robocon NITK

ENGINEER THE IMPOSSIBLE

SEASON REPORT 2023-24

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.

CSD Robocon NITK 2024

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

2024

Hosted by Vietnam, this season's theme was *Harvest Day*. Two robots had to perform multiple tasks that resembled the planting, harvesting, and sorting process of grains on a 12 x 12m arena. The arena was divided into 3 zones for each of the three tasks. The team with the highest harvest after 3 minutes won.

MILESTONES

Our Journey

OCTOBER '23
Ideation and Brainstorming

NOVEMBER '23
Prototyping and Iterating

DECEMBER '23
Manufacturing

JANUARY '24
Stage 1 - Design Doc Submission

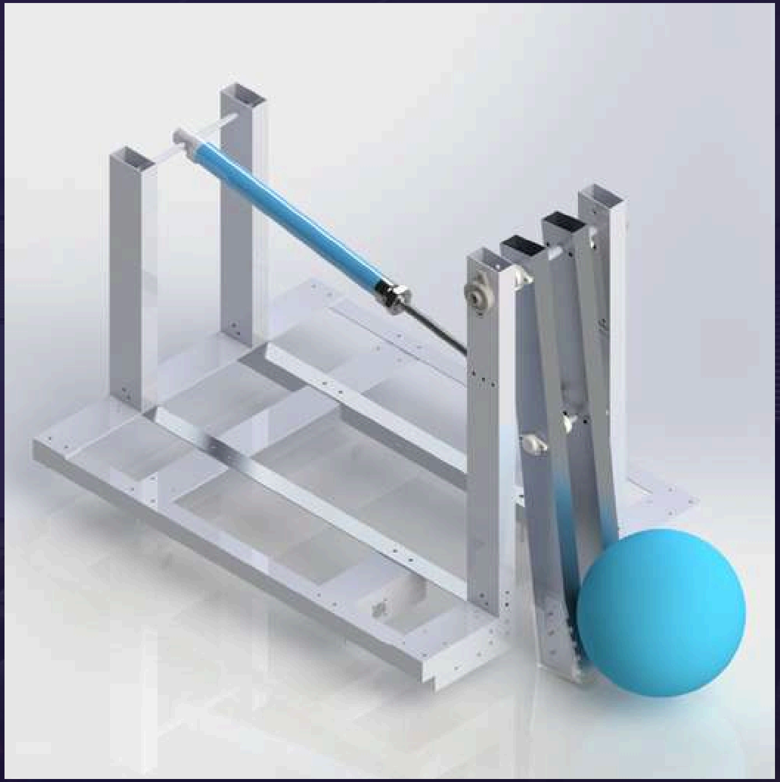
APRIL '24
Stage 2 - Video Submission

JULY '24
Nationals - DD Robocon

AUGUST '24
ABU Robocon 2024 - Vietnam

IDEATION & PROTOTYPING

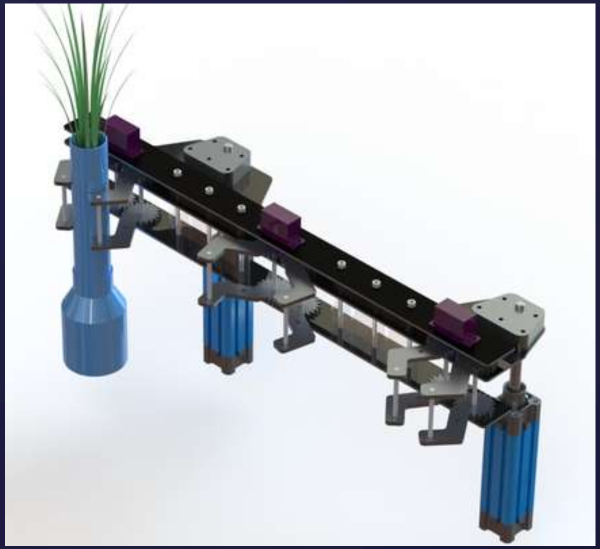
To kick the ball, we first decided to utilize a simple gear train to stretch elastic bands released to launch the ball. A prototype was made with an acrylic frame, nylon gears, and elastic bands. However, the prototype didn’t yield promising results.

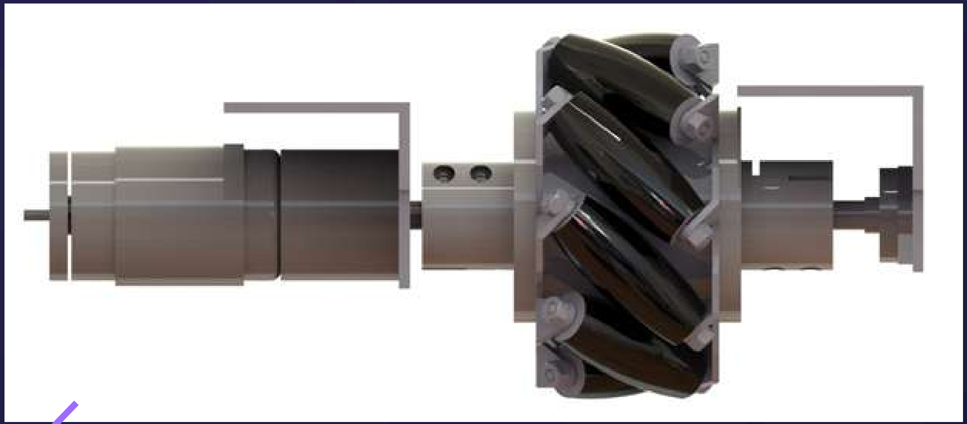


Next, we developed a pneumatic-actuated four-bar sliding mechanism. The mechanism was simple and met the force necessary to kick the ball. As a result, it appeared in the bot.

