# VISHEK MASALIA

M.S.E ROBOTICS AT JOHNS HOPKINS UNIVERSITY

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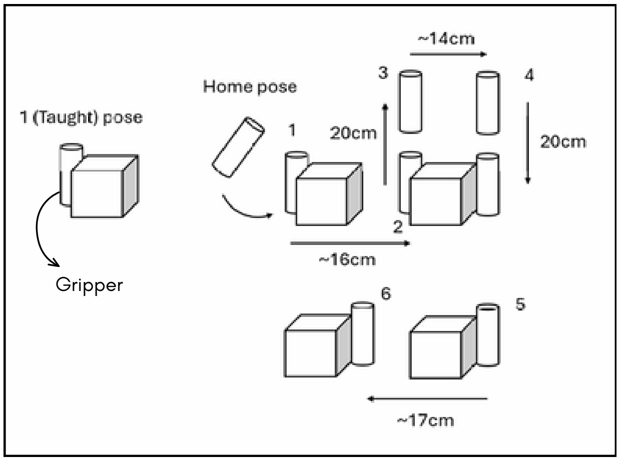
## UR5e AUTONOMOUS MANIPULATION TASKS- JHU 2025



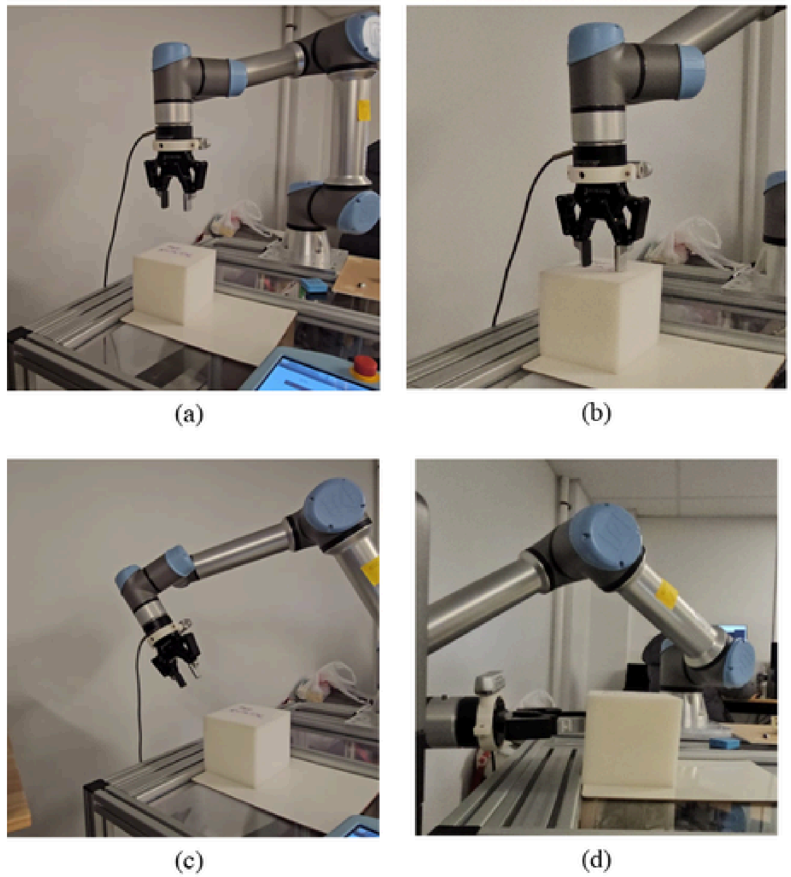

*Motion of robot for push-and-place task*

**What?**

- Used a UR5e manipulator to perform two tasks:
  - **Autonomous push-and-place task**: pushed a foam cube along a straight line, then autonomously executed a return push.
  - **Precision evaluation task**: assessed near-contact motion by approaching multiple surfaces of a foam cube without visible deformation.
- Implemented and compared Inverse Kinematics (IK) and Resolved-Rate (RR) Cartesian control for both.

**How?**

- Taught initial pose using freedrive mode and planned motion in SE(3).
- Implemented controllers in:
  - ROS 2 (IK + RR control, simulation and hardware)
  - MATLAB RTDE (RR control)
- Designed IK solution selection to:
  - Filter infeasible joint solutions
  - Maintain motion continuity
  - Avoid large joint jumps using joint-space proximity thresholds
- Developed control and execution code in MATLAB and Python.
- Validated performance in RViz simulation (ROS 2) and on real hardware




*Motion of robot for precision evaluation task*

**Results**

- Achieved accurate straight-line Cartesian pushing and consistent, repeatable near-contact positioning on the real robot.
- IK control produced smoother, faster motion with minimal tuning
- RR control achieved similar accuracy but required careful gain tuning
- ROS execution showed lower latency and better reliability than RTDE
- Validated the robustness of the IK-based control strategy for precision manipulation tasks
- **Watch both tasks in action below:**
  - Push-and-Place Task
  - Precision Evaluation Task

