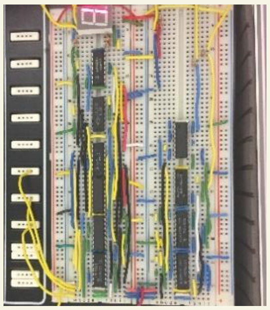
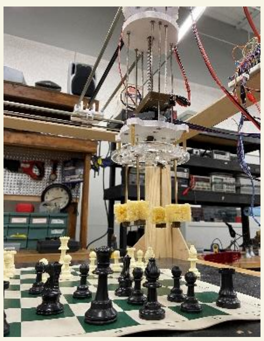



Joshua D. Eckels

Engineering Portfolio

University of Michigan
eckelsjd@umich.edu

Contents

About Me

This page is intended to give some background on who I am and what I do. The rest of the portfolio showcases some of the cool projects I've done over the years.

I am currently an Aerospace Engineering PhD student at the University of Michigan, (I received my B.S. in Mechanical Engineering at Rose-Hulman in 2021). My current research is focused on predictive plasma dynamics modeling for electric propulsion systems. I have significant project experience in computer vision and machine learning, and I have worked in the field of nondestructive evaluation at Los Alamos National Laboratory. I also enjoy working with embedded systems and microcontrollers.

Technical skills

- Java, C, Python, MATLAB
- Embedded systems, microcontrollers
- CAD (Solidworks)
- FEA, CFD (ANSYS, STAR-CCM+)
- Machine learning (Fast.ai, PyTorch)
- Shop and fabrication (CNC, welding)

I love playing piano and guitar. I'm really into running, cycling, and swimming, and hope to do an Ironman soon. I love flying and adventuring, and I dream of going to space one day.

Interests, Aspirations, etc.

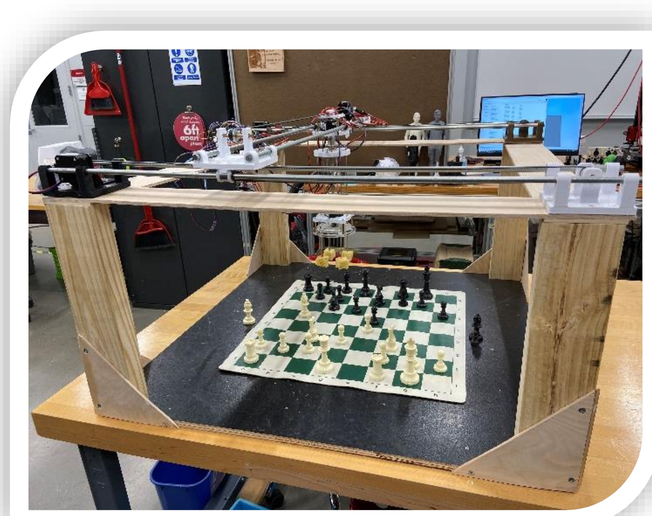
- Piano, Guitar, Choir
- Building and flying a plane
- Completing an Ironman
- Going to Mars

Stockfish Mecha: A Chess Robot

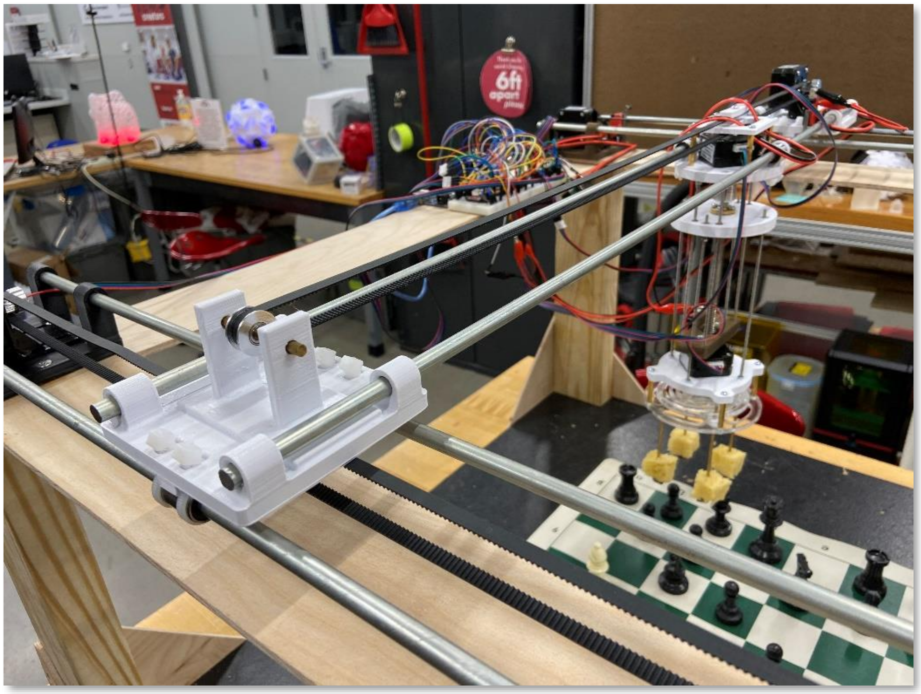
Rose-Hulman, Terre Haute, IN

In 4 weeks, I designed, modeled, constructed, programmed, and tested a full-size chess-playing robot that will defeat any opponent who challenges it.

The wood frame and all small parts and components were designed and modeled in Solidworks. Several stepper motors and 3-D printing components were used to make an X-Y-Z gantry system that moved a claw arm around a chess board. All motors and sensors were controlled with C running on an Arduino Mega board. After the human player makes a move, the Stockfish 12 chess engine decides the robot's next move and instructs the microcontroller to actuate the move on the real chess board.



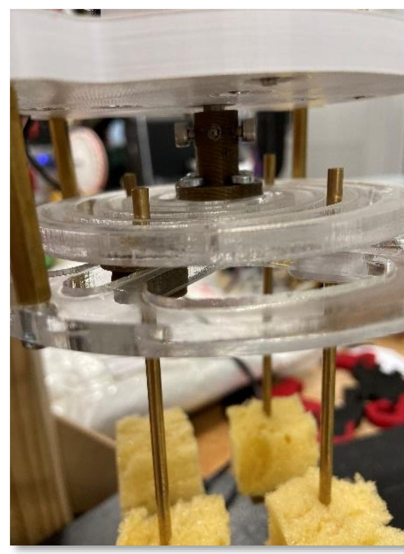
Mark-II of the chess robot is on its way, complete with a camera vision system, a new frame, and an adjustable machine learning algorithm to learn the skill level of the human opponent.

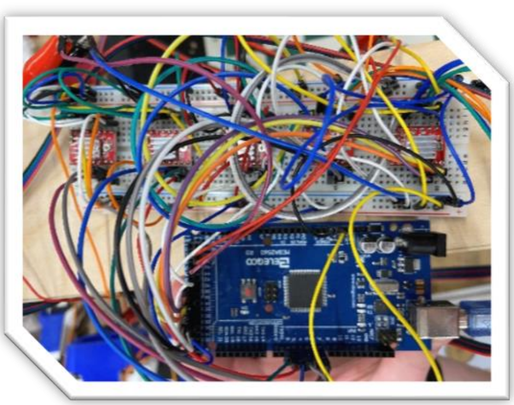


Design, Model, Build: A full X-Y-Z gantry and gripper system was modeled and built based off of 3D-printer systems and components.

