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Phlebot

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Mid-Semester Presentation

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Design Requirements

Explicit Requirements

- Operate on a Geriatric IV Training Arm
- Budget: \$800
- Robust and Portable
- Dedicated Power Supply
- Does not damage environment
- Vein visualization error: $\pm 0.5\text{mm}$





Explicit Requirements

- Disinfect the injection region with a disinfecting wipe
- Robot localization and calibration must be completed in a 5 minute period before hand
- Pick any visible and wide vein to withdraw blood or inject medication with the syringe
- Robot must withdraw the needle afterwards



Implicit Requirements

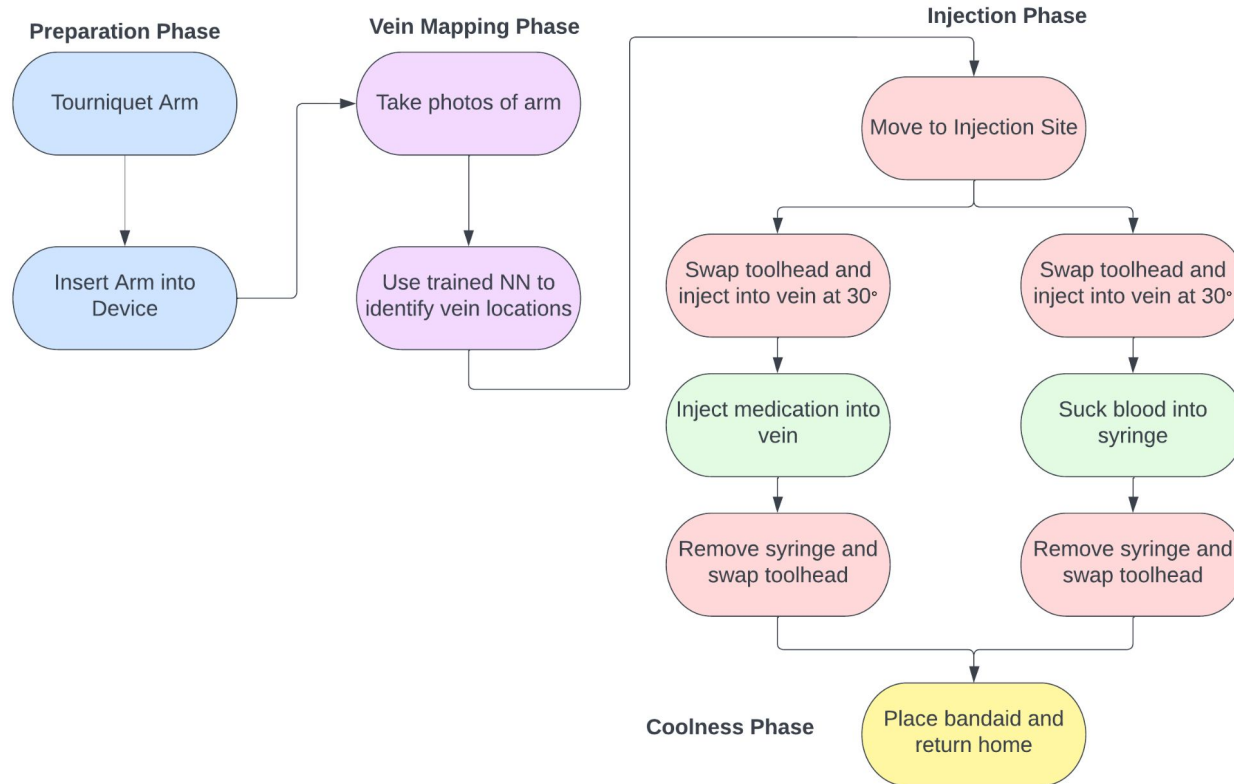
- Robot maximum operating time: 10 minutes
- Size: less than 2ft x 2ft footprint
- UI: simple and effective for display and commands
- Injection angle: shallower than 30°