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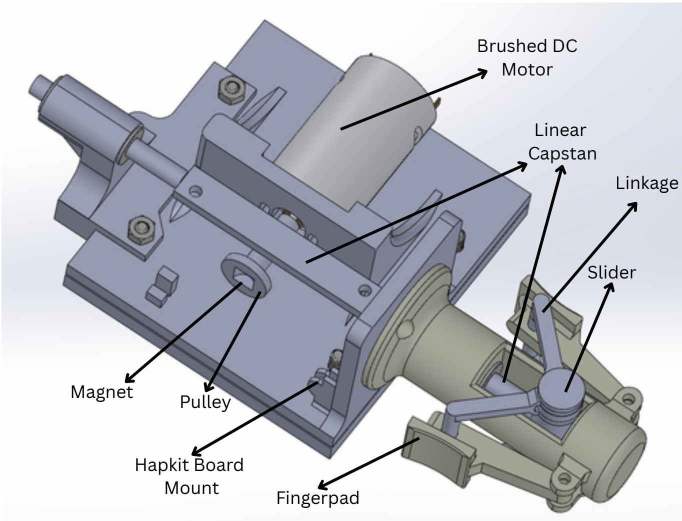
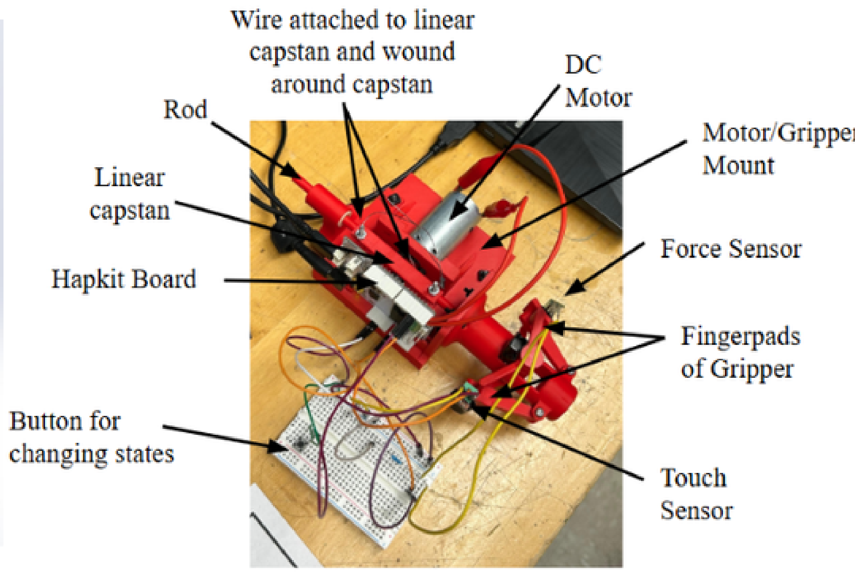
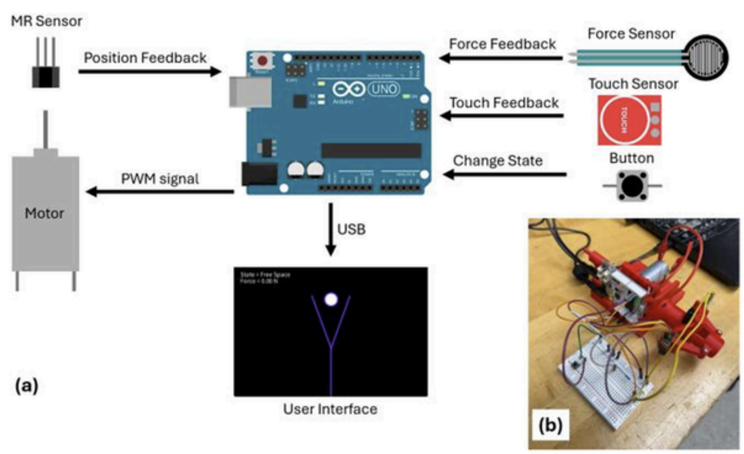
## GRASPING FORCE FEEDBACK FOR DA VINCI SURGICAL ROBOTS - JHU 2025




### What?

- Developed a kinesthetic haptic interface to add grasping force feedback to a da Vinci-style surgical gripper
- Addressed the lack of haptic feedback in robotic minimally invasive surgery (MIS)
- Designed to preserve the original ergonomics and workflow of the da Vinci leader hand
- Enables users to distinguish between:
  - Free space
  - Soft tissue
  - Hard tissue
- Goal: Provide intuitive perception of tissue stiffness without redesigning the surgeon interface




### How?

- Designed and 3D printed a 1:1.2 scale da Vinci gripper replica
- Built a capstan-driven actuation system powered by a DC motor for force rendering
- Integrated MR position sensing + FSR-based force sensing for closed-loop interaction
- Implemented embedded control using the Hapkit 3.0 board (motor driver + sensing interface)
- Developed real-time C++ control architecture for stable haptic feedback
- Implemented physically-based models (spring, damping, friction, impact) for tissue simulation
- Applied signal filtering and state estimation for smooth, noise-robust force output
- Synchronized hardware with a real-time Processing simulation for visual–haptic coupling
- Enforced mechanical and software safety constraints (≤ 5 N force limit)

### Results

- Successfully rendered distinct interaction states: free space, soft tissue, and hard tissue
- Achieved realistic grasping force ranges:
  - Free space: ~0 N
  - Soft tissue: 0–2 N
  - Hard tissue: 1–4 N
- Demonstrated smooth mechanical performance of the fully 3D-printed capstan-linkage system
- Identified motor commutation granularity (brushed DC motor) as the primary source of residual force ripple
- Despite time constraints, successfully delivered a fully functional working prototype (see demo video)
- Established clear path for industry-level smoothness via brushless motor + higher-resolution actuation
- **Watch the gripper in action here**

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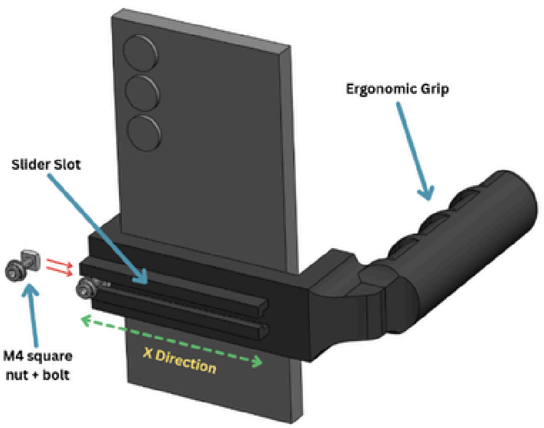
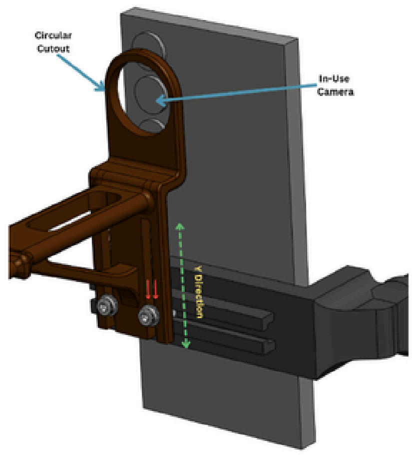
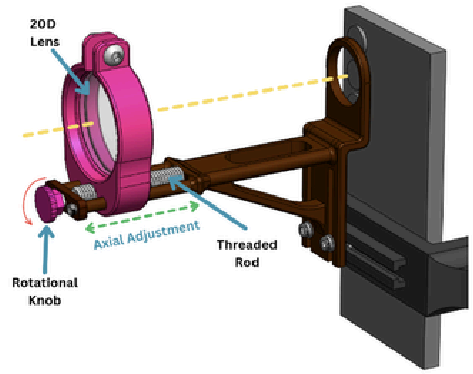
## CLARIFEYE: AFFORDABLE AI-BASED FUNDUS IMAGING - JHU 2025

