IIT MADRAS

ROBOCON TEAM 2011

TECHNICAL DOCUMENTATION

LOY KRATHONG

IITM TEAM ROBOCON 2011

Faculty Advisor:- Prof. Sandipan Bandyopadhyay

Techno-Manager:- Sandeep M

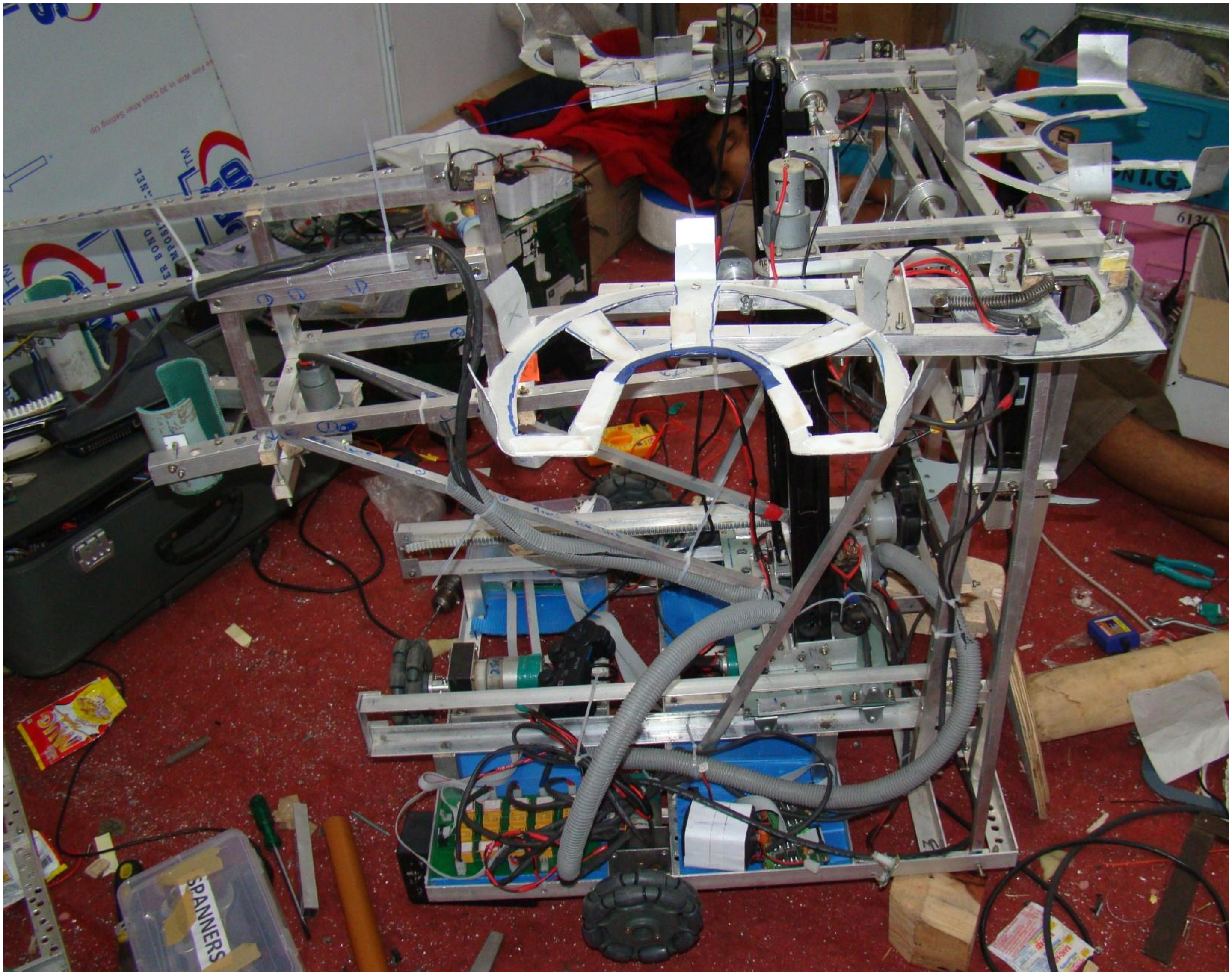
Team Members:- Sohan Jawale, Anusheel Pareek, Anant Jain, Gaurav Jain, Rakesh S, Vaidheeswara Sharma, Tanuj Jhunjhunwala, Varun Nalam, Siddharth S, Vimal M, Abraham Vinod, Shehzman Khatib, Manaswi Mishra, Harish Guda and Mithun Mohan.

Mentor:- Abhishek Venkataraman and Ashwin Sudhakar

Our Journey in Robocon 2011

- There were a total of 58 teams that participated.
- We started with playing against IIT-Bombay in our first league match. We had two of our bots working properly in the match. We lost against them two matches to one.
- In our second league match we won all the three games.
- In the first round we were 7th & we qualified to the Super league which had 18 teams.
- Our first super league match was again against IIT-B which we lost, in this round also our second autobot wasn't working.
- In our second super league match we won all the three games.
- We got through to the quarters as the first runner's up
- Our quarters match was against COEP-Pune. We drew all the three games in the match. So we played another game in which one of the mechanisms on our manual bot stopped working because of a technical problem and we lost the game. In this round our second autobot was line following properly but wasn't doing rest of the task.
- Finally by points we stood 5th.

DOCUMENTATION: MANUAL BOT



Tasks of the bot

The following were the tasks to be performed by this bot:

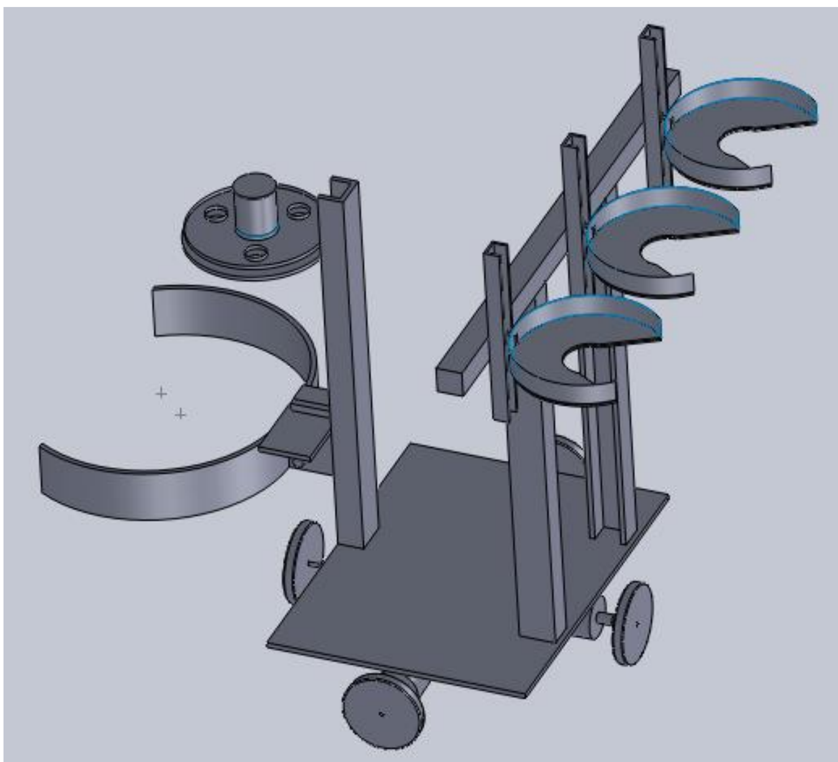
1. Pick up Joss Pots from the storage point and place them on any of the three poles out of six in the common zone.
2. Pick up the candle base and place it on the decoration point on the sala.
3. Pick up three joss sticks from the joss pots and place them in the partially decorated Krathong.

MECHANICAL MODULE

Mechanisms on the bot

Since there are many mechanisms on the bot we will analyze them separately. The following are the different mechanisms on the bot

1. Locomotion
2. Joss Pots mechanism
3. Candle base mechanism
4. Joss sticks mechanism
5. Trolley for moving the mechanisms

