Qilong (Jerry) Cheng's Portfolio

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Education

University of Toronto, Toronot, Canada
B.S., Mechanical Engineering, 2017 - 2022
Minor in Robotics & Engineering Business in Rotman Commerce

Research Experience

STARS (Space and Terrestrial Autonomous Robotic Systems) Lab

Professor Jonathon Kelly University of Toronto, Toronto, ON 09.2021 – current

- Developed novel algorithms for 2D-radar-to-2D-radar and 3D-radar-to-camera **extrinsic calibrations** based on the radar/camera ego velocity estimation and rigid body motion on **MATLAB** without help from external targets
- Implemented different filtering methods like **RANSAC**, **Sliding-Window** and **Hampel Filter** to filter out noisy radar data
- Calibrated the **camera intrinsic parameters** via Kalibr, rectified the data using mage_undistort and SLAM pose estimation comparison using ORB_SLAM on **ROS**

Advanced Controls Research Lab

Professor Naira Hovakimyan University of Illinois, Chicago, IN 07.2021 – 12.2021

- Developed a novel lightweight chassis design for a unicycle robot via **generative design** on **Fusion 360** and **Altium Designer** for its controller board
- Researched on the **2DOF unicycle robot balance control** and maneuvering control using **reactional wheels**. Completed real-life testings and simulations on **MATLAB, Simulink, and Simscape**

Publication

- 2D Radar-to-Radar Extrinsic Calibration Using Ego Velocity State Estimation (To be submitted in Feb. 2023)
  - Determined the distinguishable states in 2D radar-to-radar extrinsic calibration using only estimated ego-velocities.
  - Proved the locally weak observability of our problem and identified degenerate motions for the method
  - Analyzed the sensitivity of our method to radar measurement noise in simulation
  - Determined, using a dataset, that our method produces more accurate parameters for radar ego-velocity fusion than state-of-the-art methods
- "Spatiotemporal Calibration of 3D mm-Wavelength Radar-Camera Pairs" (Under review)

  - Extended the algorithm in [**?**] to enable full spatiotemporal calibration of monocular camera-3D radar pairs in arbitrary configurations;
  - Analyzed the accuracy of spatiotemporal calibration with varying amounts of sensor noise, through a simulation study;
  - Carried out three different real-world experiments, which demonstrated that our algorithm is able to match the accuracy of an existing, target-based method and that we are able to perform calibration reliably in different environments, including for sensors on board an AV (autonomous vehicle).

- "Weakly Supervised Semantic and Attentive Data Mixing Augmentation for Fine-Grained Visual Categorization" in IEEE Access, vol. 10, pp. 35814-35823, 2022
  - Proposed a new data augmentation method(SADMix) for FGVC task,which based on a Semantic and attentive part localization module and a class activation resize module.
  - Implemented the SADMix and compare it with 4 general used data augmentation methods, also compare it with SOTA methods with baseline model with SADMi
  - Did some ablation study and visualization to discuss the effectiveness of the modules in SADMix .

- "Generative Design for Self-balancing Unicycle Robot in Additive Manufacturing" on ACAIB 2022
  - Proposed a self-balancing unicycle robot designed using generative design tools from Fusion 360 to reduce weight and the number of assembly parts
  - Validated the controllability of updated robot design using MATLAB Simulink and compared the generative-designed robot with the traditionally designed robot

Working Experience

BOE Technology Group Co.

Machine Learning Engineer Intern 05.2021 - 08.2021

- Developed and trained two CNN neural networks using TensorFlow and PyTorch that distinguish people's age, gender and clothing
- Carried out web crawlers and extracted over 3000 useful video and picture data online. Doubled the usable data for machine training. Overall accuracy increased from 64% to 89%

China State Shipbuilding Corporation (PEY)

Mechanical Engineer Intern 09.2020 - 04.2021

- Assisted designing the HVAC system layout of an upcoming 12-deck cruise ship using CADMATIC and Bentley
- Designed and filed a patent for a high-pressure spray nozzle and its associated fire pipeline system. The resulted CFD simulation achieved using 1/5 volume of water compared with existing design, and can put off fire in 1/3 of the time

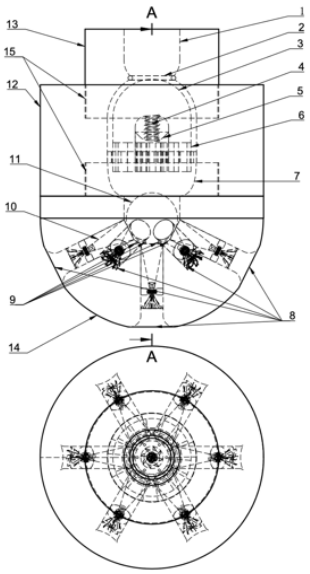

Figure 1: Patent design drawing illustration of the fire nozzle mechanism

Autodesk Inc.