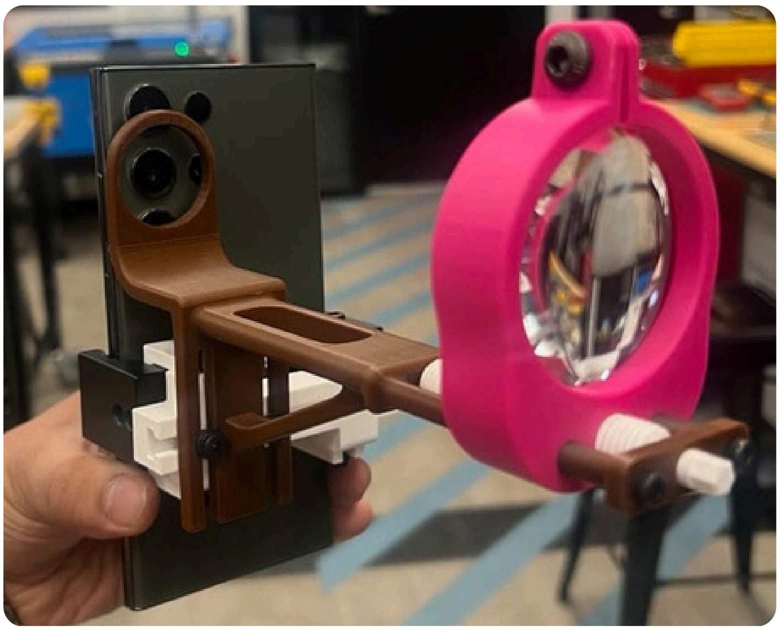



**What?**

- Co-founded Clarifeye, a startup providing scalable AI-powered retinal screening in LMICs.
- Led hardware design of a handheld, smartphone-agnostic fundus imaging attachment.
- Designed a modular, fully mechanical system integrating a 20D condenser lens, X–Y alignment, and axial lens adjustment.
- Ensured universal smartphone compatibility without device-specific adapters.
- Optimized hardware for low-cost (<$100) and rapid field deployment (<4 min screening).
- Hardware supports AI pipeline: image enhancement, stitching, GAN-based restoration, and disease classification.



**How?**

- Designed full CAD architecture in SolidWorks with modular components for easy 3D printing and replacement.
- Engineered X–Y planar alignment and axial lens adjustment to maintain concentric optical alignment across phones.
- Integrated a threaded Z-axis mechanism with guide rails and manual knob for precise focusing.
- Used lightweight PLA and standard fasteners for rapid prototyping and low cost.
- Developed ergonomic grip and rigid locking mechanisms to reduce motion artifacts.
- Iterated prototype on commercial mounts to refine alignment, stability, and usability.
- Reviewed patents and competitor designs to ensure universality, low cost, and manufacturability.

**Results**

- Produced a functional handheld prototype with smartphone-agnostic alignment and axial focus control.
- Reduced hardware complexity compared to existing adapters and FDA-cleared devices.
- Achieved lightweight, ergonomic, modular design for CHW-friendly operation.
- Designed system to maximize image gradability for downstream AI processing.
- Supports multi-disease detection pipeline while remaining cost-effective.
- Positioned Clarifeye as a scalable, low-cost alternative to competitors.
- Contributed to market research, patent differentiation, and startup strategy.

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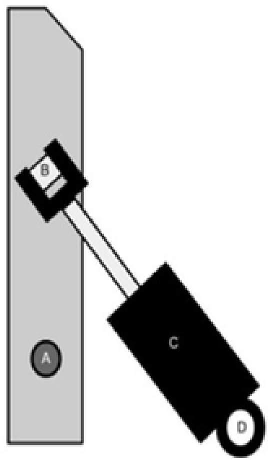
## ADAPTABLE PEDAL BOX DESIGN - UIC 2024




**What?**

- Design of a pedal box for the Formula SAE team at UIC that is compatible for combustion and electric racecars

