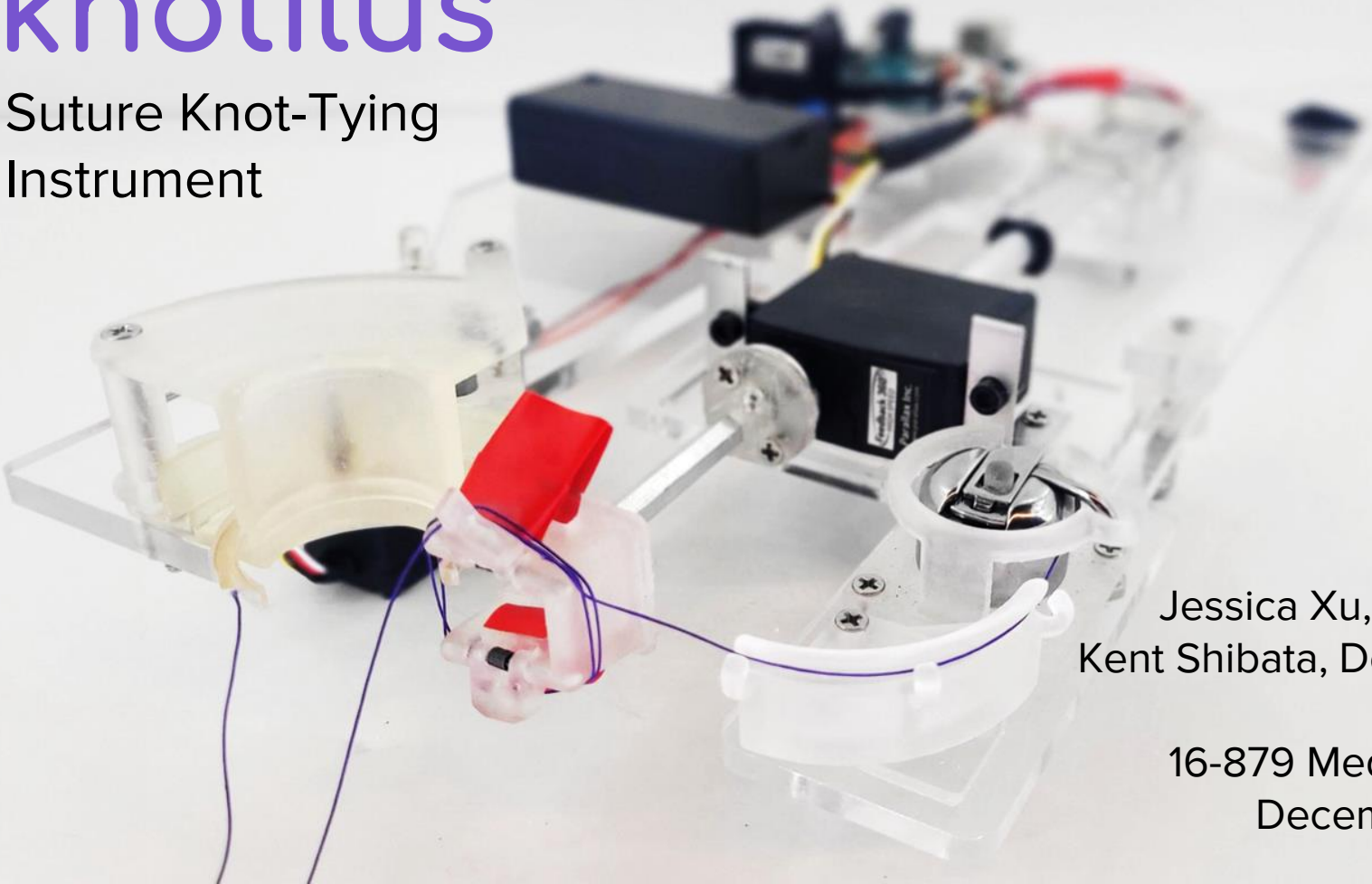
knotilus

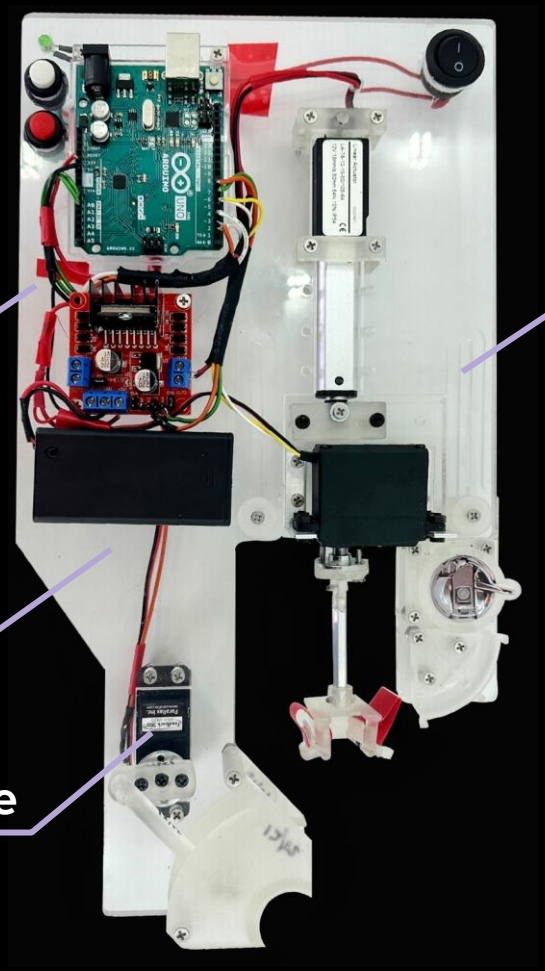
Suture Knot-Tying Instrument



Jessica Xu, Michael Gee,
Kent Shibata, Desmond Kuan

16-879 Medical Robotics
December 15, 2022

knotilus Proof-of-Concept