IDEATION & PROTOTYPING

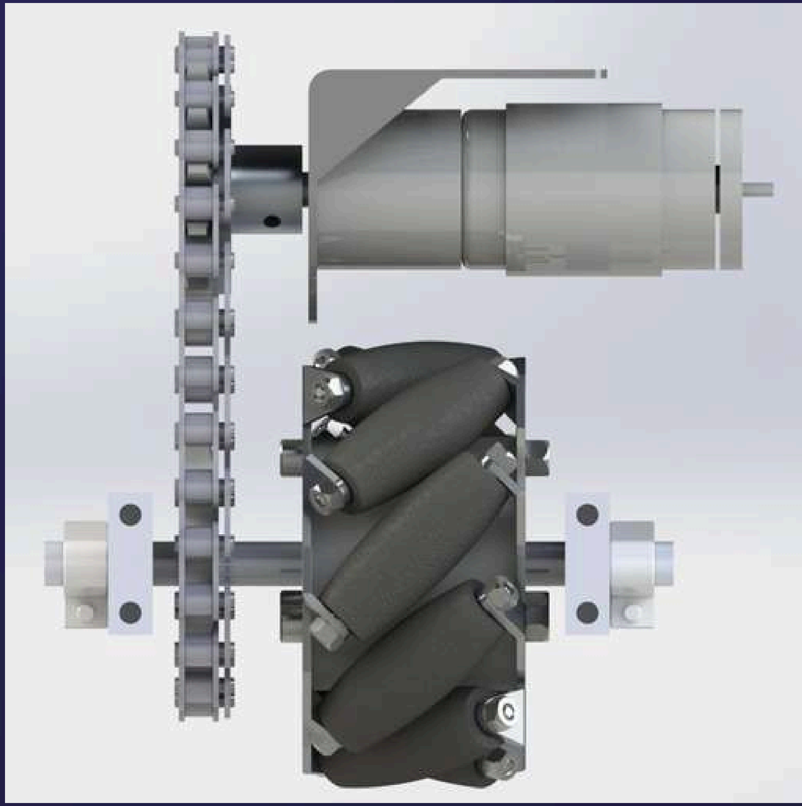
The seedling picking mechanism design was an extending gripper mechanism with pneumatic cylinders and linkages between evenly spaced grippers. This approach was later revised to use individual servo motors to control the grippers. An acrylic prototype was laser-cut, demonstrating good gripping performance.





We finally settled for a three plate modular gripper assembly using servo actuated grippers mounted on two pneumatic cylinders for its simplicity in providing vertical motion and minimizing cantilever effects.
It could lift three seedlings at once.

IDEATION & PROTOTYPING



We initially considered using bevel gears for the drive mechanism, but they had high rotation speed. We then opted for a chain drive to avoid ball interference with the motors. However, chain slippage due to manufacturing errors led us to reattach the motor directly to the chassis with a supporting shaft.

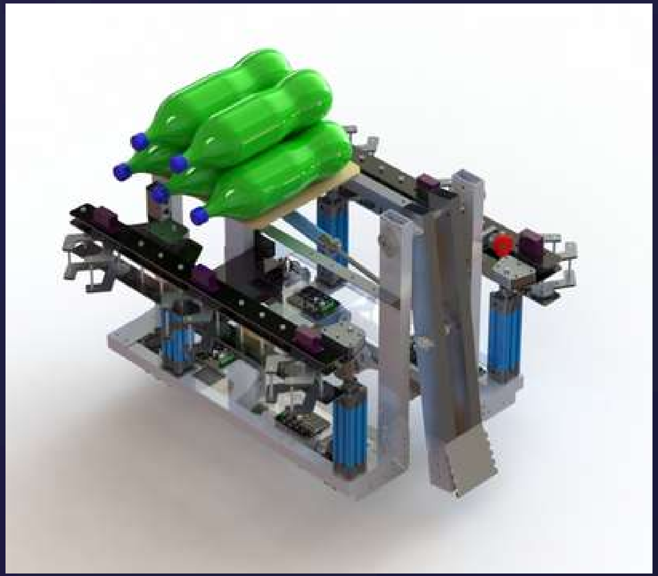
We initially tried using a chain-driven arm in a virtual four-bar mechanism to pick up a ball, ensuring a vertical gripper alignment, but it didn't generate enough torque. As a solution, an epicyclic gear train, which has a 1:10 gear ratio was finalized.

DESIGN INTEGRATION

The team integrated finalized mechanisms into both bots, which featured a four-wheel mecanum drive.

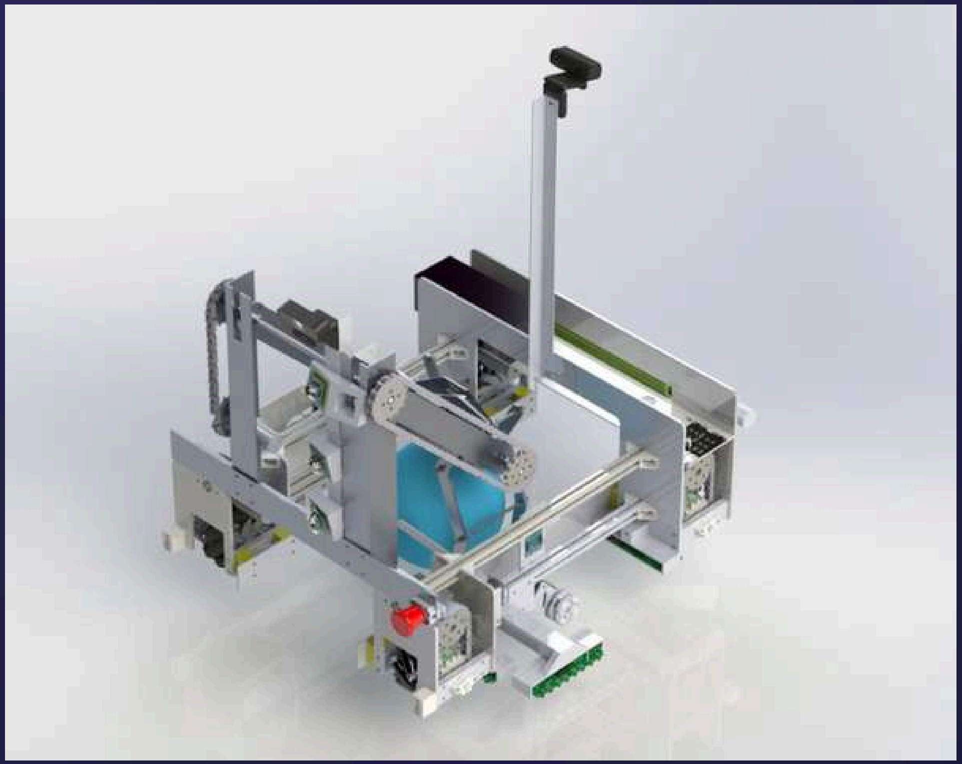
In the final version of R1, a three-plate modular gripper assembly with servo motor actuated gear profile grippers was used. Two 80mm stroke pneumatic cylinders provided vertical motion and structural support, while a mirrored sub-assembly enabled the robot to pick six seedlings simultaneously.