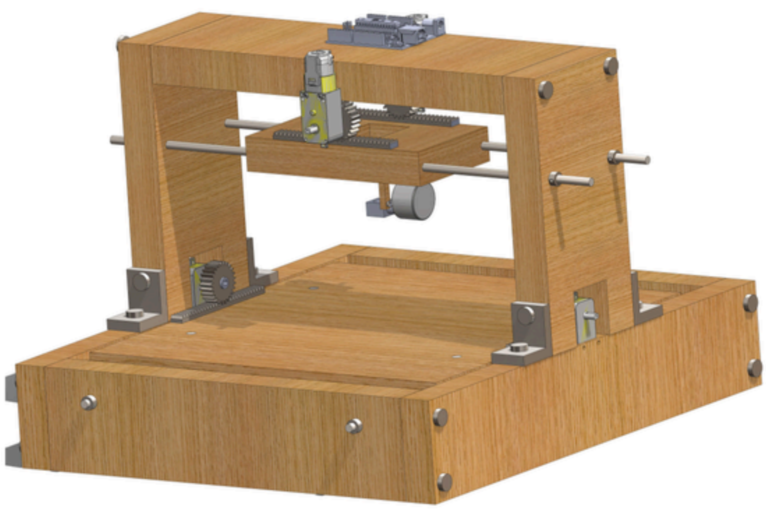
**How?**

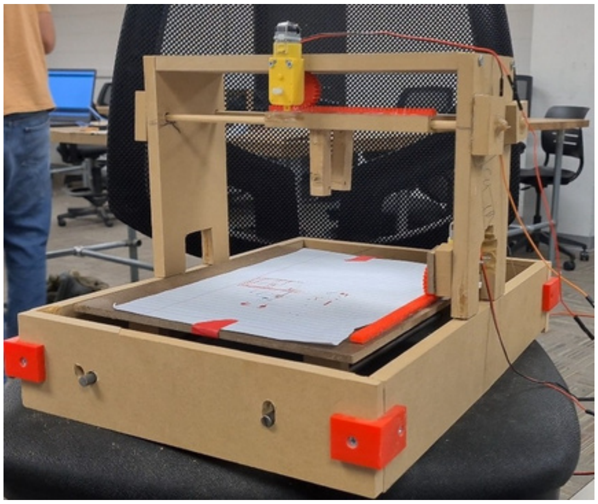
- Used SolidWorks to design all the iterations
- Simulated several iterations using ANSYS
- Created prototypes using laser-cut acrylic sheets and 3D printed parts

**Results**

- The final prototype fit perfectly into its designated area and adhered to all the FSAE rules
- Presented this project at EXPO UIC 2024 and won the "Best in show award"

## AUTONOMOUS WRITING DEVICE - UIC 2021





**What?**

- Created a handmade autonomous writing device from MDF wood, 3D-printed custom parts, and an Arduino UNO microcontroller.
- Developed as a project for an Introduction to Design and Graphics course at UIC.

**How?**

- Designed and refined iterations in SolidWorks.
- Cut and shaped MDF wood sheets for structural parts using machine shop equipment.
- Integrated a 3D-printed rack-and-pinion mechanism for precise control.
- Programmed the device in C++ on an Arduino UNO microcontroller to enable automated functionality.

**Results**

- The final device successfully drew shapes and letters with stability and operated seamlessly at the push of a button.
- Presented the project to UIC professors, receiving valuable feedback on optimizing the design for reduced mass and cost.

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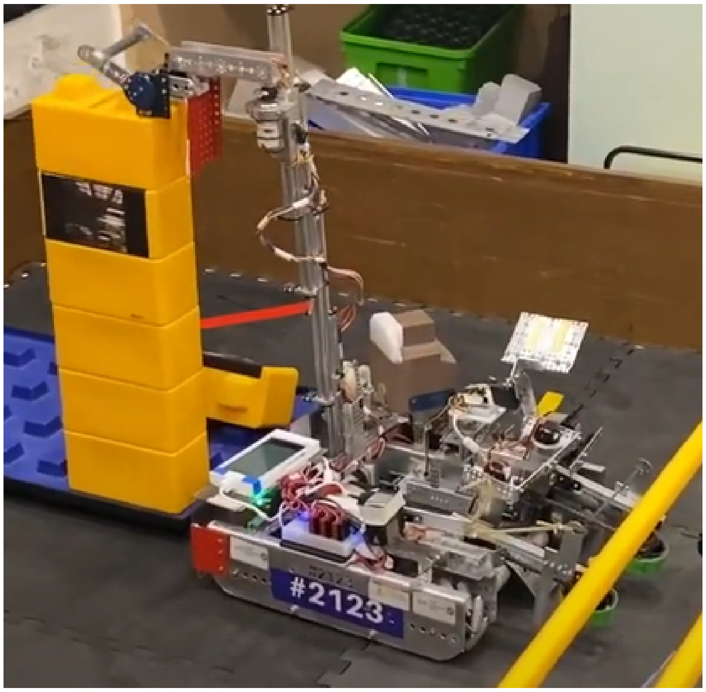
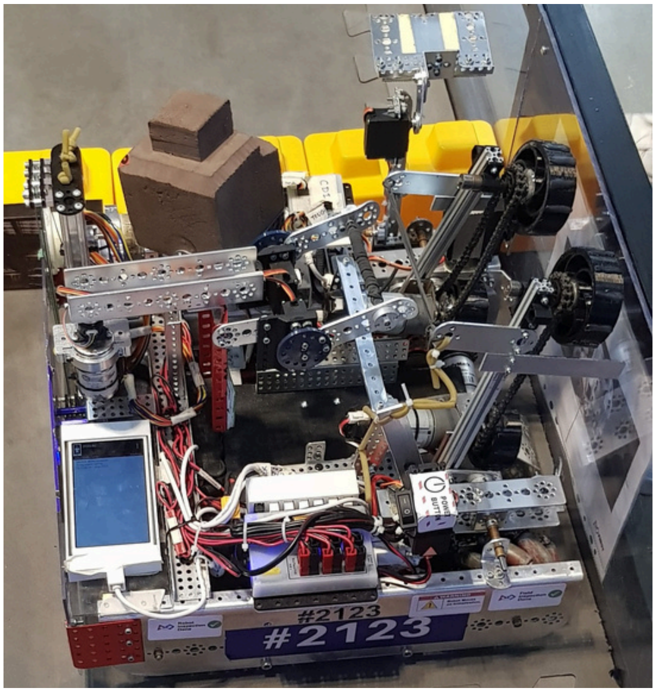
## FIRST TECH CHALLENGE (FTC) SKYSTONE 2019-20



