robocon NITK

ENGINEER
THE
IMPOSSIBLE

SEASON REPORT
2022-23

ABOUT US

Founded in 2017, CSD Robocon NITK is the college's official robotics team. As a group of 30 interdisciplinary undergraduates mentored by Dr Gangadharan KV and Dr Pruthviraj U at the Centre for System Design at NITK Surathkal, we aim to win the Grand Prix at the prestigious ABU Robocon.

ABU ROBOCON

Started in 2002 by the Asia-Pacific Broadcasting Union, the ABU Robot Contest themes the host country's traditional sport annually. Undergraduate college teams worldwide build two robots for one-on-one matches in pursuit of winning the tournament.

1000+
Teams from
20+
Countries

Broadcasted on
YouTube
and
Television
by ABU

2023

Hosted by Cambodia, this season's theme was *Casting Flowers on Angkor Watt*. Two robots with restricted areas of operation on the 12m x 12m arena had to pick and throw flexible rings onto poles with varying heights and points. The team with the highest score after a 3-minute match won.

MILESTONES

Our Journey

OCTOBER '22
Ideation and Brainstorming

NOVEMBER '22
Prototyping and Iterating

JANUARY '23
Stage 1 - Design Doc Submission

FEBRUARY '23
Manufacturing

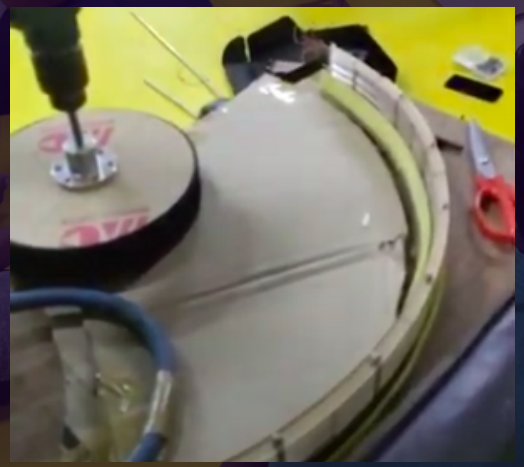
APRIL '23
Stage 2 - Video Submission

JUNE '23
Nationals - IIT Delhi

AUGUST '23
ABU Robocon 2023 - Cambodia

IDEATION & PROTOTYPING

The robot was broken into basic functions - shooting, reloading, picking, and navigation. Mechanisms for those were discussed. Promising ideas were shortlisted and debated on their viability with an emphasis on manufacturability, performance and ease of operation.



The first prototype was a single flywheel throwing mechanism. We developed a simplistic model of the prototype to obtain the proof of concept. However, it failed to provide satisfactory results.

Moving ahead, a dual roller system aimed to overcome the shortcomings of the single flywheel model. Two pairs of coupled flywheels, instead of a single wheel, achieved better results.

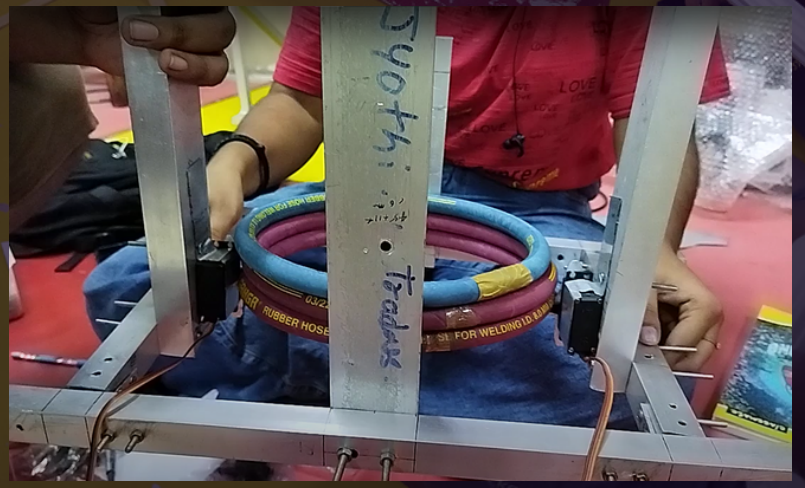
IDEATION & PROTOTYPING

We then experimented using a resistance band to launch rings similar to a catapult. It offered us the maximum range.

For picking the rings, we tried a multi-servo motor mechanism to pull the rings in using horns. It was, however, slow and irreliable.