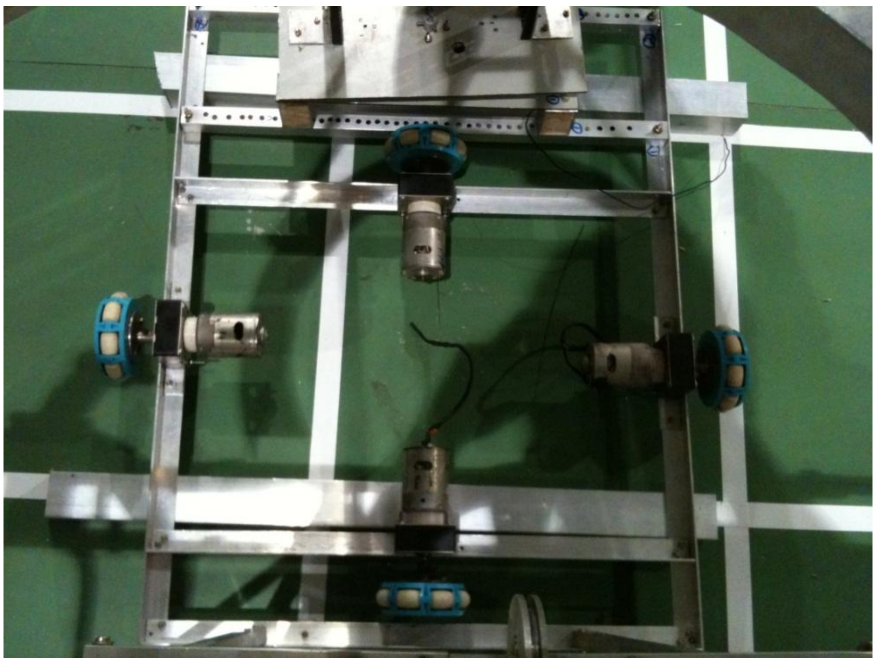


INITIAL DESIGN IN SOLID WORKS

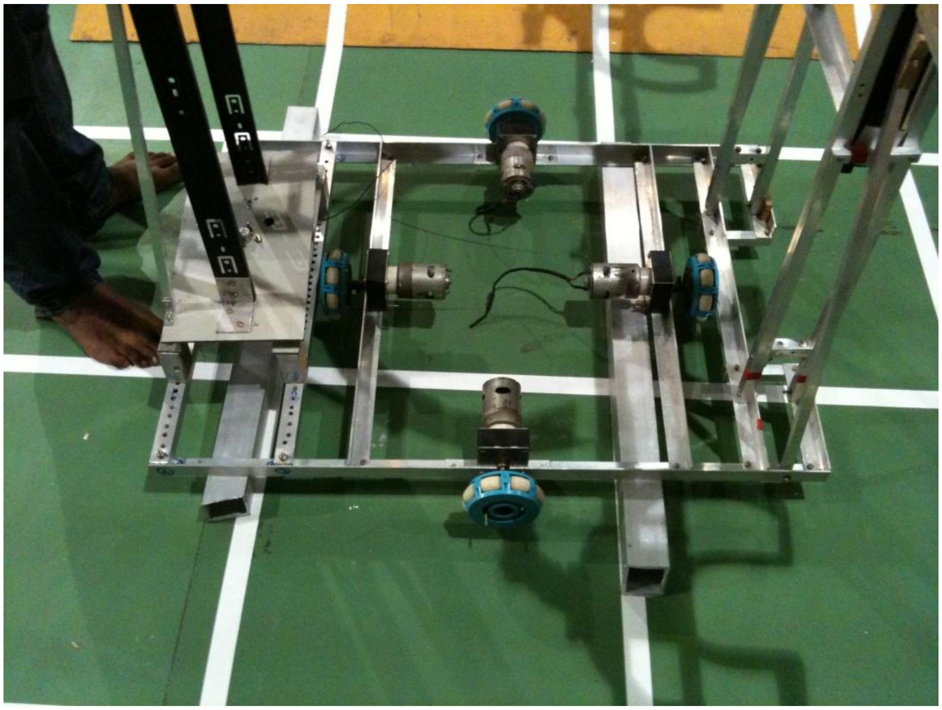
Locomotion

- This year's locomotion of manual bot was using transwheels. Transwheels are wheels which have rollers on their circumference with their axis of rotation tangential to the wheel. Four wheels and motors were used. When two wheels would be powered the other two would act as free rollers and vice versa.
- A prototype was made and tested before robocon started. It was successful hence we went ahead with the design.
- Challenges faced:-

    - Co-planarity of the four wheels. We all know that three points lie on a plane but in this case to make sure all four points would be on the same plane was extremely difficult. The motors had to be mounted very accurately.
    - Making a flange for this wheel to attach it to the motor.
    - The manual bot operator had to do lots of practice.
- Advantages:-
    - We saved time for every 90 degree turn.
    - The problem statement required lots of movement of the bot in all direction, it should be able to align itself to a pole, and hence transwheel was extremely helpful.
- The transwheels were ordered from Australia from the company Rotacaster. Web site:- www.rotacaster.com.au. Model number:- R 2125 8510 GG grey/green omni wheels with rubber rollers.
- Improvement:- Suspensions should be introduced.



FOUR TRANSWHEELS MOUNTED WITH MECHTEX MOTORS



Joss Pots mechanism

This mechanism performed task 1.

Design Process

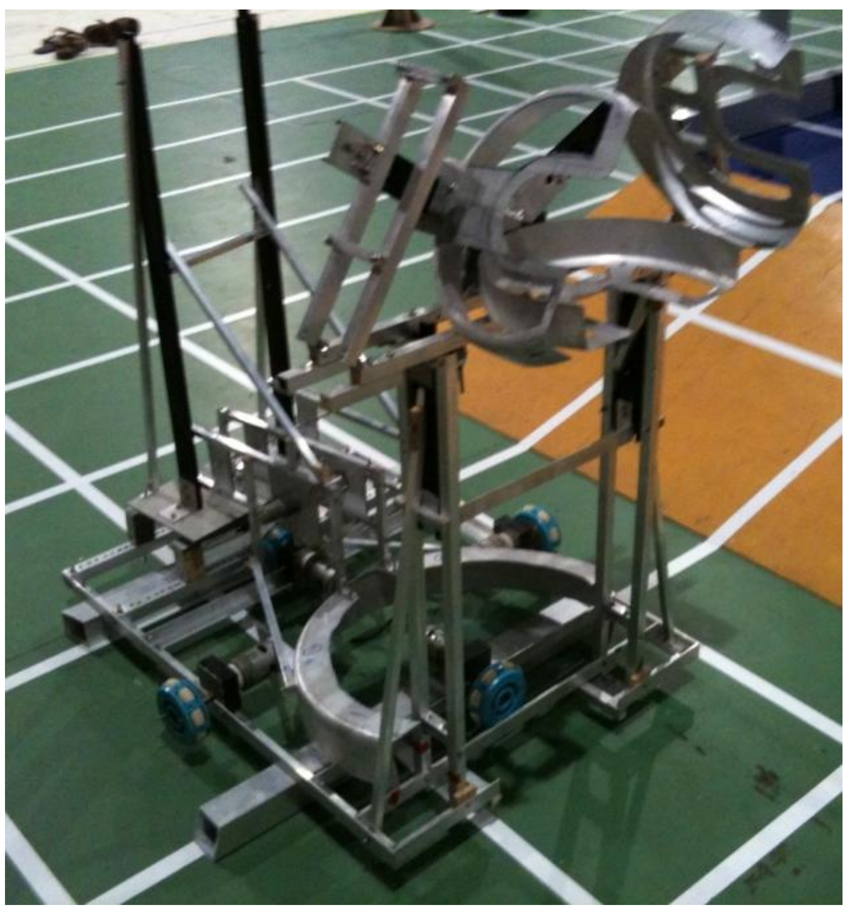
1st Design:

- The very first design was to lift all the three joss pots simultaneously. The poles were separated by 50cm and thus picking all three pots together required the mechanism to be at least 150cm long. But as per the rules the bot was constraint to initial dimensions of 1m by 1m. So the mechanism had to extend at the start of every game.
- In the design three plates were cut out from aluminum vessels of 26cm dia. These plates were used to pick up the joss pots.
- The center plate was placed on a box channel of 1” by 2”. Box channel was around a meter long.
- The other two plates were mounted on horizontal sliders fixed to the box channel and thus they could extend out to the required dimension.
- The use of sliders became difficult because when the sides plates extended out the sliders bent. Also the mechanism became very heavy. Hence this design was changed for the following one.

Second Design:

- In this design the side plates were lifted up to fit inside the initial dimensions.
- A motor unwounded a thread to lower the plates.
- The entire mechanism was mounted on two vertical sliders and a pulley system was used to actuate the sliders.
- The two side plates could move independent to the other plates so that if required only one or two joss pots could be placed at a time. This was simply done by mounted the plates on 10” vertical sliders.
- Compared to the earlier design this was less cumbersome and lighter, but when released the plates fell with a thud and they also bent when joss pots were placed on them. Thus placing the joss pots on the poles by the side plates became difficult.

Fully extended Joss Pot mechanism



Initially closed side plates

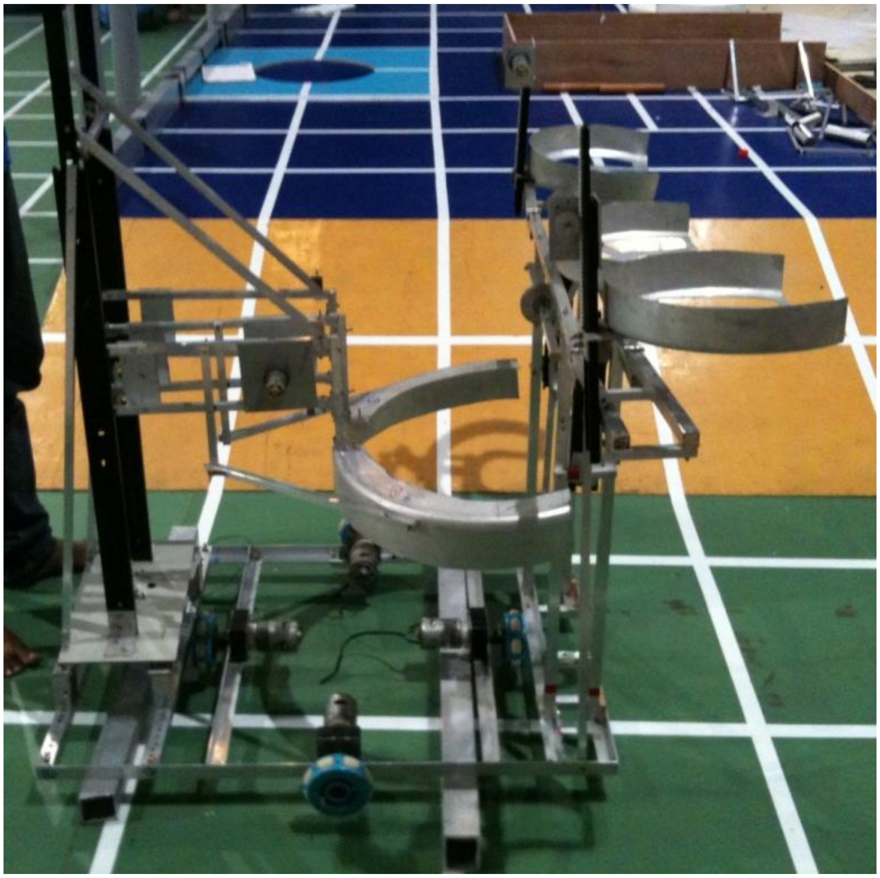
Third Design:

- In this design the side plates could be rotated by 90 degrees to fit it in the initial dimensions.
- A motor with a pulley and thread was used to rotate the plates inside. A spring was also used so that when the thread was unwound the plates came to their required position.
- Now the side plates could be supported with a bottom plate, and thus the problem of side plates getting bend was solved.
- Also the side plates were not required to be placed on vertical sliders as they could be pulled when it was not possible to place all three pots simultaneously. This reduced the weight and made the mechanism simpler.

Candle Base mechanism

Initial design:

- The mechanism consisted of a clamp to lift the candle base.
- The clamp was based on screw mechanism. The candle base was clamped from the base and thus the side supports were arcs (of radii 50cm) a little smaller than a semi-circle.
- These arcs were well supported and one of them was fixed.
- The other one could move sideways on two guide rods.
- When the motor attached to the screw was powered the clamps moved closer.
- Using a screw based clamp insured that the mechanism could take jerks.
- Entire system was mounted on vertical slider to give it a vertical degree of freedom also.



Candle bas mechanism: 1st design

Screw clamp of the candle base mechanism

Second Design:

- Later it was made clear that in the candle base, the pipe was fixed to the base. Thus the design was changed to the obvious one in which the candle base was lifted from the 9cmdia pipe, fixed on the circular base.
- Instead of the screw clamp, a two bar clamp with a spring was used. The bars were placed in a cross and they were hinged at the contact point. The front end of the bars had the clamps to lift the candle base and their rear end was tied to strings which were pulled by a motor to open the clamp. A spring was fixed on the front half of the bars so that in the normal position the clamp was closed.