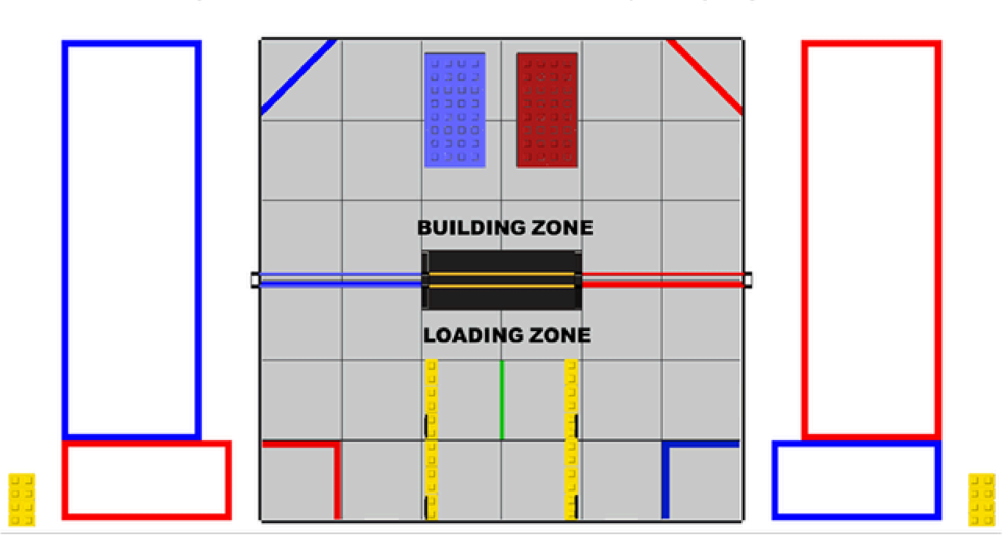




**What?**
- Designed and built a robot for the FIRST Tech Challenge Skystone 2019-2020 competition in India as part of the team "Mad Engineers."
- The robot autonomously and manually collects and stacks large blocks on a tray within a 2.5-minute timeframe on the playing field.

**How?**
- Designed using SolidWorks and iteratively prototyped and tested.
- Constructed with laser-cut metal, 3D-printed parts, and Tetrix components.
- Programmed in Java to enable both autonomous and manual wireless operation.

**Results**
- Awarded the Collins Aerospace Innovative Award for the most creative and innovative robot design.
- **View the robot completing tasks in the playing field <u>here</u>**

**Top view of the playing field**



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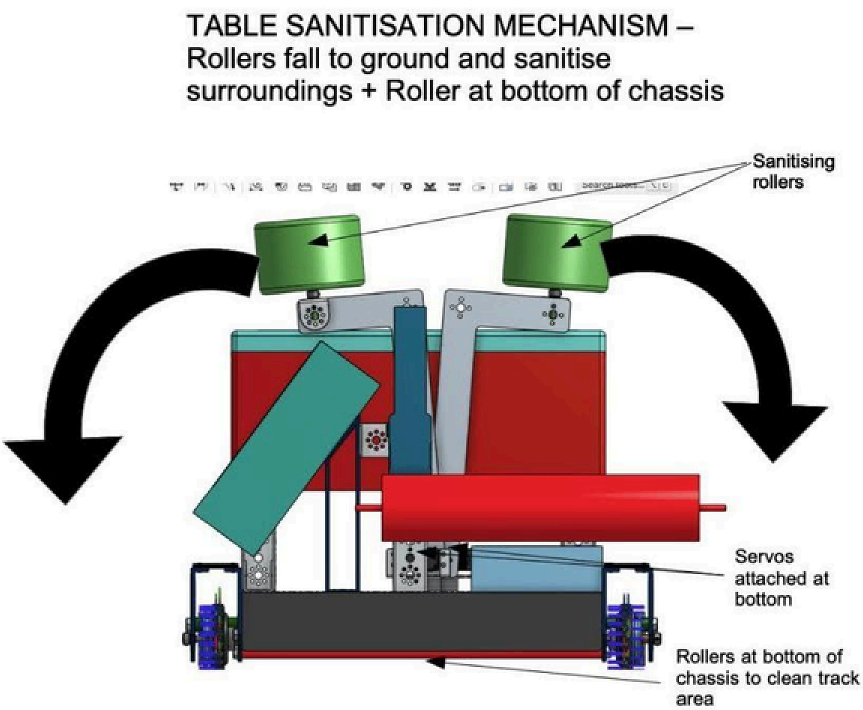
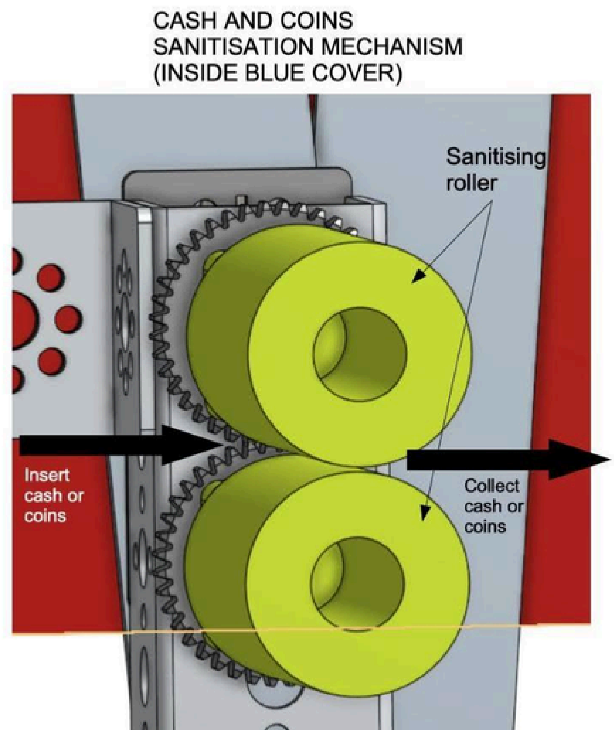
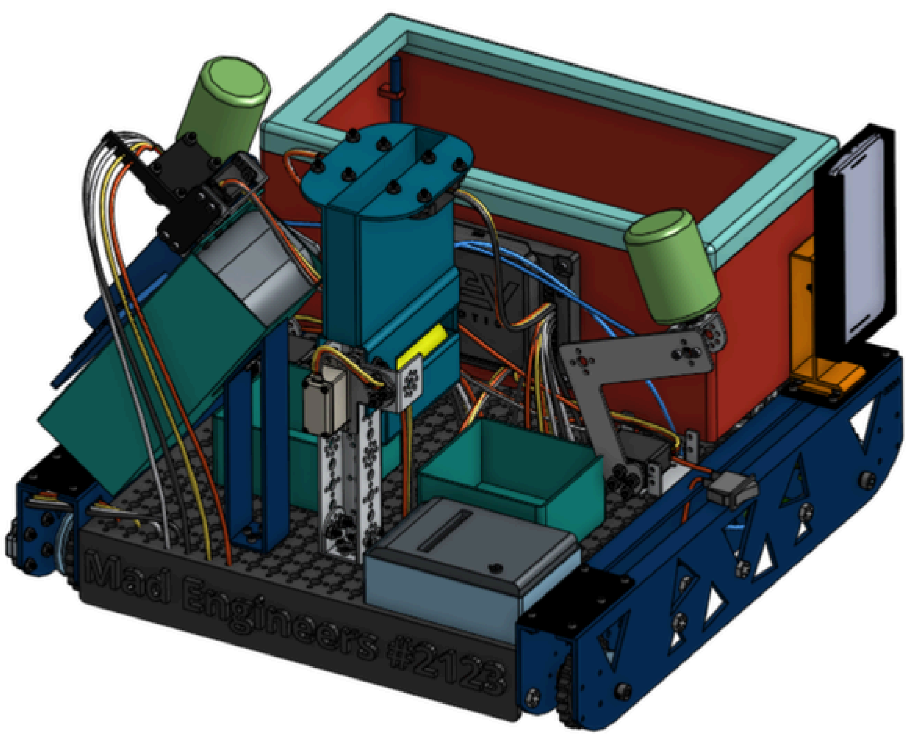
## ROBOTS TO THE RESCUE - FIRST® 2020




