fewer customers, so he is generally quite free and at service most of the time. The entire chassis for both the robots was cut and welded by him. He also worked on the hub and shafts of the drive systems and many other small components. However, a person has to accompany him otherwise he loses focus and is not productive enough. Also, he charges exorbitant rates at times, and bargaining over prices is common with him.
- **Okhla manufacturer**: He has multiple workmen and good infrastructure including a CNC machine and a CNC lathe. However, he is a bulk manufacturer and has a large workload from other sources. Hence, he rarely spares workmen and machinery for small orders like ours. This time, the team members themselves had to learn CNC machining and work on CNC (which had a slower production rate) to meet deadlines, as all other machines and workmen were not available. This lead to fatigue of the members and created a delay of about 2 days. All components related to hitting mechanism were manufactured here.
- **Laser cutting**: To improve the reliability and reduce weight of the shuttle dropping mechanism, the gun barrel was manufactured from acrylic sheet. The gun barrel was precision manufactured using laser cutting done at Chuna Mandi.
- **Printing of circuit boards**: To avoid inaccuracies in manually soldered boards and making compact boards for complex circuits which require traces on both faces, all the circuits were designed on dipTrace© and printed from Lajpat Nagar.

The assembly of the robot started as soon as components were manufactured i.e. 22nd December, 2014. By the end of winter break, the robot was assembled mechanically and provisional circuits were used in testing the robot and we were able to test the robot.

Note in Hindsight:

Circuits should be designed preferably on single-sided board as they are much cheaper to manufacture.

The main board was to fit in the cavity of the chassis, but due to some errors, the dimensions of the board was larger and could not fit into the chassis.

the team had to settle with the timing of midnight onwards till 3 AM for practice. Still, there were daily(rather nightly) practices and during the weekends practices stretched till 6 AM in the morning, if the court was available. Prior to the practice, the team would service the robots daily.

Since no reliable detection method could be implemented, the entire onus of performance fell directly on the riders themselves. In the beginning, Rishabjit (front robot operator) practiced servicing and Ayush (back robot operator) practiced returns. Service was almost always successful and highly reliable. After a few days, Rishabjit and Ayush both practiced returning, while other members served to them. An auxiliary service robot was later made to have more uniform practice. Individually, their return rates had gone up to 50% in some stretches and averaged around 30-40%. When both played together the return rate was also similar because the yellow zone was too small and did not have enough space for two robots. Rishabjit played with upper rackets and played well with low lying serves. However, overall he had slightly lower return rate than Ayush.

Note in hindsight: **The effort devoted by the entire team in the practice phase was commendable and noteworthy despite the unearthly timings of the practice. The effort was well awarded in Robocon as well where we had arguably the most experienced manual drivers with the best response and reflexes in the tournament and the entire team had contributed to this.**

However, a few other things could have gone better if we had some more automation. Our failure lied in the ability to implement a detection mechanism which worked well enough. Also, a variety of services should have been fabricated. The team did this during Robocon itself and the results were not up to the mark and as reliable as the normal service due to the limited time. Winning strategies should also be focused upon in this stage, while the team focused only on the return rates.

PACKING AND MOVING TO PUNE

Three wooden boxes were fabricated for the purpose of transportation of robots and other tools. One box each was used by one robot and the last box carried the tools. Most of the tools were transported to deal with any uncertainty. The smallest box was used for carrying the tools and it turned out to be the heaviest. The workman employed was from a furniture shop in Munirka. The boxes had castors in the base, which were fixed by screws.

Foreseeing chances of rain, the boxes were lined with bubble wrap from the inside. **Every component packed was bubble wrapped to deal with shock and water. The robots were tied and fixed in their place by using wooden fixtures and packaging tapes.** The bots were partially disassembled to reduce the space taken. However, the drive system was not disassembled. The boxes were sealed and nailed and locked from the outside. Packaging tapes were also used.

The boxes were left at the railway station a day before the departure day. And it rained heavily that night and also during the journey. This created quite a scare in the team. Also, the box used for transport of tools was too heavy and the screwed castors gave way. The box was extremely difficult to move and lift and also led to minor injury to a team member in a particular incident. The journey was otherwise smooth and the transport in Pune was handled by the organizers.

