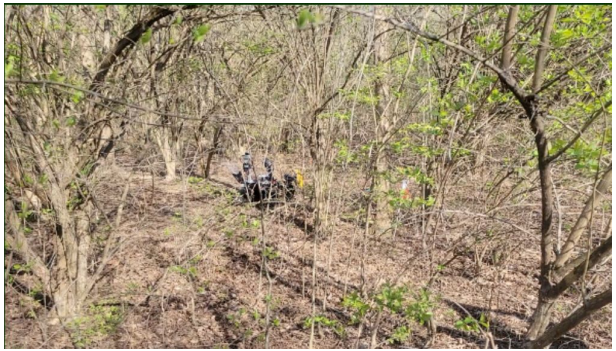
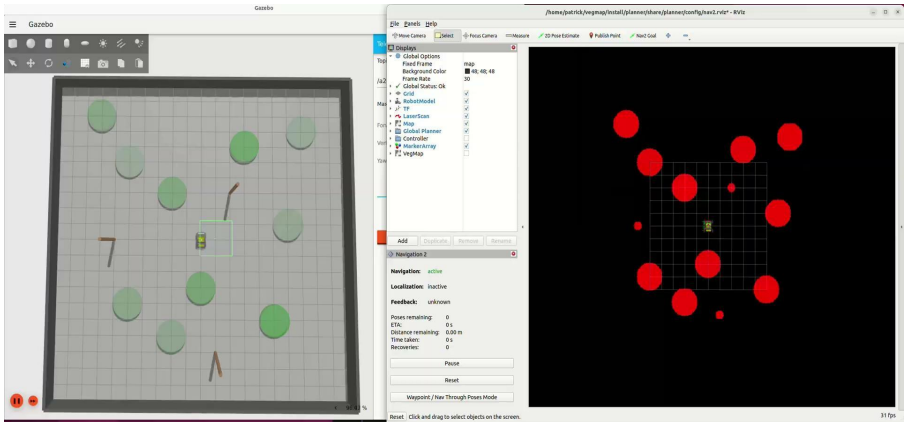
Robotics

Proprioceptive Vegetation Navigation(CMU-16350 Project)

- Implemented an end-to-end simulation in **ROS2** and **Gazebo** using a **Husky robot**, demonstrating planning and traversal through dense vegetation
- Developed **a resistance zone contact model** using proprioceptive sensors to apply velocity reductions in vegetated zones and experimented with **solid obstacle interactions** (e.g., STL trees, friction patches)
- **Integrated a custom costmap plugin** into the **Nav2 stack** to support adaptive path planning
- Compare the performance of **A* and D* Lite** Algorithms.



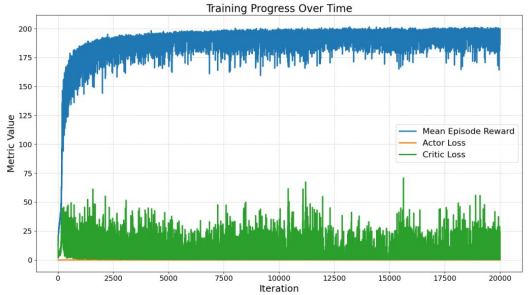
Vegetated Area



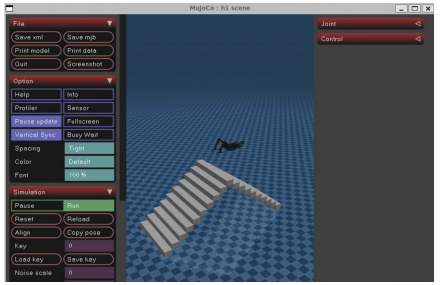
Demo: Obstacles as non-lethal

Robust Bipedal Locomotion on Uneven Terrain via Deep Reinforcement Learning (CMU-16745 Project)

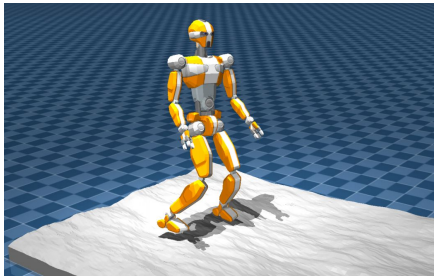
- Proposed a **reinforcement learning (RL) framework** to enable robust bipedal walking without explicit trajectory planning, ensuring **adaptability to complex and changing terrains**;
- Trained a deep policy using the **MuJoCo physics simulator**, constructing rough terrain environments to evaluate model performance and robustness;
- Developed an **MPC-based** controller using RL-generated trajectories on flat terrain as reference, and **compared its performance** against the RL model.