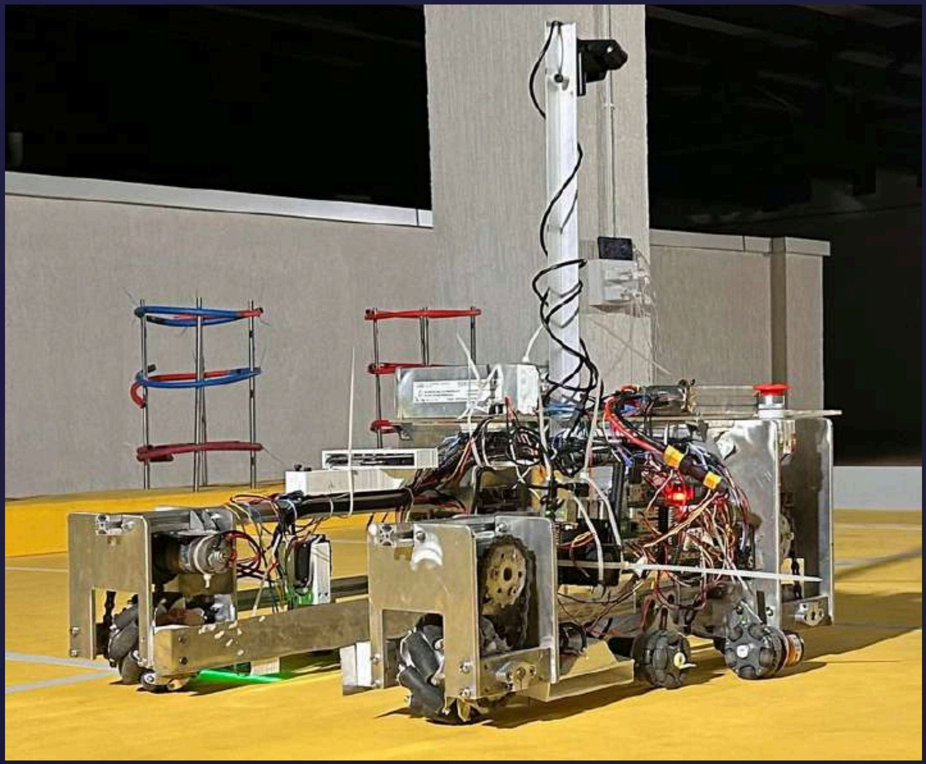
The kicking mechanism was placed at the bot's center for even force distribution. Placed above the kicking mechanism, an air tank was made easier to route with thin metal angles supporting it.



DESIGN INTEGRATION

The ball gripper system used a virtual four-bar mechanism to maintain vertical alignment during circular motion, ensuring precise positioning with support from the direct drive system.





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 them. The design quality, with careful consideration of safety and design integrity, was judged by the organizers. We are happy to say that we cleared the round with a score of **94 out of 100**.

Scan to view the design documentation
robocon.nitk.ac.in/2024/designdoc

FABRICATION

Mechanical Subsystem

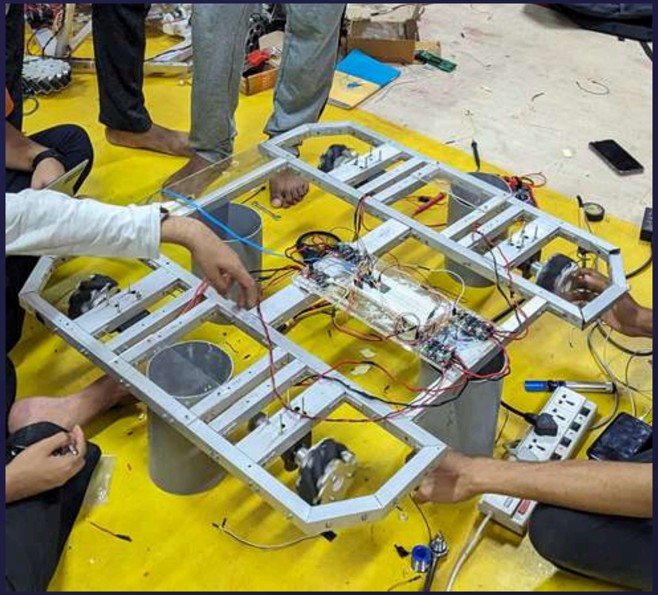
Components requiring high dimensional precision and strength were CNC milled from grade 6 aluminum. Other components were laser cut from acrylic sheets. Pulleys, shafts, and rollers were turned on a lathe. Components with complex shapes were 3D printed in PLA.