Student Ambassador 09.2019 - 06.2020

- Established Fusion Design Association Club and served as club president. Helped the company trained over 30 students on using Fusion 360's solid modeling, sculpture, generative design and sheet modeling features
- Setup an annual 3D-printed glider competition and designed the glider launching system for the competition

Projects

Turtlebot2 SLAM, Navigation, Image Recognition and Machine Learning on ROS

- Implemented Frontier Exploration and PID controller for robot's exploration and path-following;
- Designed the control architecture based on Gmapping, AMCL and ROS navigation stack
- Incorporated Open-CV to distinguish different pictures within an unknown environment
- Implemented a Convolutional Neural Network to distinguish human's 7 different facial emotions.

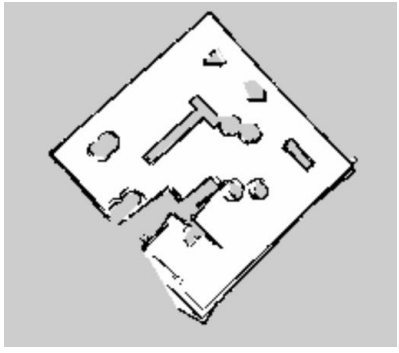

Figure 2: The final map generated via Gmapping using Gazebo on Rviz

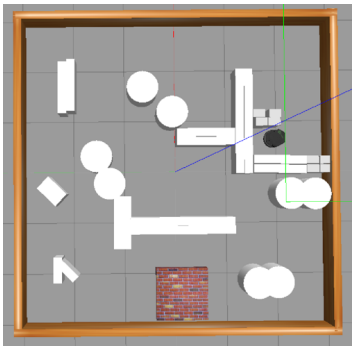

Figure 3: Robot in the unknown maze illustration

Mobile Robot Design and Maze Navigation & Localization

- Designed a 3D printed Arduino based mobile robot on SolidWorks and Fusion 360 that is able to navigate a maze and pick up objects within the maze.
- Implemented the Histogram Localization and PID controlled obstacle avoidance algorithm for maze navigation on MATLAB
- Developed an odometry state estimation algorithm by fusing ultrasonic sensor, IMU and wheel encoder,
- Developed A* Path Planning algorithm and object detection algorithm to pickup the block and unload to the specified loading zone