### What?

- Designed a robot to replace the role of pharmacists, cashiers and security guards for Onshape's Robots to the Rescue competition for FIRST® in 2020.
- Automated the packaging and delivery process for supplies, incorporating a disinfection mechanism that sanitizes currency and the robot's workspace to ensure a contact-free, germ-free experience during transactions.

### How?

- Developed detailed CAD models on Onshape for the robot, ensuring accurate and functional designs for each component.
- Worked closely with a diverse team to ensure the CAD designs aligned with both the technical and functional requirements of the project.

### Results

- Our team ranked 18th out of 151 particpating teams
- The robot's design was well-received for its practicality in real-world applications, showcasing innovative solutions for contactless operations in essential services.

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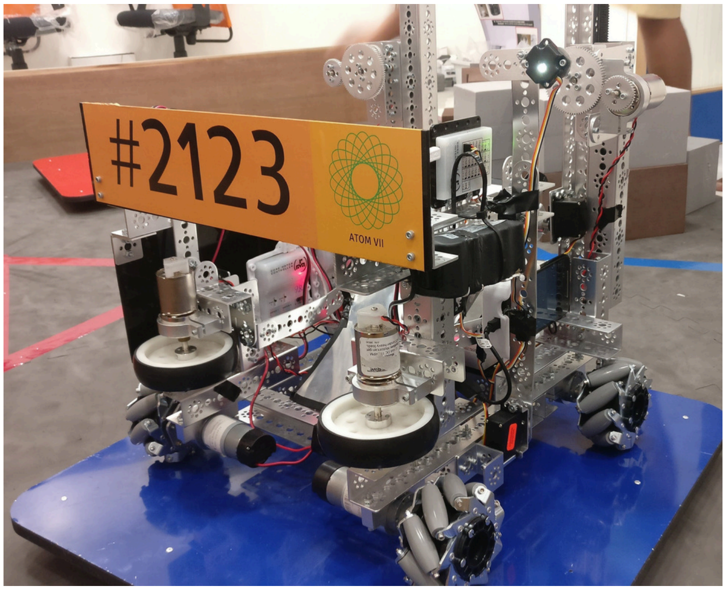
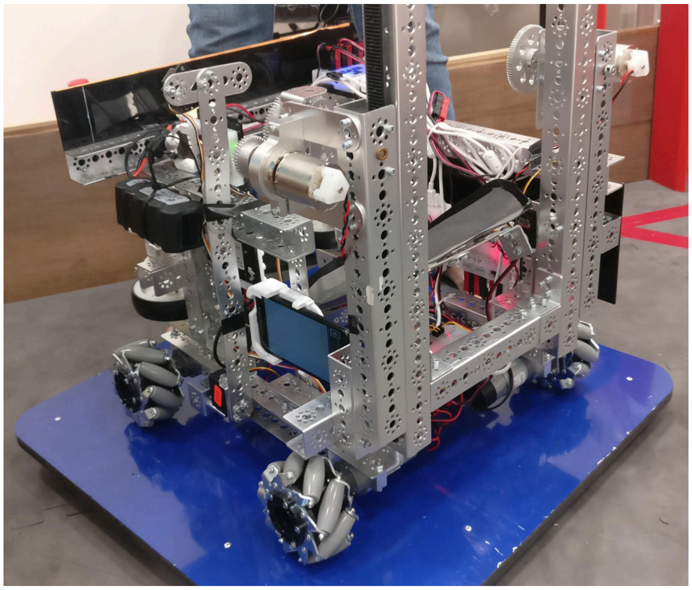
## FIRST TECH CHALLENGE (FTC) RELIC RECOVERY 2017-18



**What?**

- Designed and built a robot for the FIRST Tech Challenge Relic Recovery 2017-2018 competition in India as part of the team "Mad Engineers."
- The robot autonomously and manually collects and stacks 6-inch foam cubes into four columns within a 2.5-minute timeframe.