Joss Sticks Mechanism

This was the most difficult task/mechanism of this year's robocon. After three designs we finalized and got it working. Three joss sticks have to be picked by the manual bot and have to be placed in three holes on the flower at the decoration point on the sala.

First Design:

- Two parallel sandwich aluminum plates were used. These plates would relatively move up and down but the whole assembly would rotate by a high torque motor attached to the top plate. Three PVC pipes where attached to the top plate in an equilateral triangle (according to the joss sticks orientation). The second plate had three holes (of the same diameter as of the pipes and also at the same pcd). The three pipes would pass through this second plate. The lower parts of the pipes were curved outwards in order to receive the joss sticks. The full setup would position itself over the joss sticks, it was lowered. The second plate would be actuated downwards in order to engulf the joss sticks in the pipes.

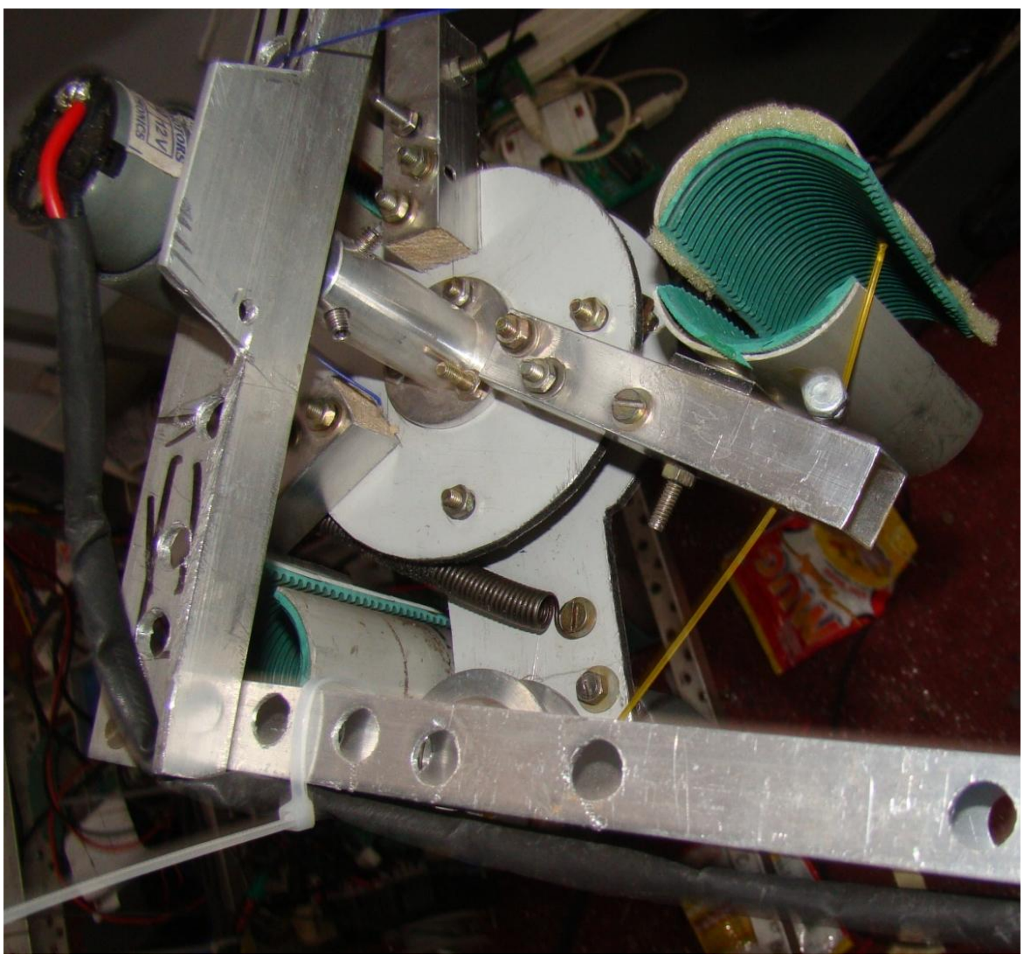
- Problems:-
  - We couldn't find this kind of a linear actuator.
  - The second plate would get jammed some times.

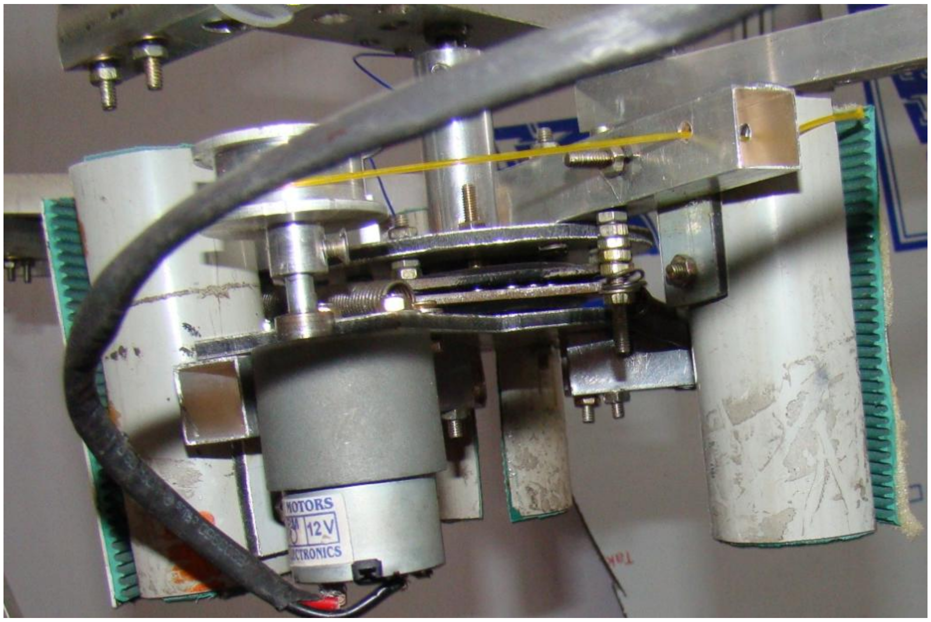
Second Design:

- Three plastic hair clips/paper pad were used. One of the ends was fixed while the other was controlled by a motor. So when the motor would wind the clip would open up and a spring would elongate. When the motor's direction was reveres the spring would ensure that the clip would close in order to grab the joss sticks. The arrangement was similar to that of the previous design. Whole assembly would rotate by a high torque motor attached to the top plate.
- Problems:-
  - The clips would break very fast.

Third/Final Design:

- Two parallel sandwich plates were used, which were attached on two sides of a swivel plate. Whole assembly would rotate by a high torque motor attached to the top plate. Three pipes were used which were cut into two halves longitudinally. The two parts were attached to the top and bottom plates of swivel plate. The upper part would rotate by a motor against the spring and hence the two halves would move away from each other in order to engulf the joss sticks. The spring would help it retreat back and keep the joss sticks clamped. Sponge/grip was put on the inner sides of the pipe to increase friction.



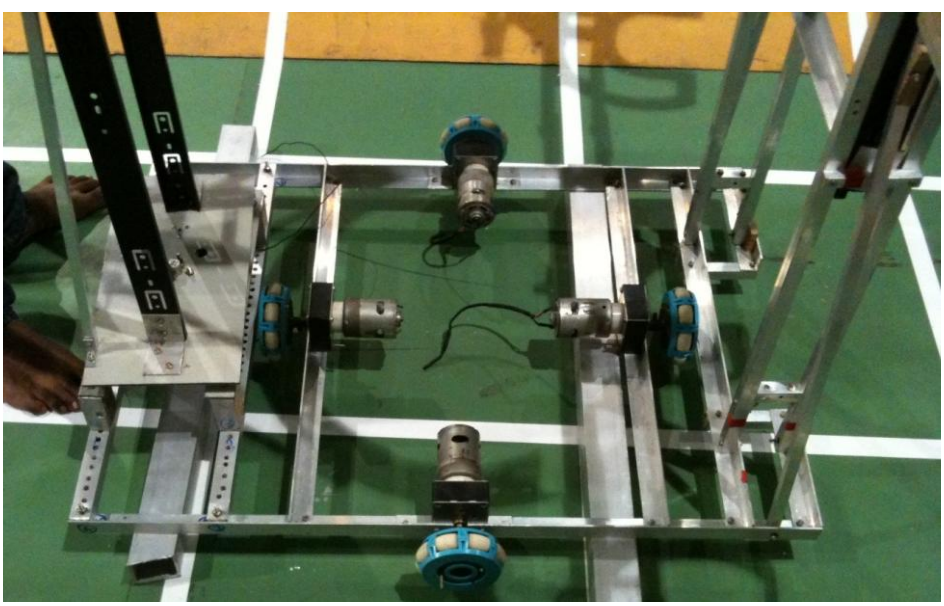


Trolley mechanism

The candle base was to be placed on the decoration point on the sala. The manual bot was not allowed to climb the sala, thus it had to place the candle base from ground itself. This required it to extend the mechanism (by around 25cm) so as to reach out to the decoration point. Same was the condition when the joss sticks were to be placed. The trolley mechanism provided for this. This mechanism also evolved and the first design was not even a trolley but a turret.

First Design:

- In this design both the candle base and joss sticks mechanism were placed on a rotating base (turret).
- A swivel plate made the rotating part of the mechanism. The upper plate of the swivel plate could be rotated with respect to the lower plate by employing a motor through a specially designed flange.
- The drawbacks of the design were large weight, reduced stability as trusses to the mechanism could not be provided, rpm of the turret was very large.



Turret mechanism (left side) shown with the bot chassis

Second Design:

- In this design instead of the turret a trolley which could move in and out was used.
- Rails were provided on which the trolley could move. The turret had two motors on the front edges of the trolley. The motors had pinions on them and a rack was pasted on the rails. Thus by powering the motor the trolley could move in-out.
- This was a very stable mechanism and was very light in weight. The only problem was that the trolley plate had to be strong enough to take the heavy load of the two mechanisms. We had to replace that thrice.

Specifications of the final design:

Motors used:

Type	Specifications	Use	Quantity
Mech tex	250rpm/24 V	Locomotion	4
Power window	High torque/12 V	Vertical slider motion for joss pots and candle base	2
Robokits	300 rpm/12 V	Joss pots 90 deg rotation, spring motion & trolley pinnion	4
Bombay electronics	High torque/10 rpm/12 V	Candle base mech, Joss sticks	3

Sliders:

Type	Size	Purpose	Quantity
Telescopic	10”	Joss pots	2
Telescopic	24”	Candle base & Joss stick trolley	2

Structure:

- Made of Aluminum box channels/L channels
- Sandwich Aluminium
- Aluminium Vessels

Wheels: Transwheels from Rotacaster.