Piece Gripper: A spiral disk was laser cut from acrylic and attached to a stepper motor. The rods follow the spiral profile upon rotation to actuate a gripping motion.

Arduino Mega: The microcontroller receives commands over serial from the Stockfish 12 engine (running on a Raspberry Pi) and actuates the linear motion gantry system.

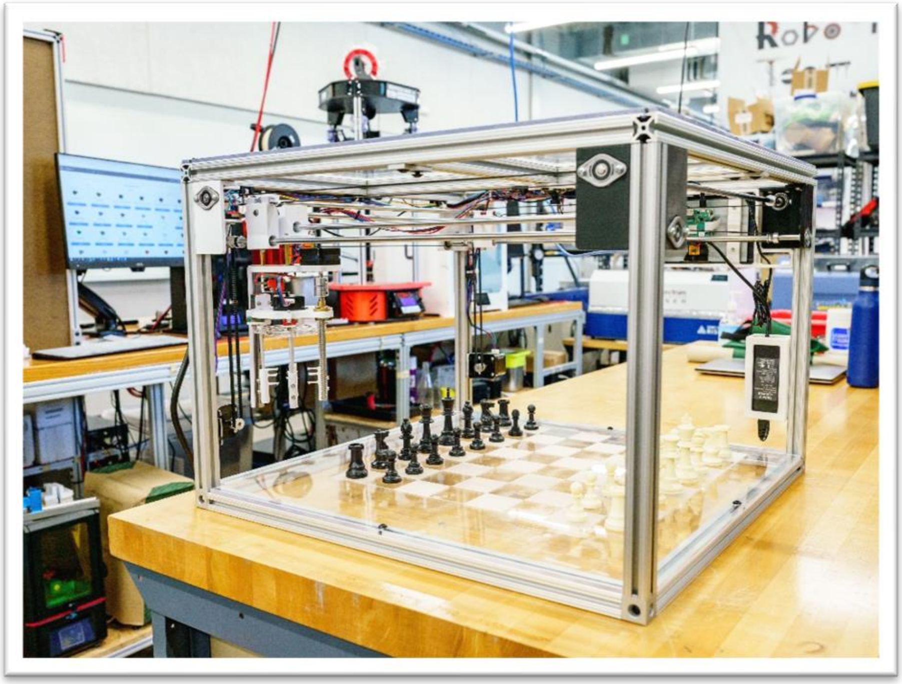


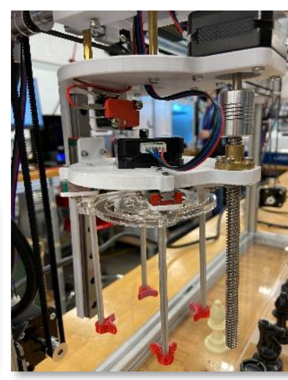


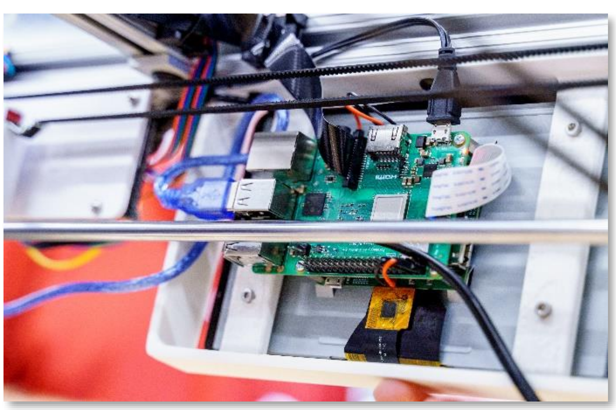
Relevant skills:

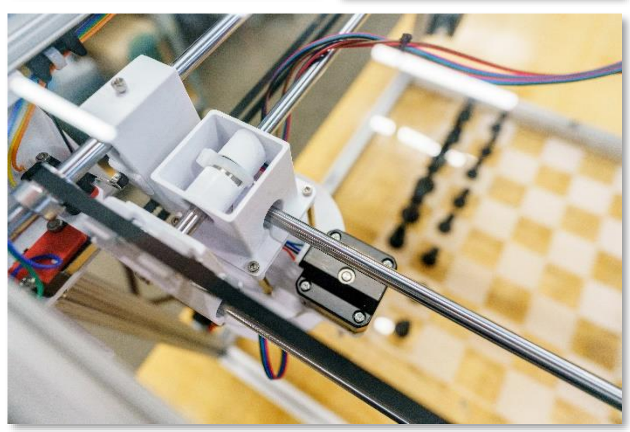
- Solidworks
- Microcontrollers, C
- 3D-printing, laser cutting, etc.
- Computer vision, chess engine

Stockfish Mecha: Mark II





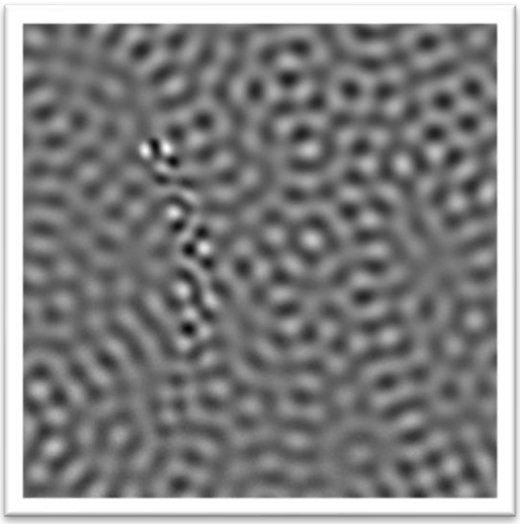


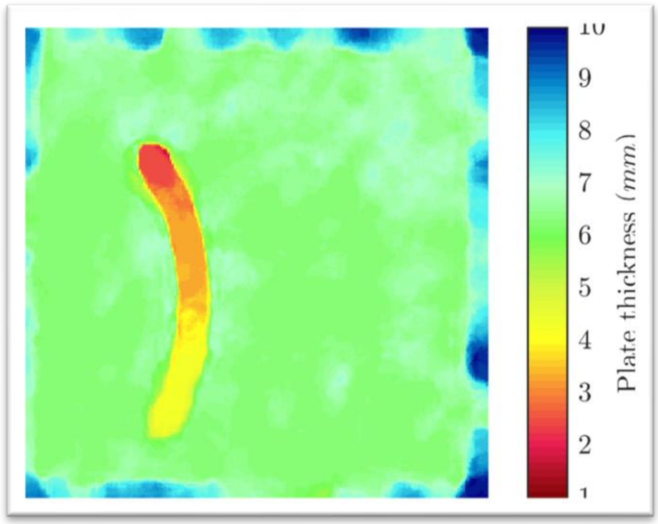


❖ Chess Robot Promo Video

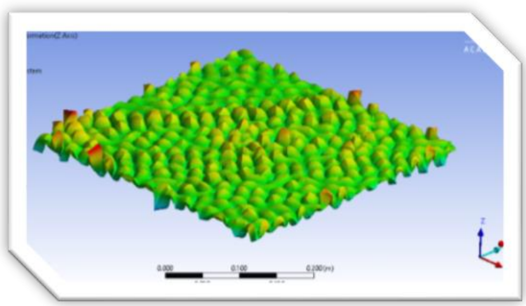
Ultrasonic Wavefield Defect Detection

Los Alamos National Laboratory, Los Alamos, NM



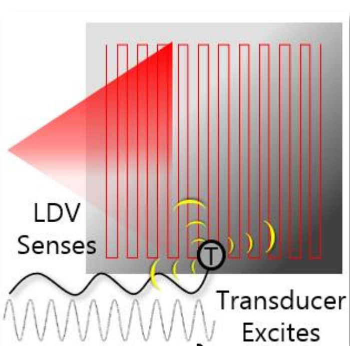


An ultrasonic transducer excites a plate-like structure to steady-state and a laser Doppler vibrometer (LDV) scanner obtains the surface velocity response shown above on the left. The wavenumber of the propagating waves is dependent on local changes in thickness of the plate, which indicates damage such as corrosion, cracking, or delamination.