3 Electronics & Control

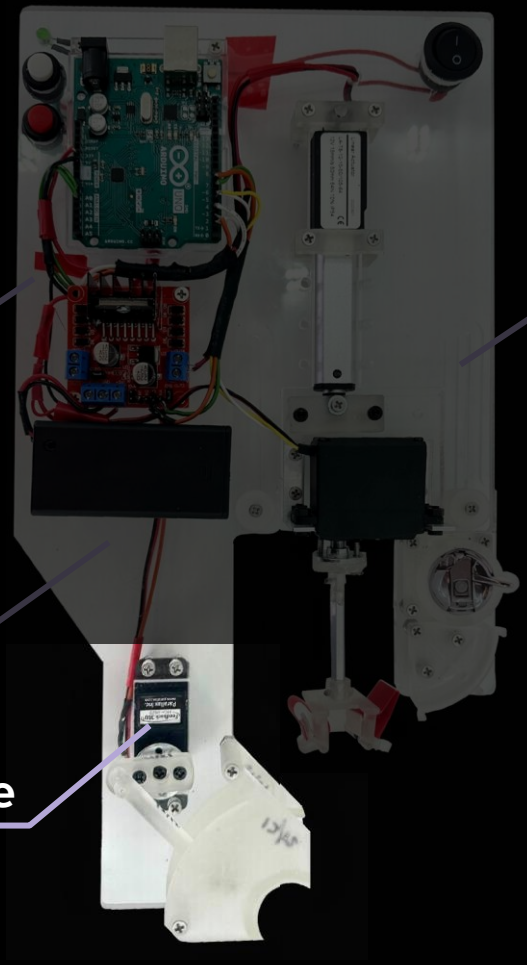
4 Housing & Integration

1 Needle Drive

Looping 2

KEY RESULTS

- ✓ Novel looping mechanism
- ✓ Clinically relevant knot quality
- ✓ Close to realistic needle size