Problems Faced

During the course of making the bot many complications were faced and had to be dealt with. Given below are most of them:

- **Weight issues:** The bot was designed to weigh 17 kg without the electronics, and 18.5 kg with the electronics. But these figures turned out to be an underestimation and the real weight of the bot went till as much as 21 kgs. Several weight reduction measures were taken to remove all the unwanted materials. The final weight (before the match) of the bot without the flame mechanism was 19 kgs.

- **Placement of mechanisms:** Though it was anticipated, the placement of all the mechanisms in 1m by 1m turned out to very difficult. The bot in its fully extended state was exactly according to the acceptable dimension. It was a critical situation.
- **Wobbling sliders:** The telescopic sliders used were of a bad make and wobbled. They also couldn't take large loads and got bend when loaded.
- **Stability issues:** We had structures of height about 80cm, so giving support to this kind of structure was difficult. Lots of trusses were put, which added to unnecessary weight.

Results:

The bot worked fine in all the matches except for one in which it a vertical slider got jammed. In other matches it did all its tasks properly and swiftly. Our manual bot was the second fastest to place the joss pots. This bot would work always, 100% reliability. Thanks to our Manual Bot operator.

Improvements and drawbacks:

The following are the areas were the bot could have been bettered upon and should be taken care of by next year's team:

1. **Use of alternate materials:** Alternate materials like acrylic sheets could have been used for the plates to lift the flowers and petals. They could also be used instead of sandwich aluminum at other places. They are considerably light weight and do not deform unlike aluminum plates.

2. **Stable slider mechanism:** A better sliding mechanism should be developed which can take heavy loads and doesn't wobble much. This cannot be expected from the telescopic sliders used in this bot.

3. **Aluminum Welding:** All the joint were held using only nuts and bolts, thus they reduced the overall stability of the bot. Aluminum welding should have been done on at least the critical parts of the bots.

4. **Use of suspensions**

ELECTRICAL MODULE

Requirements:

- 4 locomotion motors – mounted on trans-wheels, for independent motion along perpendicular directions
- 9 robokit motors for the mechanism

Electrical Components:

- One manual board – Microcontroller, 5 x L293D motor drivers (for the mechanisms), 4 x 16 pin FRC connector outputs for NEX-Robotics Hercules Motor drivers (used for locomotion), 2 x 10 pin FRC connector outputs for the Relay board, DB-9 female connector for the hacked PS-2 controller, Male molex connectors for power input and a switch, fuse

- One PS-2 controller – hacked and connected to a male DB-9 connector

- One Power distribution board – 2 x male molex connectors for 12 V Battery inputs, 4 x 12 V male molex outputs, 6 x 24V male molex outputs for locomotion motor drivers
- Four NEX-Robotics Hercules motor drivers – to control the locomotion motors
- One Relay Board – has the ability to control 10 motors and it is controlled by 2 x 10 pin FRC inputs from the manual board, 10 x male molex outputs for motors
- 6 limit/trip switches – for some mechanism which require the motors to operate only to a certain extent
- 16 pin female to female FRC connectors, 10 pin female to female FRC connectors, female molex connectors, red and black wires – many in number

Techniques used in the manual bot code:-

- Acceleration – the analog joysticks on the PS-2 remote reach their maximum position very soon, and giving a proportional output directly to the locomotion motors causes the robot to jerk. To prevent this, a slight delay is calibrated into the code by using a function which increments the PWM value over a certain number of process cycles. This rate of increase in velocity from zero till maximum helps to increase the stability of the manual robot. The same technique is also applied for deceleration.
- Toggle switch – every motor on the robot requires 2 buttons on the PS-2 remote, which were not sufficient. Incorporating 'select' button as a toggle switch to change the configuration of the remote layout so that it could control some motors when in the first layout and other motors when it is in the second layout.
- Hacking PS-2 remote – set up SPI communication between Atmega-16 and the remote, with Atmega-16 as the master and PS-2 remote as the slave. Please note the communication does not work according to the data sheet or web tutorials, **we must add a resistor (pull up)**. This makes the remote function properly.
- Using L293D – to control the relays, than directly giving its out put to the motor. Relays can handle large amounts of current and can handle the spike current of any motor. L293D's would burn up.

Very useful technique used to bypass microprocessor control

- Limit/trip switch – making the following connections, COM given to motor output; NC given to motor signal; NO given to ground. This will ensure that the motor will not rotate in this direction once the trip switch is engaged.

Problems faced with solutions:-

- Wobbling of vertical sliders during locomotion – our manual bot controller found it very difficult to align the mechanisms to the required position (for example the candle base) as the vertical slider would wobble too much when the bot is made to move. There is a limit to which stability can be provided from the mechanical side.

  To resolve this issue, we incorporated acceleration and deceleration into the code, when the joy stick is placed into its forward position for acceleration – that is full extension – slowly increment the PWM vale of the locomotion motor till the maximum to avoid jerking. It made it easier for our manual bot operator to align the bot.

- While incorporating acceleration, sometimes the locomotion wheels do not stop rotating. This problem can occur for 2 reasons:

  The potentiometer in the joystick is faulty; it can be fixed by opening up the joystick and set the zero position properly. Or replace it with a new one

  This can also happen if the increment value to the PWM is very low, increase it by trial and error.

- One of the joss pot holders was not being stopped by the trip switch

  Make sure the connections made to the trip switch are correct. See clearly if NO , NC and COM on each switch and make the appropriate connections, as discussed earlier. Generally trip switches don't fail, it will most probably be with the connections.

- Relay switches keep clicking

  This problem will occur if the micro is getting reset every time, add a capacitor between input and GND. Above this check if all the L293D's with a multimeter to make sure they are working properly.

- Relay controlled motor works on its own – it is not controlled by the remote

  This happens due to some residual voltage in the board. Around 3V input will set the relay and the motor will function. Check where this problem is arising using a multimeter

  Replace the microcontroller and check all the GND connections

DOCUMENTATION: AUTOBOT 1

Tasks:

The autonomous bot A1 is specialized to perform two tasks –

1. Taking the flower and petal from the storage point and placing them at the preparation point. Ten points for picking and placing each object.
2. Picking the candle flame from the storage point and dropping it on the completed Krathong floating on the River. 150 points for placing the flame.

The bots are designed symmetrically in such a way that the same bot can be used in both the red and the blue arenas. A change of the code - mirroring all operations is for operation on other arena apart from removing the slider mechanisms and placing them in the other direction.

MECHANICAL MODULE

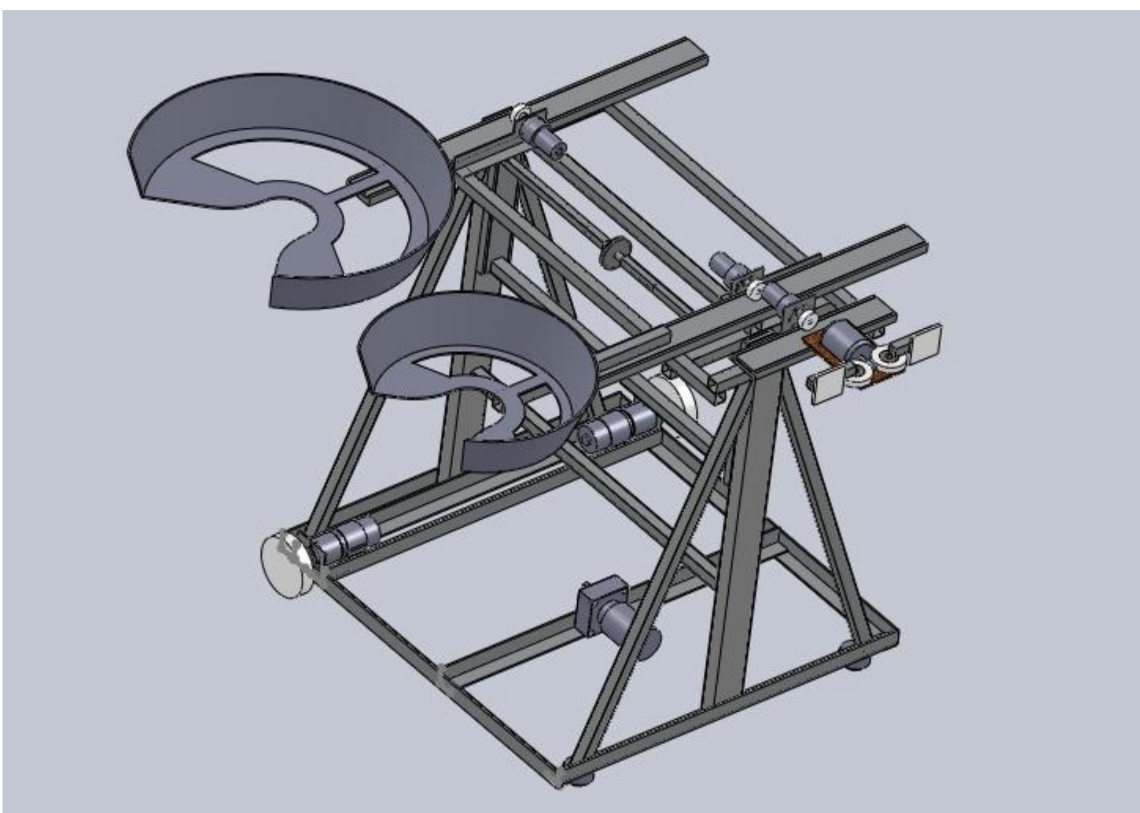
Design Process:

Initial design:

- Square chassis with powered wheels at the center and two castors, one in front of the wheels and other behind the wheels
- This design insured that the bot could move in both reverse and forward direction, hence could be easily used in both the blue and the red arena.
- But because the wheels were at the center, this bot could not climb the Sala (Raised platform with the river surface), hence this design had to be changed

Second Design:

- The chassis was a normal square one, with rear powered wheels and a castor at the front.
- The picking plates were mounted on sliders for horizontal motion. The entire system of the two picking plates and the sliders attached to them could move vertically also with the help of another slider system.
- Sliders for horizontal motion were actuated using rack and pinions and the vertical sliders were actuated using a motor and pulley assembly.
- The plates were specially designed and were cut out from aluminum vessels of nearly correct size.
- The plates could be removed and fitted to the slider from the other end. This was to make sure that it could be used in both the sides of the arenas.



3D Model of the Second Design

Third Design:

- There were not many drastic changes in this design, but only additions to the previous design.
- While placing the flowers and petals the earlier design did not have any mechanism to guide them correctly onto the poles. This problem was solved in this design by providing guides to the plates.
- The candle flame mechanism was incorporated. The design of the clamp was a four-bar, with grips on the two leading bars to grip the candle flame. It was operated with a servo motor.