A convolutional neural network was trained on simulated ultrasonic wavefield images in order to classify plate thickness on a pixel by pixel basis, as shown in the top right.

This algorithm performs orders of magnitude faster than traditional methods and provides more accurate results.

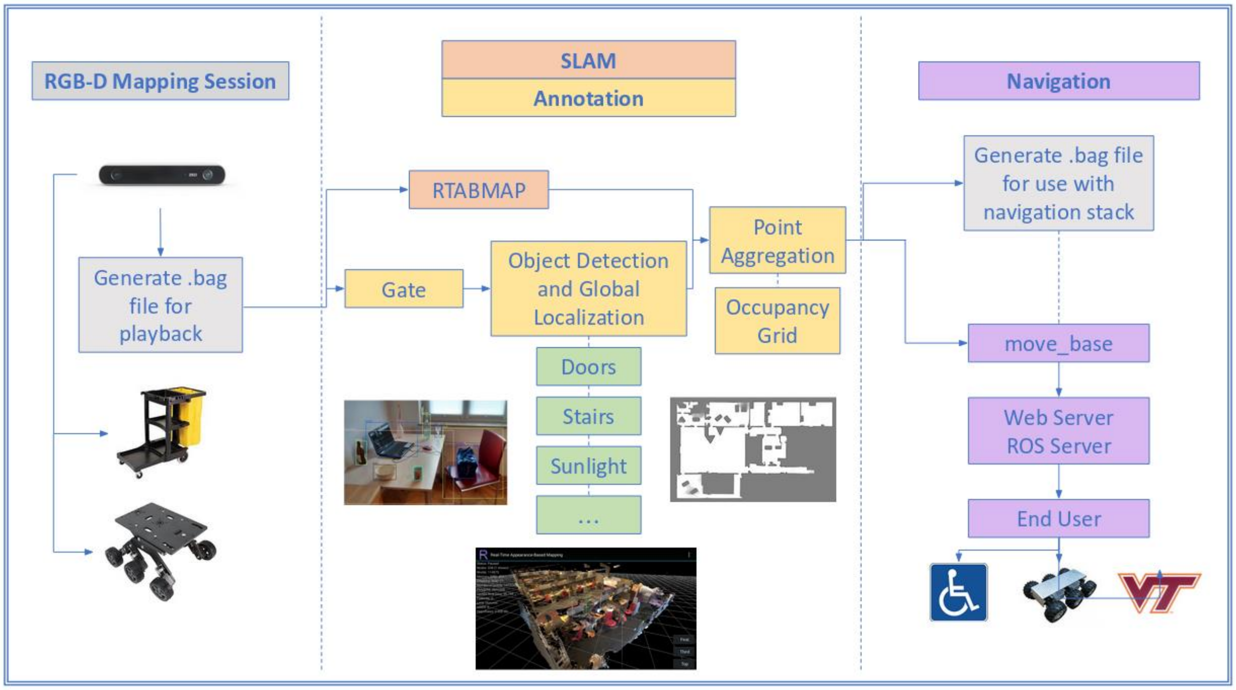


Relevant skills:

- ❖ Ultrasonic inspection
- ❖ Convolutional neural networks (CNNs)
- ❖ CAD and FEA (Python automation)
- ❖ MATLAB image processing

Accessibility Constraint Mapping

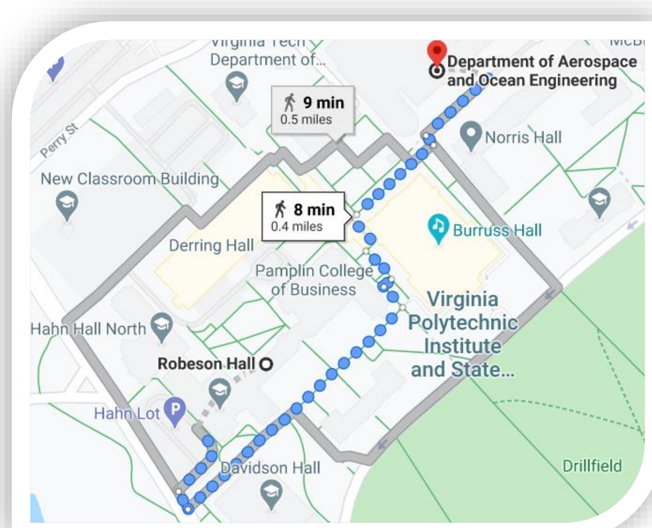
Virginia Tech, Blacksburg, VA

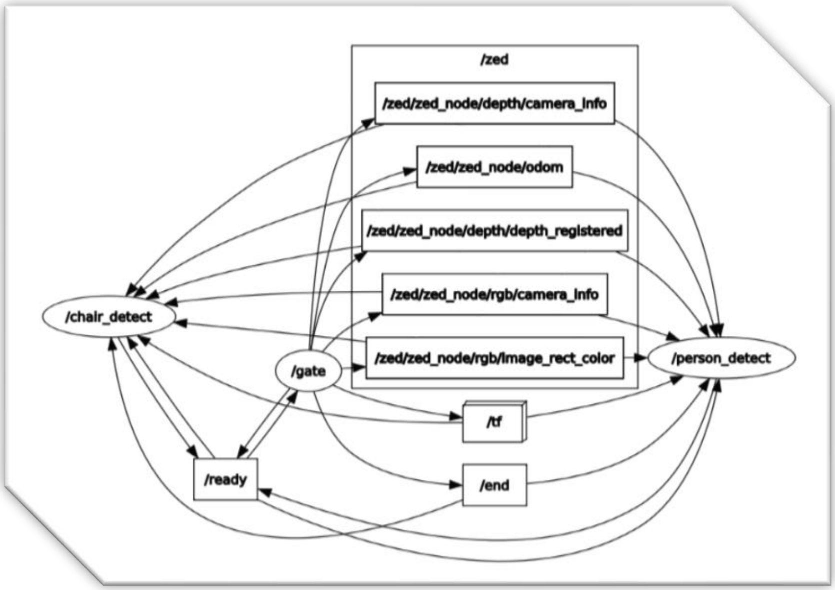


This is a research project at the Assistive Robotics Lab at Virginia Tech.

The goal of this project is to use the Robotic Operating System (ROS) to identify potential barriers or constraints in the environment for autonomous robot or handicapped/accessibility navigation and traversability.