Extra Requirements

- Place band aid after injection
- Complete task within 5 minutes of deployment
- Minimally invasive on patient

Functional Architecture





Design Concepts



Perception Strategy

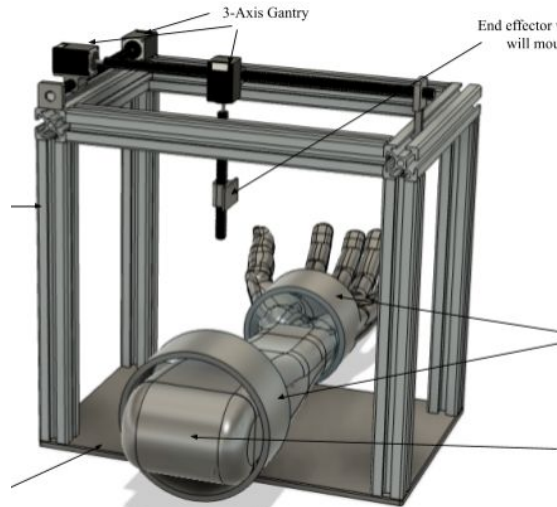
RGB Camera

- Lower contrast images
- Low cost
- Will work on the mock arm

NIR Camera + Lamp

- IR light absorbed by Hemoglobin
- On human arms, produces high contrast images

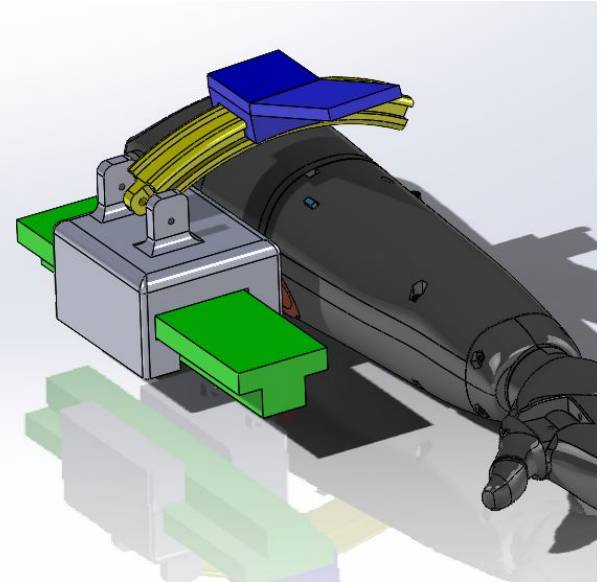
Physical Architecture



“3D Printer”



Multi DOF Arm



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Actuators

Stepper
Smart Servo (Torque control)
Servo
DC
Linear Actuator
Pneumatics

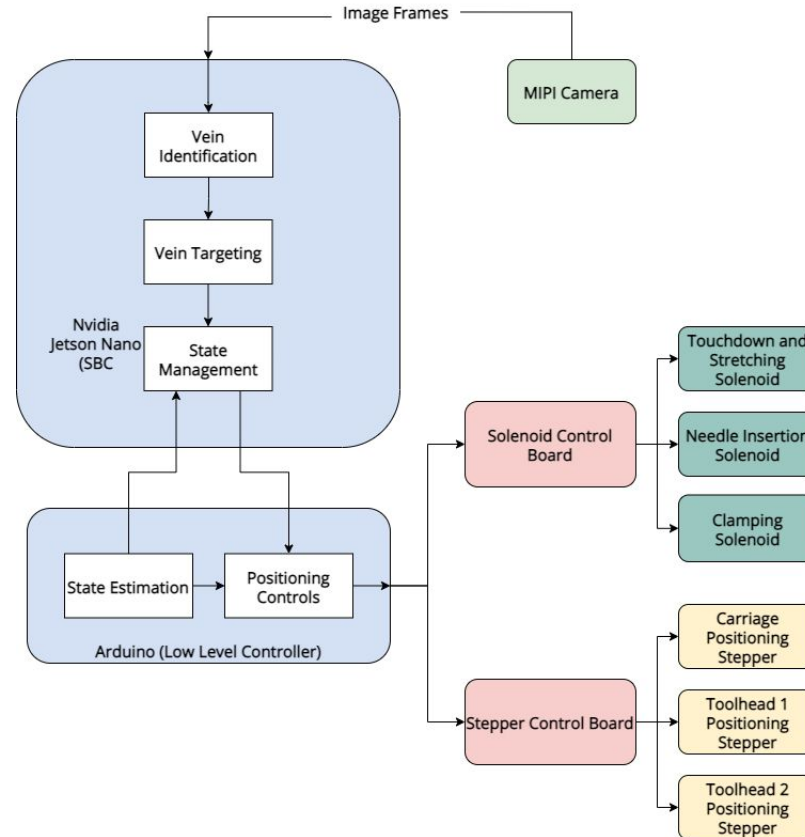
Cost
Force bandwidth
Position bandwidth
Size

