Nathan Kim

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Hello!

My name is Nathan Kim and I am a graduate student in Autonomous Systems at UCLA. Through my experiences with projects, research, and engineering internships, I have gained valuable technical knowledge and teamwork skills. I hope to apply the things that I have learned in the field of robotics.

01.

School Projects [4-10]

- Space Additive Manufacturing Print Head
- FEA using Abaqus
- 4DOF Robot Arm
- Robotics Trajectory Generation
- Autonomous Vehicle Simulation

02.

Capstone Projects [11-14]

- Bobabot
- STMicroelectronics Qvar Sensors

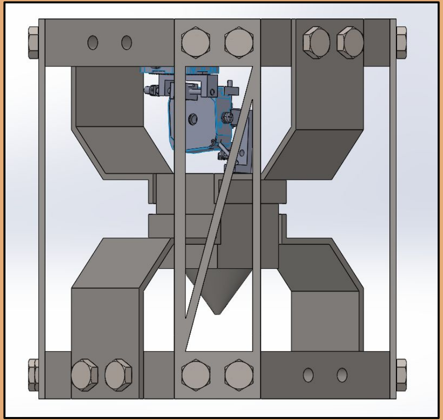
03.

Intern Experience [15-16]

- Jet Propulsion Laboratory

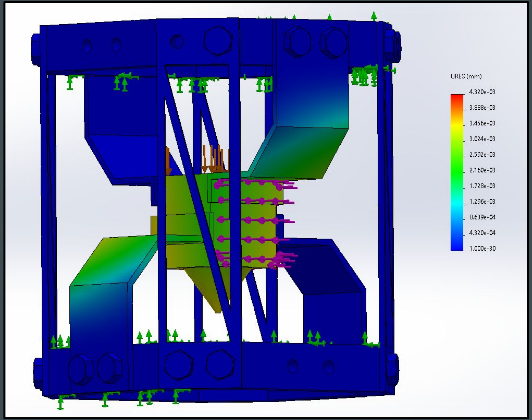
School Projects

Space Additive Manufacturing
Print Head Design



Final Design with Compliant Elements

Fully developed part design for compliant movement in 6 degrees of freedom



Stress Analysis

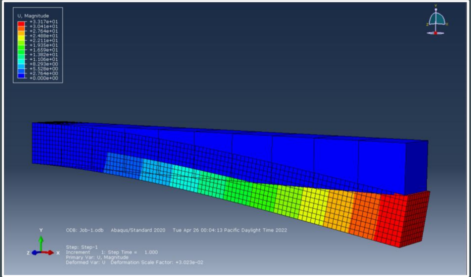
Conducted stress analysis for the compliant parts to ensure no permanent deformation

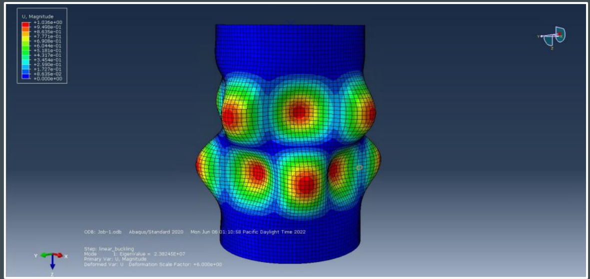
Link to final paper: https://docs.google.com/document/d/18J5h58R6f8TFTpfm6753KFgFwjPF58ScRy2BzmNJAvE/edit?usp=sharing

Abaqus Finite Element Analysis

- Learned the basics to conducting FEA on Abaqus for different geometries and materials
- Used hand calculations of equations to check results of Abaqus simulations
- Geometries simulated:
  - Cantilever beam
  - Structural cylinder for launch vehicle
  - Engine regen cooling tube
  - Heat Sink for heat transfer