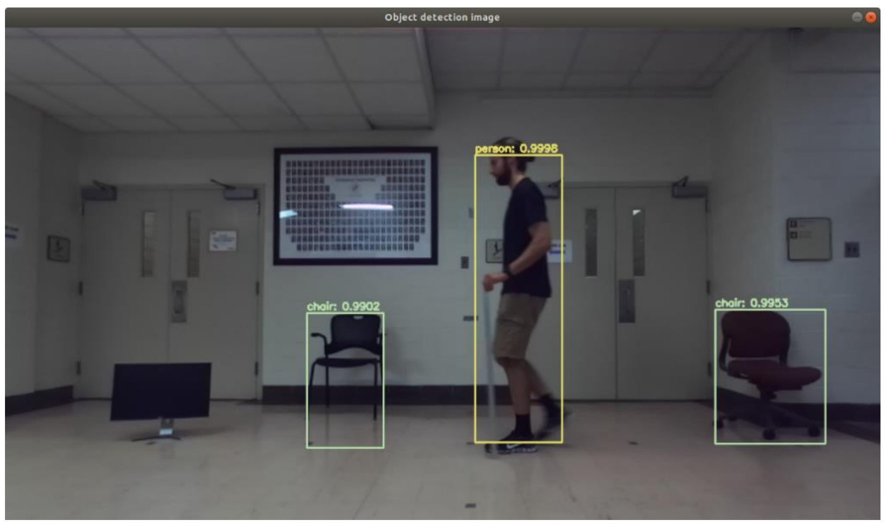
This project would generate global maps of the environment (using existing Simultaneous Localization and Mapping (SLAM)-based approaches) that are annotated and labeled with barriers, such as stairs, doors, and handicap-accessible blue buttons. This map would allow a user to plan an optimized path from point A to point B that accounts for all personally potential barriers, whether the user is a handicapped wheelchair user or a small autonomous rover.





ROS node and topic diagram: SLAM annotators are shown with ZED camera topics for object detection and localization in a 3D environment.

Computer vision using OpenCV: Chairs and people are detected in the environment using neural networks and computer vision.



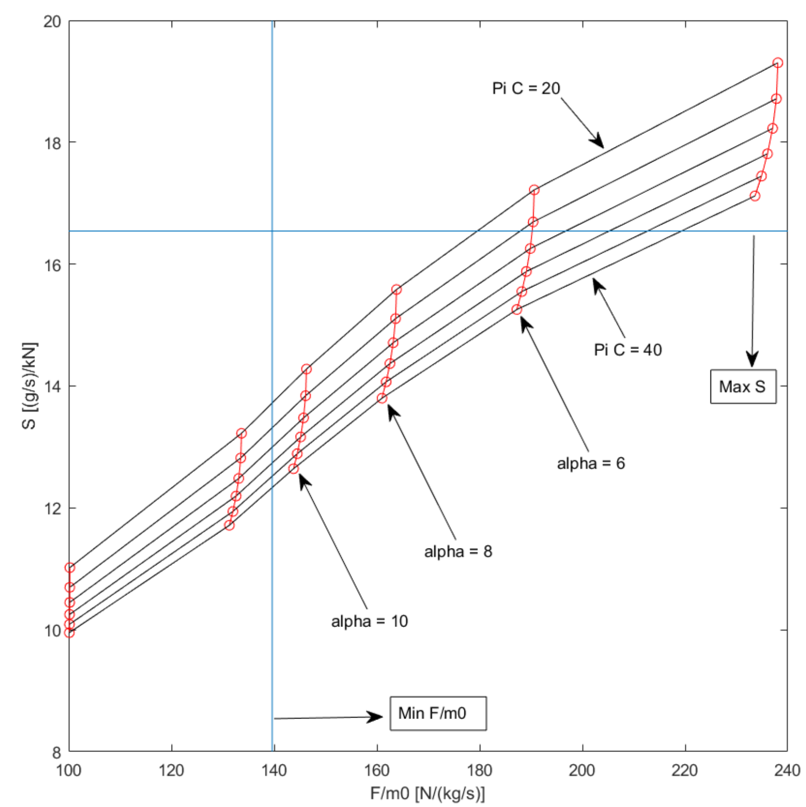
Relevant skills:

- ❖ Python software development
- ❖ Robotic Operating System (ROS)
- ❖ Computer vision (OpenCV)
- ❖ Simultaneous Localization and Mapping
- ❖ Convolutional neural networks (CNNs)

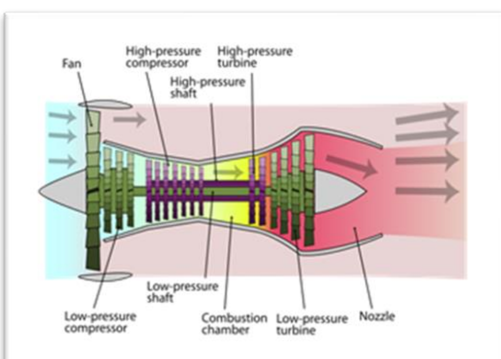
Github:

- ❖ https://github.com/eckelsjd/access_mapping.git

Turbofan Cycle Analysis



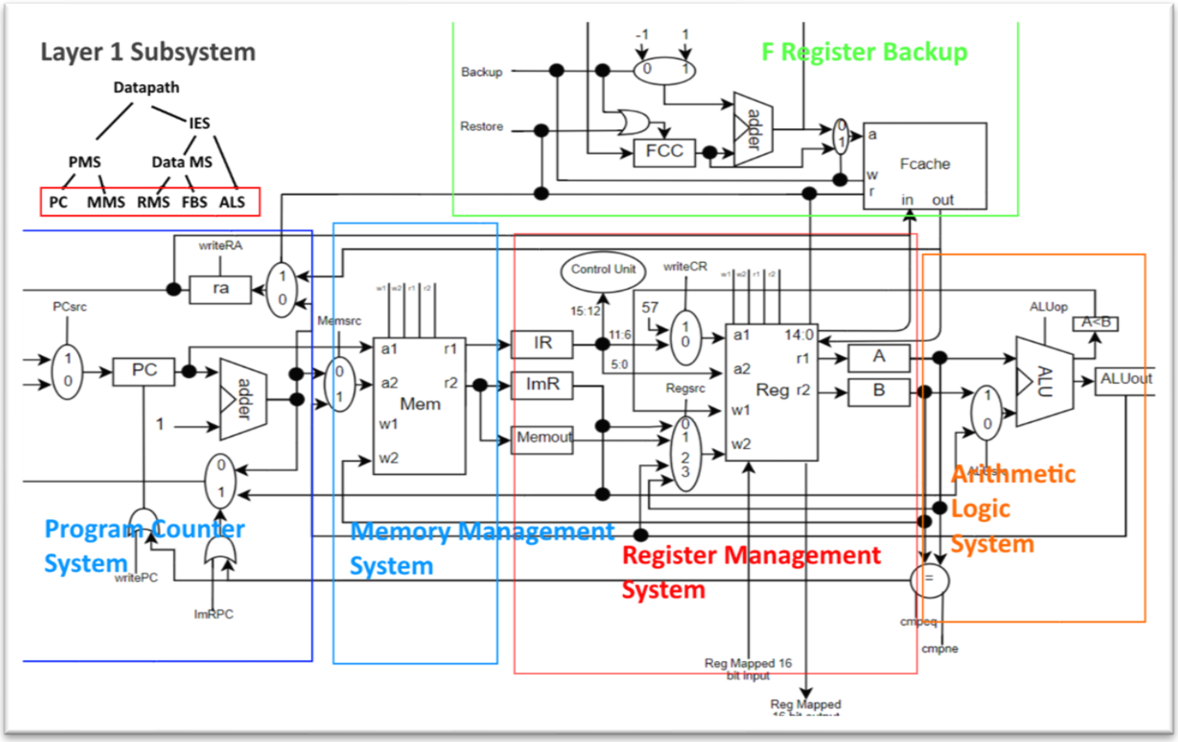
All inlet and outlet properties of a turbofan engine were analyzed with varying bypass and compressor ratios to produce the carpet plot shown above of specific thrust $(\frac{F}{\dot{m}_o})$ vs. thrust-specific fuel consumption (S).