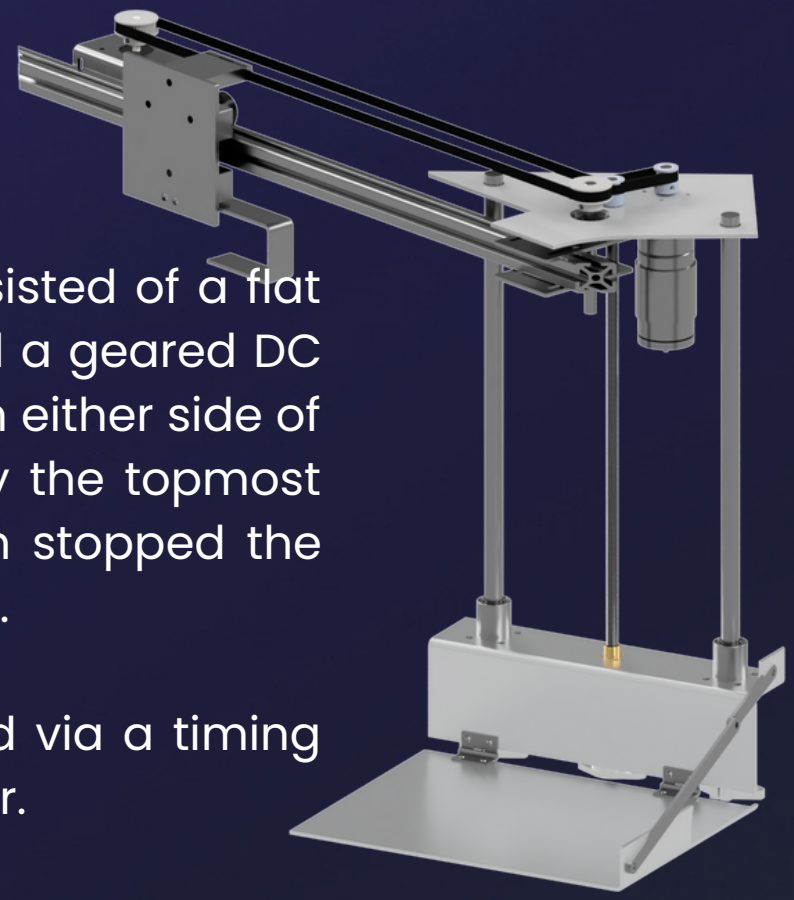
We finally settled for a thin metal sheet to be pushed under the ring stack to lift it for its simplicity and the least number of moving parts.

It could also lift the entire stack of rings at once.



DESIGN INTEGRATION

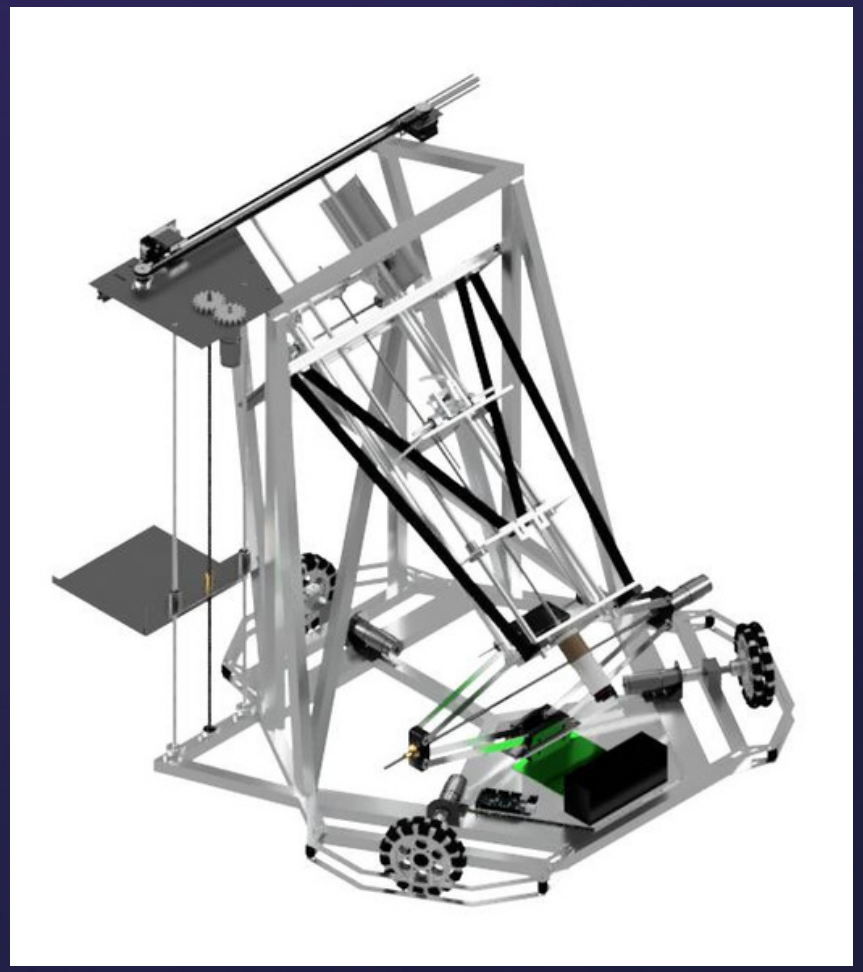
Having finalised the shooting, picking and loading mechanisms, the team now began integrating them into each robot.