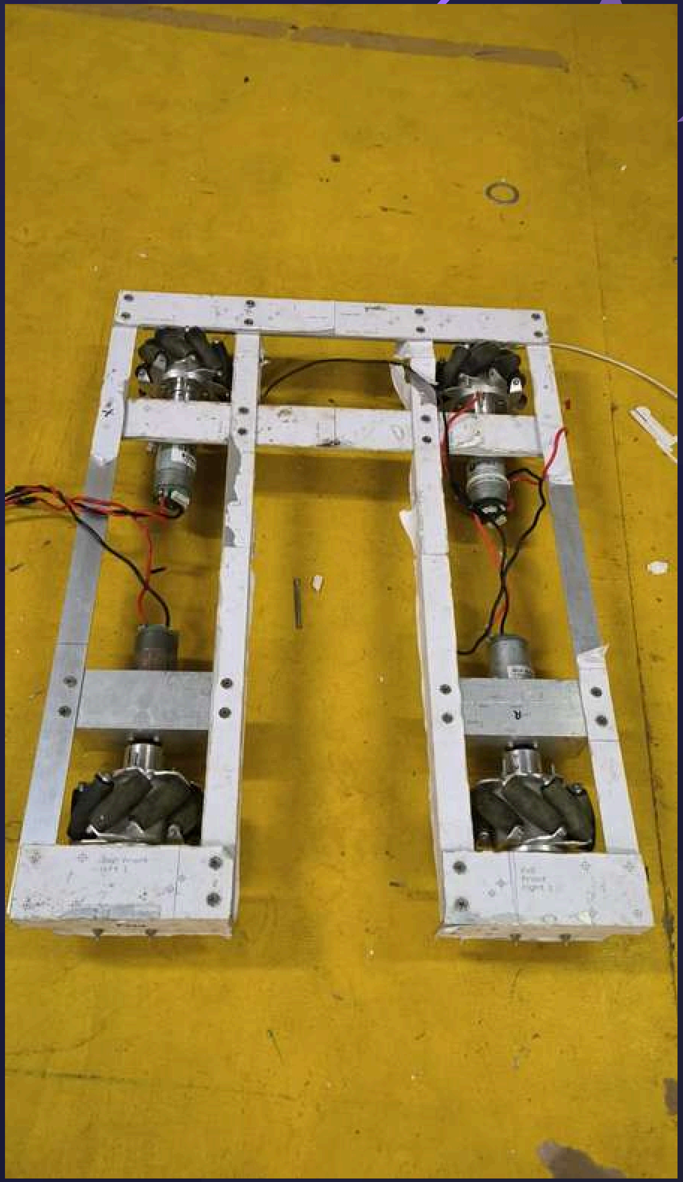
FABRICATION

Mechanical Subsystem

The Chassis

The R1 robot's chassis is designed with 2"x1" and 1"x1" 3mm thick aluminum angles for increased space, improved stability, and easier component placement.





FABRICATION

Mechanical Subsystem

The R1 Gripper

A modular three-plate design was used for the gripper mechanism. This was mounted on pneumatic cylinders. Servos were attached to each of the grippers to control them.

FABRICATION

Mechanical Subsystem

Kicker R1

The kicker was fabricated using 2"x1" aluminum tubes. The tubes were precisely cut to the required lengths, and holes were drilled at specific points for secure assembly. The tubes were then connected to form the kicker frame. Springs and pneumatic cylinders were integrated to provide the necessary force for kicking the balls.

FABRICATION

Mechanical Subsystem

The R2 Gripper

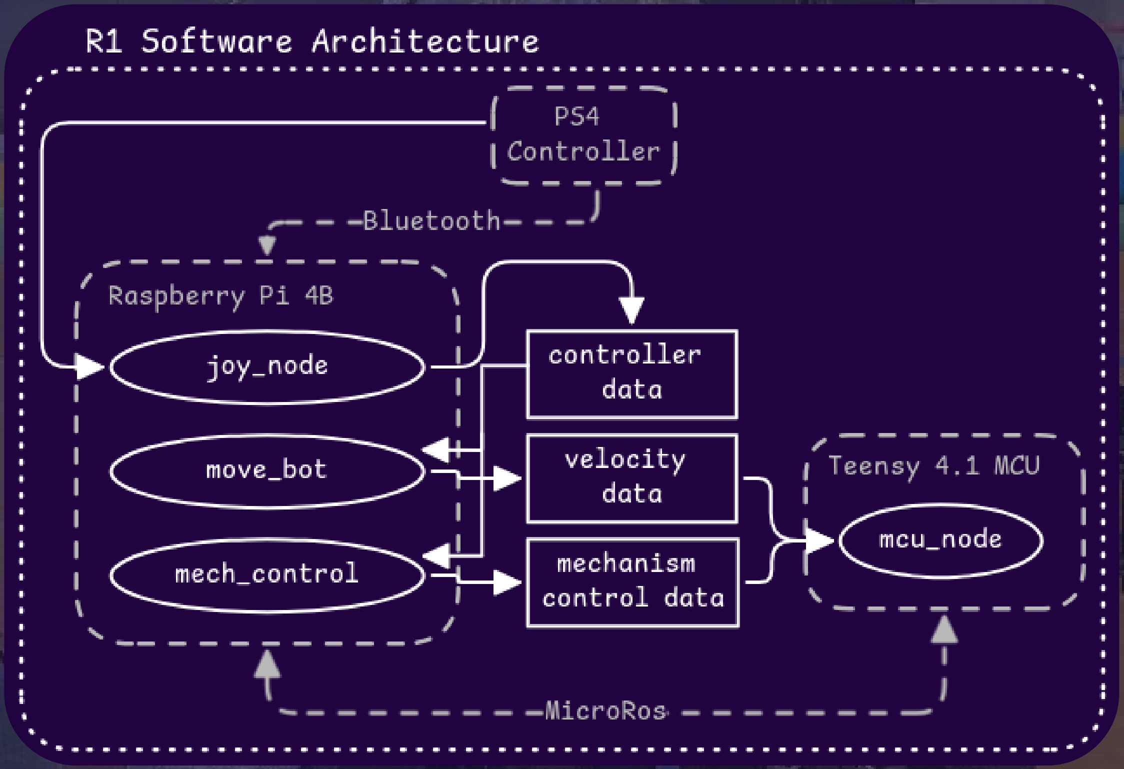
The gripper components are laser-cut from a 5mm thick acrylic sheet, ensuring a lightweight assembly. The gripper arms are connected using screw rods and locknuts, with bearings incorporated to enable smooth movements. The two arms were actuated using a 45 kg-cm servo motor.

FABRICATION

EC&P Subsystem

Overview

This season, the ROS2 framework has been used in both robots. Each robot uses a single-board computer (Raspberry Pi in R1 and Jetson Nano in R2) and a Teensy 4.1 microcontroller for computation and interfacing with other sensors and motor drivers. The robots are programmed to perform several operations, including navigation, odometry, driving mechanisms, and image processing.