Cantilever beam

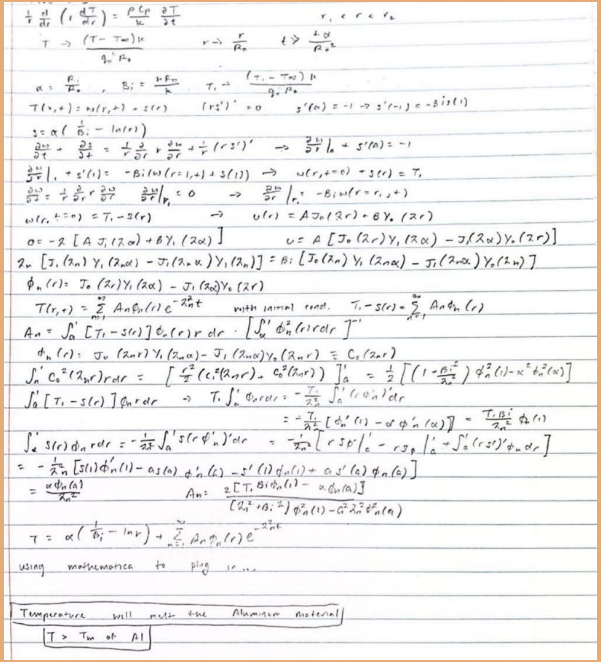




Launch vehicle part

Abaqus FEA: Example Hand Calculations

Regen Cooling Tube



$$\frac{1}{r}\frac{d}{dr}\left(r\frac{dT}{dr}\right) = \frac{\rho c_p}{k}\frac{\partial T}{\partial t} \qquad r_1 < r < r_2$$

$$T \to \frac{(T - T_\infty)k}{q_0'' R_0} \qquad r \to \frac{r}{R_0} \qquad t \to \frac{t\alpha}{R_0^2}$$

$$\alpha = \frac{R_i}{R_0}, \quad B_i = \frac{hR_0}{k} \qquad T_1 \to \frac{(T_1 - T_\infty)k}{q_0 R_0}$$

$$T(r,t) = w(r,t) + s(r) \qquad (rs')' = 0 \qquad s'(\alpha) = -1 \to s'(1) = -B_i s(1)$$

$$s = \alpha\left(\frac{1}{B_i} - \ln(r)\right)$$

$$\frac{\partial w}{\partial t} + \frac{\partial s}{\partial t} = \frac{1}{r}\frac{\partial}{\partial r}r\frac{\partial w}{\partial r} + \frac{1}{r}(rs')' \to \left.\frac{\partial w}{\partial r}\right|_a + s'(a) = -1$$

$$\left.\frac{\partial w}{\partial r}\right|_1 + s'(1) = -B_i(w(r=1,t) + s(1)) \to w(r,t=0) + s(r) = T_1$$

$$\frac{\partial w}{\partial t} = \frac{1}{r}\frac{\partial}{\partial r}r\frac{\partial w}{\partial r} \qquad \left.\frac{\partial w}{\partial r}\right|_{r_1} = 0 \to \left.\frac{\partial w}{\partial r}\right|_{r_2} = -B_i w(r=r_2,t)$$

$$w(r,t=0) = T_1 - s(r) \to u(r) = AJ_0(\lambda r) + BY_0(\lambda r)$$

$$0 = -\lambda[AJ_1(\lambda\alpha) + BY_1(\lambda\alpha)] \qquad u = A[J_0(\lambda r)Y_1(\lambda\alpha) - J_1(\lambda\alpha)Y_0(\lambda r)]$$

$$\lambda_n[J_1(\lambda_n)Y_1(\lambda_n\alpha) - J_1(\lambda_n\alpha)Y_1(\lambda_n)] = B_i[J_0(\lambda_n)Y_1(\lambda_n\alpha) - J_1(\lambda_n\alpha)Y_0(\lambda_n)]$$

$$\phi_n(r) = J_0(\lambda r)Y_1(\lambda\alpha) - J_1(\lambda\alpha)Y_0(\lambda r)$$