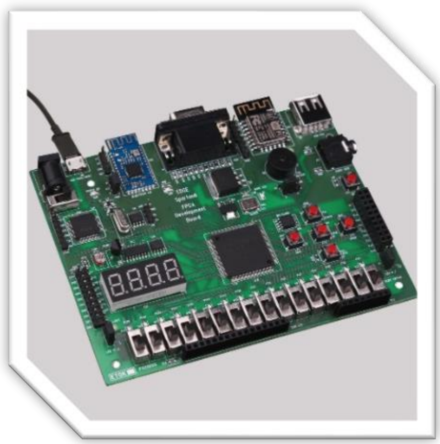


Relevant skills:

- ❖ MATLAB
- ❖ Excel
- ❖ Propulsion / thermodynamics
- ❖ Turbofan engine cycle analysis

16-bit Computer Processor





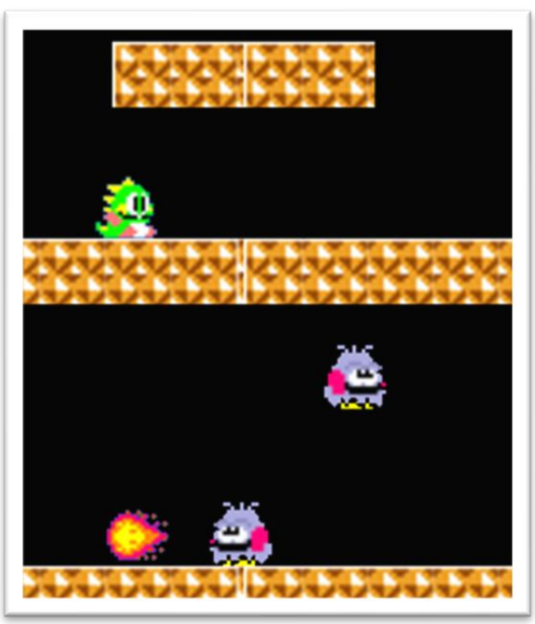
The culminating group project of a computer architecture course had our team of four design and implement a mini computer processor capable of performing several basic algorithms.

A 16-bit assembly language instruction set was modeled off of the 32-bit MIPS assembly language and a load-store and cache-based datapath was implemented, as shown above. The datapath was fully implemented and tested extensively in Verilog. In addition, an assembler and code simulator were built in C++ for our assembly language.

Relevant skills:

- Verilog
- C++
- MIPS assembly
- Low-level programming

Java Arcade Game



The classic platform 8-bit arcade game, Bubble Bobble, was implemented in Java.

Using software engineering principles and Unified Modeling Language (UML), classes were designed to encompass major components of the Bubble Bobble arcade game. These classes were fully implemented in Java and a graphical user interface (GUI) was also created that supported mouse movement and keyboard input.

Relevant skills:

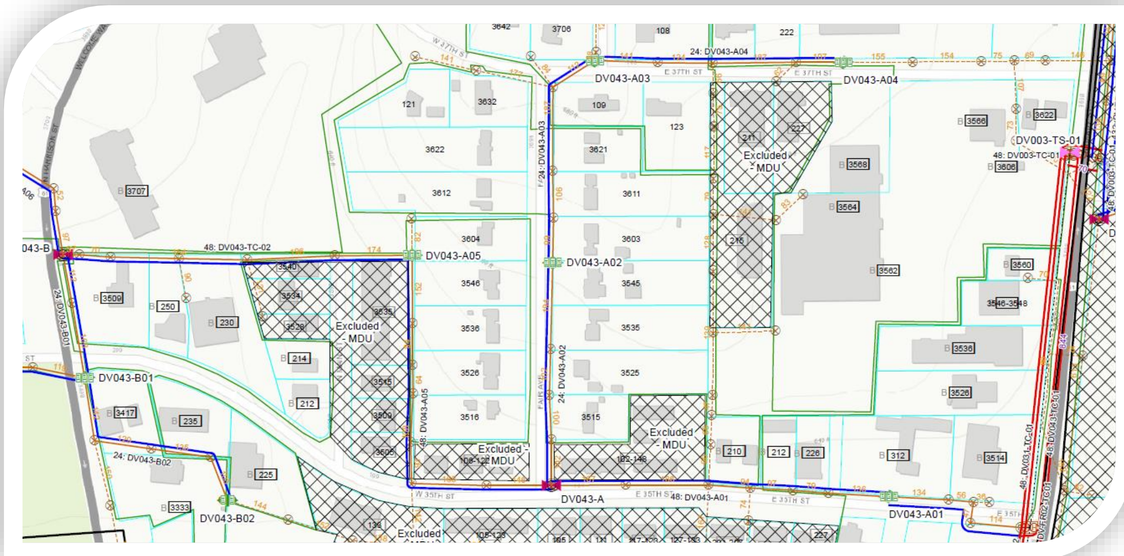
- Java
- UML

Github:

- https://github.com/eckelsjd/BubbleBobble.git

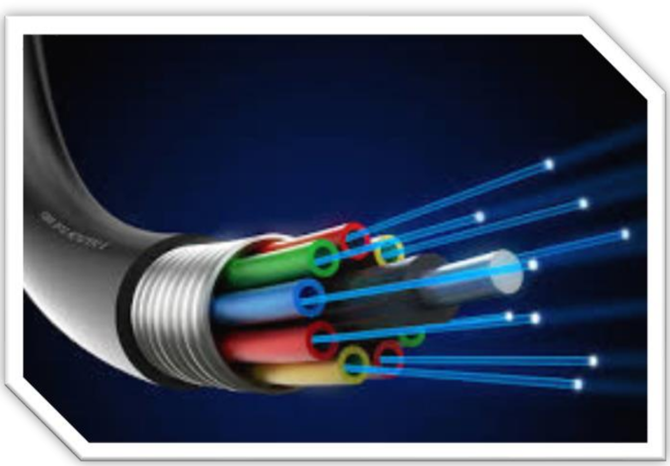
Fiber Cable Distribution

Metronet, Evansville, IN



Project work at Metronet involved updating and maintaining fiber distribution maps, as shown above.