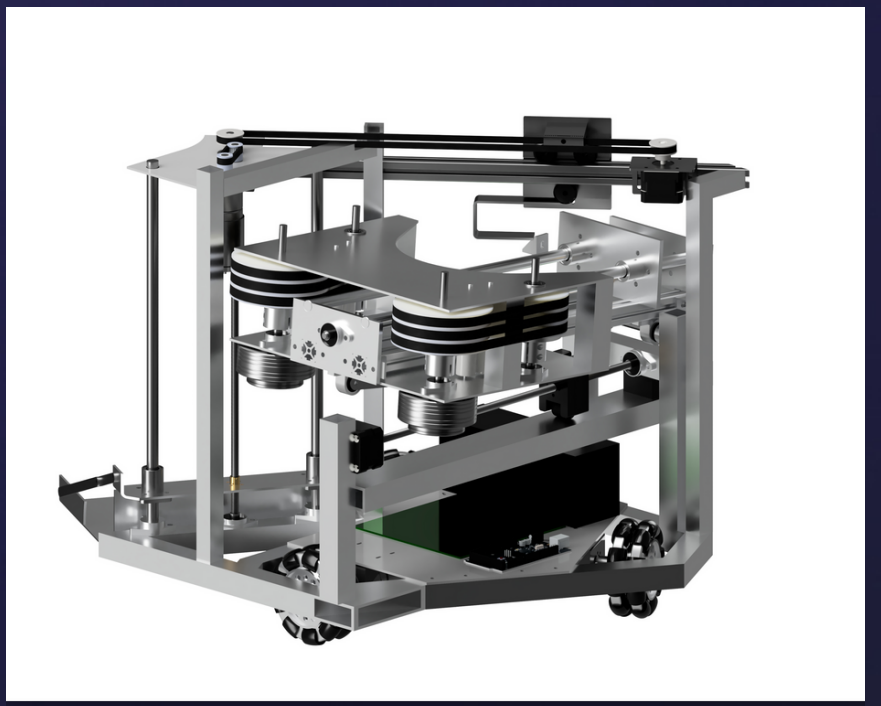


The final version of the picking mechanism consisted of a flat sheet metal plate actuated by a lead screw and a geared DC motor. It slid vertically along two shafts placed on either side of the lead screw. An upper limit switch was hit by the topmost ring while reloading, while a bottom limit switch stopped the plate at a position capable of picking all the rings.

A horizontally sliding plate with a hook, actuated via a timing belt, transferred the topmost ring onto the shooter.

DESIGN INTEGRATION





THE RENDERED ELEPHANT AND RABBIT ROBOTS

3D CAD models of both robots were developed in Autodesk Fusion 360.

STAGE 1
DESIGN DOCUMENTATION SUBMISSION

At the end of January, the team was required to submit a document that detailed the specifications of the robots, the various mechanisms employed and justifications for the same. The design quality, with careful consideration of safety and design integrity, was judged by the organisers. We are happy to say that we cleared the round with a score of **95 out of 100**.

Scan to view the design documentation
robocon.nitk.ac.in/2023/designdoc

FABRICATION

Mechanical Subsystem

Most components were manufactured and assembled manually using hand or power tools. Flat components requiring high dimensional precision and strength were CNC milled from grade 6 aluminium. Other flat components were also LASER cut in acrylic. Pulleys, shafts and rollers were turned on a manual lathe. Components with complex shapes were 3D printed in PLA.

FABRICATION

Mechanical Subsystem

The Chassis

Hollow aluminium tubes were cut to calculated lengths and welded to form the two chassis. The chassis were sufficiently triangulated to ensure structural rigidity.

FABRICATION

Mechanical Subsystem

The Catapult (ER)

CNC-milled aluminium plates and 2020 extrusions formed the frame of the catapult. An ultra high-torque brushless stepper motor stretched the resistance band, guided by linear bearings and steel rails. An intricate linkage was employed to hook onto and release the rings to pull and shoot. The mechanism took 5 seconds to reload, providing a maximum range of 10 metres. It was mounted on the ER via a linear actuator to vary its inclination while shooting.