Metric Value on flat/uneven terrain over iterations



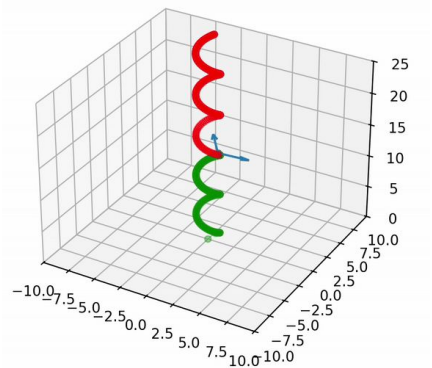
Terrain Creation



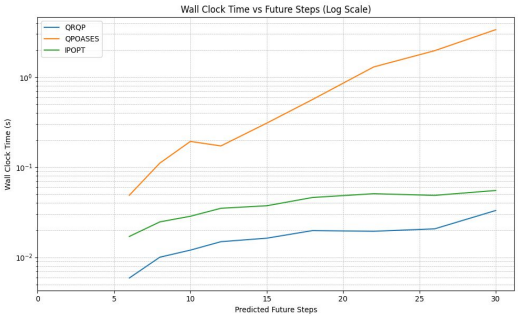
Jvrc1 walking on uneven field

Model Predictive Control for Quadcopter(CMU-18660 Project)

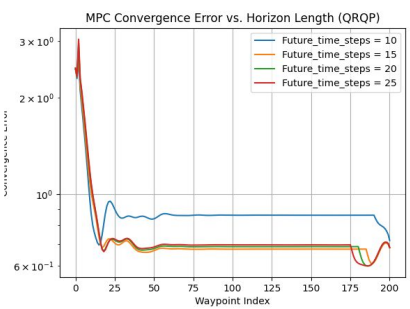
- **Designed a Model Predictive Control (MPC) policy** for a quadcopter to achieve accurate reference trajectory tracking
- **Implemented and compared multiple optimizers** (IPOPT, QPOASES, QRQP) within the CasADi framework, focusing on optimality gap and computational efficiency
- **Analyzed performance trade-offs** among different solvers to guide the selection of the most suitable optimizer for real-time MPC-based online control.



