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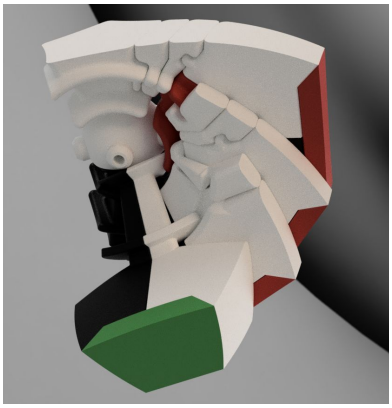
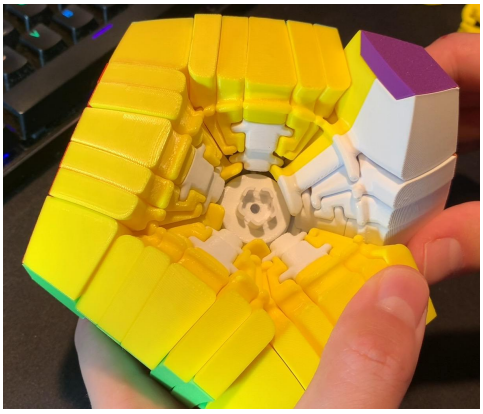
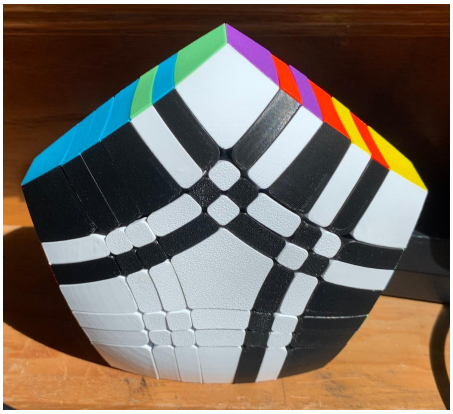
Floppy Teraminx - Complex Interlocking Mechanical Twisting Puzzle



CAD Rendering of partial mechanism



Partially assembled mechanism prototype



Final Puzzle

What?

- Designed and refined a custom 3D-printed mechanical puzzle over 4 prototype iterations.
- Focused on ease of assembly, structural stability, smooth operation, and DFM.

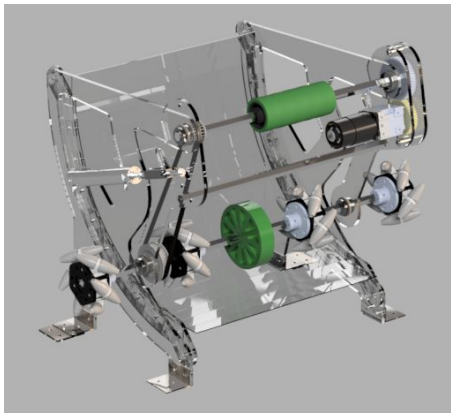
How?

- Solid and Surface Modeling in **Fusion 360.**
- Spring pre-loading system for high performance turning.
- Added extra rails and anchors to stabilize the puzzle during use.

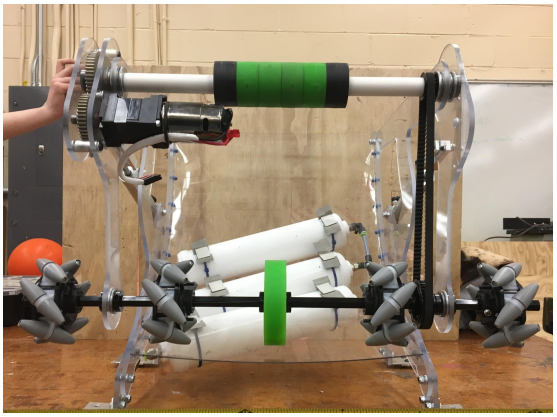
Results

- High-performance puzzle.
- Eliminated centerpiece popping in the final design, following frequent issues in earlier prototypes.
- Positive community feedback on potential commercialization.

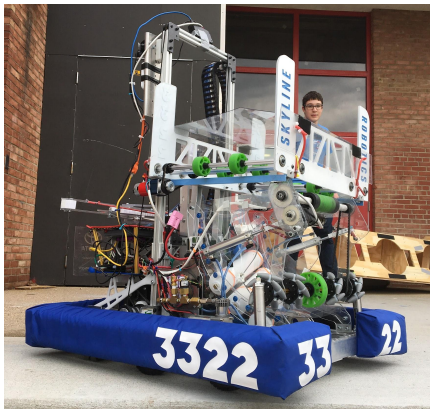
Robotic Kickball Intake - FIRST FRC Deep Space, Team 3322



CAD Rendering



Assembled intake mechanism



Fully Assembled Robot

What?