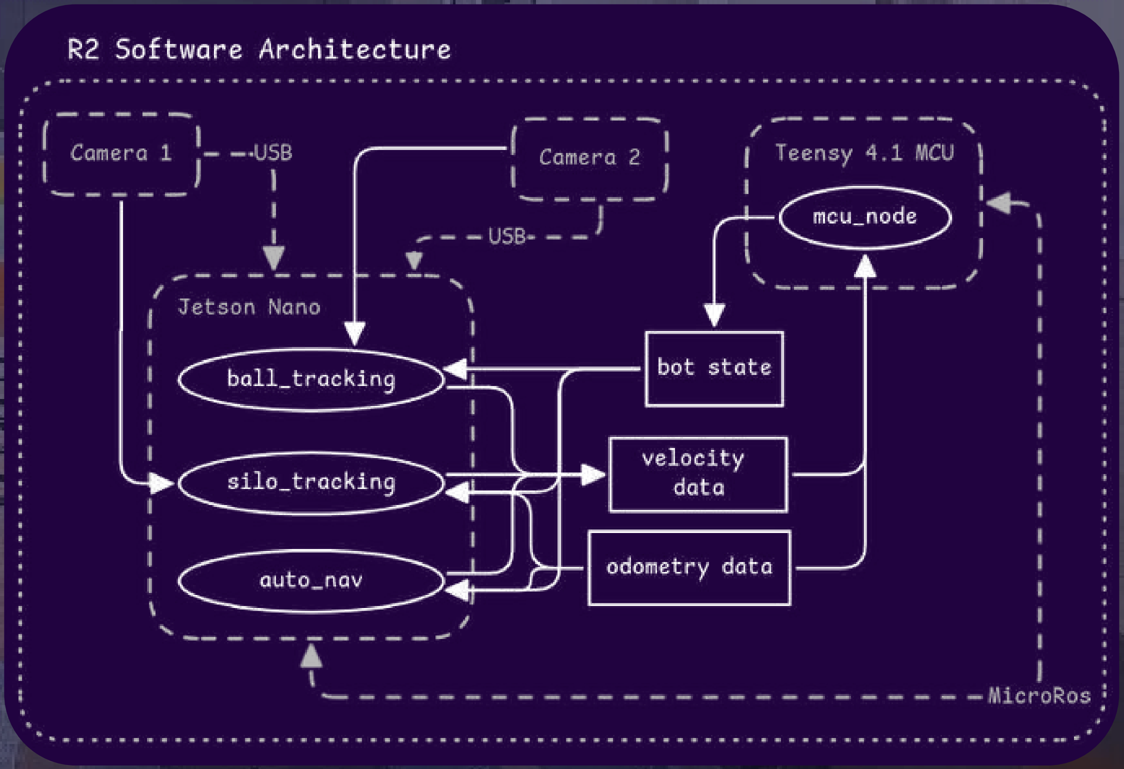


FABRICATION

EC&P Subsystem

Architecture

The ROS2 framework was used to parallelize and effectively separate tasks. The single-board computer (SBC) makes high-level decisions and calculates the target points and paths. The SBC communicates with the microcontroller via microROS. The microcontroller is responsible for executing the instructions from the SBC, fetching sensor readings, and calculating the odometry data of the robots.



FABRICATION

EC&P Subsystem

Odometry

The robots use freewheel encoders to determine the distance moved. The freewheel encoders provide accurate measurements, which is crucial for precise navigation and movement control. A BNO055 IMU is also used along with the freewheel encoders to keep track of the orientation of the robots.

Navigation

Both robots use mecanum drive. The teensy receives the robot velocity data from the SBC and converts them to the velocities of each motor using a conversion matrix. For R1, the velocity is calculated based on the data received from the PS4 controller and a closed loop PID control on the odometry data.

FABRICATION

EC&P Subsystem

Automation

This season's theme required the R2 robot to be fully automatic. The R2 robot is designed to perform three primary tasks: waypoint navigation, ball tracking, silo tracking, and ball picking and dropping.

For waypoint navigation, the robot uses odometry data to determine its current position and moves through a set of pre-determined waypoints using a PID control system.

The robot uses a camera to sort the balls of different colors. The robot moves towards the balls with the required color. A second verification is performed using a color sensor to confirm the ball's color before picking it up.

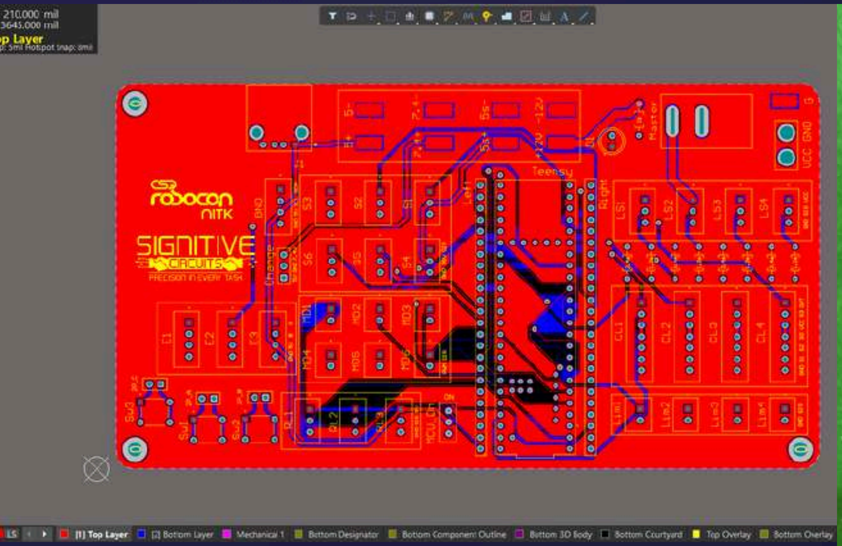
To keep track of the silos, the robot uses another camera. The program prioritizes the silos based on their current ball configuration, directing the robot to the silo with the highest priority.