Specifications of the final design:

Motors used:

Type	Toque/RPM	Use	Quantity
Transmotec	12 kg-cm/300 rpm	Locomotion	2
Power-Window	60 kgcm	Vertical Sliders	1
Robokits	300 rpm	Horizontal Sliders	2
DC Servo		Flame Mechanism	1

Sliders:

Type	Size	Purpose	Quantity
Telescopic slider	24”	Horizontal motion of picking plates	2
Telescopic Sliders	10”	Vertical motion	2

Structure:

- Made of Aluminum box channels
- Sandwich Al. used for guides

Wheels:

- 12 cm diameter
- Material: polypropylene
- Geared and wound with track belt
- Extra cricket bat grip stuck on the wheels for better friction
- Aluminum flanges to fix with motor

Problems Faced:-

During the course of making the bot many complications were faced and had to be dealt with. Given below are most of them:

- **Weight issues:**
  The bot was designed to weigh 10kg without the electronics, and 11.5 kg with the electronics. But these figures turned out to be an underestimation and the real weight of the bot went till as much as 15kgs. Several weight reduction measures were taken to remove all the unwanted materials. The final weight (before the match) of the bot without the flame mechanism was 12.2 kg.

- **Placement of mechanisms:**
  Though it was anticipated, the placement of all the mechanisms in 1m by 1m turned out to very difficult. The bot dimensions exceeded the maximum when the flame mechanism was introduced. Thus the flame mechanism had to be folded and raised to insured that at the start of the match the bot was within the maximum dimensions.

- **Wobbling sliders:**
  The telescopic sliders used were of a bad make and wobbled. They also couldn't take large loads and got bend when loaded.

- **Guides for the clamps:**
  The guides which were provided with the plates, for placing the objects accurately, were not very reliable. They were a little shaky and got worn out very easily. They had to be checked for before every match.

Results:

The bot worked fine in all the matches except for one in which it didn't place the flower onto the poles and tipped it over. In other matches it placed all the four objects (two flowers and two petals) correctly on the poles in the decoration point. But the flame mechanism was never tested in any of the matches. This bot would work always, 100% reliability.

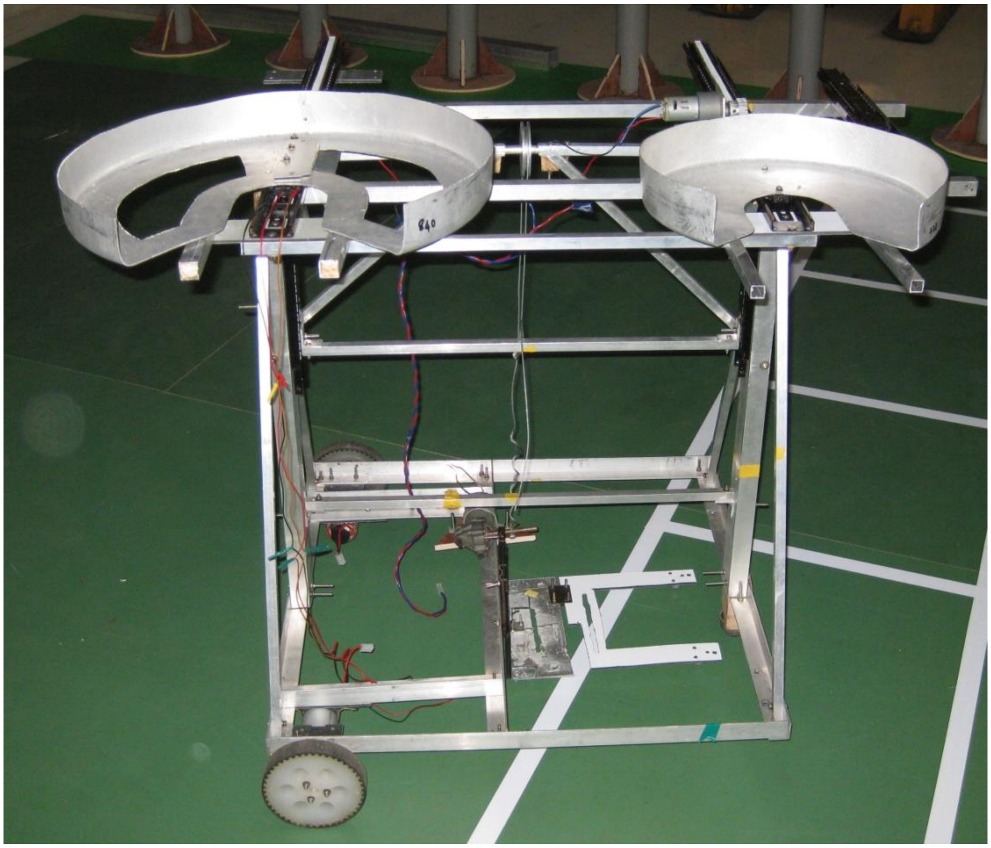
Improvements and drawbacks:

The following are the areas were the bot could have been bettered upon and should be taken care of by next year's team:

- **Use of alternate materials:** Alternate materials like acrylic sheets could have been used for the plates to lift the flowers and petals. They could also be used instead of sandwich aluminum at other places. They are considerably light weight and do not deform unlike aluminum plates.

- **Stable slider mechanism:** A better sliding mechanism should be developed which can take heavy loads and doesn't wobble much. This cannot be expected from the telescopic sliders used in this bot.

- **Aluminum Welding:** All the joint were held using only nuts and bolts, thus they reduced the overall stability of the bot. Aluminum welding should have been done on at least the critical parts of the bots.



ELECTRICAL MODULE

Actuators and sensors:

- 2 locomotion motors – Transmotec motors driven using motor drivers powered by 24V
- 3 motors for the mechanisms – 2 robokits motors and 1 power window motor controlled through relays
- 6 sensors – Green Autonics, 4 for line following and 2 for line counting
- 4 trip switches

Electronic components:

- One **main autonomous board** with –
    - 40 pin ZIF socket for **Atmega 16** Microcontroller
    - 3 x **L293D** motor drivers (for the mechanisms)
    - 2 x 10 pin FRC connector outputs for the Relay board
    - 2 x 16 pin FRC connector outputs designed for NEX-Robotics Hercules Motor drivers (used for locomotion)
    - 4-pin male RMC for each 12V input from sensor or trip switch, 3-pin male RMC for each 5V input from trip switch
    - Male Molex connectors for 12V, 3-pin male RMC for a switcher, a switch, fuse
- One Power distribution board – 2 x male molex connectors for 12 V Battery inputs, 4 x 12 V male molex outputs, 6 x 24V male molex outputs for locomotion motor drivers
- One switcher – **LM2576** to convert 12V to 5V for powering the main board
- 2 motor drivers for locomotion - **MC33886**
- One Relay Board – has the ability to control 6 motors and it is controlled by 2 x 10 pin FRC inputs from the manual board, 6 x male molex outputs for motors. It is powered with 12V battery.
- 4 limit/trip switches – for mechanisms which require actuation to a certain extent
- 16 pin female to female FRC connectors, 10 pin female to female FRC connectors, female molex connectors, red and black wires – many in number

Techniques used in the autonomous bot 1 code:-

- **Line following** – 4 sensors (Autonics) are used for line following and they are mounted at a distance d/2 from the back wheels of the bot (d is the distance between the wheels).

- **Line counting** – 2 sensors (Autonics) are used for line counting. They are mounted in the front of the bot. One of them is on the left side of the bot (between the centre and left edge of the bot) and the other on the right side. A line is counted on a Rising edge input to the sensor. The left line counting sensor is used during left turns and right sensor during right turns.

- **Turns** – Turn algorithms were developed looking at sensor inputs during and after the turn. Soft turn was used (One wheel stationary while other rotates) against (One wheel rotates in opposite direction to other) Hard turn since it was faster and looked to be more stable mechanically.

- **Reverse, Reverse turns** – Since there were no sensors at the back, reverse movement was without line following. i.e. it was achieved by just reversing with delays. Reverse soft turns were similar to the normal turns and done using sensor feedback.

- **Trip switches** – Trip switches were used to limit the extension of mechanisms. The trip switch was connected to the microcontroller. The common was connected to the micro pin. 5V was given to the Normally Open (NO) end of the trip switch. GND (0V) was given to the Normally Closed (NC) end of the trip switch.

- **Using L293D** – to control the relays, rather than directly giving its output to the motor. Relays can handle large amounts of current and can handle the spike current of any motor. The principle used is that when a current flows through the coil of a relay the relay switches. The Normally Opened (NO) pin of the relay connected to the 12V of a battery is shorted to the motor pin thus supplying power.

Specific Problems faced:

Some major problems faced in Autonomous bot 1. All the solutions have been tested and implemented on Autonomous bot 1 during the competition.

1. Microcontroller resets:

If a motor draws too much current, the micro does not get sufficient current and it resets.

Solution: Use a capacitor between the VCC and GND pins of micro. The capacitor is placed as close to the micro as possible. By trial and error, the capacitance value suitable for our bot was found to be 100uF.

2. Mechanisms on PORTC don't function according to requirement:

Solution: Check if JTAG is disabled

3. Faulty interrupts or Sensor inputs:

A sensor may not give exact 5V output but sometimes gives only 3.5V especially when it is pulled down.

Solution: Remove the pull down resistor or Add a pull up resistor

4. Extra interrupts during reverse:

While stopping, the bot is stopped as soon the line count sensor gets a rising edge when it just enters a line. But due to overshoot the bot moves forward and may or may not cross the 3cm line. When moving forward this does not matter as no rising edge occurs. But while reversing, there could be an extra rising edge interrupt depending on the overshoot.

Solution: Move forward slightly till line count sensor comes out of the line and account for the extra interrupt.

5. Extra interrupts:

If there is a slight bump in arena in green area, it could give rise to extra interrupt.

Solution: Try to calibrate sensor at that position. In worst case scenario, put a white vinyl tape and account an extra interrupt in the code. Make sure this is removed from the final code!

6. Extra interrupts on the ramp:

Since line counting sensors are not perpendicular to the ramp, they may give an extra interrupt at the top edge of the ramp.

Solution: Use the line following sensors that are always at a fixed height from the ground for line counting. Line count is incremented when 3 of 4 sensors come on the line (i.e at a junction)

Avoid using line count sensors for climbing ramp even if it works in the home arena, as it may not be calibrated during the competition because of the lighting effects.

And not to mention, *avoid TSOPS for the same reason* unless absolutely required.

7. Lighting effects:

Sensors may not get calibrated due to excessive lighting.