Visualization



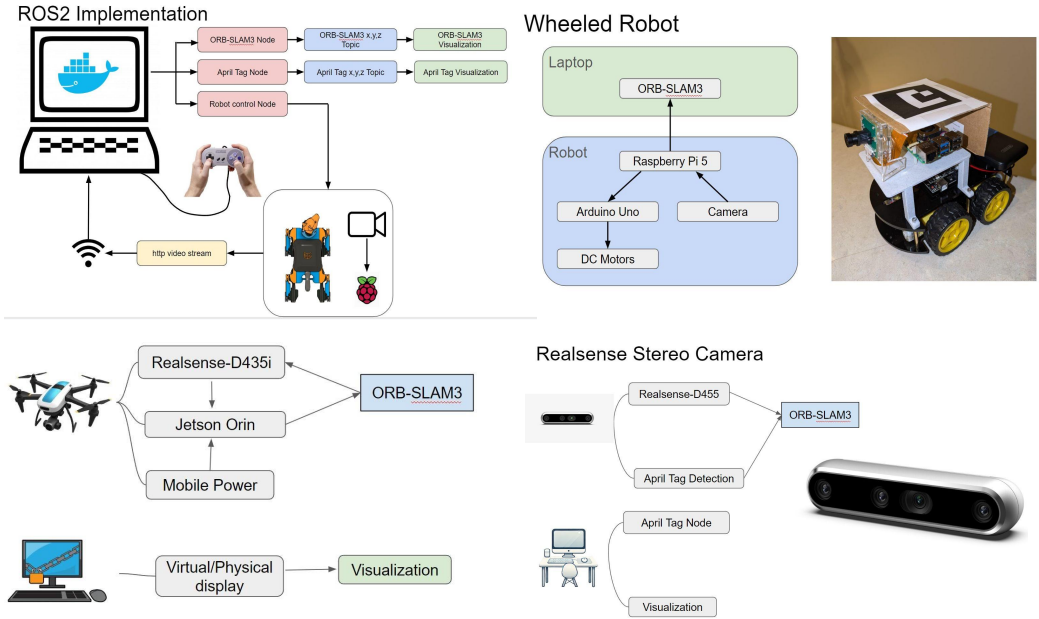
Wall Clock Time



Parameter Tuning

ORB-SLAM3 on Hardware (CMU-16833 Course Project)

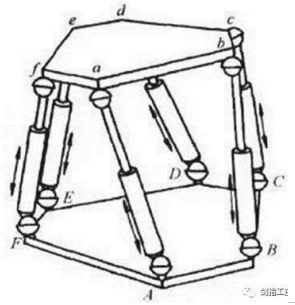
- ORB SLAM3 is the state of the art for **SLAM,** as demonstrated by its performance on the EuRoC and TUM datasets.
- We evaluated the performance and limitations of the algorithm on a diverse set of hardware:
  - **Realsense** Camera
  - Small Arduino and Raspberry pi based quadruped robot (**Petoi Bittle**) with monocular camera
  - **Drone**
  - Raspberry pi based **wheeled robot**



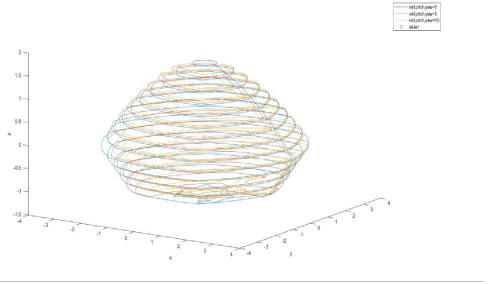
Hardware Structure

Modeling, analysis and control of Stewart parallel robots (SJTU-ME3804 project)

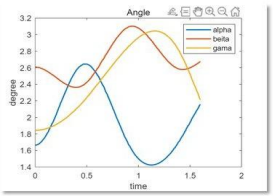
- Reimplemented forward and inverse **kinematics and dynamics algorithms** of Stewart parallel robot
- Analyzed the **work space** of Stewart parallel robot
- Carried out the **kinematics parameter identification** algorithm of Stewart robot
- Developed an optimization algorithm for **TOPP** problem.

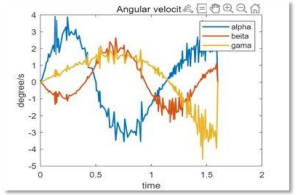


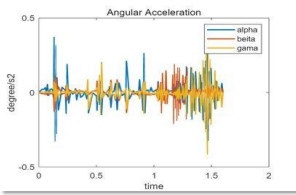
Stewart Robot



Workspace Analysis



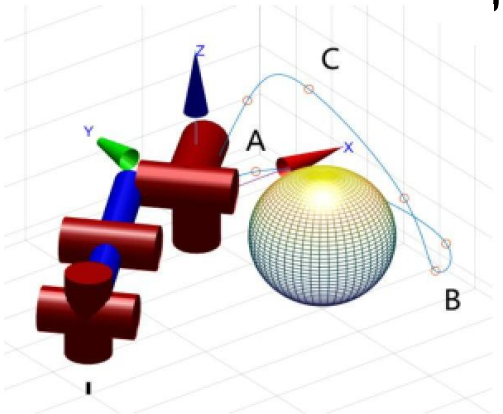




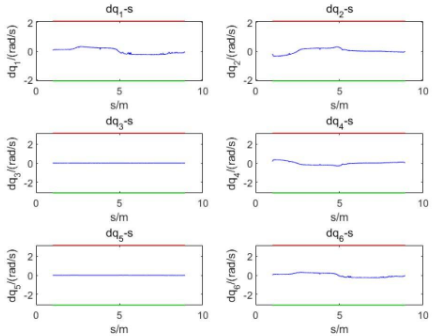
Outcome of TOPP problem

Robot arm trajectory time optimization(SJTU-ME3305 Project)