$$T(r,t) = \sum_{n=1}^{\infty} A_n\phi_n(r)e^{-\lambda_n^2 t} \quad \text{with initial cond.} \quad T_1 - s(r) = \sum_{n=1}^{\infty} A_n\phi_n(r)$$

$$A_n = \int_a^1 [T_1 - s(r)]\phi_n(r)r\,dr \cdot \left[\int_\alpha^1 \phi_n^2(r)r\,dr\right]^{-1}$$

$$\phi_n(r) = J_0(\lambda_n r)Y_1(\lambda_n\alpha) - J_1(\lambda_n\alpha)Y_0(\lambda_n r) \equiv C_0(\lambda_n r)$$

$$\int_a^1 C_0^2(\lambda_n r)r\,dr = \left[\frac{r^2}{2}(C_1^2(\lambda_n r) + C_0^2(\lambda_n r))\right]_a^1 = \frac{1}{2}\left[\left(1 + \frac{B_i^2}{\lambda_n^2}\right)\phi_n^2(1) - \alpha^2\phi_n^2(\alpha)\right]$$

$$\int_a^1 [T_1 - s(r)]\phi_n r\,dr \to T_1\int_a^1 \phi_n r\,dr = -\frac{T_1}{\lambda_n^2}\int_a^1 (r\phi_n')'dr$$

$$= -\frac{T_1}{\lambda_n^2}[\phi_n'(1) - \alpha\phi_n'(\alpha)] = \frac{T_1 B_i}{\lambda_n^2}\phi_n(1)$$

$$\int_\alpha^1 s(r)\phi_n r\,dr = -\frac{1}{\lambda_n^2}\int_a^1 s(r\phi_n')'dr = -\frac{1}{\lambda_n^2}\left[rs\phi'\Big|_a^1 - rs'\phi\Big|_a^1 + \int_a^1 (rs')'\phi_n\,dr\right]$$

$$= -\frac{1}{\lambda_n^2}[s(1)\phi_n'(1) - as(a)\phi_n'(a) - s'(1)\phi_n(1) + as'(a)\phi_n(a)]$$

$$= \frac{\alpha\phi_n(a)}{\lambda_n^2} \qquad A_n = \frac{2[T_1 B_i\phi_n(1) - \alpha\phi_n(a)]}{(\lambda_n^2 + B_i^2)\phi_n^2(1) - \alpha^2\lambda_n^2\phi_n^2(a)}$$

$$T = \alpha\left(\frac{1}{B_i} - \ln r\right) + \sum_{n=1}^{\infty} A_n\phi_n(r)e^{-\lambda_n^2 t}$$

using mathematica to plug in...

Temperature will melt the Aluminum material

$\boxed{T > T_m \text{ of Al}}$

Cantilever Beam SFG

Problem 1: SFG

$$\tilde{w}(x) = a_0 + a_1\frac{x}{L} + a_2\left(\frac{x}{L}\right)^2 + a_3\left(\frac{x}{L}\right)^3 + a_4\left(\frac{x}{L}\right)^4 + a_5\left(\frac{x}{L}\right)^5$$

$$\tilde{w}(0) = a_0 = 0$$

$$\tilde{w}'(x) = \frac{a_1}{L} + \frac{2a_2x}{L^2} + \frac{3a_3x^2}{L^3} + \frac{4a_4x^3}{L^4} + \frac{5a_5x^4}{L^5}$$

$$\tilde{w}'(0) = \frac{a_1}{L} = 0$$

$$\tilde{w}''(x) = \frac{2a_2}{L^2} + \frac{6a_3x}{L^3} + \frac{12a_4x^2}{L^4} + \frac{20a_5x^3}{L^5} \to \tilde{w}''(L) = \frac{2a_2}{L^2} + \frac{6a_3}{L^2} + \frac{12a_4}{L^2} + \frac{20a_5}{L^2} = 0$$

$$\tilde{w}'''(x) = \frac{6a_3}{L^3} + \frac{24a_4x}{L^4} + \frac{60a_5x^2}{L^5} \to \tilde{w}'''(L) = \frac{6a_3}{L^3} + \frac{24a_4}{L^3} + \frac{60a_5}{L^3}$$