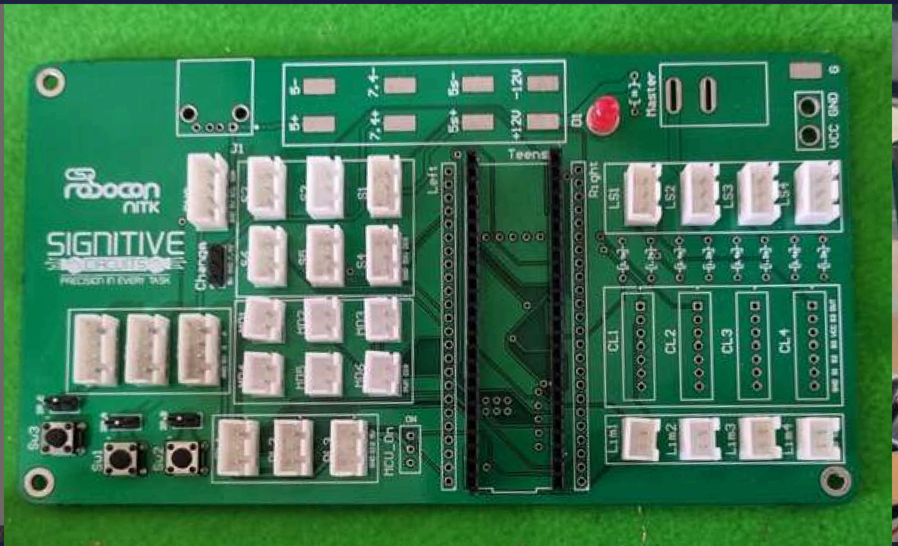
FABRICATION

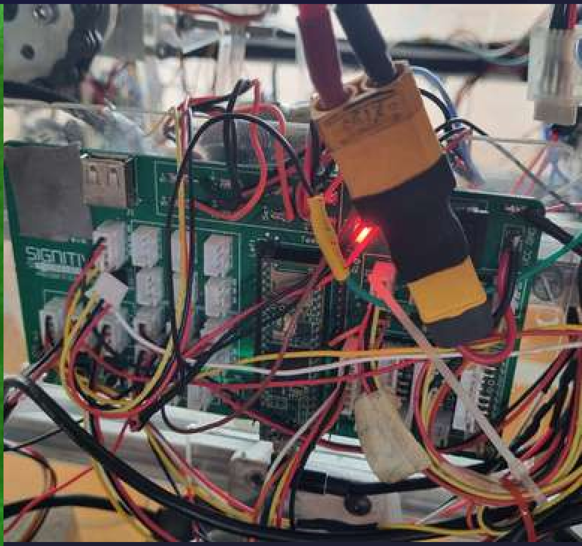
EC&P Subsystem

A single PCB was designed for both R1 and R2 this year, as they required similar hardware configurations.

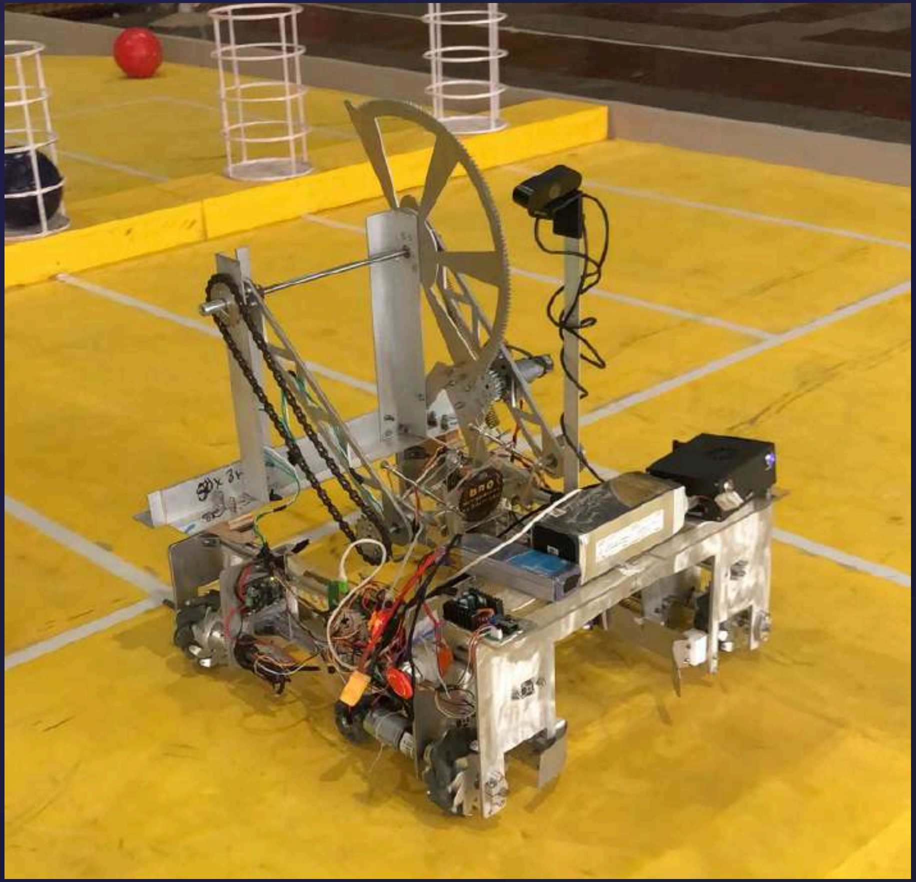
The PCB is powered using a 3S battery (~12V), and onboard buck converters step the voltage down to 7.4V for powering servo motors and 5V for powering the MCU and all the other components. The PCB also includes a USB port, which supplies power to the SBC used in the robot.