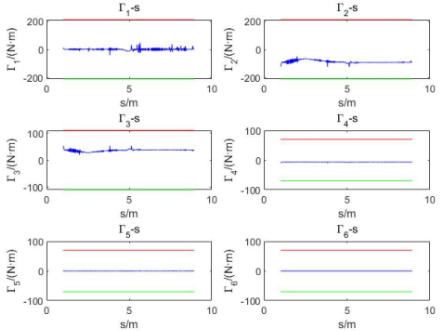
- Implemented a **time-optimal trajectory algorithm**, achieving robot arm movement within 1.35 seconds
- Leveraged **variable redundancy**, **time derivatives**, and **numerical differentiation** to overcome issues such as **increased optimal time** relative to initial solutions and trajectory instability under **singular configurations**
- Validated the algorithm through **practical factory production scenarios**, addressing key challenges in workpiece handling during real-world operations.



Working Scenario



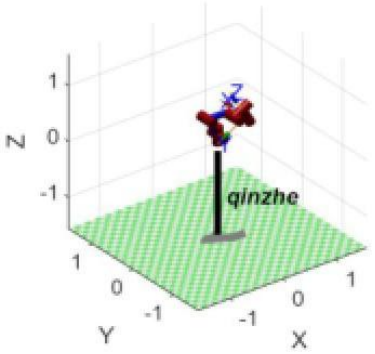
dq-t curve



τ-t curve

Robotics(SJTU-ME3403 Course Project)

- Realized the algorithm of forward and inverse **kinematics and forward** and inverse dynamics of series **industrial robot**
- Carried out the **dynamic parameter identification** algorithm of series robot
- Conducted a **dynamic algorithm** called **propagation method** with time complexity of N
- Designed the **control policy** to **maintain accuracy under inaccurate dynamic parameters.**



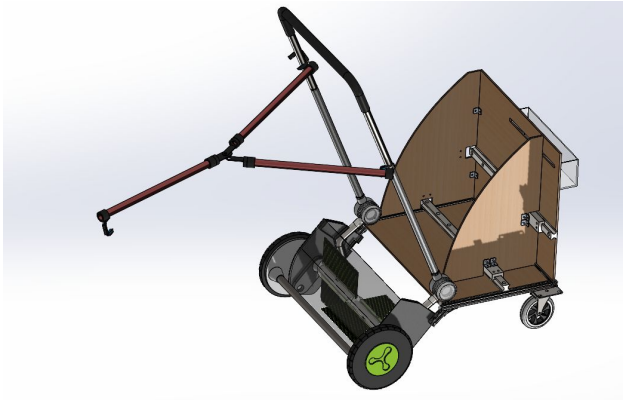
Control Policy in Simulink

Qinzhe Robot

Mechanical Design

Dual-Mode Lawn Sweeper(CMU-24441 Project)

- Enhanced traditional lawn sweeper design by introducing **dual operation modes** — **manual push** and **bike towing** — to improve user efficiency and versatility
- Designed **mechanical compression system** using integrated sliding rails in the trash bin to improve cleaning effectiveness



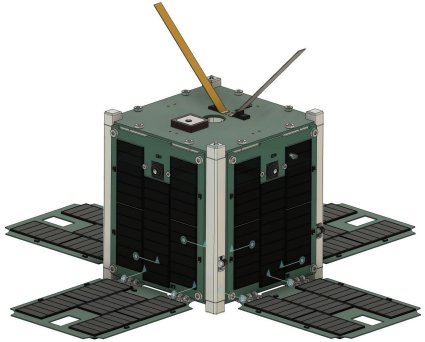
CAD Model

Hand Operation

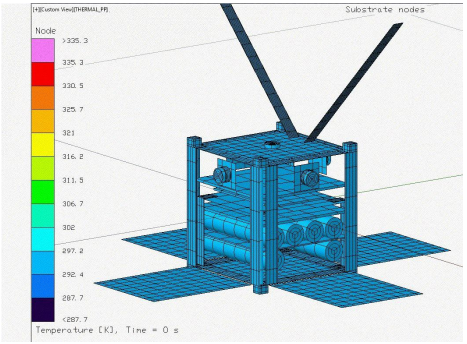
Bike Operation

Argus-2 (CMU-16873 Course Project)