- Robotic mechanism to collect kickballs off the ground then feed them to an outtake
- Pneumatic actuation to extend outside the frame for collection and back inside to avoid damage

How?

- Prototyped with wood, dolly, spare parts, and power drills
- Designed in Autodesk Fusion 360 to be cut out on a CNC router
- Performed kinematic analysis to optimize ball collection

Results

- Reliable ball intake throughout the competition season and off-season
- Durable and lightweight polycarbonate design lasted the whole competition season

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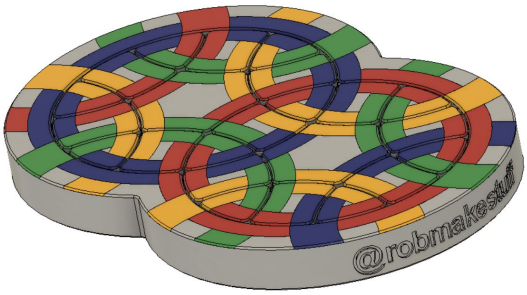
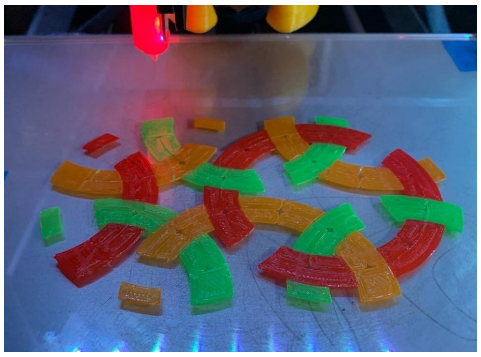
3D Printed Geranium Puzzle

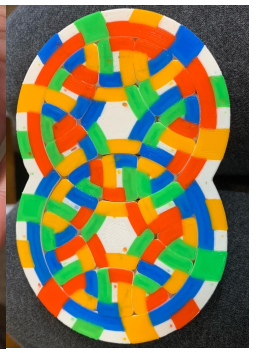


CAD model



Operation 3/5 of the printing process

Solved puzzle



Scrambled puzzle

What?

- Designed and created a 3D printed-in-place geranium puzzle (similar to a Rubik's Cube).
- Demonstrated multi-material printing capabilities on a single nozzle printer .

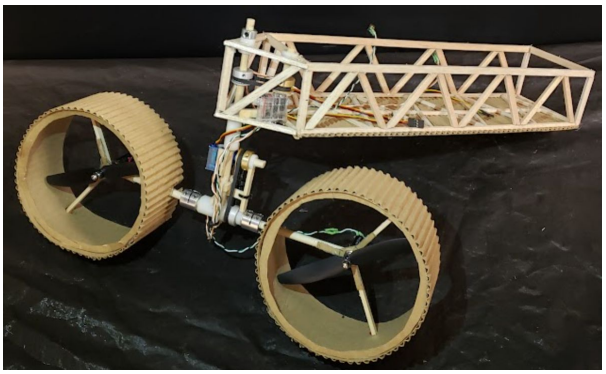
How?

- Modeled in Autodesk Fusion 360 and toleranced to print in place
- Created STL files for each different color on the puzzle
- Wrote custom G-CODE to run multiple operations and ensure a consistent origin reference point

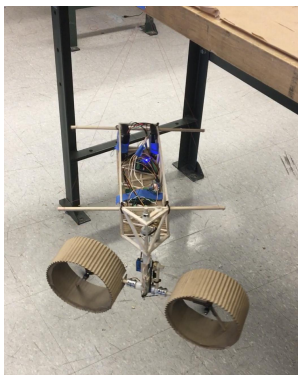
Results

- Validated multi-material 3D printing technique
- Smooth turning, non-locking, visually pleasing puzzle
- Produced several prototypes to validating the mechanism and tolerances

Blimp Thrust-Vectoring Propulsion Subsystem - ENGR 100



Assembled gondola and propulsion system



Maneuverability testing

Final blimp in competition

What?

- 2 DOF thrust vectoring propulsion system for a remotely operated blimp.
- Lightweight construction minimizing weight and maximizing maneuverability.

How?

- Dual servo motor actuation with lightweight timing belts/pulleys for precise positioning.
- Maneuverability verified through hanging test stand.
- Nylon bushings with low friction coefficient for smooth rotation.

Results

- Won 1st place in all events in competition (speed and recon) against 11 other teams
- Superb maneuverability for quick and precise reconnaissance flight mission.