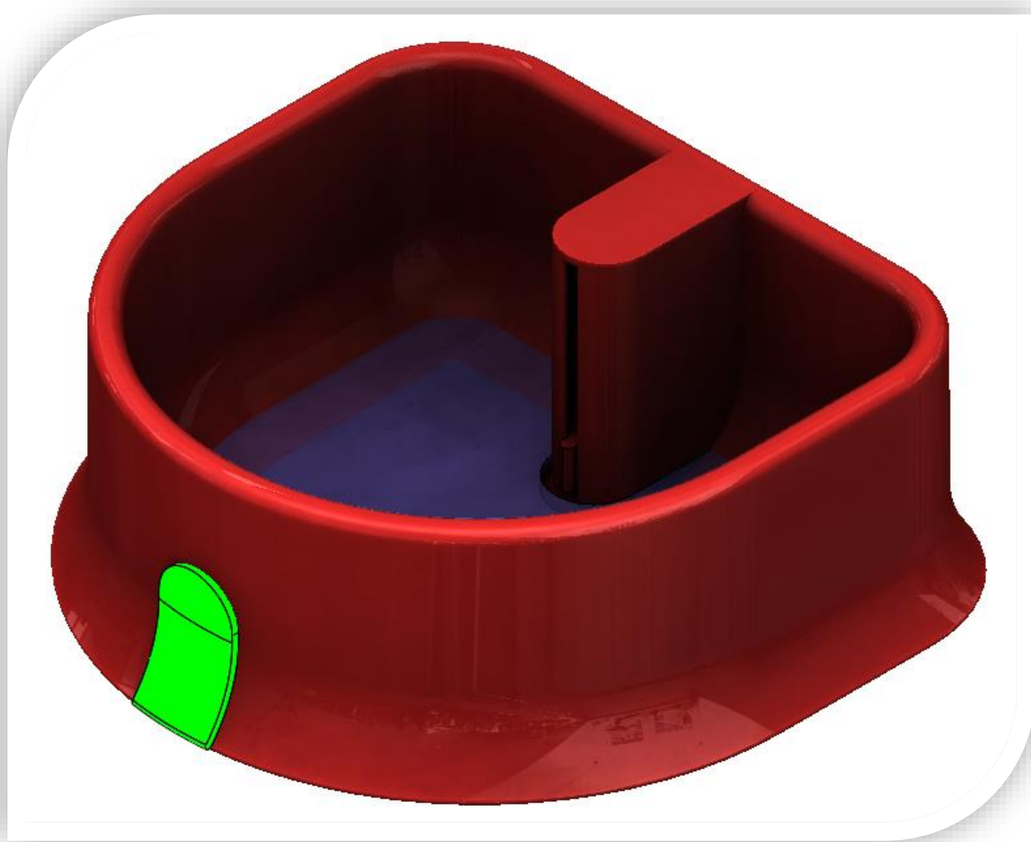
Using geographical information systems (GIS) software, the fiber distribution was spread into new regions, while placing and tracking all fiber and telecommunications equipment and providing a bill of materials and cost analysis. The project also involved performing quality control on previously designed distribution maps.



Relevant skills:

- Geographical information system (3-GIS)
- Bill of materials and cost analysis
- Microsoft Excel, Word

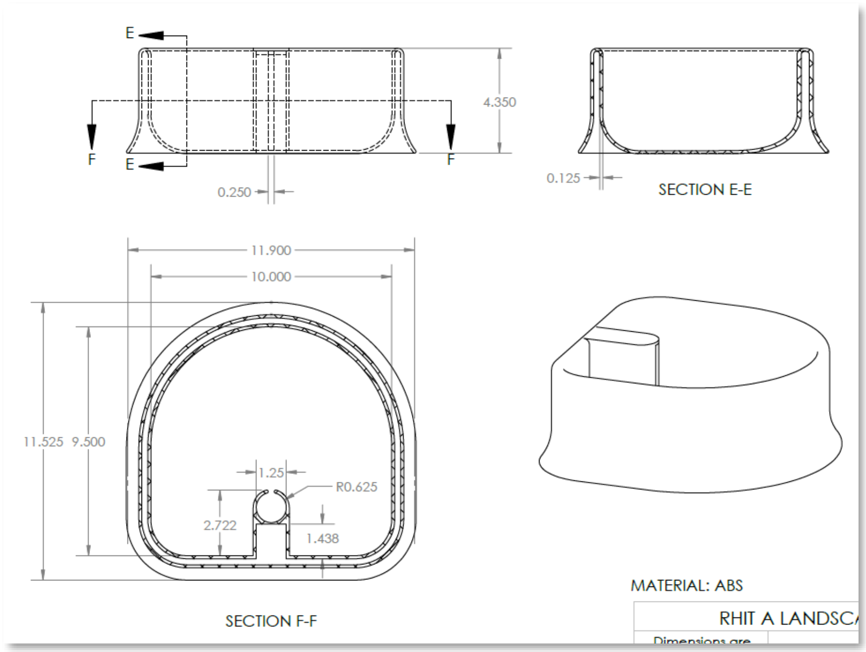
Pet Bowl Design



The pet bowl shown above was designed, prototyped, and documented following basic design process principles. The green LED at front indicates low water level by means of a floating magnet that triggers an on-board Hall-effect sensor circuit.

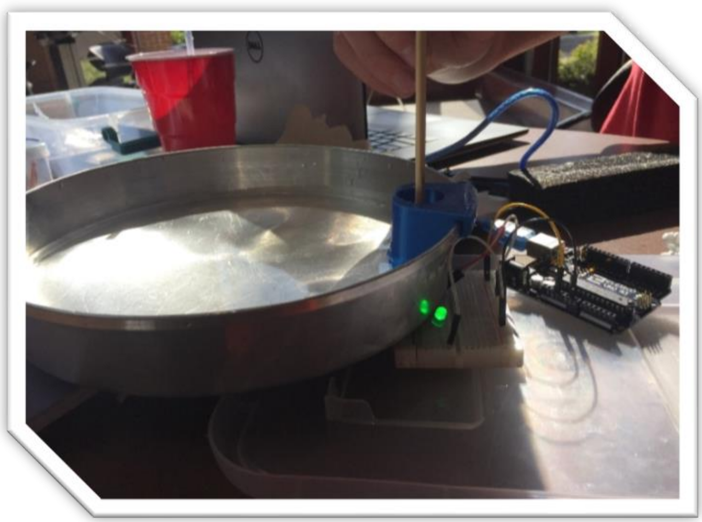
The market was first evaluated and product benchmarking was performed on similar products. Several gaps in the user's experience were discovered and solved with several design ideas. A decision matrix was used to evaluate all design ideas against tangible metrics. The chosen design was further revised and reviewed to meet original design goals.

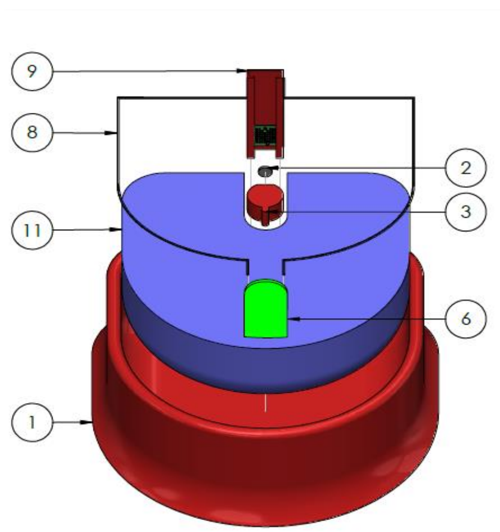
Solidworks was used to implement part geometry and show the final product. The design was prototyped, tested, and evaluated against design criteria.