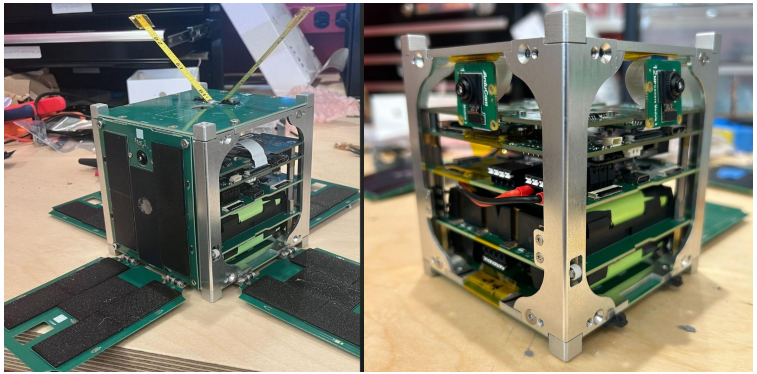
- **Argus** is a type of **CubeSat** designed to pioneer low-cost, lightweight, and accurate vision-based orbit determination.
- Member of **Mechanical Team**
- Developed **CAD model** for Argus-1 and Argus-2
- Contributed to **physical assembly** of Argus-1
- Conducted TVAC testing plan and Vibration testing plan



CAD Model



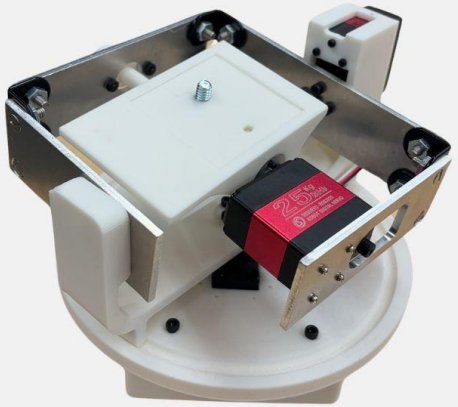
Thermal Simulation



Physical Assembly

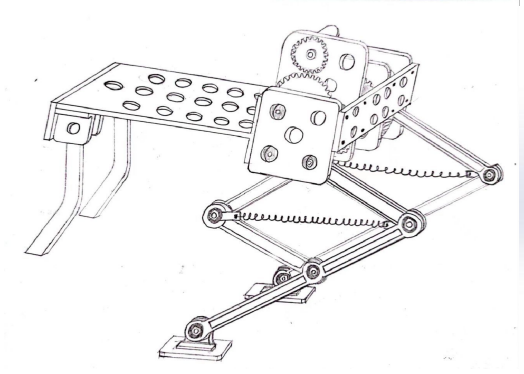
Self-leveling Tripod Attachment(CMU-24370 Project)

- Designed a **self-leveling tripod** to assist individuals with wrist pain or hand disabilities
- Integrated **IMU** and **Arduino-based control system** for automatic leveling
- Validated design through **FEA** and **hand calculations**, ensuring reliability under operational loads
- Prototyped with **PLA base** and **aluminum arms**, keeping the device lightweight and durable.