Solution: Cover all sensors (*esp TSOPs*) with black chart paper.

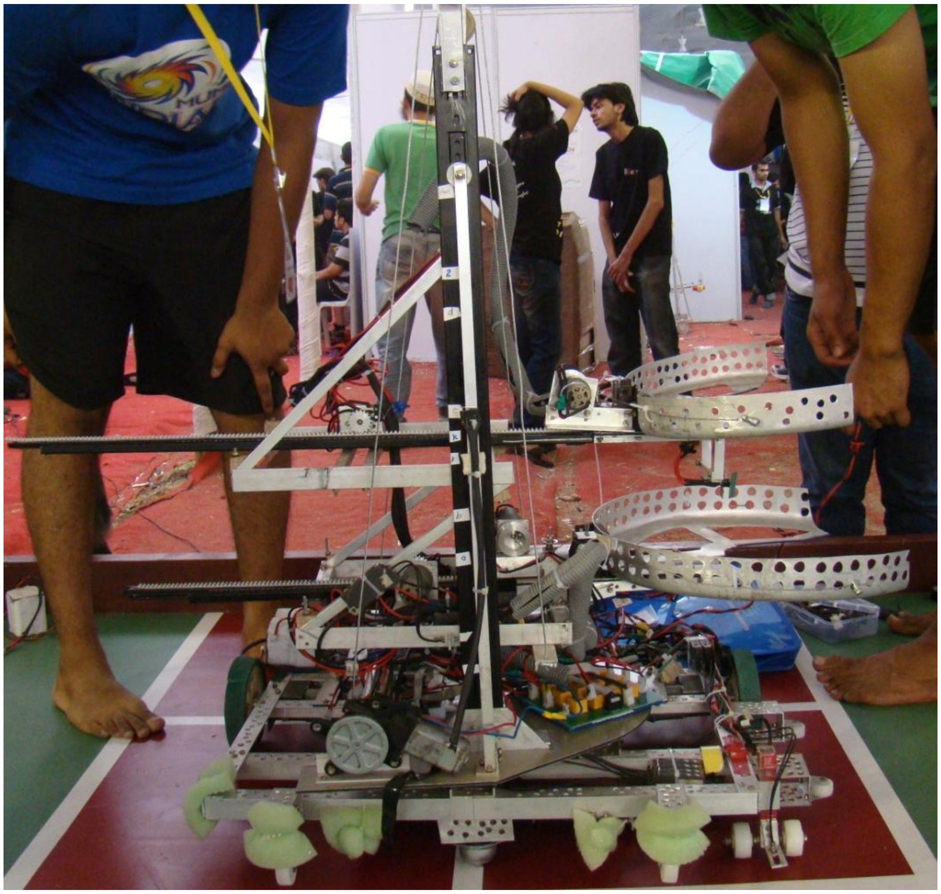
8. OR Gates:

Due to shortage of pins, OR gate was used to couple sensor inputs that are not used simultaneously. Ineffective and prone to problems.

Solution: Avoid OR gates soldered on General Purpose PCBs.

Shortage of pins won’t occur on using Atmega128 or the likes that has more pins and more interrupts.

Documentation: Autobot 2



Tasks:

The autonomous bot A2 is specialized to perform three tasks –

1. Pick the petal and flower from the preparation points.
2. Place the petal and flower on to the candle base in the decoration point.
3. Place the decorated Krathong on to the river surface. Souvenir

The Strategy

The locomotion of the bot was achieved using differential drive mechanism. To avoid the complex maneuvers on the sala, the bot had a turret mechanism which was calibrated to rotate in a quadrant. The quadrant available for movement could be switched corresponding to the obtained game arena. The turret had two clamps:

- Flower Clamp – A dedicated clamp which was used for picking up the flower and placing it on the candlebase while decorating the Krathong.
- Petal Clamp - A clamp which served two purposes:
  a. It could be used for picking up the petal and placing the petal on the Krathong.
  b. It could be used to pick up the decorated Krathong.

MECHANICAL MODULE

A. Design Process

1) The main thing that we had in mind was to pick up and/or place both the flower and petal on one go, in order to save on the time by reducing the number of turns and re-aligning.
2) Since all the flower, petal and candle base were of different dimension we needed three different clamps for each.

Task one – Picking and placing of the flower and the petal

We had two options-

1) Keep the two clamps horizontal side by side like Autobot1 and pick both the flower and the petal at the same time.
2) Keep a vertical array i.e keep flower clamp over the petal such that the centers of both fall on the same vertical line.

The former design was rejected because, even though picking up was easy, while placing ,the bot can align the first clamp to the candle base and to do so for the second one the bot would have to move by a distance of 50cm and from the point C.5 it is clear that it is not possible.

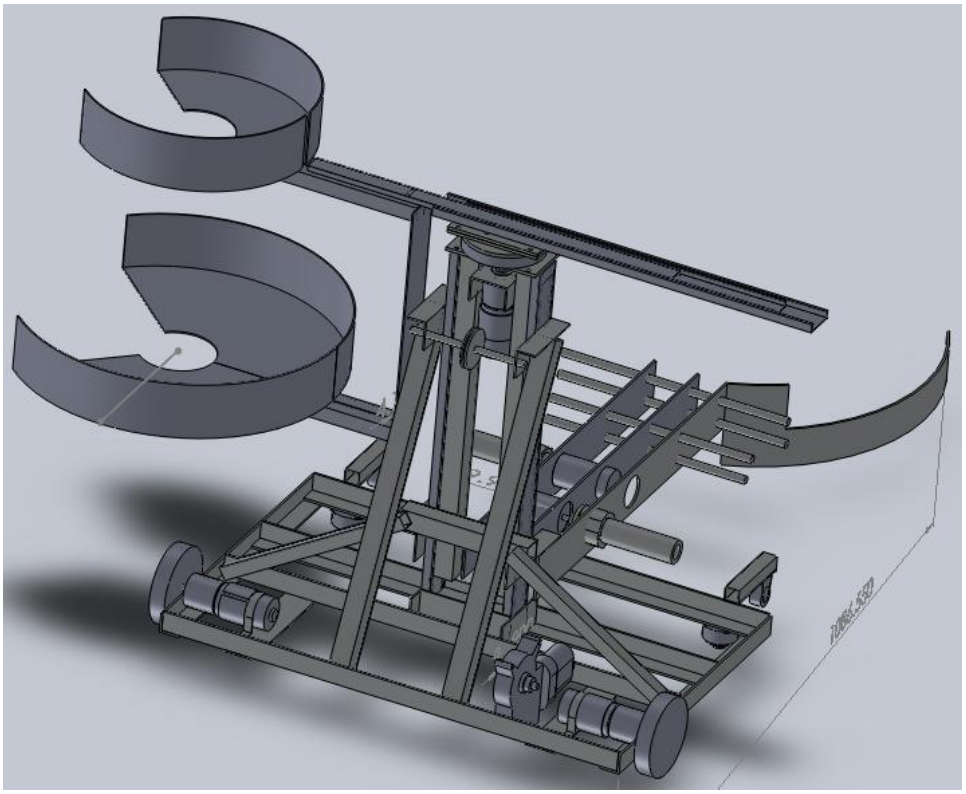
So we decided to go ahead with the second design keeping the flower clamp right above the Petal clamp.

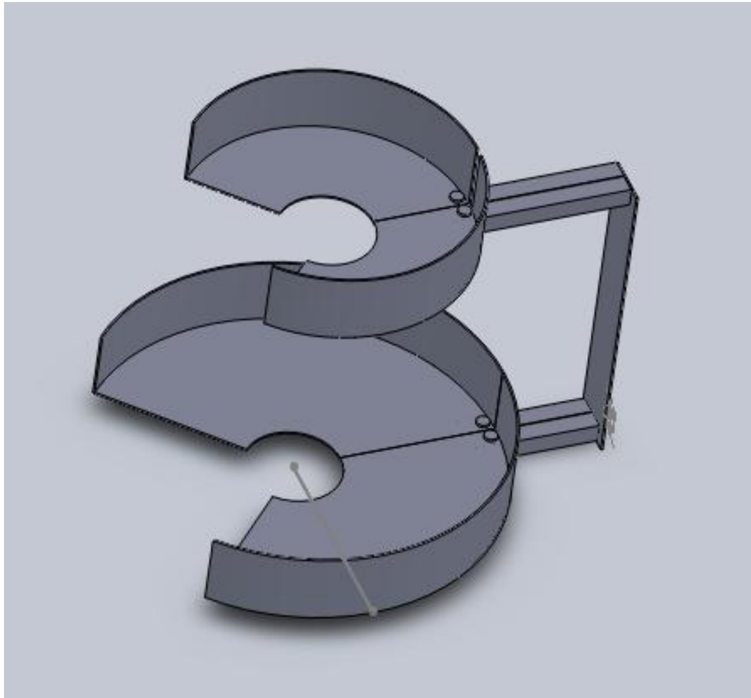
B. PROTOYPE-1

DESIGN-

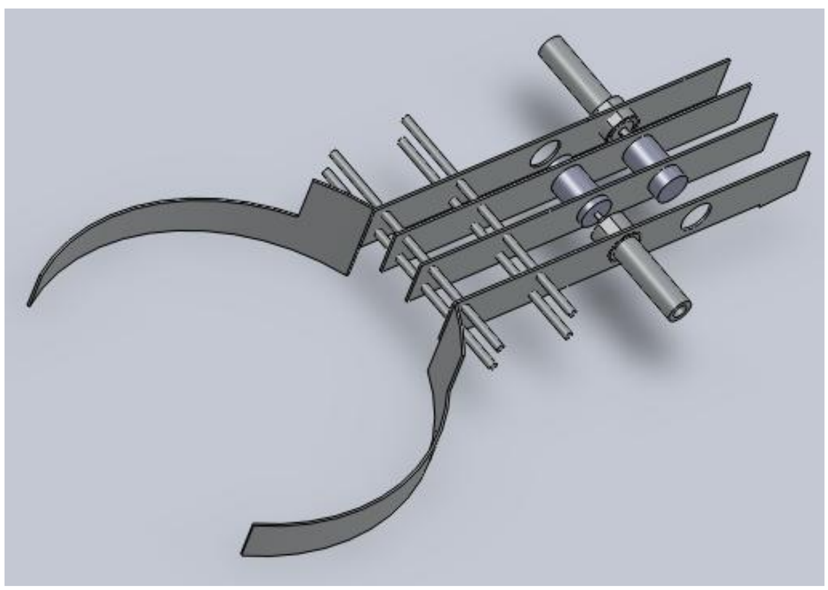
1) In the first prototype we attached two vertical sliders to the main chassis. These two sliders were interconnected and the extension was achieved by a pulley and motor.
2) On top of the slider was mounted a turret which was again powered by a transmotec motor.
3) On the turret was attached one horizontal slider.
4) The clamps were made using aluminium vessels and the clamps were rigidly joined together and the whole clamp structure was mounted on to the horizontal slider.
5) **Degrees of freedom**-
   a) Locomotion of the bot
   b) Vertical extension of the main sliders.
   c) Rotation of the turret wheel.
   d) Horizontal extension of the clamps.
6) **The clamps** unlike that of Autobot 1 Could not just place the objects in the candle base due to the lack of a base hence after putting the objects into the candle base pole they needed to open up. For that the clamps were cut from the middle and joined to the rigid structure through a hinge. The corners of the clamps were attached to threads which were wound on small robokit motors, which could open the clamps, the two separate parts of each clamps were attached through a spring to facilitate closing of the clamps.