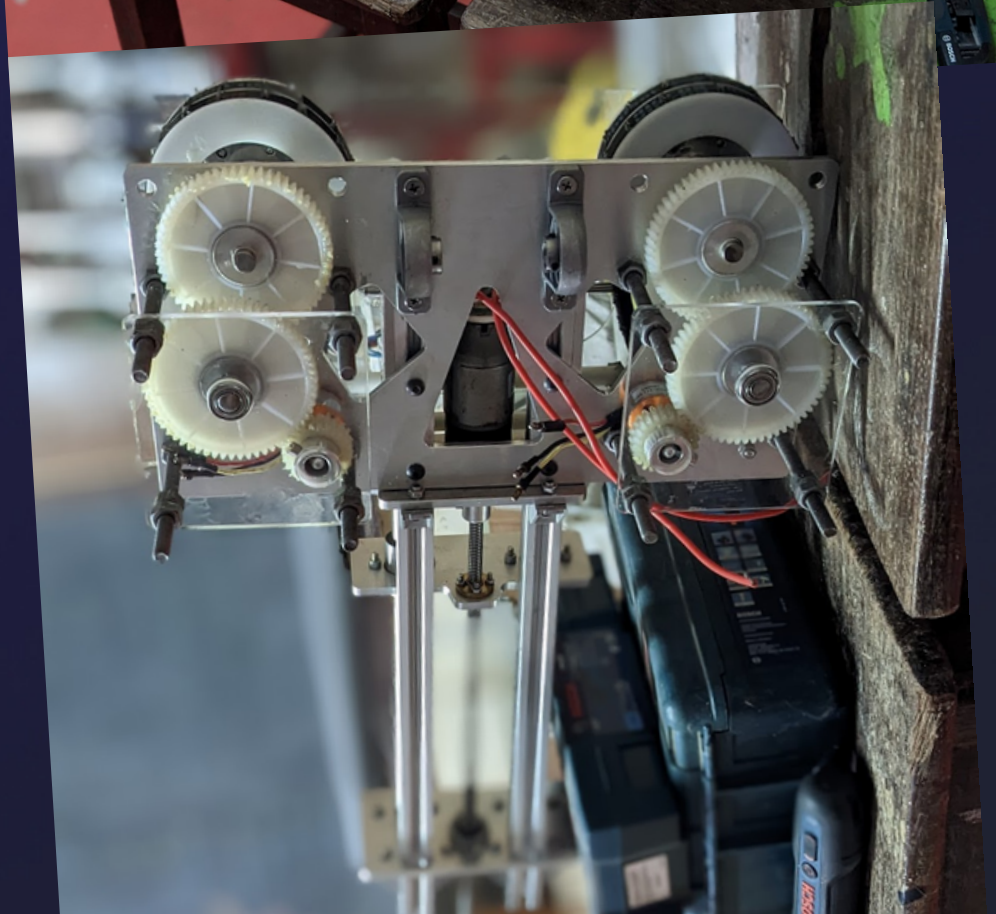
FABRICATION

Mechanical Subsystem

Dual Roller (RR)

It had a similar but smaller frame as the catapult. It used two pairs of lathe-turned nylon pulleys connected via v-belts. The pulleys were geared to brushless motors for high speed and torque. Nylon rollers along the base allowed the ring to travel smoothly.

A sliding plate fed a ring into the belts, squeezing it to launch off the other side. Providing a lesser range of 8 metres, the mechanism could reload in less than 2 seconds. It was mounted on the RR using a sliding linkage for tilt control.



FABRICATION

Mechanical Subsystem

Picking Mechanism (ER and RR)

The robots required a lightweight and rigid mechanism to pick up 10 rings weighing about 100g each safely. The required sheet metal parts were cut, drilled, and bent. The ring plate was driven by a lead screw and used a pair of spur gears for power transmission. Linear bearings running on steel shafts were used as guides. The Rabbit Bot's mechanism also incorporated hinges for the intake plate due to its smaller size requirements.