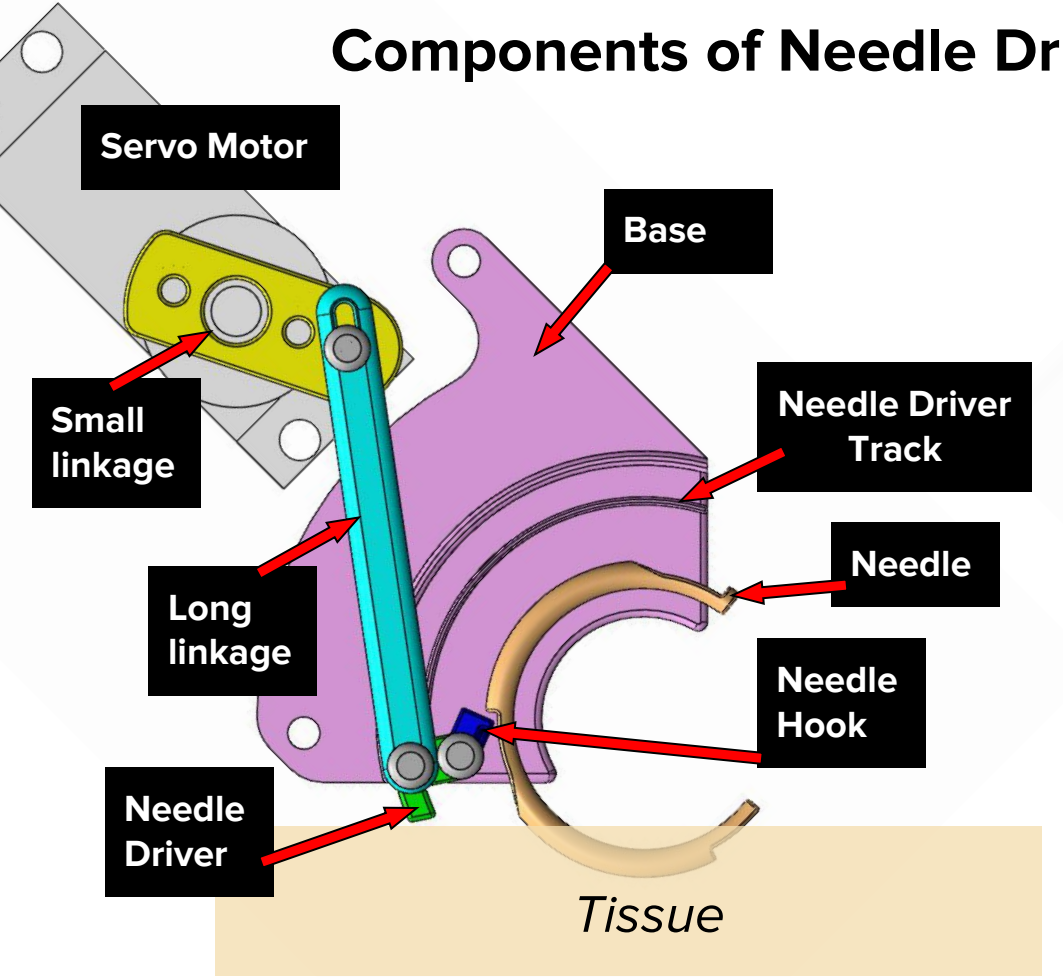
3 Electronics & Control

Looping 2

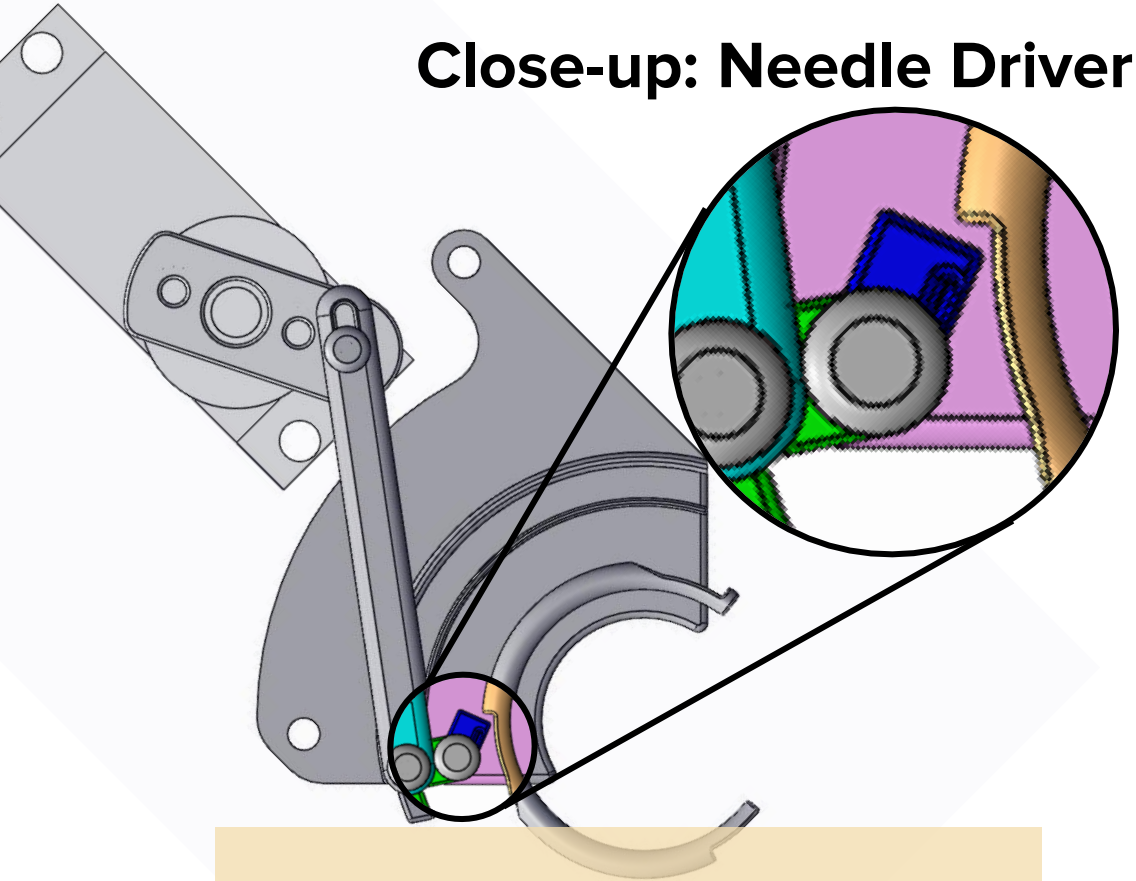
4 Housing & Integration

1 Needle Drive

Components of Needle Drive Linkage System