Solidworks design and drawing: Solidworks is used to fully describe part geometry and produce a viewable result of product design for the end user.

Product prototyping: A magnet with a basic Hall-effect sensor circuit is setup and shown to the right. The green LED lights up as proof of concept for a low water level indicator for a pet bowl.

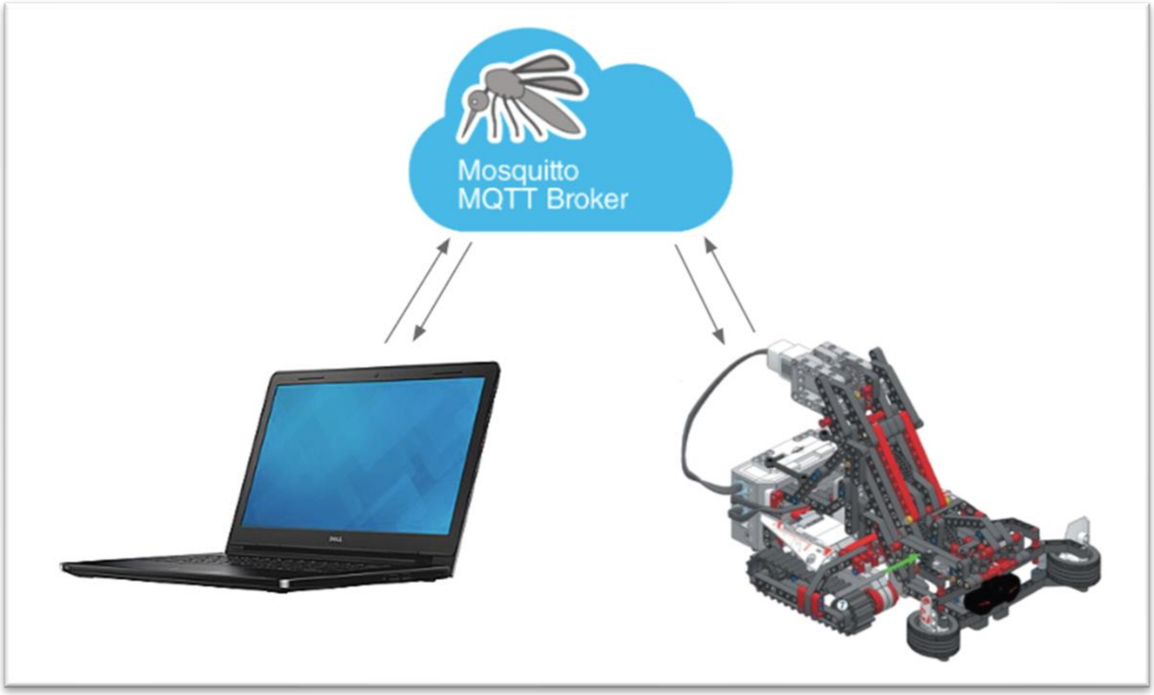




Relevant skills:

- Solidworks
- Integrated circuits
- Product benchmarking
- Design evaluation
- Prototyping
- Functional analysis
- Cost analysis and modeling

Python Robotic Control



Using Python as a platform and MQTT communication through a Linux command-line, the popular Mario Kart game was simulated with a legoEV3 robot. A laptop was used for keyboard communication and control of the robot, and the robot was programmed to respond to the environment in a fashion similar to the Mario Kart game.

The full project is located on the Github page below, and a video demonstration is included on YouTube.

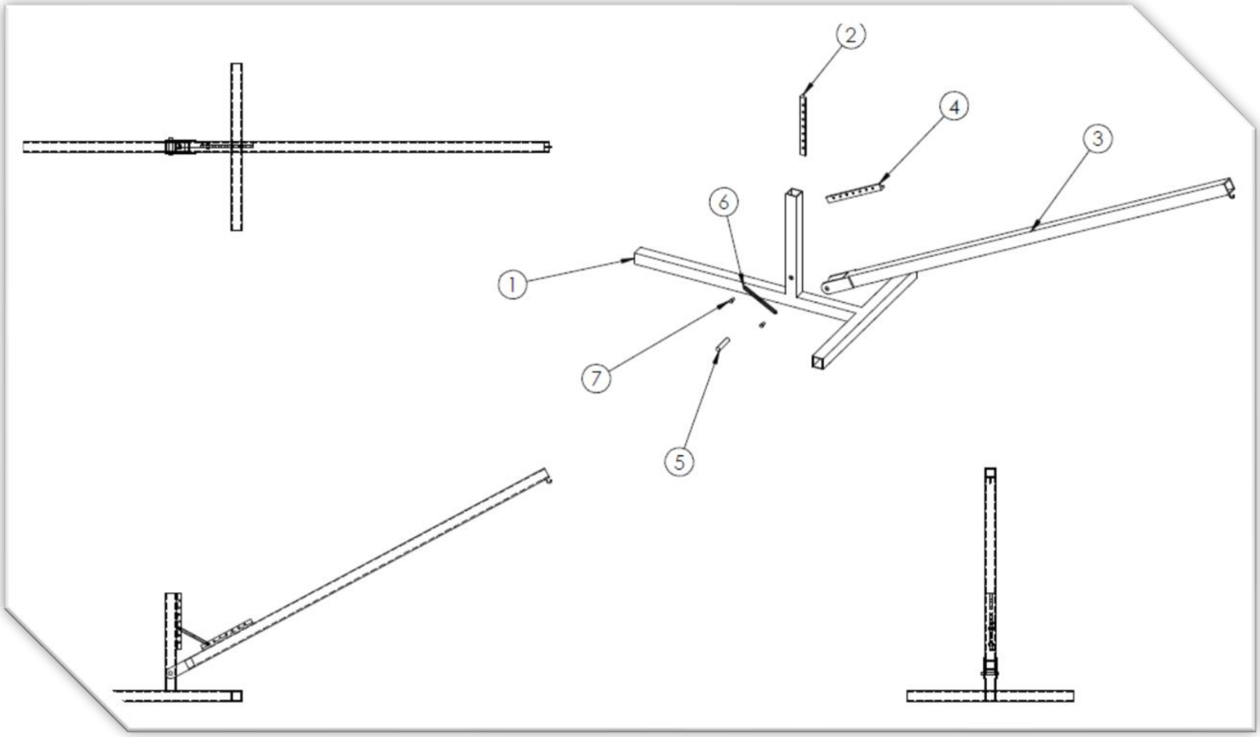
Websites:

- https://github.com/eckelsjd-rose-old/csse120.git
- https://youtu.be/EWk-NJnEr0Q

Skills:

- Python
- Linux

Crane Linkage



The goal of this project was to design and fabricate a link to hold the crane assembly (shown above) in a static state when a given load is applied.