$$\tilde{w}''(L) = 2a_2 + 6a_3 + 12a_4 + 20a_5 = 0 \to a_2 + 3a_3 + 6a_4 + 10a_5 = 0$$

$$\tilde{w}'''(L) = 6a_3 + 24a_4 + 60a_5 = a_3 + 4a_4 + 10a_5 \to a_3 = -4a_4 - 10a_5$$

$$\tilde{w}''''(x) = \frac{24a_4}{L^4} + \frac{120a_5x}{L^5}$$

$$a_2 = -3a_3 - 6a_4 - 10a_5$$

$$\to a_2 = 12a_4 + 30a_5 - 6a_4 - 10a_5$$

$$\tilde{w}(x) = \frac{x^2}{L^2}(6a_4 + 20a_5) + \frac{x^3}{L^3}(-4a_4 - 10a_5) + \frac{x^4}{L^4}a_4 + \frac{x^5}{L^5}a_5$$

$$[\times L^4] \quad 6a_4x^2L^2 + 20a_5x^2L^2 - 4a_4x^3L - 10a_5x^3L + x^4a_4 + \frac{x^5a_5}{L}$$

$$\tilde{w}(x) = a_4\underbrace{x^2(6L^2 - 4Lx + x^2)}_{\phi_1} + a_5\underbrace{x^2(20L^3 - 10L^2x + x^3)}_{\phi_2}$$

$$\tilde{w}'(x) = a_4x(12L^2 - 12Lx + 4x^2) + a_5x(40L^3 - 30L^2x + 5x^3)$$

$$\tilde{w}''(x) = a_4(12L^2 - 24Lx + 12x^2) + a_5(40L^3 - 60L^2x + 20x^3)$$

$$\tilde{w}'''(x) = a_4(-24L + 24x) + a_5(-60L^2 + 60x^2)$$

$$\tilde{w}''''(x) = a_4 24 + 120a_5x$$

$$R = EI\frac{d^4w}{dx^4} - Gb\frac{d^2w}{dx^2} + kbw - qb = 0$$

$$\int R\,v\,dx = 0$$

$$q = -1000 \text{ lbf}$$

$\boxed{\text{specs}}$

(thick)

where: $b = 1''$, $L = 10''$, $h = 1''$, $k = \frac{EI}{L}$

$E = 30000$ ksi, $G = 11500$ k, $I = \frac{1}{12}$

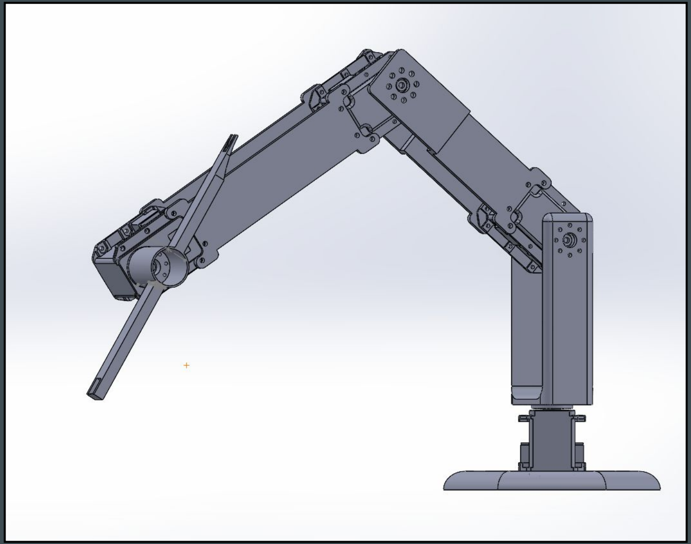
with mathematica:

$$c_4 = 6\times10^{-7} \qquad c_5 = 1.6\times10^{-7}$$

thus $\boxed{\tilde{w}(L) = -0.004 \text{ in}}$

4DOF Robot Arm

- **Problem Statement:**
  - Create a robotic solution to a specific application
- **Problem Solution:**
  - 4 DOF Robot Arm to help feed patients in a hospital bed to minimize movement
- **Personal Impact:**
  - Designed the hardware for the 3D printed arm components (links, base, end effector)
  - Solved forward and reverse kinematics for arm movements