FABRICATION
ASSEMBLY



THE ASSEMBLED
R1 AND R2 ROBOTS

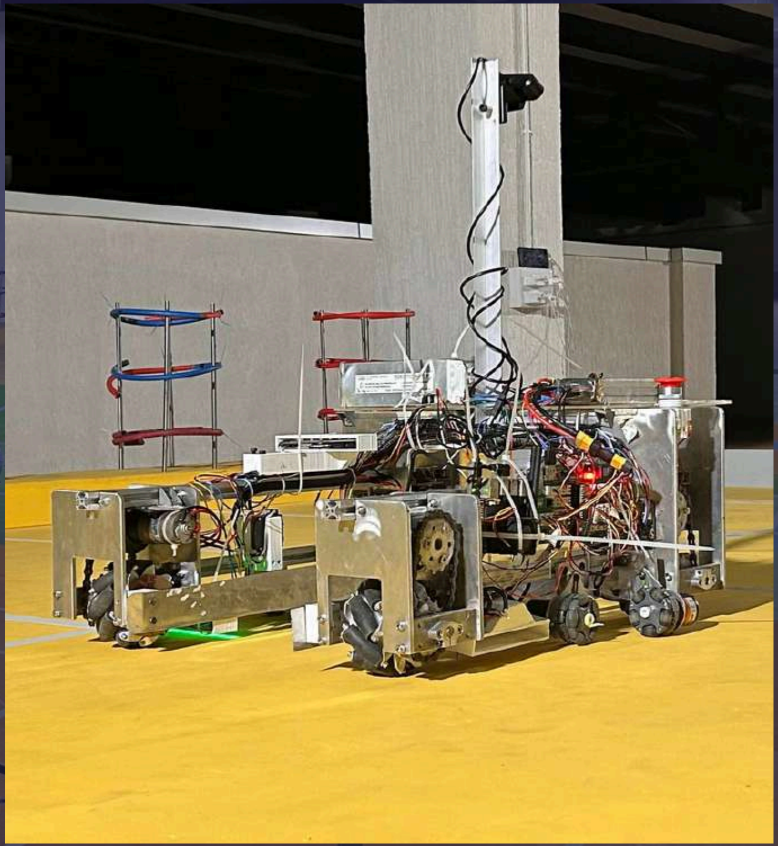
STAGE 2
VIDEO SUBMISSION

In stage 2, participating teams were required to show both robots in action performing their assigned functions 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 organizing 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 cumulative score of **74 out of 100** after the first two rounds of the competition.

TESTING & FINE-TUNING

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



We started with tuning the odometry system for measuring accurate distances.

We then tuned the PID control system for navigation. The tuning was done through hit and trial. 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.

In the case of R2, we tested the automated navigation of the robot and calibrated the control system parameters for smoother motion.

TESTING & FINE-TUNING

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

We started with tuning the odometry system for measuring accurate distances. This involved measuring the offsets found in the odometry and then correcting them by tweaking the logic.

We then tuned the PID control system for navigation. The tuning was done through hit and trial. The navigation was tested by deliberately pushing the robot out of its trajectory to ensure the algorithms were robust enough to keep the robot on track. In the case of R2, we tested the automated navigation of the robot and calibrated the control system parameters for smoother and faster motion.

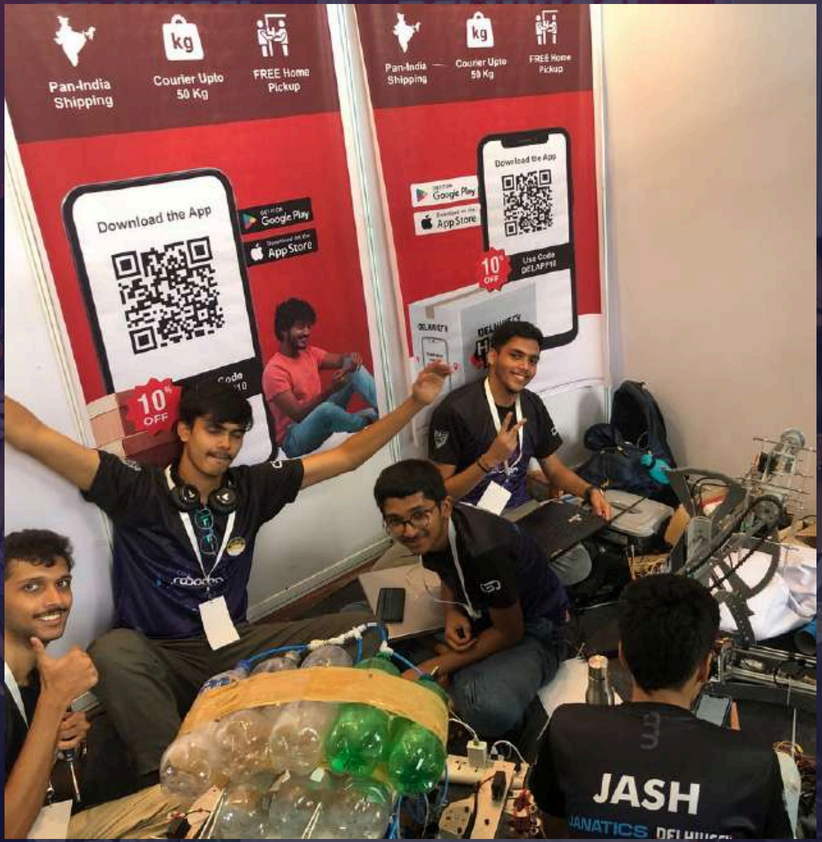
We then tested the mechanisms. This included tuning the angles of the servo motors used in the gripper mechanisms and calibrating the ball tracking logic to accurately detect balls of the required color.

NATIONALS

DD ROBOCON 2024

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 2024

DAY 1 - PRACTICE

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

Both bots started strong, with R1 picking and placing 8 out of 12 seedlings. However, R1 couldn't kick any balls due to a compressed air shortage, and R2 couldn't track balls due to color sensor issues. This made us reconsider our use of compressed air and recalibrate the color sensors.

NATIONALS
DD ROBOCON 2024

DAY 2 - TOURNAMENT

Our first match was against Bannari Amman Institute of Technology, which ended in a draw. We had our second match a few hours later against GCOE Avasari Khurd, where we scored 70 points.

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/2024/match_2

NATIONALS
DD ROBOCON 2024

As the season comes to a close, it is evident that CSD Robocon NITK has once again pushed the boundaries of what we can achieve.

We explored robotics in greater detail this year, drawing on our prior knowledge and incorporating new ideas into our designs. Despite fierce competition, we are pleased with our advancements. Our ability to make it to the nationals is a result of our perseverance, dedication, and learning. With a focused and cohesive team, we are prepared to take on new challenges and raise the bar on our performance.