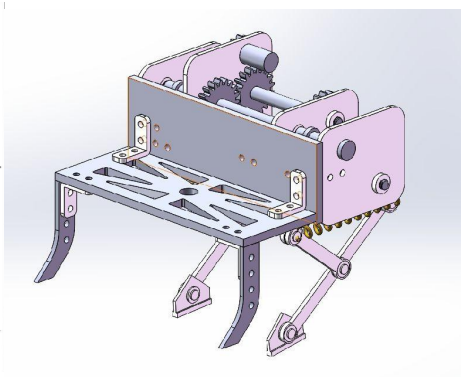


Bionic Frog(SJTU-ME3220 Course Project)

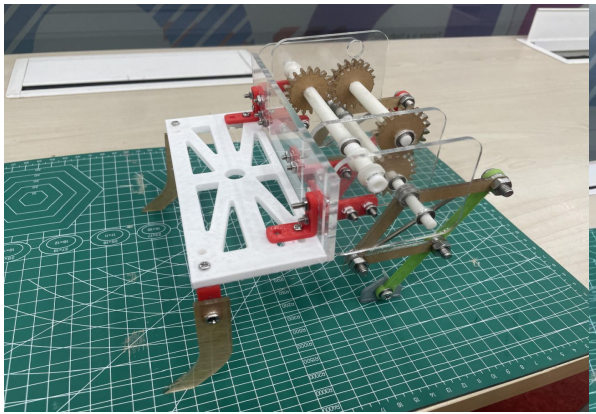
- Developed a bio-inspired **jumping robot** based on the biomechanics of frog jumping
- Designed a **four-link spring-driven mechanism** to replicate the force curve of frog hind limbs
- Created and validated a 3D model through kinematic simulations in SolidWorks
- Selected and verified components using **hand calculation** and **finite element analysis**
- Manufactured and assembled the robot with a total weight of **526.9g** including power and drive modules.



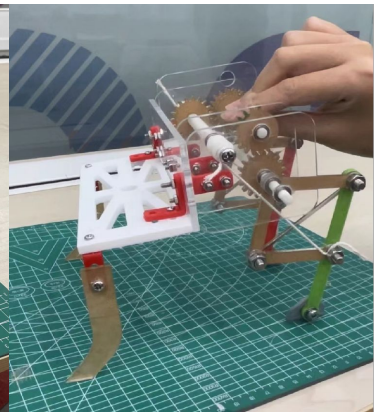
Sketch



CAD Model



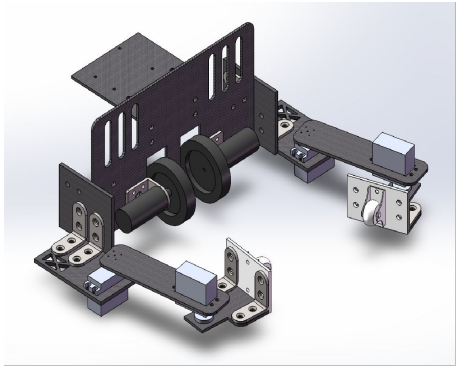
Physical Assembly



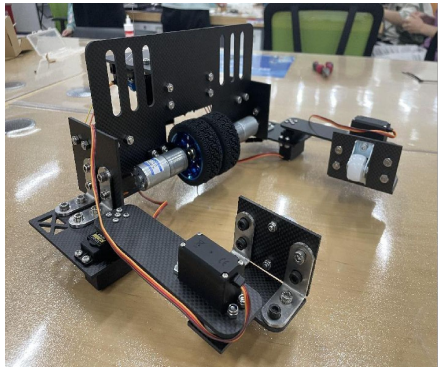
Testing

High adaptability Manned tree climbing platform(Course Project)

- Designed and developed a high-adaptability, human-carrying tree-climbing platform capable of **accommodating tree trunks of varying diameters**
- Optimized the mechanical structure using a **U-shaped embracing design** combined with lightweight **carbon fiber** materials to enhance strength-to-weight performance
- Achieved stable and reliable climbing functionality by integrating a **servo-driven wheel system**
- Completed the full mechanical assembly and system debugging, incorporating **servo motors, geared motors, and an Arduino-based control system** for precise operation and coordination.