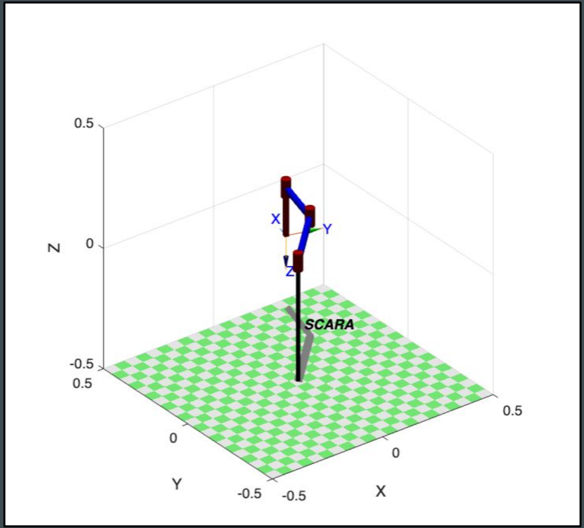


Final Design

Link to final paper: https://docs.google.com/document/d/1Qu_pvgKOTJnhQnH5T152dHWrhy1YcHUUo-mrpoCcF14/edit?usp=sharing

Robotic Trajectory Generation

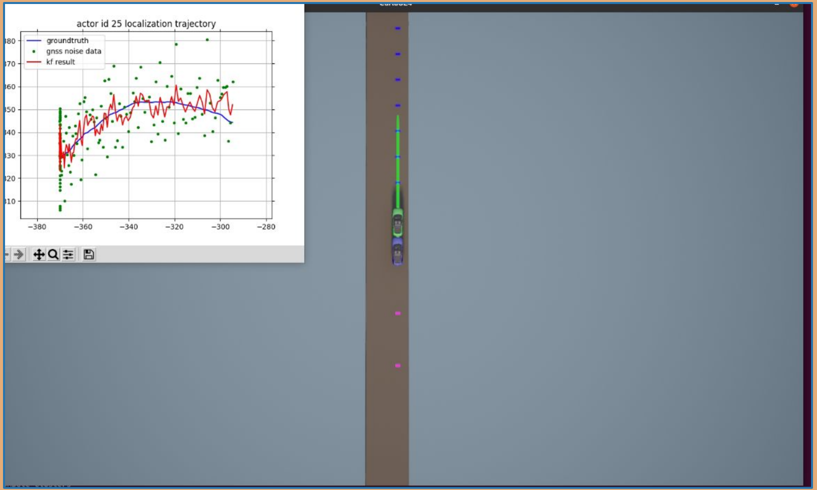
- **Problem Statement:**
  - PCB component placement by robotic arm (Mitsubishi SCARA)
- **Problem Solution:**
  - Use of Peter Corke toolbox in Matlab for simulations
  - Hand solved forward and inverse kinematics for trajectory
  - Created custom via points for trajectory to PCB corners