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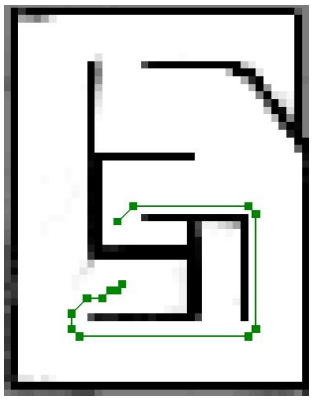
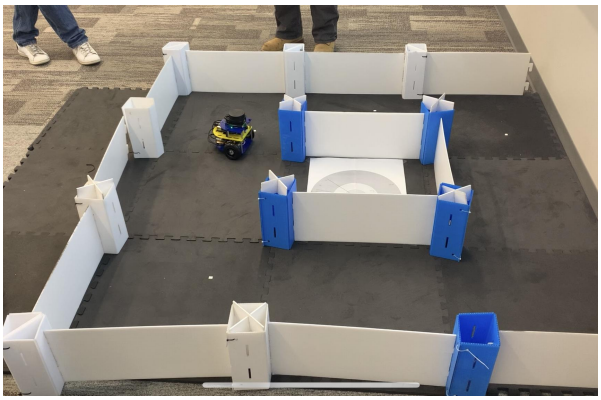
Maze Escape Robot - ROB 330



A* path generation



Robot exploring and mapping maze

What?

- Wrote probabilistic SLAM and navigation algorithms for an autonomous mobile robot to map and escape a maze
- Implemented an on-robot AI image classification model.

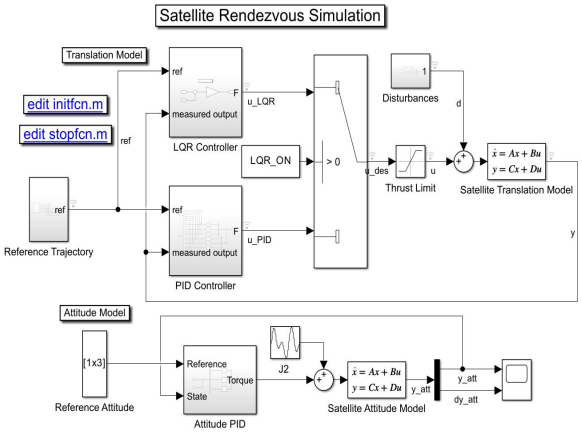
How?

- Two layered PID controls for wheel speed and robot speed.
- Monte Carlo and occupancy grid SLAM using LIDAR data.
- Navigate to frontiers with A* through obstacle distance grid.

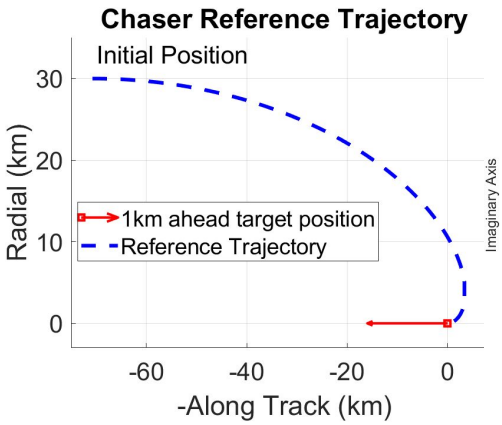
Results

- Successful exploration and mapping of a 3x3 maze.
- 65.8% accuracy on 10000 test images using a CNN model
- Successful real-time SLAM and navigation implementation.

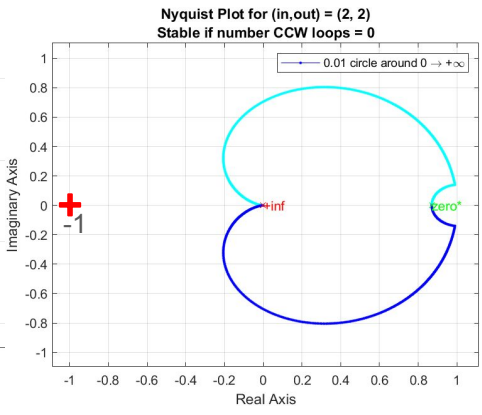
Satellite Rendezvous (RPOS) Simulation and Control System Design



Simulink Model Setup



Transfer Reference Trajectory



Stable Nyquist Plot

What?

- Design of a dual-approach control system for satellite rendezvous maneuvers in Low Earth Orbit (LEO).
- 6-DOF dynamics simulation in MATLAB and Simulink.

How? *(My Contributions).*

- Designed 6-DOF satellite dynamics simulation, then implemented and tuned PID and LQR controllers.
- Integrated disturbances (drag, J2 effect) to analyze control robustness.
- First-order dynamics approximated with Clohessy-Wiltshire equations.

Results

- Smooth and stable tracking control with LQR controller.
- Achieved accurate tracking control with the PID controller, though with some oscillations.
- Bode and Nyquist analyses support simulation results.