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Note in hindsight: A more reliable way of dealing with rain is using plastic covers from the outside. Also, two smaller wooden boxes can be used for the transport of tools as lifting of that one box is too difficult and also dangerous. Nuts and bolts should have been used for fastening of the castors. This was implemented during the return journey which was relatively smoother.

most members slept in the stadium itself. A practice field was arranged by the organizers. Initially, due to almost 100 teams, the practice slot was only 5 minutes long and the waiting time as high as 8 hours. Our team kept track of other teams' performance in the practice field by posting a member near the field to keep track of their overall performance. IIT Delhi did well in the practice slots themselves and had relatively higher return rates as compared to others. College of Engineering, Pune used semi-automated robots with LIDAR sensors and had the highest return rates at about 60%. IIT Kanpur, too, performed well and similar return rates as ours. However, the hard work during the practice phase here kicked in and our team was quite confident. While other teams were busy in finding partner teams for practice matches, we felt that it was unnecessary and would only give away our weaknesses.

Qualifying Round:

We did not face any real competition in the qualifying round and managed to beat our 2 opponents quite easily in this round. Our first opponent, *NIT Rourkela*, lost 5-0 as it failed to serve successfully. The next opponent, *A.G. Patil Institute of Technology, Solapur*, were beaten 5-1. We made one wrong service in the second match.

The qualifying round though a league round was almost like a knockout round in effect as any one loss would lead to elimination.

Super League:

Our first match in Super League was quite challenging. The opponent team from *Smt. Kashibai Navale College of Engineering, Pune*, was quite impressive in practice slots. It had high return rates. The match began and they returned 2 of our services. The score was 1-4 and it looked like the end for us. They were a point away from ending our campaign. However, the intensive training kicked in and Rishabjit, reading his opponent, constantly changed his form of service and the opponent could not return services anymore. Ayush successfully returned 2 services and the score turned to 4-4. They made a wrong serve and the score ended 6-5. This was a very close win and was purely because of the presence of mind and skill shown by our well trained drivers.

The next match against *K.J. Somaiya College of Engineering, Mumbai* was comparatively easier. After the score reached 4-4, Ayush returned a serve and later the score ended at 6-4. By winning against

these two teams, we had qualified for the quarterfinals and were seeded 2nd in the list of quarter-finalists, thanks to Ayush's 3 successful returns. College of Engineering, Pune was seeded 1st in the list of quarter-finalists. Our next match was against *Sardar Patel College of Engineering, Mumbai,* which was seeded 7th. It had a 5% return rate and only one of their robots had a working drive.

Night before the quarterfinals

By this time, we were favorites in the tournament and we expected an easy win in the next game. We expected to face Nirma Institute of Technology in the semi-finals. So, accordingly we made a strategy according to our perception of Nirma's weaknesses. However, we did notice that both our next opponent and Nirma had a very flat serve. Ayush found it difficult to play against flat serves. Some practice time had been devoted in helping him with the flat serve.

Quarterfinals

We had the second match. In the first match, surprisingly, first seeded COE Pune was eliminated by last seeded LDCOE, Ahmedabad. Our match began and the score reached 3-4. Ayush found it very difficult to return their serves and could not return any. Our next service was returned by their rider, their only return in Robocon 2015 and we lost 3-5 in the quarterfinals.

Results

Our Team stood ***7th*** in overall standings and was awarded the '***Best Innovative Design' award.*** *Institute of Technology, Nirma University, Ahmedabad,* lifted the Robocon 2015 award and won the opportunity to represent India in the international round in Indonesia.

SUMMARY

Robocon 2015 has been an enriching experience for all the team members. It gave the students a platform to try out what we have learnt as engineering students in classroom. It also gave the students an interdisciplinary platform to collaborate, learn and work together as a team. The routine guidance from faculty member and seniors was invaluable to us. The competition itself has given us the platform to meet with many other robotics enthusiasts across the nation and learn from them and an opportunity to learn about competing with the right spirit.

Our performance in Robocon in recent years has not been up to the mark. However, our performance this year is a proof that given the right leadership, methodology and spirit, we can do quite well and WIN.

As undergraduate students, we do lack knowledge of advanced robotics. However, by correct documentation of existing knowledge and training process this problem can be dealt with.

The author hopes and believes that Robotics Club, IIT Delhi will gain confidence from its experience of Robocon and set higher goals of winning at all levels and work in even better spirits than it did this year.

This document is authored and designed by Saurabh Sinha on behalf of Robotics Club, IIT Delhi.