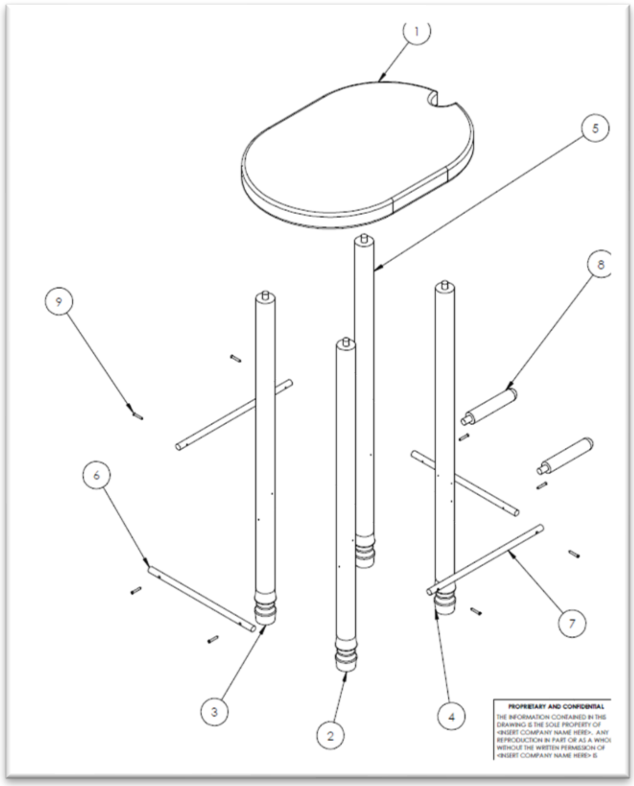
The crane assembly was first measured and modeled into Solidworks. A set of parameters was developed to fully describe the link geometry in relation to the crane geometry. Material analysis was performed on the plastic link to determine stress and strain relationships. Optimization was performed using Maple software to minimize the weight of the link.

The link was drawn, fabricated, and tested on the crane for static failure.

Relevant skills:

- Solidworks
- Material analysis

Guitar Chair



A school Solidworks idea turned into a personal summer project. Instead of buying a guitar stand online, it was way more fun to turn an old school project into reality.

From machining oak wood in the shop environment to painting those final beautiful coats of polyurethane, the improvised guitar wood stool and stand turned out for the better.

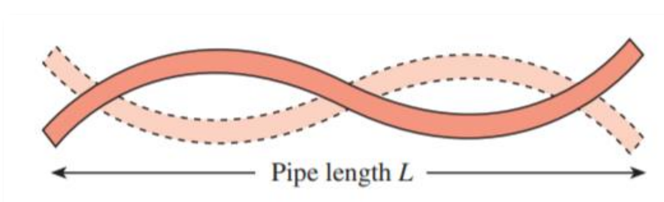
Relevant skills:

- ❖ Shop tools (mill, lathe, etc.)
- ❖ Solidworks

Copper Xylophone

Inspired by my love for music and newly-found talent for woodworking, the copper xylophone shown above was a quick summer project to prove some of the physics of sound I had been studying at the time.

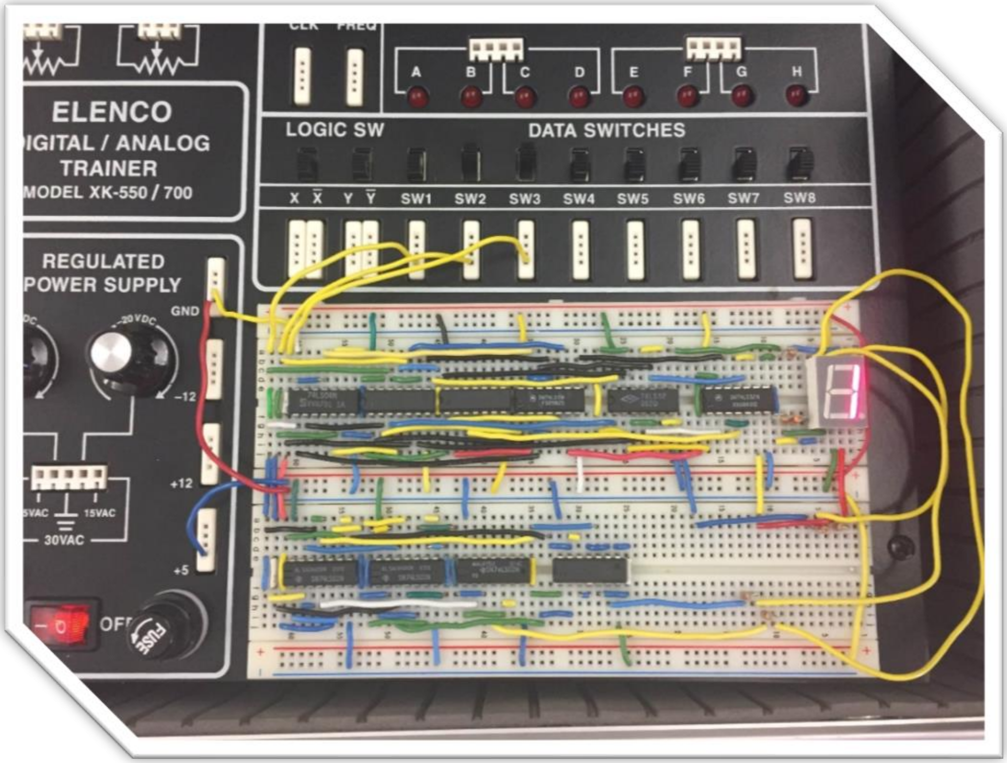
The frame was machined and cut to size in an aesthetic fashion. The copper bells were cut from regular old copper pipe that was laying around the house. The eight bells were cut to length to produce a full C scale, using material properties and the equations developed in the paper linked below.



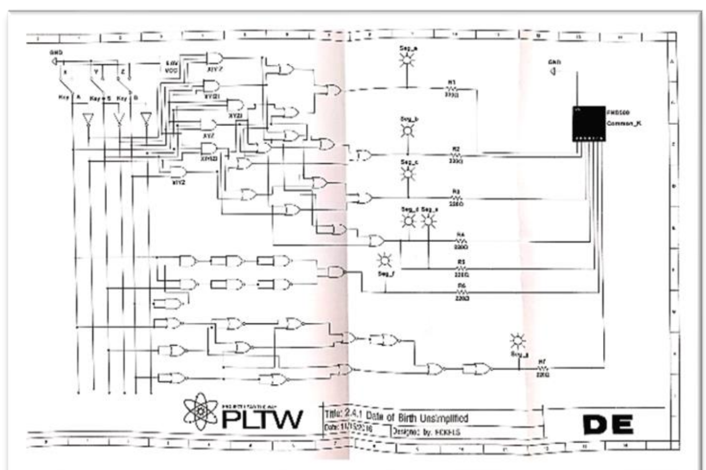
Websites:

- http://users.df.uba.ar/sgil/physics_paper_doc/papers_phys/lapp.pdf

Integrated Circuit Electronics



A school project turned into a personal hobby, and a hobby turned into a field of study in computer science, the digital electronics circuit shown above displays my date of birth one digit at a time on the seven-segment display.



While the project is more cool-looking than useful, I am including it here because it began my study and interest into the vast black box of computers. I suppose it also demonstrates a pretty thorough understanding of bread-boarding. So many hours, wasted . . .

Relevant skills:

- Absolutely None