FABRICATION

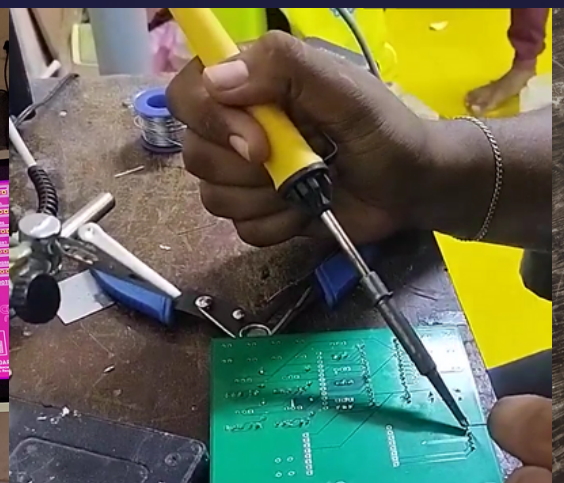
ECEP Subsystem

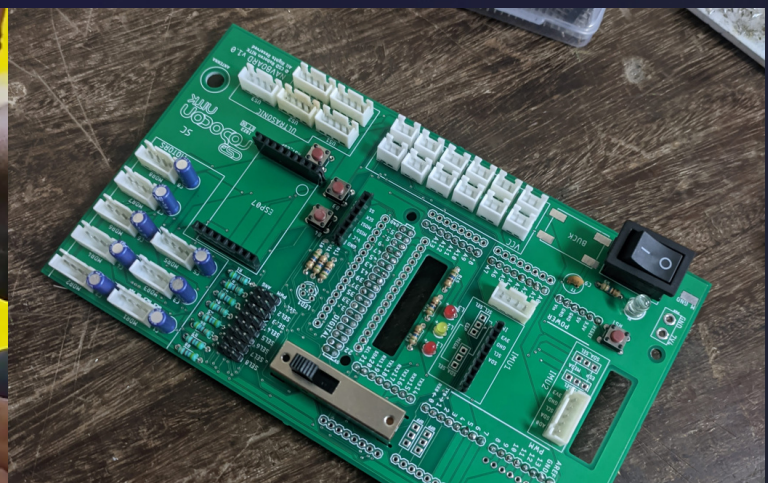
PCB Designing

Two PCBs, named the Navboard and the Hitboard, were designed on Autodesk Eagle. They were made as general-purpose as possible for future use in prototyping.

The Navboard contained an Arduino Mega and controlled the robot's navigation. The Hitboard contained an Arduino Nano and controlled the shooting and picking mechanisms.

The PCBs can be used as standalone modules or together. When used together, their microcontrollers communicate via the UART protocol and share a common power source.





FABRICATION

ECEP Subsystem

The Code

Navigation - Both robots use a 3-wheel holonomic omni drive, implying they can travel in any direction without changing orientation. An Arduino Mega read the motion of the robots using encoders on each wheel and an inertial measurement unit (IMU) on the chassis, converts them into velocities of each motor using a conversion matrix and uses a proportional-integral (PI) closed-loop control algorithm to adjust the motor's power output to achieve the desired motion.

Picking, Reloading, and Shooting - The picking, reloading, and shooting mechanisms are controlled by an Arduino Nano. Each of these processes has been programmed as an automated sequence that can be activated using the robot's controller. The settings for the shooter and its angle are set according to the inputs from the controller via the ESP-07.

FABRICATION

ECEP Subsystem

Controllers

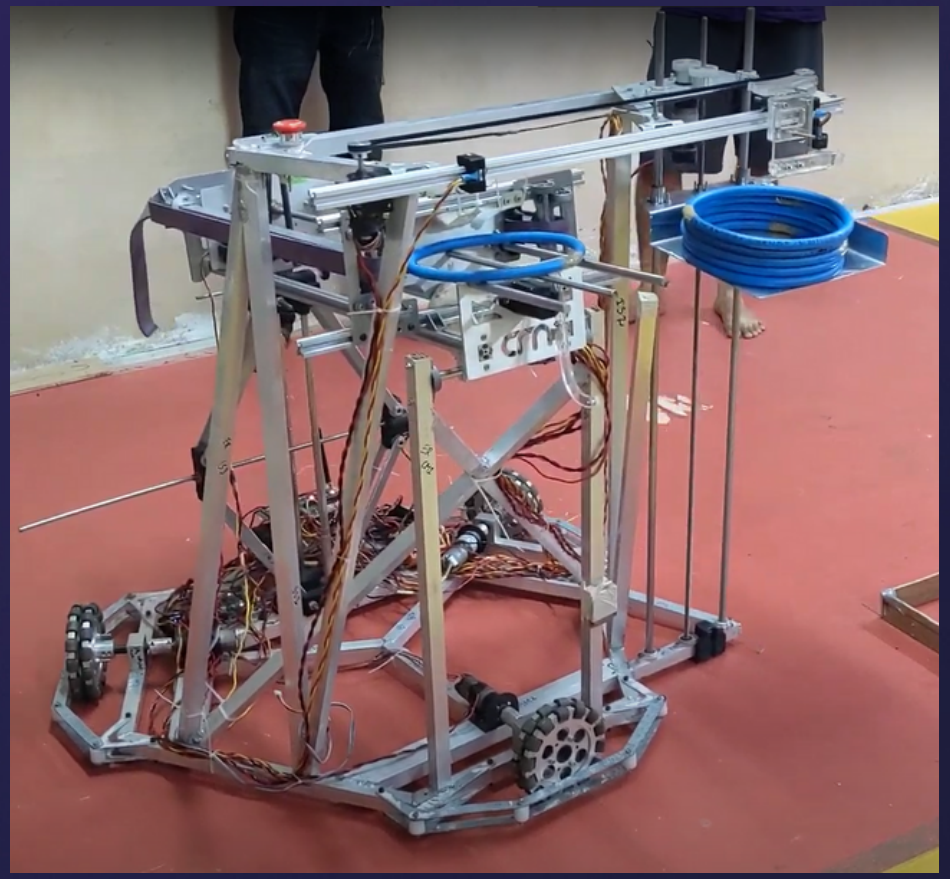
Customised PlayStation2 controllers were interfaced with a NodeMCU to enable communication with the robots via wifi.