7) To pick up the candle base we decided to mount a separate clamp with the bolt and threading mechanism for opening and closing. This clamp was supposed to be attached to the vertical slider below the rigid flower-petal clamp. This clamp only has a vertical degree of freedom.





FLOWER AND PETAL CLAMPS



SCREW MECHANISM

C. DRAWBACKS OF PROTOYPE - 1

The major drawbacks of the first prototype were –

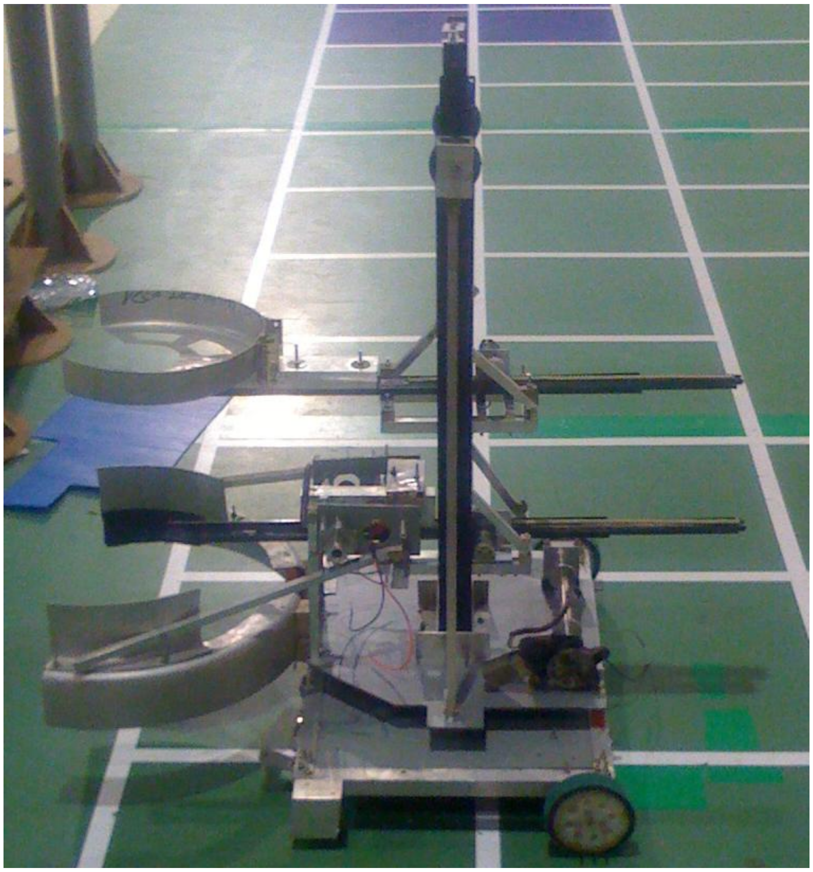
1) **The oscillations of the clamp structure –** the flower-petal clamp structure was basically just hanging to the horizontal slider, this structure was thus oscillating in air, because of the oscillation of the inner part of the slider.
2) **Placing of the candle base clamp –** Due to the height of the poles there were limitations with the height of the clamps and there wasn't much space to install the candle base clamp.

REASONS FOR CHANGE IN DESIGN

1) The only method to rectify the first problem was to reinforce the clamp structure, which was next to impossible due to the many degrees of freedoms of the clamp structure.
    - See point **B. DESIGN 5)**

D. PROTOYPE – II

Now after realizing the fact that we needed to reinforce the two clamps using trusses, one of the only solutions were to put the turret at the base.



DESIGN-

1) **The base turret –**
    a) To make the base turret we made a main chassis of 600X400 mm.
    b) On the chassis, on the vertices of an imaginary square, four castors were attached facing upwards.
    c) On the chassis a star power window motor was attached with the star facing upward.
    d) A flange was made whose one portion could be attached to the motor and the upper face was plain so that it could be attached to a flat plate.
    e) A sandwich aluminium plate was then taken which could be attached to the upper face of the flange.
    f) The flange was manufactured in such a way that it has approximately the same height as that of the castors, so that the plate that is attached to the flange can rest on the four other castors as well. The castors were attached with the whole purpose of proper weight distribution.
    g) Now this plate served as the new base of the bot on which all the mechanisms were mounted.
    h) Now again on two vertical sliders were mounted on this base.
2) **Motion of the turret**

a) The turret needed to have a motion of precise 90deg.
b) This could have been achieved by a physical obstruction.
c) But the obstruction for the front stopping could not be permanent as the direction of rotation had to be opposite on the other arena.
d) But along with a physical obstruction, a feedback was also required in order to stop the motor.
e) In order to achieve this we used trip switches, which were mounted on the top plate and hence could rotate with the turret.
f) We attached four trio switches two each for rotation in one direction.
g) And we attached long bolts on the lower base, at the positions on which the turret had to stop.
h) Therefore in order to change the direction for changing of arena, we only needed to replace the bolts.

3) **The Vertical sliders**
a) Like before two vertical sliders were mounted on the base plate.
b) Now in prototype-1 the turret and all the other mechanisms were attached right at the top.
c) This time we made a square (like small chassis) of L-channels, such that on the front and back of the chassis the horizontal sliders were attached. The remaining two opposite sides were attached to the vertical slider.
d) Now one of the problems that occurred was connecting the motors, the pulley and the strings, in most cases, for lifting a pair of vertical sliders, we use a power window motor, attach a pulley on the top exactly at the middle (horizontally) and the one end of the string is wound to the motor, the other end goes through the pulley, and is attached to the bottom, on to a plate which connects the two sliders. Thus both the sliders can be lifted in a synchronous manner using a single pulley.
In our case this could not be done, since the two horizontal sliders and the small chassis were attached exactly in the middle and hence there was no place for the string to run down. The only option now was to attach two strings on the side.
e) So we made a long flange connected one end to the motor and the other to a ball bearing cage, so both the string were attached to pulleys mounted on the corners and to the flange at the bottom.

4) **The flower clamp**
a) The flower clamp was similar to the clamps made for the first prototype.

5) **The petal and candle base clamp**
a) The petal and candle base clamp were now joined as to one complete structure.
b) The clamps consisted of only the side rims of vessels of the diameter of petal and candle base. Now this each rim was broken into two pieces.
c) The left rim of petal clamp connected to the left rim of candle base clamp. Similar for the right rim.
d) Now these two pieces were fixed at a distance which could be altered by the screw mechanism.
e) The pieces come close, to clamp and separate further off to release.

6) **The elimination of the screw mechanism (see solid works image)**
a) The screw mechanism for the petal was not working properly.
b) So before leaving we took out the screw clamp and mounted two different clamps for the candle base and the petal.
c) The clamp for the petal was similar to the flower clamp.
d) The new candle base clamp was similar to the candle flame clamp on Autobot 1.

7) **The final change**
a) Since we were having weight issues, on the last day of Robocon, we decided to use the double clamp system that IIT-B was using.

b) **The double clamp** say consists of a base plate, with a boundary at a diameter of 400mm so as to accommodate the petal and another boundary at a distance of 280mm to accommodate the flower, therefore in one clamp both flower and petal could be accommodated.

c) By doing so we were reducing the weight of one clamp.

Specifications of the final design:

Motors used:

Type	Specifications	Use	Quantity
Transmotec	300rpm/12 kgcm/24 V	Locomotion	2
Power window	High torque/12 V	Turret/ vertical slider pulley flange	2
Robokits	300 rpm/12 V	Horizontal rack and pinion slider	2
Bombay electronics	High torque/10 rpm/12 V	Krathong Clamp	1

Sliders:

Type	Size	Purpose	Quantity
Telescopic	24”	Horizontal clamp movement	2
Telescopic	30”	Vertical mechanism movement	2

Structure:

- Made of Aluminum box channels/L channels
- Sandwich Aluminium
- Aluminium Vessels

E. Major Problems Faced (Design Specific)

Some of the major design problems that were faced were-

1) The vertical distance

a) The vertical distance between the two clamps had to be more than the height of the petal.

b) The flower clamp (in the lowest position of vertical sliders) had to come below the lowest surface of the flower (kept on the preparation pole) in order to pick it up.

c) The ground clearance had to be enough so that the chassis does not hit the ramp, while climbing.

d) Optimizing all these three variables was a really big challenge throughout.

2) The horizontal extension of the clamps

a) Another big problem was that when the turret would rotate and the clamps would be facing the preparation poles then, even when the sliders had no extension the clamps would be hitting the poles or the sala walls.

b) Since the extension required while decorating was so much, hence noting could be done about the placement of sliders. If the whole horizontal sliders were moved back then the clamps could never reach the candle base pole even with maximum extension.

c) Installing bigger sliders (that give more extension) would have resulted in the bot going out of dimensions.

d) We then had to increase the distance between the vertical sliders so much such that the entire clamp could come inside.

e) This whole process resulted in a huge waste of time and could have been avoided if the problem statement had been correctly interpreted.

3) The turret flange coming off –

a) The flange that was connected to the motor and the upper turret plate, used to come off quite often.

b) The best solution for this problem is to stick it with a lot of 'Anabond'. It works and nothing happens to the motor.

F. Innovative Solution to Some General Problems

1) The lifting of the vertical slider

a) The main advantage of using the ball bearing cage is in case of using of long shafts, flanges when attached to a motor no matter how perfect always tend to oscillate, longer the shaft more is the oscillation, in order to achieve perfect rotation, the other end of the flange can be attached to the ball-bearing case

b) We used this ball-bearing cage as we needed a long shaft in order to wind both the stings which had a high horizontal distance to wind both the thread using the same motor so that both the motions are identical.

c) The mechanism has been clearly explained in the point **G. 3(Vertical sliders).**

d) Some **disadvantages** of the above method are-

- The long flange and the ball bearing cage adds to a lot of weight

2) The suspension systems turret

a) In the point **G. Design 1) (the base turret)** the whole turret mechanism has been explained.

b) As it has been explained earlier the two plates had been attached by a flange and four castors.

c) Now three points are always in a plane but five points may not be, hence to solve this situation**,** we mounted the castors to the plate with springs.

d) The bolts go into the castors, then into coil springs, and then into the base plate, therefore there is a spring in between the castor and the base plate.

e) This mechanism can also be modified to use as suspensions for locomotion.