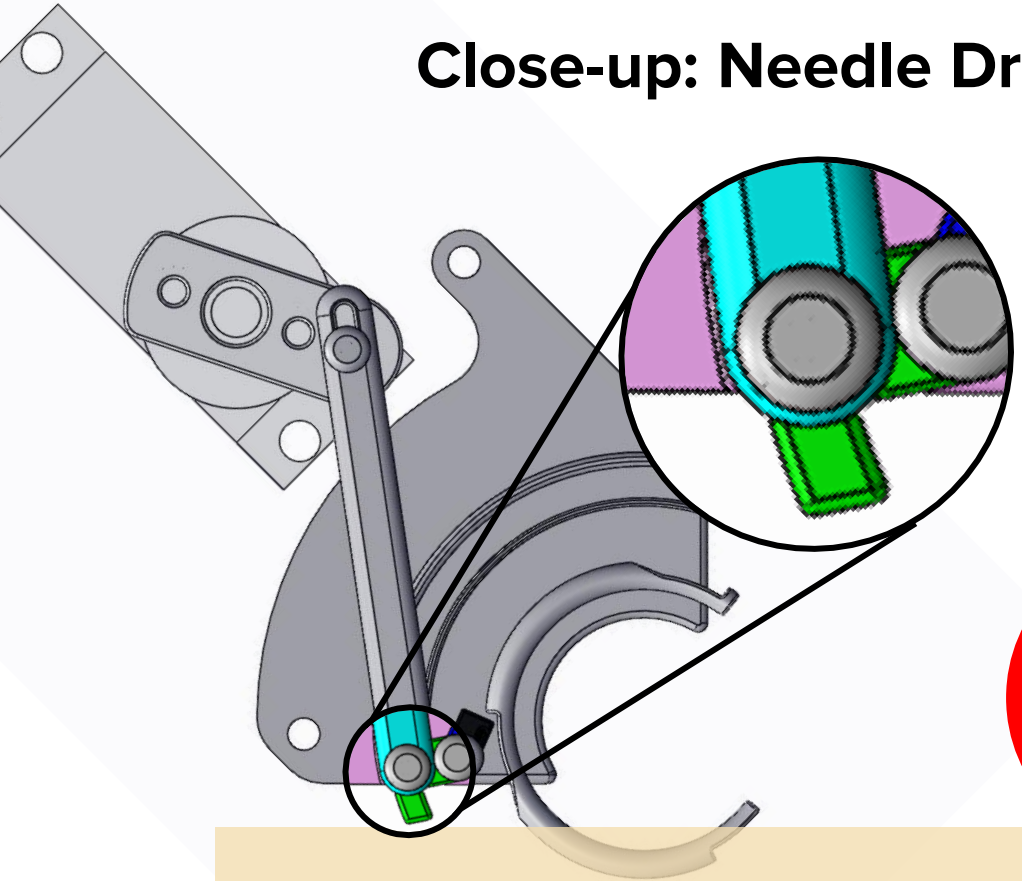
Close-up: Needle Driver and Hook



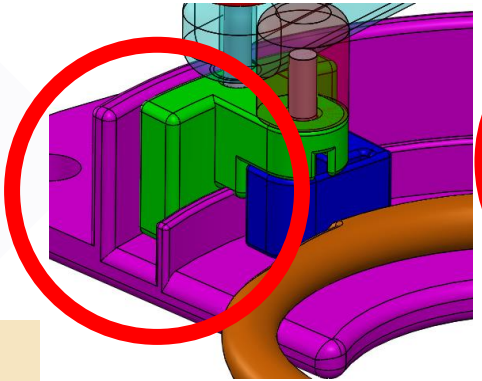
Tissue

Torsional spring connecting driver and hook for snapping motion of hook