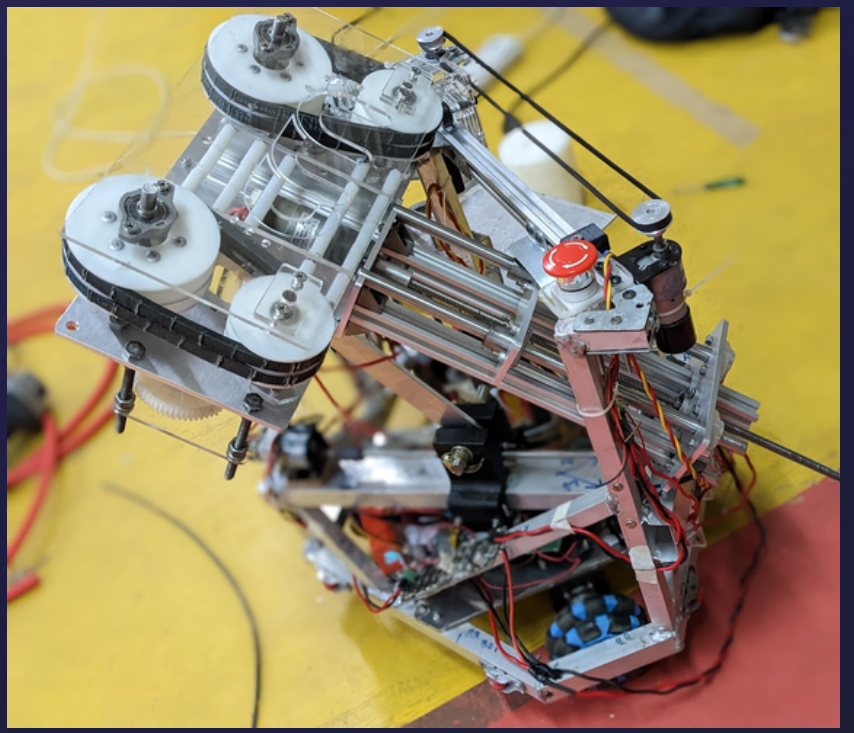
The NodeMCU interpreted the commands from the controller and converted them to a set of strings that is sent to the ESP-07 on the robots. The communication works on a server-client architecture where the NodeMCU is the server, and the ESP-07 on the robot is the client.

To facilitate easy connectivity, the NodeMCU acts as an access point of a network to which the ESP-07 would connect.

FABRICATION

Assembly





THE ASSEMBLED ELEPHANT AND RABBIT ROBOTS

STAGE 2
VIDEO SUBMISSION

In stage 2, participating teams were required to show both robots in action performing their assigned functions of navigation, loading, ring intake and shooting, all on a full-length video. Teams were judged based on the functionality of the robots and their adherence to the previously submitted design document from stage one.

Having received the guidelines for the video, the team quickly shot and submitted the same to the organising committee for judging. After reviewing the footage we sent, we were informed by DD Robocon that our team had qualified for the nationals with a strong cumulative score of 65 after the first two rounds of the competition.

CSD Robocon NITK qualified for the nationals for the first time since its genesis in 2017. It was a proud and deserving moment for the hardworking team.

TESTING & FINE-TUNING

With the nationals ahead, we set out to test the robots to the extreme.