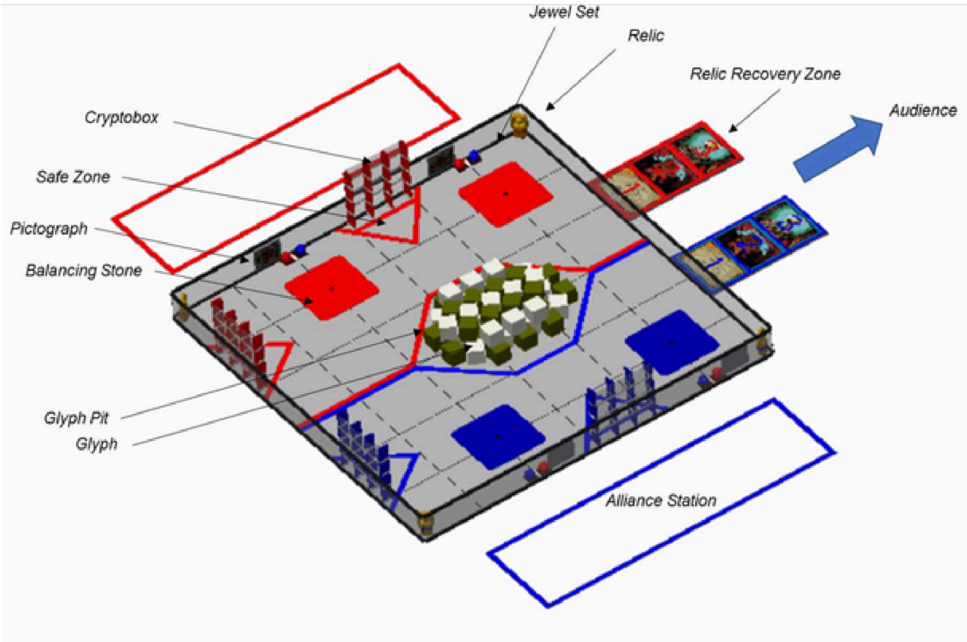
**How?**

- Designed using SolidWorks with seven iterations made and tested.
- Constructed with 3D-printed parts and Tetrix components.
- Programmed in Java for both autonomous and wireless manual control.

**Results**

- Awarded the Finalist Alliance 1st Runner Up award for securing second place in the overall competition.
- **View the robot competing in the semifinals here**

**View of the playing field**



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## ICE ADHESION AND PHASE CHANGE MATERIAL RESEARCH - UIC 2022

**What?**

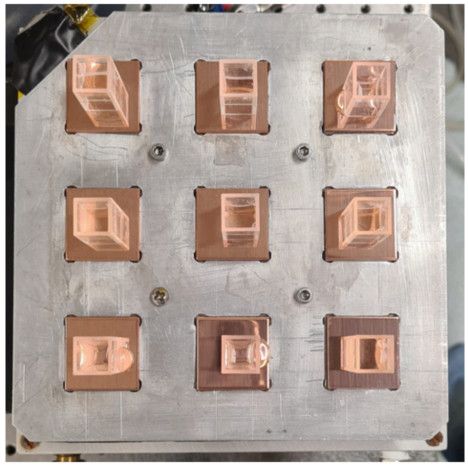
- Contributed to experimental research on ice adhesion strength using salt solutions on metallic surfaces.
- Conducted material characterization of polymers for cold-climate applications.
- Assisted in research on phase change materials (PCMs) for condensation and frost control.
- Credited for general assistance in the peer-reviewed publication: “How to Select Phase Change Materials for Tuning Condensation and Frosting,” Advanced Functional Materials (Chatterjee et al., 2022). Click here to check out publication

**How?**

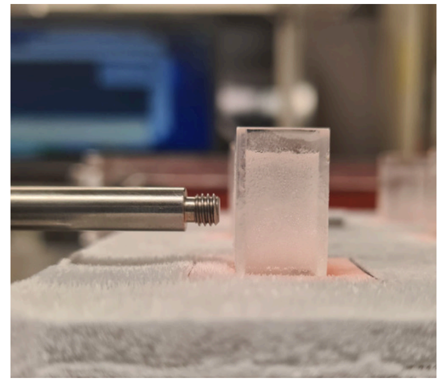
- Worked in Prof. Sushant Anand’s lab at the University of Illinois Chicago as part of a 5-member team - including Prof. Anand - under the direct guidance of PhD student Rukmava Chatterjee.
- Organized and executed lab tests to assess the adhesion strength of ice formed from various salt solutions on metallic surfaces.
- Performed polymer testing to determine suitability for cold-climate applications.
- Collected, analyzed, and visualized data using Excel, generating comparative reports for control vs experimental groups.
- Supported a study on PCMs that trap latent heat during condensation, delaying freezing.

**Results**

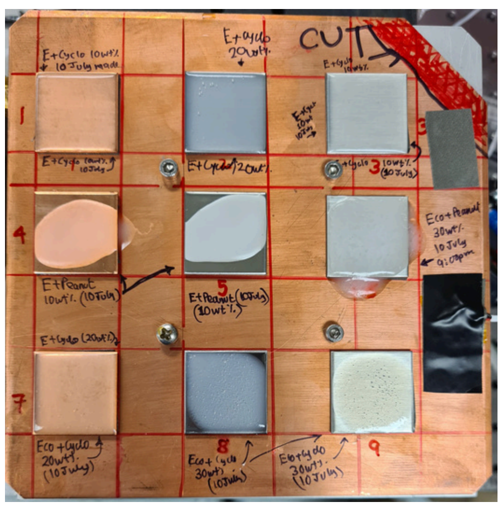
- Enhanced understanding of ice adhesion dynamics and PCM selection.
- Contributed to the development of a materials framework to reduce frost formation—relevant to energy systems, climate control, and medical applications.
- Recognized in a peer-reviewed journal, strengthening research credentials for future roles in materials, thermal, or robotics systems.