Toolhead and Carriage - Position
Clamping - Force
Insertion - Size



Cyber Physical Architecture

Cyber-physical Architecture



Subsystems

Mechanical:

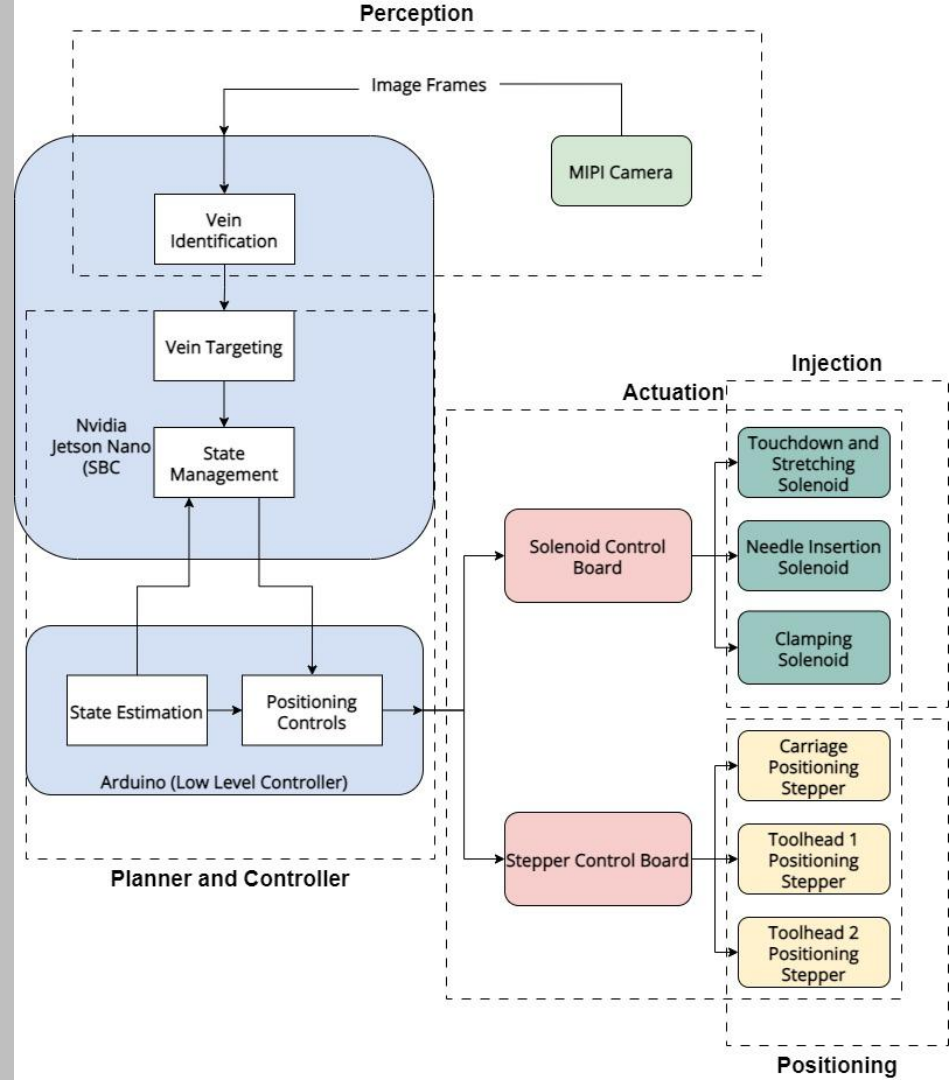
- Injection
- Positioning

Electrical:

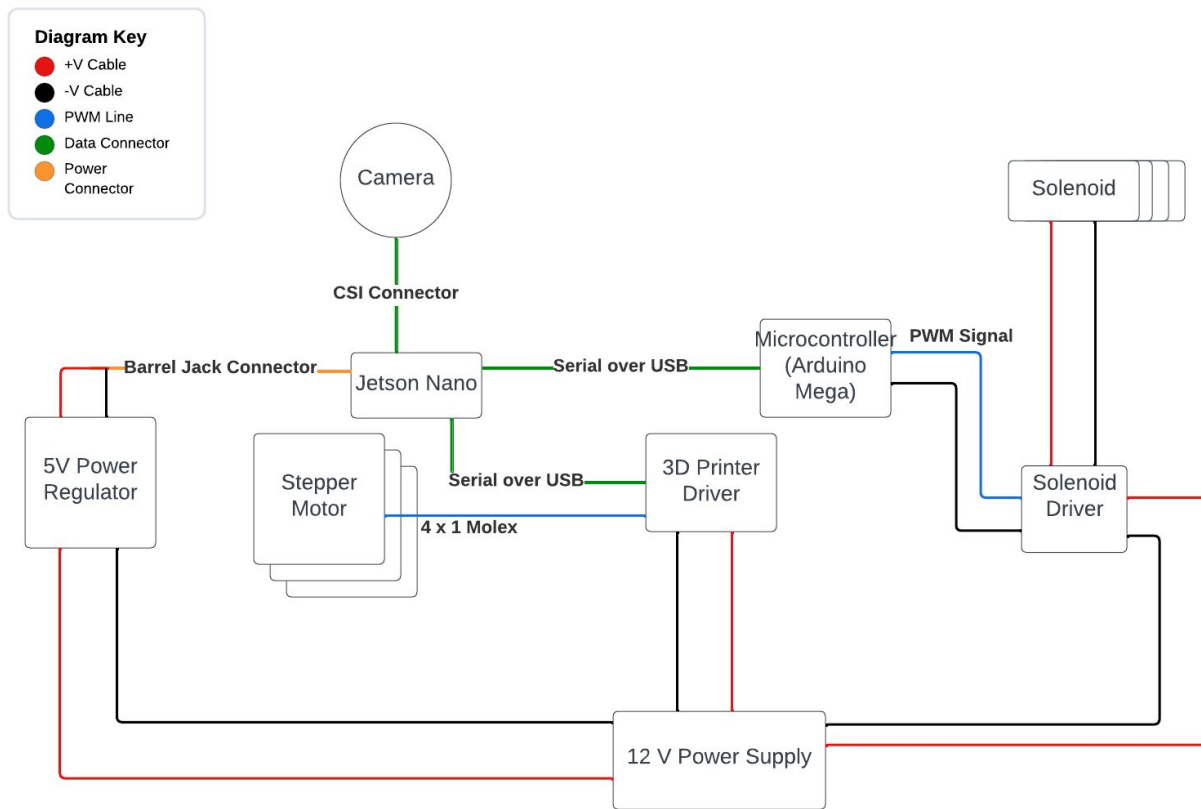
- Actuation
- Perception

Software:

- Planner and Controller



Electrical Architecture



Perception Pipeline

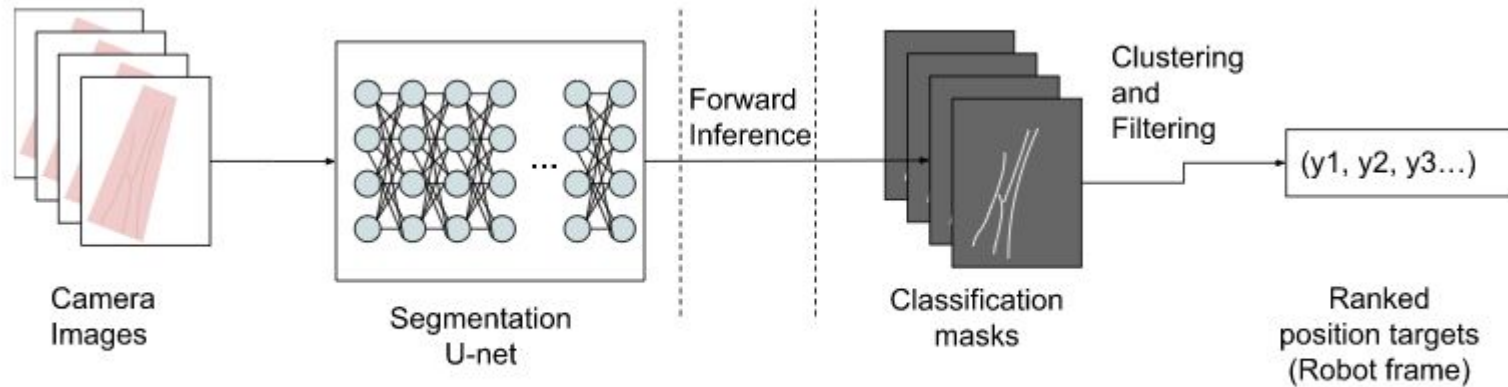
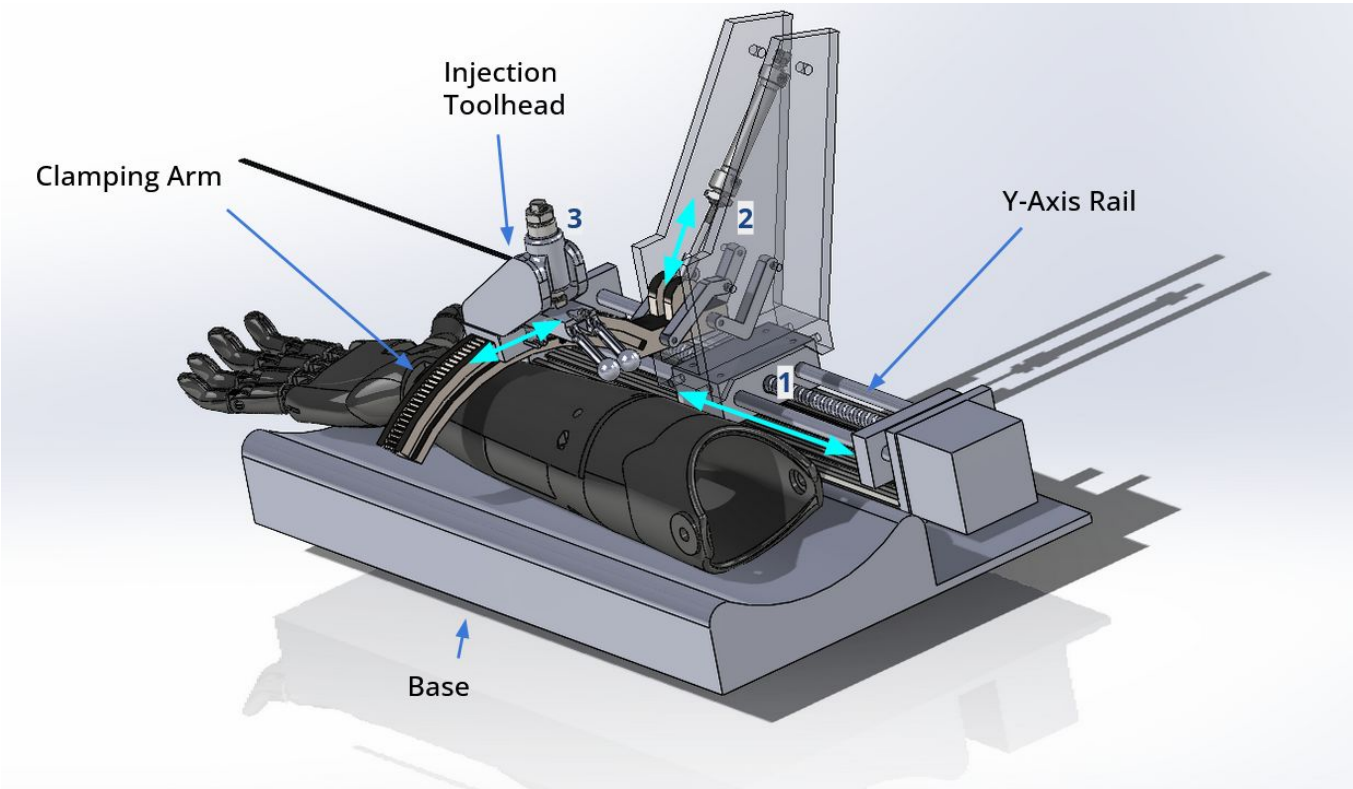