We began with tuning the PI controllers for the navigation of the robots by trial and error, adding modifications as necessary. The navigation was tested by deliberately pushing the robot out of its desired trajectory to ensure the algorithms were adequately robust to return the robot on track.

We then went ahead to test the range of the shooting mechanisms of the robots. By having an idea about the range of the mechanisms, we were able to estimate an approximate angle and, in the case of the Elephant robot, the approximate length to which the ring had to be pulled to shoot a particular type of pole. The mechanisms were then accurately calibrated to shoot each type of pole.

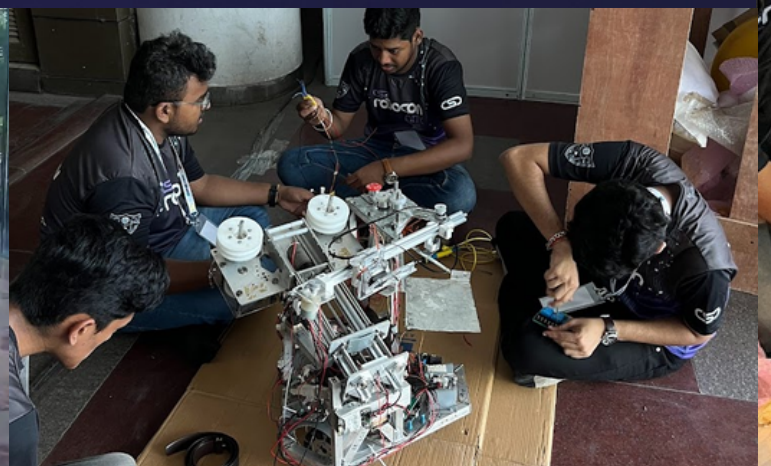
During this phase, a challenge arose when the weight of the rings caused the intake plate to bend. To overcome this issue, side support was added to prevent bending and to transfer the load onto the rotary shafts, ensuring the proper functioning of the ring-picking mechanism.

NATIONALS

DD ROBOCON 2023

The Nationals were a jam-packed three days filled with endless moments of thrill, pressure, teamwork and pride.

Having arrived in Delhi, the team began unpacking the dismantled robots from their crates. We assembled the robots and ensured everything was intact after the 2000 km road trip from Surathkal to New Delhi.



NATIONALS

DD ROBOCON 2023

DAY 1 - PRACTICE

We tested our robots around our pit before heading on to our practice match.

During the match, the RR developed an issue in its navigation PCB owing to a hardware problem which forced us to work on it after the practice match. The ER began the match with a strong start having successfully shot two rings.

NATIONALS
DD ROBOCON 2023

DAY 2 – TOURNAMENT

Our first match was against Modern Education Society's College of Engineering, Pune, which ended in a draw. We had our second match a few hours later against JSPM's Rajarshi Shahu College of Engineering, which we unfortunately lost.

With these results, we didn't expect to qualify for the top 12 teams, which would move on to the playoffs.

Scan to view our second match
robocon.nitk.ac.in/2023/match

NATIONALS
DD ROBOCON 2023

While that marked the end of the season for us, it is only the beginning of the journey CSD Robocon NITK has embarked on anew after the pandemic.

The learnings this season have been stellar. About robotics, about ourselves, and about the team. Connecting to other teams and analysing their robots in the competition, we expanded our thought process.

Regardless of the defeat, we are extremely proud of our growth and performance this season, making it to the nationals from scratch. We have and will continue to persevere for the upcoming seasons. The team is more prepared and ambitious than ever.

ACKNOWLEDGEMENT

We express our gratitude to the institute for permitting and supporting us in this endeavour. The following people at NITK enabled us to make it possible.

The Director
The Registrar
Dean, Alumni and Corporate Relations
[Formerly, Dean, Alumni and Institutional Affairs]
Dean, Student Welfare
Dean, Planning and Development
The Administrative Officers
The Security Officer

We are grateful to our faculty advisors at the Centre of System Design, NITK, for their guidance through thick and thin.

Dr. Gangadharan KV
Dr. Pruthviraj U

OUR SUPPORTERS

We wholeheartedly thank our donors for believing in us. They are the team's foundation and are invaluable to our success.