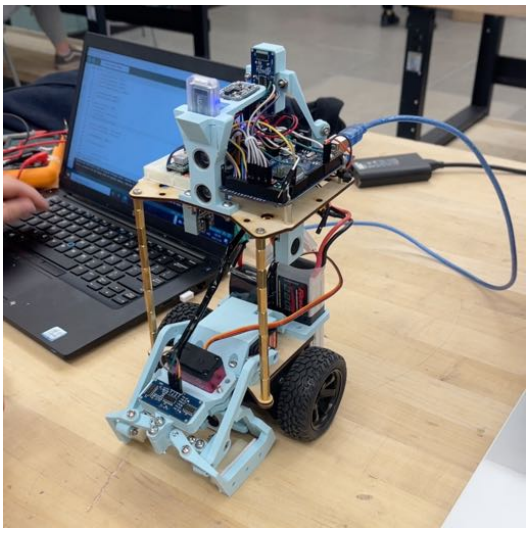

Figure 4: Designed mobile robot final assembly

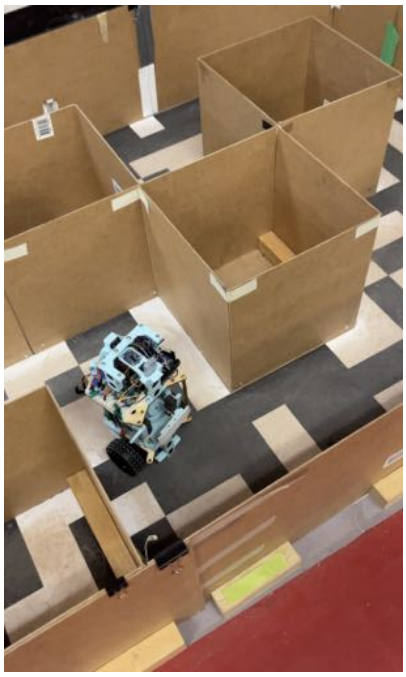

Figure 5: Robot navigation and localization in the maze

Electric Formula Racing Car Drive-train Capstone Design

- Designed the gearbox for the electric motor on Fusion 360 that increase the output torque by 4 times while maintain 90% above efficiency
- Validated the kinematics through **Kissoft** and related stress, thermal and vibration analysis using **Ansys**

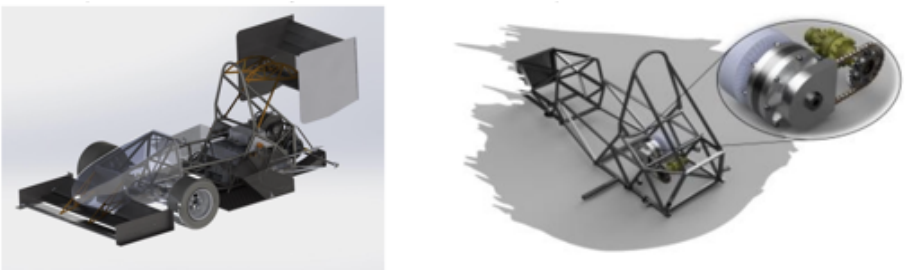

Figure 6: Overview of the electric formula car and the drive-train location

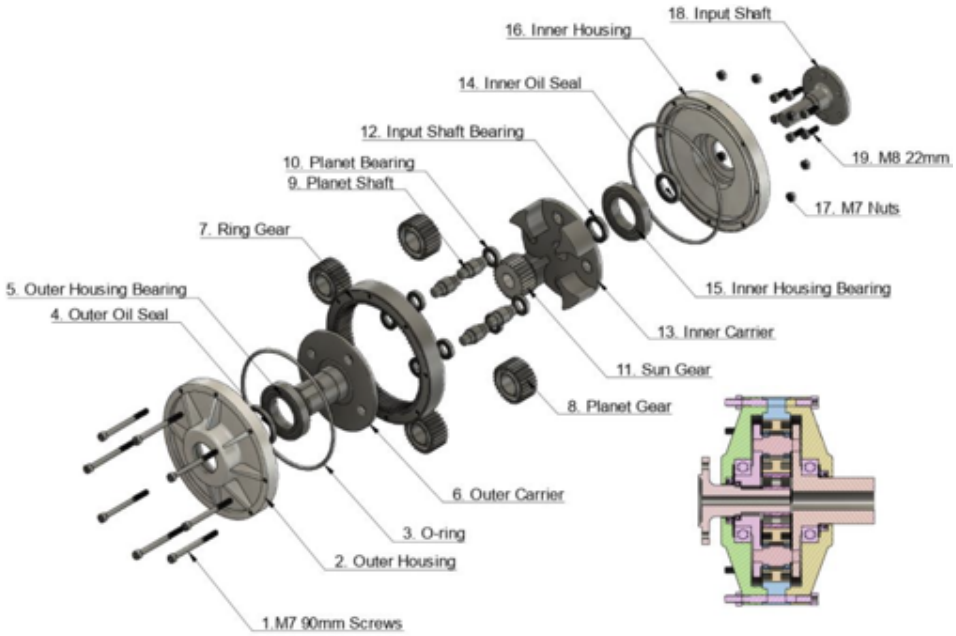

Figure 7: The exploded view of the gearbox and its components placement

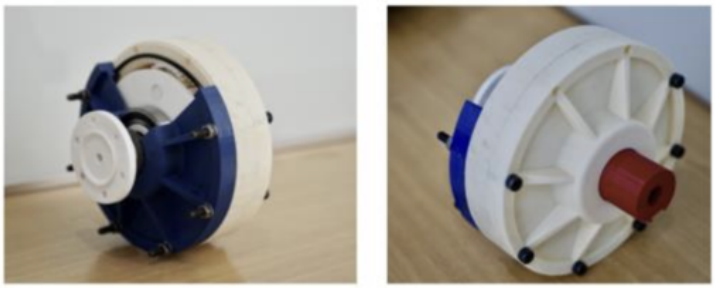

Figure 8: 3D-printed gearbox assembled for demonstration

Manipulator's Inverse Kinematic, Path Planning and Control

- Simulated the inverse kinematics and path planning algorithms on the PUMA robot in MATLAB
- Implemented the algorithm on the real-world KUKA industrial robot. The results achieve the robot's avoid obstacles in space, end-effector calibrations, and path planning to the desired locations