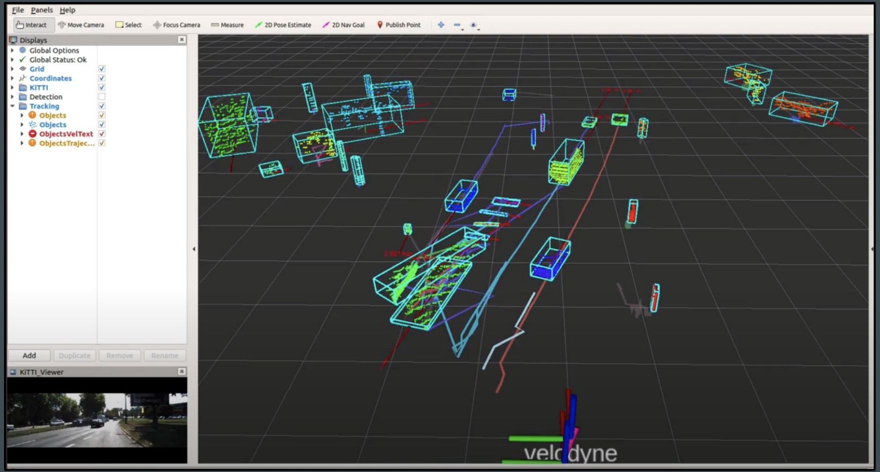
SCARA Matlab Simulation

Link to final paper: https://docs.google.com/document/d/1xhxPukbUUQwkXltBZmcQ7FZBU9wwlic-cftlJfvsuWs/edit?usp=sharing

Autonomous Vehicle Simulations



- Programmed LiDAR detection using point cloud generation around ego vehicle
- Implemented PID controller for vehicle



Used kitti ROS to process public LiDAR data

Link to final presentation: https://docs.google.com/presentation/d/1W75cnVwte1FkCiKBQDzKS_xftgdEERkpempOGKD0Fac/edit?usp=sharing

Capstone Projects

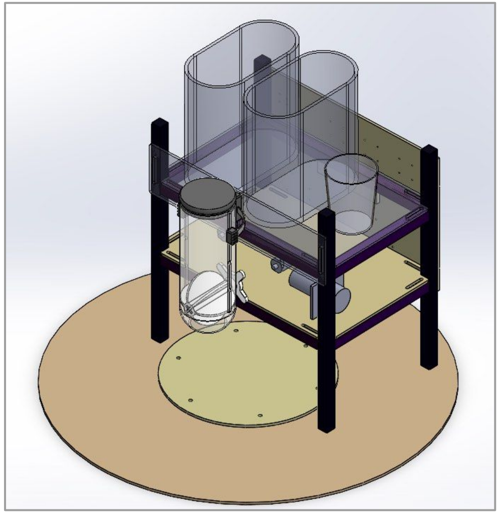
Capstone Project: Bobabot

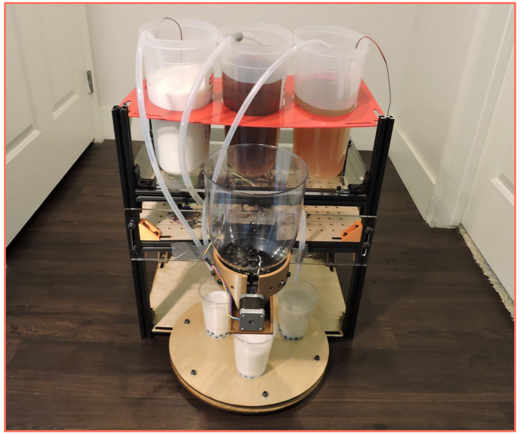
Problem Statement:

- Undergraduate capstone project creating a robotic mechanism

Personal Impact:

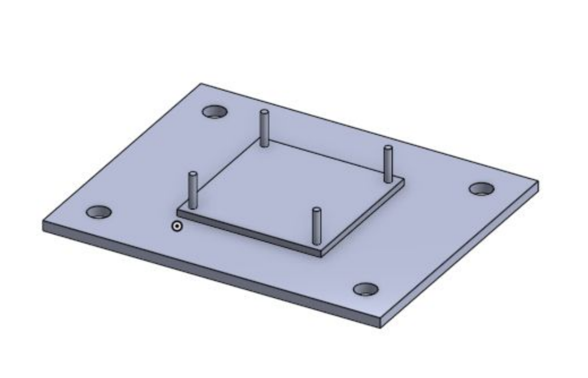
- Designed multiple hardware elements
  - Battery plate
  - Spur gear
  - Motor driver mounts
  - Hub axle
- Created assembly for machine using Solidworks
- Worked with 5 teammates in dividing the workload and meeting project deadlines