*Experiment Setup*



*Picture from ongoing experiment*



*Various metals and polymers*

*Tensile tests of polymers*

*Team Photo*

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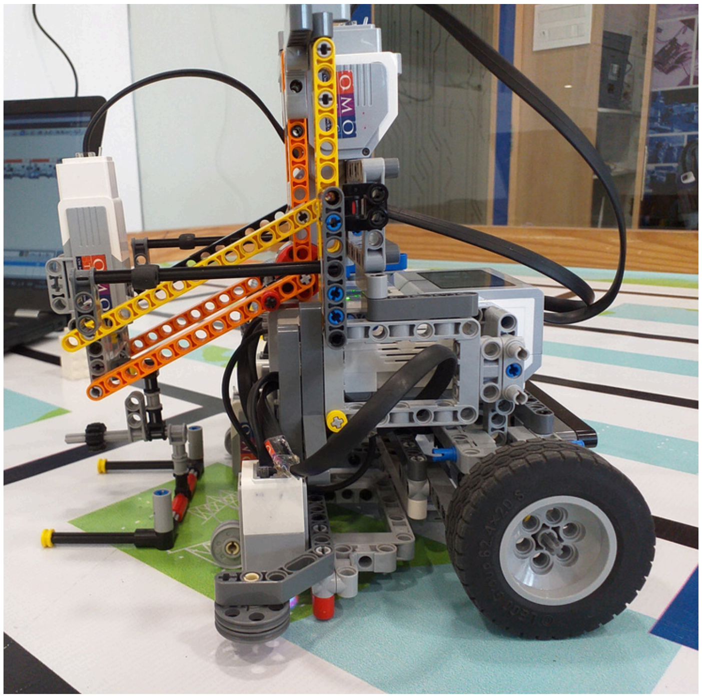
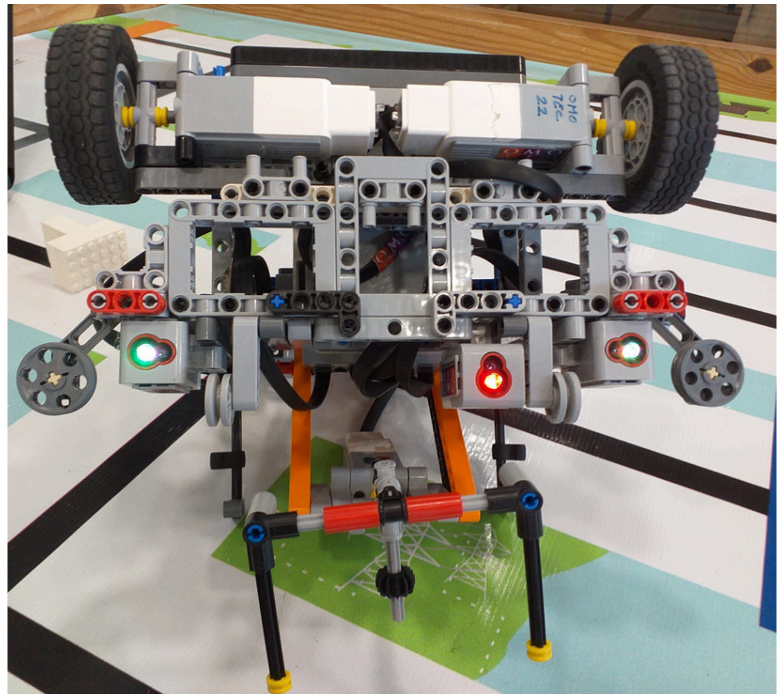
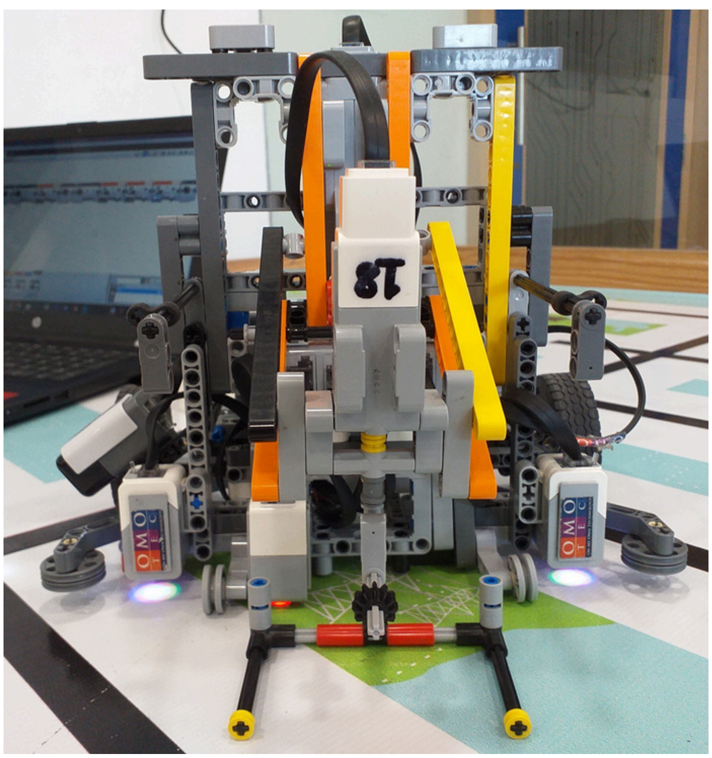
## WORLD ROBOT OLYMPIAD (WRO) SMART CITIES 2019







**What?**

- Participated in the World Robot Olympiad (WRO) 2019 Senior High category at the national level in India.
- Designed, built, and programmed autonomous robots to complete challenges related to the "Smart Cities" theme, focusing on tasks involving transportation and urban infrastructure.

**How?**

- Collaborated in a team of 2 members to design and build a robot using LEGO Mindstorms.
- Developed solutions through iterative design, testing, and refinement to optimize robot performance.
- Programmed the robot to autonomously navigate the course using black line following and perform tasks using sensors and pre-programmed instructions.
- Competed in multiple rounds, with robots judged on accuracy, speed, and reliability.
- Presented project details to judges, explaining design and programming choices.

**Results**

- My team secured 3rd position in the national competition.
- Our robot was successful in completing the maze autonomously with some minor mistakes.