ELECTRICAL MODULE

Actuators and sensors:

- 2 locomotion motors – Transmotec motors driven using motor drivers powered by 24V
- 2 Power window Motors- One for powering the turret and one for actuating the vertical sliders.
- 5 robokit motors for the mechanisms –Two of them were used to move the sliders attached to the clamps. One was dedicated for actuation of the flower clamp. The last two were used to actuate the petal clamp.

- 6 sensors – Green Autonics, 4 for line following and 1 for line counting and 1 for controlling the vertical motion of the slider
- 1 wall following sensor based on IR transmitter and TSOP was used to detect the wall on Sala.
- 12 trip switches – The bot was a mechanism intensive bot. Trip switches serve as good feedback systems for mechanisms which have only 2 states. The feedback mechanism using trip switches developed during Robocon 2009 was used extensively. The mechanism was further developed to control mechanisms having three states (explained in detail below). This feedback mechanism was also used to reduce the no. of microcontroller pins used. The trip switches were used in the following places:
    1. 3 trip switches to control the actuation of the petal slider
    2. 2 trip switches to control the actuation of the flower slider
    3. 1 trip switch to control the actuation of the flower clamp
    4. 2 trip switches to control the actuation of the petal clamp
    5. 4 trip switches to control the actuation of the turret.

Electronic components:

- One **main autonomous board** with –
    - 40 pin ZIF socket for **Atmega 16** Microcontroller
    - 3 x **L293D** motor drivers (for the mechanisms)
    - 2 x 10 pin FRC connector outputs for the Relay board
    - 2 x 16 pin FRC connector outputs designed for NEX-Robotics Hercules Motor drivers (used for locomotion)
    - 4-pin male RMC for each 12V input from sensor or trip switch, 3-pin male RMC for each 5V input from trip switch
    - Male Molex connectors for 12V, 3-pin male RMC for a switcher, a switch, fuse
- One Power distribution board – 2 x male molex connectors for 12 V Battery inputs, 4 x 12 V male molex outputs, 6 x 24V male molex outputs for locomotion motor drivers
- One switcher – **LM2576** to convert 12V to 5V for powering the main board
- 3 motor drivers- 2 for locomotion - **MC33886** and 1 for the turret motion.
- One Relay Board – has the ability to control 6 motors and it is controlled by 2 x 10 pin FRC inputs from the manual board, 6 x male molex outputs for motors. It is powered with 12V battery.
- 12 limit/trip switches – for mechanisms (as mentioned above).
- 16 pin female to female FRC connectors, 10 pin female to female FRC connectors, female molex connectors, red and black wires – many in number

Techniques used in the autonomous bot 2 code:-

- **Line following** – 4 sensors (Autonics) are used for line following and they are mounted at a distance d/2 from the back wheels of the bot (d is the distance between the wheels).

- **Line counting** – A single autonomic sensor was used for line counting. An indigenous solution was developed which is discussed in detail in the next section.(Point 3)

- **Turns** – Turn algorithms were developed looking at sensor inputs during and after the turn. Soft turn was used (Both wheels rotate in the same direction but at different speeds) against (One wheel rotates in opposite direction to other) Hard turn since it was faster and looked to be more stable mechanically.

- **Trip switches** – Trip switches were used to limit the extension of mechanisms. It is discussed in detail in the next section (point 4).

- **Using L293D** – to control the relays, rather than directly giving its output to the motor. Relays can handle large amounts of current and can handle the spike current of any motor. The principle used is that when a current flows through the coil of a relay the relay switches. The Normally Opened (NO) pin of the relay connected to the 12V of a battery is shorted to the motor pin thus supplying power.

Some things we learnt:

Apart from the discussion of the problems faced in the documentation of the autobot-1, which is quite exhaustive, the following are the things we learnt while working with Sala bot:

1. **Connections:** The motor drivers are good as long as we did not mess with the connections. Please ensure the boards follow a commonly agreed connection layout. The molex connectors used must also follow the convention.

2. **Clean wiring:** Due to the complex structural disadvantage which the turret brought along with it, the wiring had to be as clean and crisp as possible. Plan your wiring well and use the least amount of wire possible after accounting for all the extensions. Use heat shrinks as they not only avoid the entanglement of wires but also increase the aesthetics of the bot.

3. **The line count sensor trouble:** To avoid the variation in the activation of the sensor while climbing the ramp, the sensor was mounted on an L-channel fixed onto the inner box of the “box-in-box slider”. The L-channel was provided with a roller and hence the sensor was always at the constant height from the ground.

4. **Trip Switch Mechanism:** The following systems were adopted.

    a. **The trip switch as a sensor:** The common was connected to the micro pin. 5V was given to the Normally Open (NO) end of the trip switch. GND (0V) was given to the Normally Closed (NC) end of the trip switch. It was used in:

        i. 1 trip switch to control the actuation of the flower clamp

    b. **The trip switch to control the actuation of the slider:** Two trip switches are used. The aim of this system is that motion of the slider happens in a direction as long as the trip-switch corresponding to that direction in not pressed. This is achieved by connecting the NO pins of the trip switch to GND, the C pins to the motor and the NCs to the micro.(NO-Normally Open; C-Common; NC-Normally Closed) The trip switch which has its NC pulled high by the micro will allow current to pass through to the motor through the C pin as long as the trip switch is not pressed. When the trip switch is pressed, its C is pulled to GND. Thus, using 2 pins of the micro, we can not only actuate the sensor but also ensure it is controlled desirably without any more sensors. It was used in:

i. 2 trip switches to control the actuation of the flower slider

ii. 2 trip switches to control the actuation of the petal clamp

iii. 4 trip switches to control the actuation of the turret.

c. **The trip switch to control the actuation of the slider (modified):** For the petal slider, we faced a problem with the above mechanism. The slider had to move forward even when the front trip switch was pressed as the slider has to extend after picking up the petal (which means the front trip switch is pressed according to the design). The solution to this fix was a third trip switch. The slider wouldn't move forward because its C pin was pulled to GND. So we control this by introducing a trip switch who's C will be connected to the NO of the front trip switch. The NO pin of the third trip switch is GND and NC is the output of a relay. It is GND when performing the initial extension and is 12 V when performing the second extension. The front trip switch is located on/near the clamp, the second trip switch on the motor clamp(to control the reverse actuation) and the third trip switch is strategically placed at the position so that it is tripped when the slider has extended the required distance forward in its second extension. It was used in:

i. 3 trip switches to control the actuation of the petal slider

5. **KISS:** This is a universal rule, which we nearly always fail to follow. Anticipating the trouble of maneuvering the big bot on the sala, we came up with the idea of the using a turret. Later on, we found that the trouble and pain that we had to undergo to ensure the idea to materialize did not give us the advantage, we thought it would give.

POSITIVES FROM HIS YEAR

- We had a really dedicated, responsible and hardworking team, with all the members selected worked to their level best.
- Several new mechanisms were tested and a few of them were also inculcated in the bot design.
- Springs were used effectively, these are very reliable and robust, many gripping mechanism can be made.
- Work was started on time and deadlines of first two bots were met.
- Arena was made on time and most of the requirements were procured on time.
- Emphasis on 3-d diagrams :- Remember, one hour spent on solid works in laptops, saves 10 hours of manufacturing.

WHAT WENT WRONG & SOLUTIONS

1) **Slider system**: The sliders used for linear actuation were not reliable enough. The wobbled andbent when loaded.
   Solution: We need to work a developing a reliable mechanism for linear actuation. This has to be done before the problem statement for the next year is released.

2) Dead-lines for the third bot were not met: We started out with setting deadlines for making all the three bots mechanically. They were all supposed to be made by the end of December. We could make both the manual bot and the first autobot, but the third auto-bot was made much later then the set deadline. The main reason behind this was that the design of this bot had to be changed in late December.
   Solution: Before finalizing the design a few critical prototypes of the mechanism must be tested out. Only them we must go ahead with building the entire bot.

3) **Complex designs**: Designs were sometimes made unnecessarily complex. When a simpler solution existed we opted for the rather complicated one as we considered factors like time and complexity for the electrical-team to work on it.
   For e.g.:
   We had a turret on the second autobot. We thought that having it will make the work easier for the electrical team and also save time, but the end result was opposite of it as wiring the bot became very difficult and also coding it became tougher.

4) **Motor drivers**: Motor drivers which were ordered by us didn't suite our requirements and so we ended-up burning a few of them. At one point of time we were left with in-sufficient number of motor drivers and thus we couldn't work on all three bots together. Finally we had to spend more money on buying new motor driver, but the delivery took time and hence we had to use the old motor-drivers itself.
   Solution: We will be designing our own motor-driver as per our requirements and make sure we have proper motor drivers before the problem statement is released.

5) **Outdated technology**: The micro-processor we used is a pretty basic one and not suitable considering the requirements of the bot.
   Solution: Next year we will be using a better microprocessor like Atmega 128. Work on it will be started in this summer itself.

6) **Bots were shaky**: The bots we made were well designed but were very shaky and we not very stable. One of the reasons behind this was that we never got the joints welded.
   Solution: Next year once the bot design is finalized and the bot has been properly tested for mechanical flaws, we will have aluminum welding done at the joints, at least for the critical parts if not for the entire structure.

7) **Arena was read wrong**: We made a mistake in understanding the cad diagrams of the arena. The decoration point had a circular wall of 1 centimeter around it. We understood it wrongly and took it as a raised square platform with a circular depression. This mistake resulted in an even more complex design for the second autobot.

8) **Better motors**:
Though our manual bot had one of the best mechanisms for placing the joss pots, we failed to place them before our opponents in two of our matches. This was because our bot was slower when compared to these teams.
Solutions: We will look for better (faster) motors and after considering all aspects we will try to procure a couple of them.

FUTURE PLANS

1) We felt that our team lacked the experience. Except for one of us, we were all second years who were participating in Robocon for the first time. Hence would like to have a few of the members from this year's team in the next year also. Others who do not join the team will act as mentors and will give in their suggestions from time to time.
2) We will get ourselves acquainted with better micro-controllers, better motors so that we can use with them in the next year's competition. This should be done before the problem statement is released.