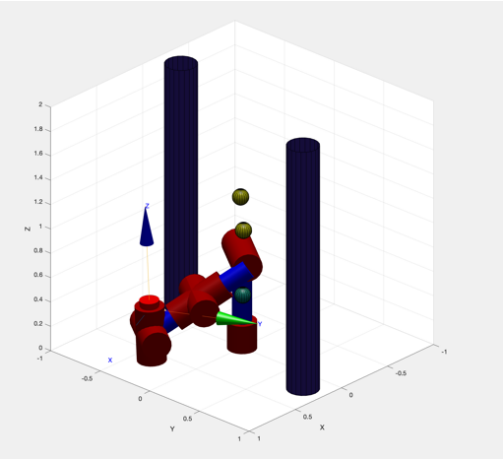

Figure 9: Simulated PUMA robotic arm obstacle avoidance and path planning in MATLAB

Figure 10: KUKA robot real-world obstacle avoidance, block pickup and path planning experiment

Unicycle Robot Design and Control

- Design a unicycle robot via generative design to reduce the overall weight and number of components
- Validated the controllability via MATLAB Simscape and justified the superiority using generative design for more responsive feedback control
- Built the actual robot for validation

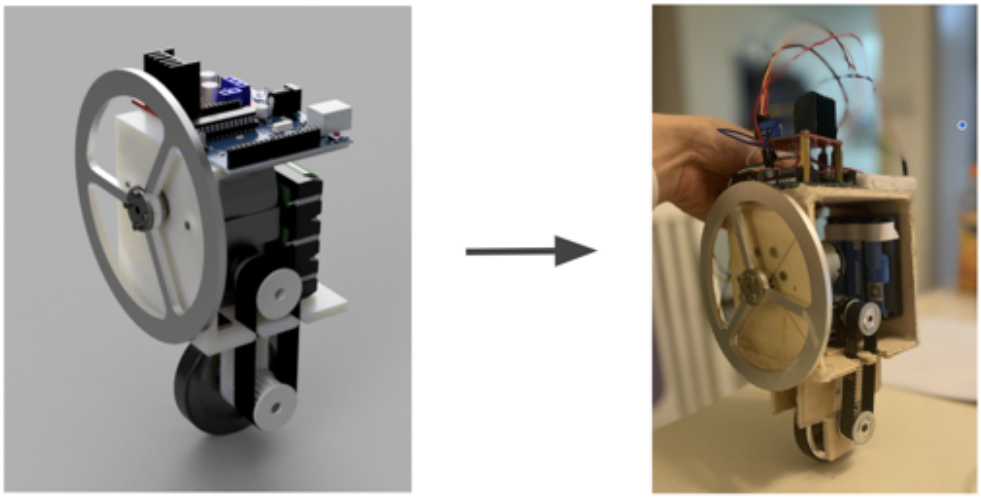

Figure 11: Unicycle robot model and the real-world assembly design

All-in-one Home Gym Mechanical Design

- Designed a highly integrated all-in-one home gym that is able to assist users complete 90% of the workouts.
- Replaced the common dead weights with pneumatically actuated "weights" for their cheap cost and compactness. By using a spiral gear-set, it also achieved consistent force output
- The two arms extended are equipped with 3-DOFs with two wires coming out as outputs