Mr. N V Raghuramu - Electrical and Electronics Engineering, 1980
Mr. Kumar Govindrajpuram Vaidyanathan - Mechanical Engineering, 1991
Mr. Sreekumar KT - Electronics and Communication Engineering, 1991
Mr. Harinath Renukamurthy - Electronics and Communication Engineering, 1991
Mr. Prashanth R Samaga - Electrical and Electronics Engineering, 1991
Mr. Prasanna Koteshwara - Metallurgy, 1991
Mr. Prasanna Udupi - Electrical and Electronics Engineering, 1991
Mr. Sadanand Hegde - Electronics and Communication Engineering, 1982
Mr. Umesh Sangurmath - Electrical and Electronics Engineering, 1991
Mr. Keshav Venkatraman Nayak - Mechanical Engineering, 1973
Mr. Srinivas Kudligi and Mr. Sreedhar - 1989

We thank the **NITK Alumni Association** to grant us a soft loan until June 2023 to assist with the DD Robocon 2023 Nationals registration.

OUR SPONSORS

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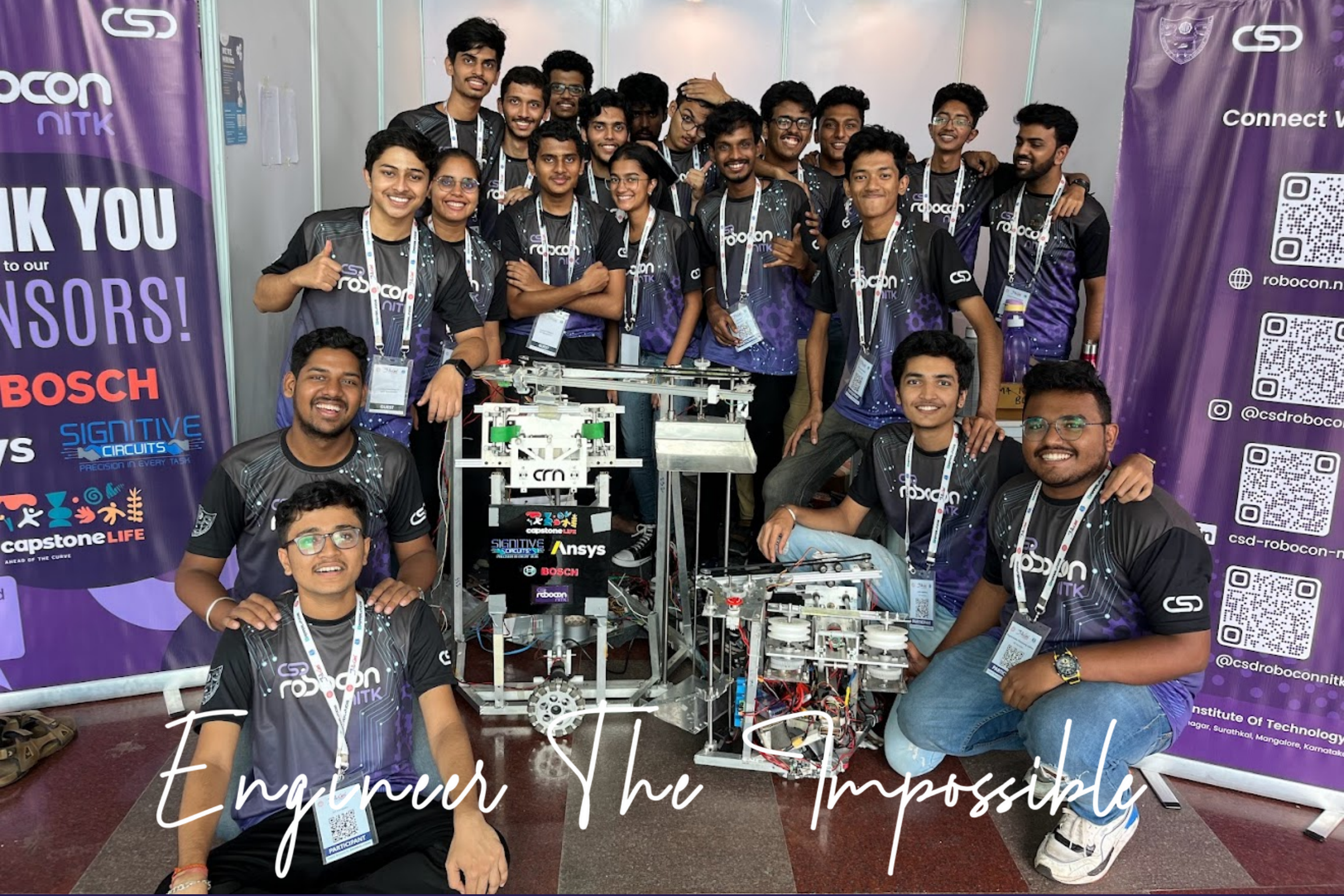
PRECISION IN EVERY TASK

capstone LIFE

AHEAD OF THE CURVE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