Close-up: Needle Driver Track

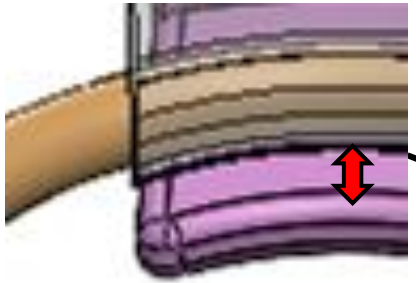


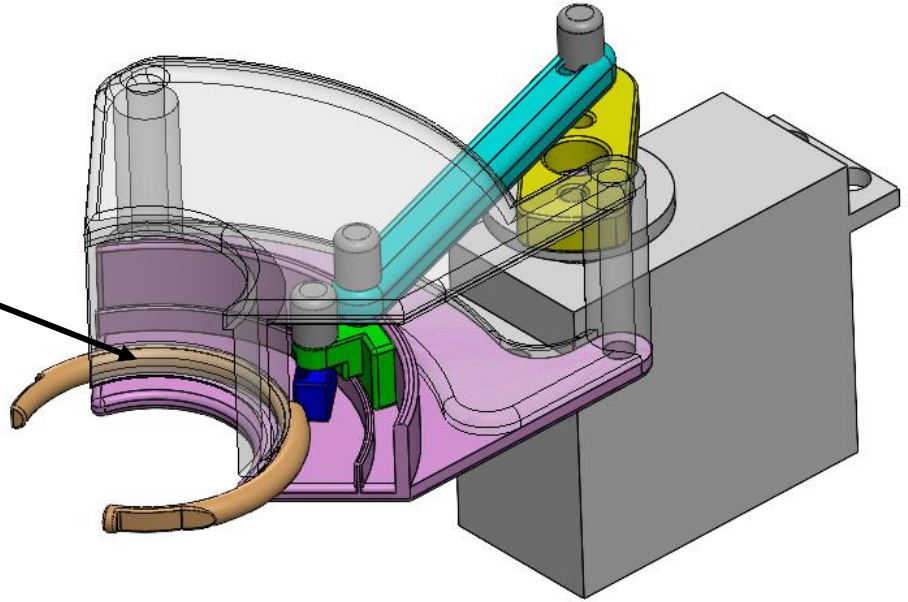
Dual track allows needle driver to be normal to the needle surface at all times