Figure 5: Perception Subsystem Description

Mechanical System





Progress

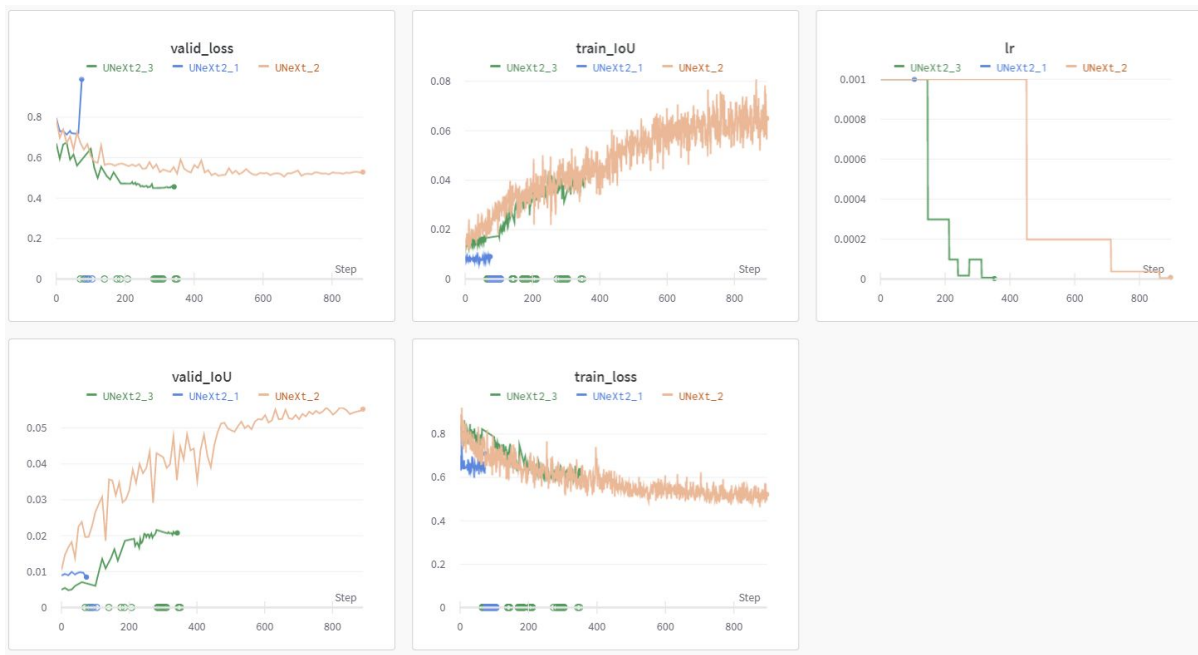
Perception

- Labelling, training and testing pipeline
- Neural Network converges but does not perform well enough
- More data needed
- Reformulate the problem