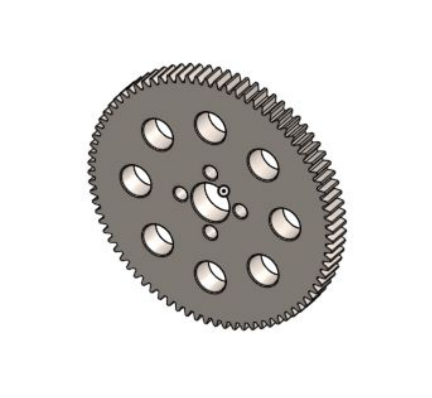




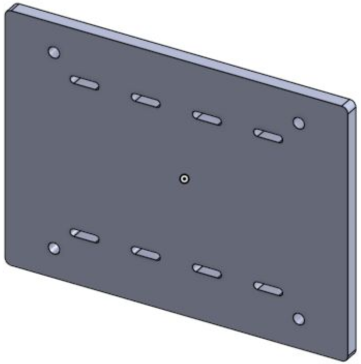
Capstone Project: Bobabot: CAD

Motor drive mount

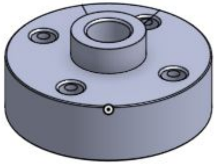




Custom spur gear



Battery plate



Hub axle

Capstone Project: STMicroelectronics Qvar sensors

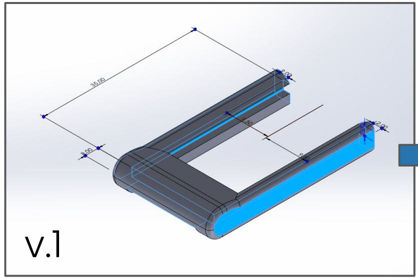
Problem Statement:

- Create a design using Qvar tile sensors and accelerometer data to interpret sign language

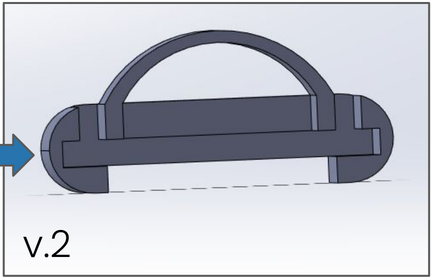
Personal Impact:

- Designed hardware fasteners for accelerometer tile
- Preliminary designs for fasteners to Qvar tiles (not used)
- Recorded data of ASL alphabet for training the ML model
- Processed data using Python to feed into ML model

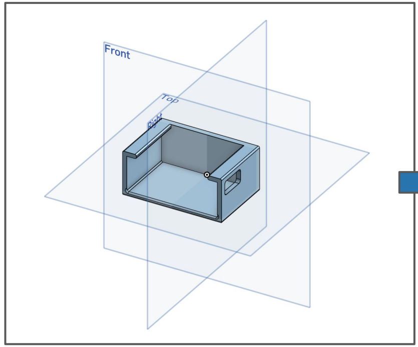
Preliminary designs

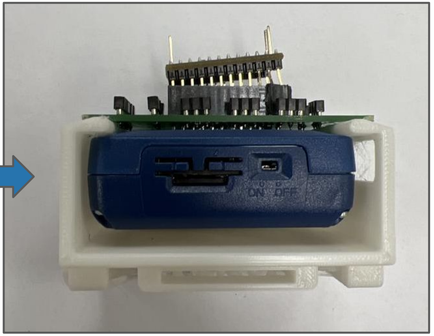


v.1



v.2





Internship Experience

Jet Propulsion Laboratory
California Institute of Technology

Jet Propulsion Laboratory: Submillimeter Wave Tech. Intern

Summer 2020 (Covid)

- Replicated schottky diodes with Silvaco TCAD to extract I/V curves
- Simulated with different materials to maximize current flow before diode fabrication
- Prepared a final presentation on findings and research of experimenting with diode parameters