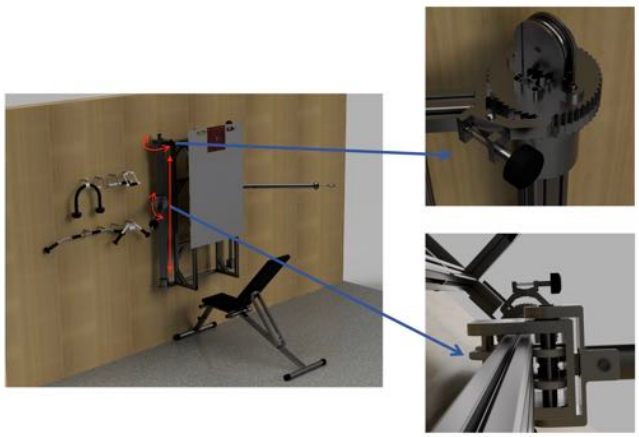

Figure 12: All-in-one home gym CAD model on the arm mechanism design

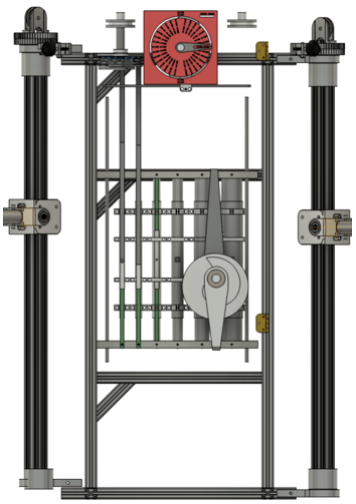

Figure 13: All-in-one home gym CAD model design on the pneumatic cylinder mechanisms layout

Classical Music Generation AI

- Implemented TensorFlow based **Recurrent Neural Network** and **Generative Adversarial Network** as training model to generate new classical music pieces that are unique with strong audibility.
- Collected thousands of classical music pieces, formatted and standardized them

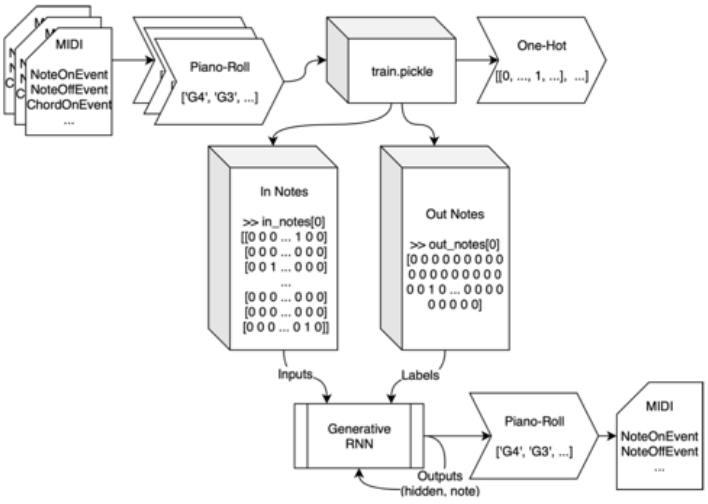

Figure 14: A high-level overview of the data pipeline for model training

8*8*8 LED Cube Embedded System

- Designed an 8*8*8 LED cubic matrix based on ESP32;
- Programmed an API library for the 3D cube that can be control each individual LED using SPI communication protocol and multiplexing
- Programmed a 3D Snake game and 3D Pong game on the cube using C++