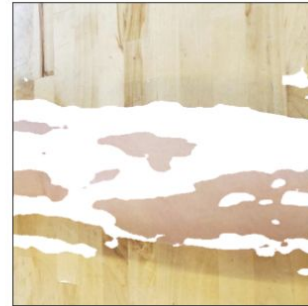


Benign Case

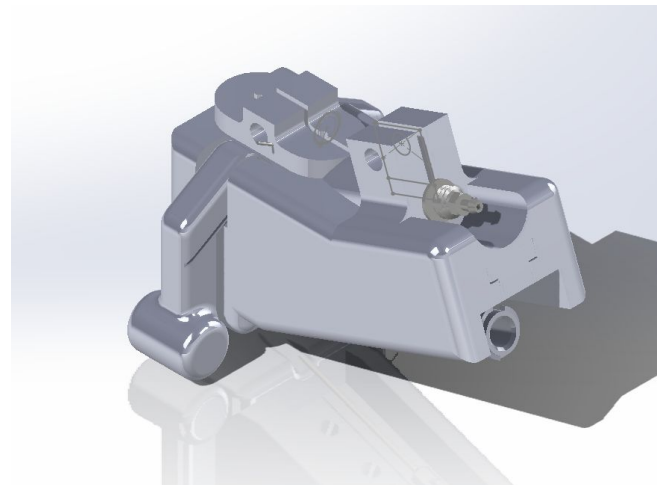
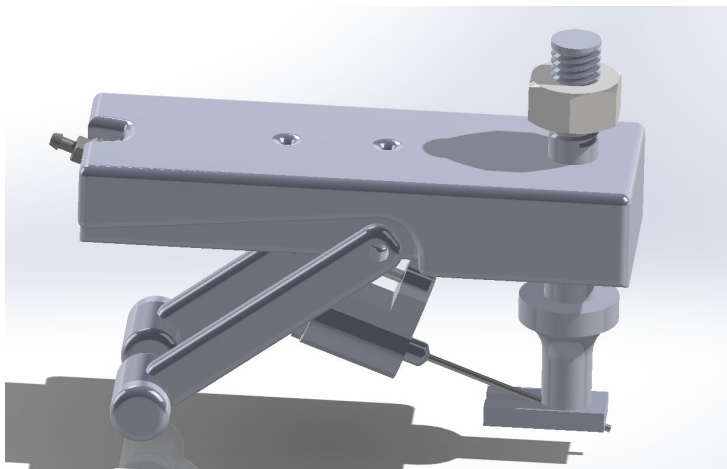
Perception Progress