CAD Model



Physical Assembly

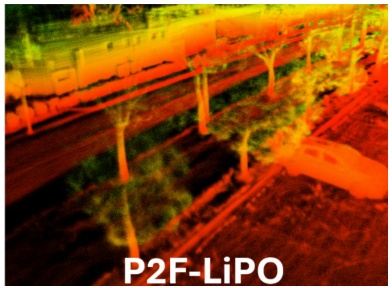
Research and Intern Project

Lipo(Research Project)

- Integrated a **Realsense Stereo Camera** (D455) to replace the original monocular camera and LiDAR sensors, enhancing perception capabilities
- Incorporated a **stereo factor** into the **Lipo factor graph framework** to achieve improved map reconstruction quality
- Link to the github repo: https://github.com/mmpug/lipo?tab=readme-ov-file

Wheeled Robot Platform

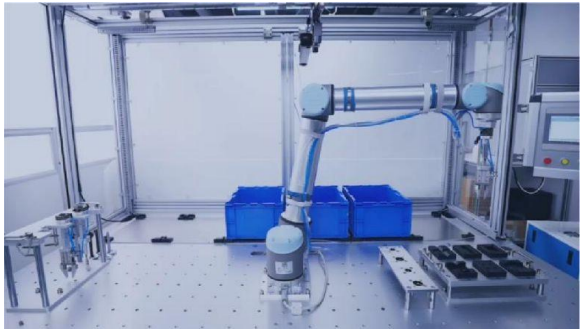
D455 Camera



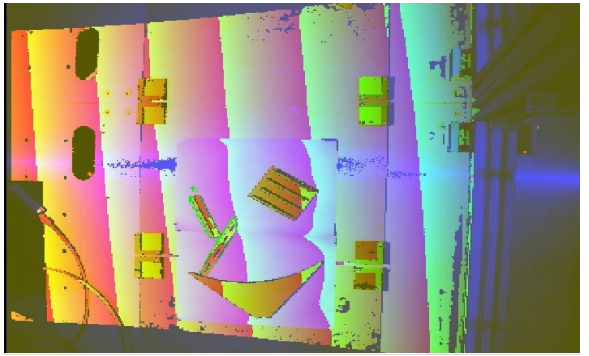
Map Reconstruction

Random Bin Picking System(Intern Project)

- Designed, 3D-printed, and tested various **ship component models** for robotic gripping tasks
- Developed a bin-picking and sorting work station, leveraging Halcon software and **machine learning algorithms** to train models for r**ecognizing different components** and enabling effective random bin picking.



Working Platform

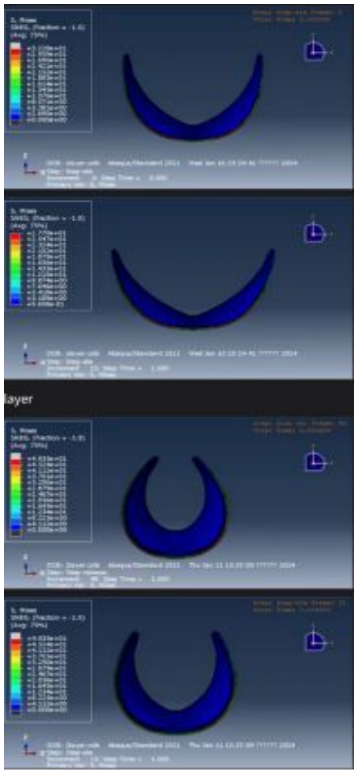


Picture captured by the camera

Design and optimization of silicon holder(Research Project)

- Participated in **experimental testing** focused on fabricating linear and controllable dielectric elastomer actuators (DEAs)
- Simulated the **deformation behavior** of DEAs under pre-stretched and powered conditions using **Abaqus**, providing insights into their mechanical response and performance.

Experimental Testing

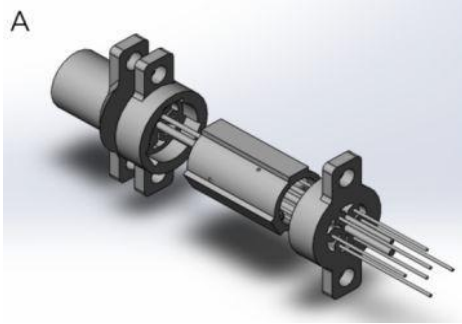


Abaqus Results

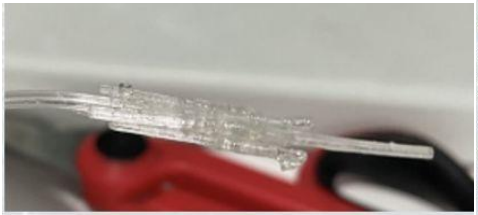
6DOF Pneumatic Robot(Research Project)

Designed and fabricated a 6 DOF **pneumatic robot** capable of remote operation inside confined cavities, guided by live **images** from a front-mounted camera.