The journey doesn’t end here—it is only the beginning of another chapter for CSD Robocon NITK. The road ahead promises exciting opportunities, and with the passion we have, the next season looks even brighter.

ACKNOWLEDGEMENT

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

The Director
The Registrar
Dean, Alumni and Corporate Relations
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. Prashanth Samaga (Posem Products & Services) - 1991
Mr. Pankaj Jain - Mechanical Engineering, 1991
Mr. Sreekumar - Electronics and Communication Engineering, 1991
Mr. Prashanth Samaga (Posem Products & Services)
Mr. Purshotam R Bhat - Electrical and Electronics Engineering, 1984
Mr. Umesh Rao Kondeppady - Civil Engineering, 1983
Mr. Prabhhuling Padadayya Chaukimath - Chemical Engineering, 1982
Mr. Rajeev Hulyalkar - Mechanical Engineering, 1980
Ms. Lavanya G - Electronics and Communication Engineering, 2019
Mr. Manish Garg - 2003
Mr. Damodar Shenoy - 1978
Mr. Vishwanath Jayaram - Mechanical Engineering, 2007
Mr. Ramamurthy - Chemical Engineering, 1980
Mr. Pradeep Kumar L - Chemical Engineering, 1997

We thank the NITK Alumni Association for granting us a soft loan until June 2024 to assist with the DD Robocon 2024 Nationals registration.

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Mr. N V Raghuramu - Electrical and Electronics Engineering, 1980
Mr. Sadanand Hegde - Electronics and Communication Engineering, 1982
Mr. Harinath Renukamurthy - Electronics and Communication Engineering, 1991
Mr. Kandanadan - Civil Engineering, 2001
Mr. Praveen Rao - Mechanical Engineering, 1991
Mr. S C Balawat - Metallurgy, 1972
Mr. Anand Kumar - M.Tech, 2022
Mr. Ashok Rao - Mechanical Engineering, 1986
Mr. Gopal Bhupal - Metallurgy, 1977
Mr. Sreenivas Rao - Mechanical Engineering, 1965
Mr. Prashanth Kamath - Mechanical Engineering, 1995
Mr. Shailesh Gadad - Chemical Engineering, 1993

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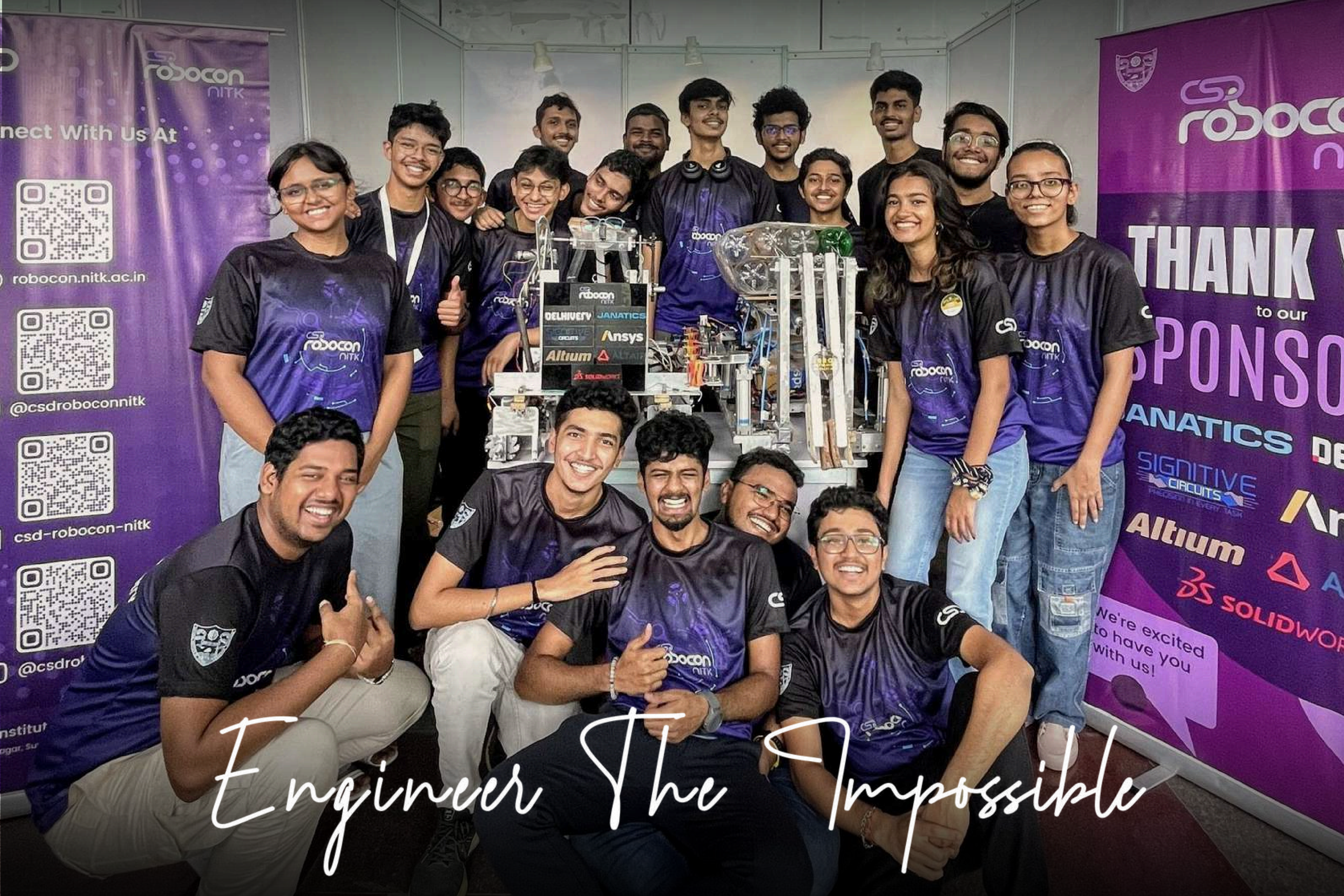
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