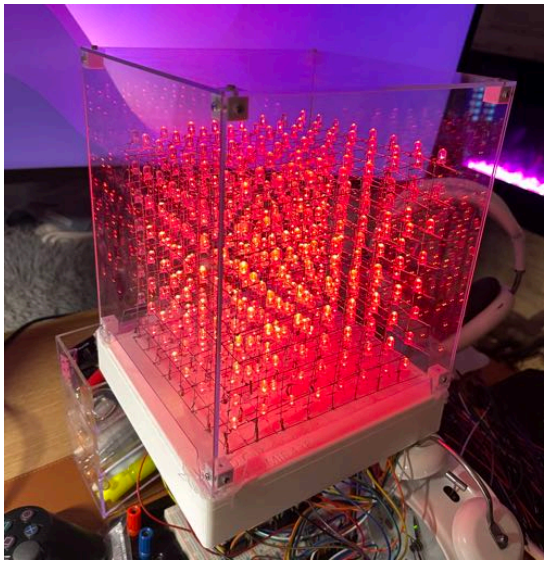

Figure 15: 8*8*8 LED Cubic Game Console

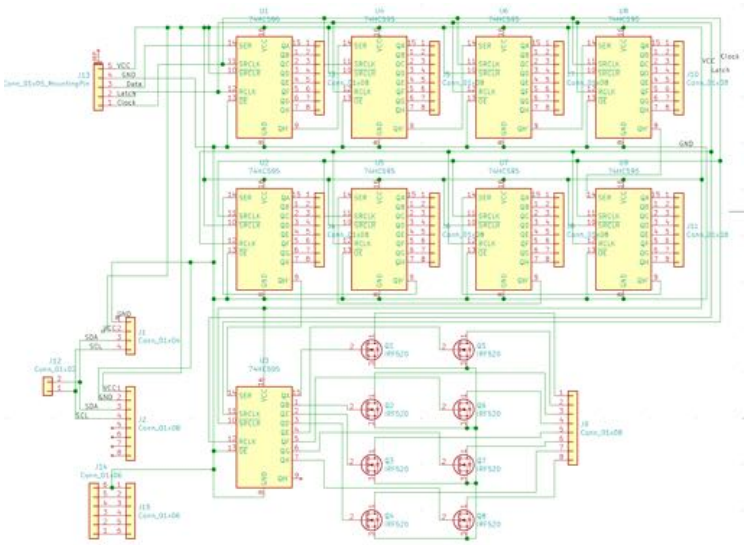

Figure 16: LED Cube Schematics

CNC Plotting Machine

- Designed a 3 DOF plotting machine based on CNC sheld and controlled via modified Gcode for plotting and drawing purposes
- Created an algorithm that process any image into a pencil-like drawings using OpenCV for the plotter

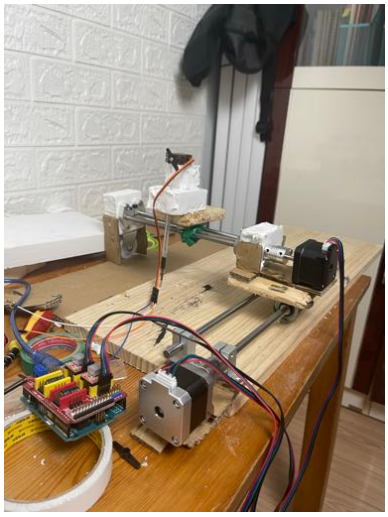

Figure 17: Final assembly of the CNC plotting machine

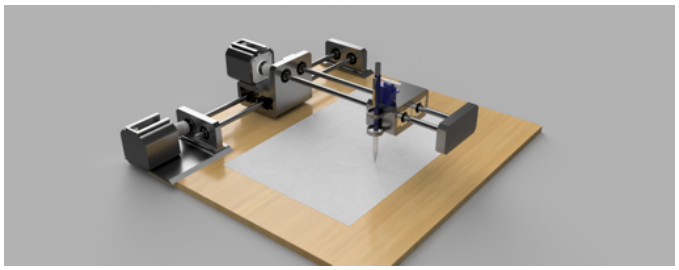

Figure 18: Updated CAD of the CNC plotting machine

Skills

- Programming:
  - **C/C++**: Programming for Embedded System; Objected Oriented Programming; Able to implement different algorithm for path planning and navigation
  - **ROS**: Experienced in controlling mobile robots using ROS; collecting and processing camera, radar, lidar data via rosbag; implementing different SLAM tools for mapping and navigations.
  - **MATLAB**: Simulink and SimScape for control system simulation; Data analyzing and visualization
  - **Python**: Experience in machine learning, using Numpy, Panda and TensorFlow; building various types of neural network, including CNN, RNN and GAN.
  - **Linux**: Efficient in using command lines; programming for embedded systems and building servers using Raspberry-Pi
- Hardware:
  - **PCB Design**: Experienced designing digital control circuits, analog power supply, etc on Eagle, KiCAD, generating manufacture-ready Gerber files, BOM for cost analysis. And simulations on LTspice.
  - **IMU**: Experienced with Sensor Fusion, Kalman Filter, Complementary Filter. Worked with various IMU sensors: MPU6050, BMO055 etc.
- Modeling:
  - **SolidWorks**: Obtained a Certificate from SolidWorks Association
  - **Ansys**: Able to perform CFD, Fluent, Static Stress, Dynamic Stress, Vibration simulations, etc.
  - **Fusion 360/AutoCAD**: Proficient in Generative Design, Computer Aided Manufacturing, able to perform CFD and other Mechanical Simulations,