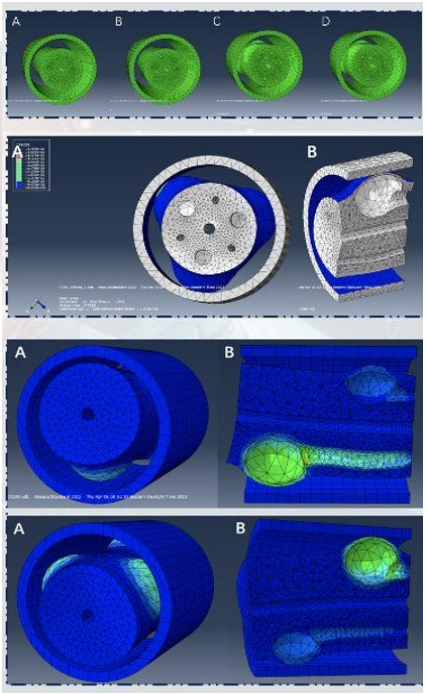
- Conducted **simulations in Abaqus** to optimize and validate the robot's movement and steering performance, achieving **precise and reliable control**.



CAD model



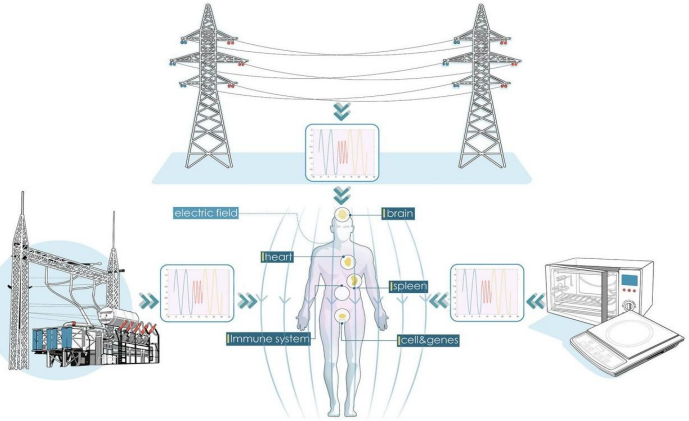
Pneumatic Actuator

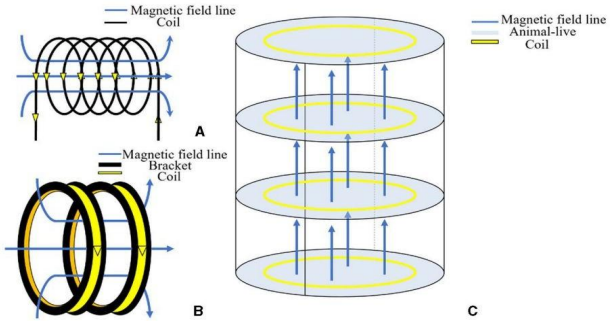


Abaqus Results

ELF-EMF (Research Project)

- Published a **review article** ”Biological effects of extremely low frequency electromagnetic fields: an experimental review” as a second writer
- Analyzed the **biological effect** of ELF-EMF by comparing physical parameters of mice exposed to ELF-EMF and mice growing up in normal environment
- Constructed a **Magnetic field generator** which could produce a uniform and low frequency electromagnetic field at an amplitude of 200 μT
- Obtain the influence of ELF-EMF on the neural signal by using the **machine learning model**





Other Projects

Bomberman(CMU-15112 Term Project)

- Bomberman is a game tailored for two players competing against each other.
- Main game features include multiplayers, game props, blockers(which cannot be stepped upon and blown up), landscapes(which can be blown up by the bombs.
- The term project is included in the TP Gallery and term project lightning round video which can be found in: https://www.cs.cmu.edu/~112/gallery.html and https://www.youtube.com/watch?v=lKIYhucQLhI&t=74s.