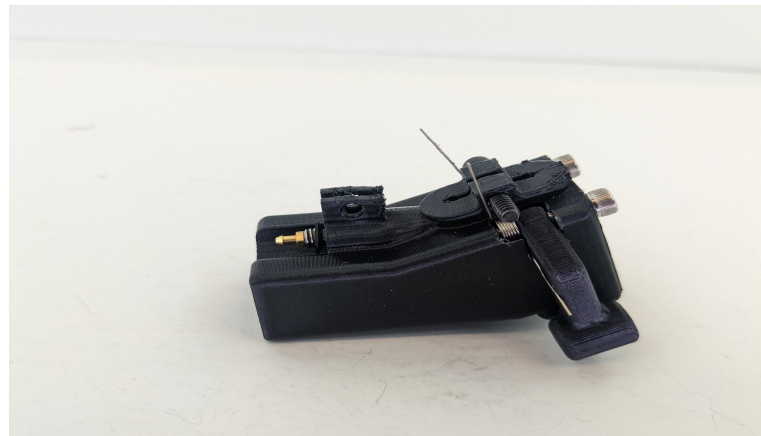
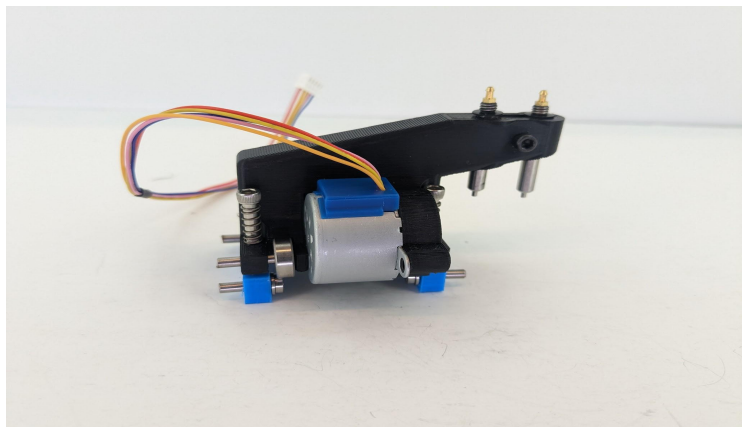
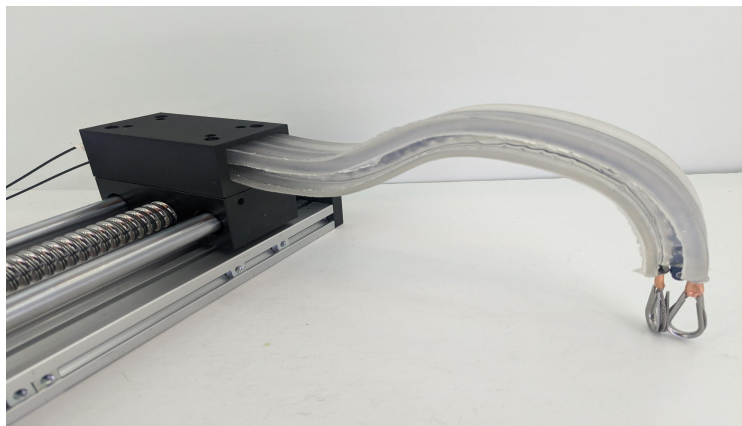


Failure Modes



Injection Toolhead







Actuators

Solenoid control interface (Hardware and Software)

Stepper control interface

- Debugging 3D printer controller
- Back-up interface with L298N



Looking Ahead

Schedule

Dates	Assignment	Goals
3/22/23 - 3/29/23	System Demo #4 / Website Check #2	Find solution to electronic drivers problem, reprint all parts for better quality
3/29/23 - 4/5/23	System Demo #5	Integrate NN and movement of steppers for toolhead translation to vein
4/5/23 - 4/12/23	System Demo #6	Refine entire build ...
4/12/23 - 4/19/23	System Demo #7	Increase precision and speed for puncturing
4/19/23 - 5/3/23	Final System Demo	Demo robust final design of device
4/24/23 - 5/5/23	Final Report	Complete report, updating all sections
5/4/23 - 5/8/23	Peer Evaluations II / Website Check #3	Update final version of website for entire project

Budget

Part	Price
Linear Rail System	88.80
Tourniquet	4.35
Small Stepper Motor	30.80
12V 5A Power Supply	11.99
Flanged Ball Bearing	11.49
Stepper Motor Controller	29.99
Solenoid Manifold	39.99
Flexible Filament	25.75

Part	Price
Pressure Regulator	20.97
Subminiature Air Cylinder	54.51
Compression Springs	5.43
Clamping Pneumatic	48.00
Raspberry Pi NoIR Camera	25.00
Motor Driver Bonnet	22.50
PLA	22.49
Fixtures	~120.00

Total: \$633.75

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Risk Management

- Design
 - Vein ID
 - IR in parallel with RGB development
 - Rigid and Flexible carriages
 - Stepper Driver adjustments
- Schedule
 - Reassign workload to complete electrical subsystem lagging
 - Lost some time for optimization and precision tuning
- Budget
 - Still have about \$300 allocated as backup/emergency funds