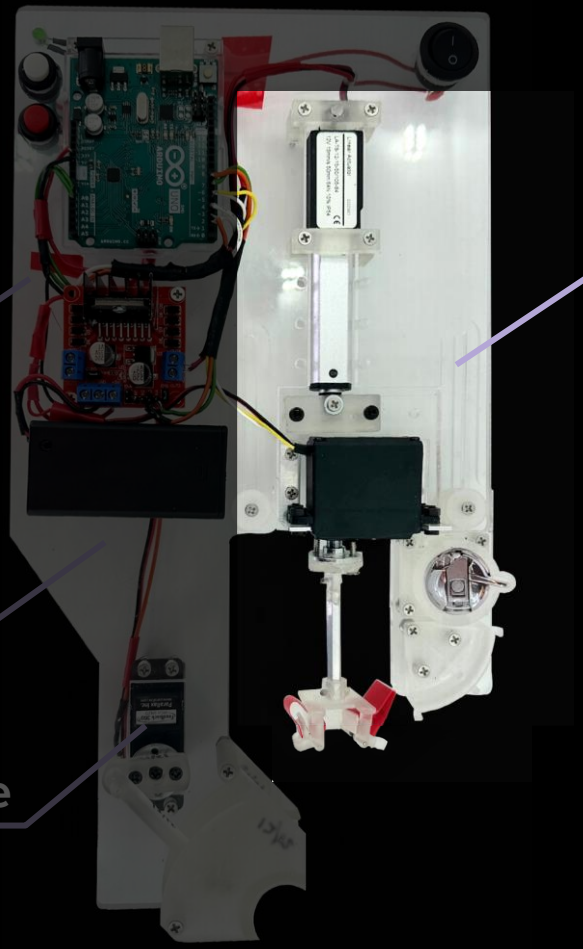


Close-up: Needle Sleeve and Suture Thread Gap

Gap between base and needle sleeve allows suture thread to not get tangled







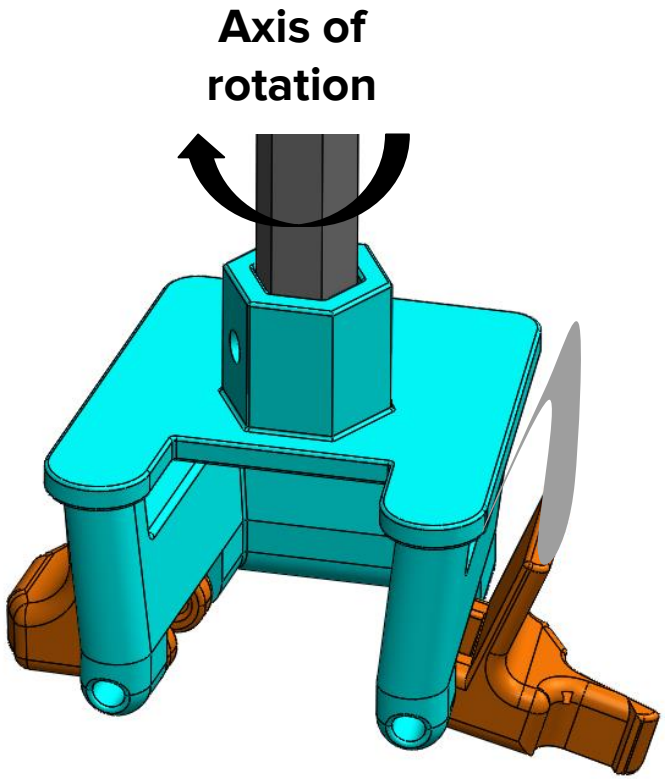
3 Electronics & Control

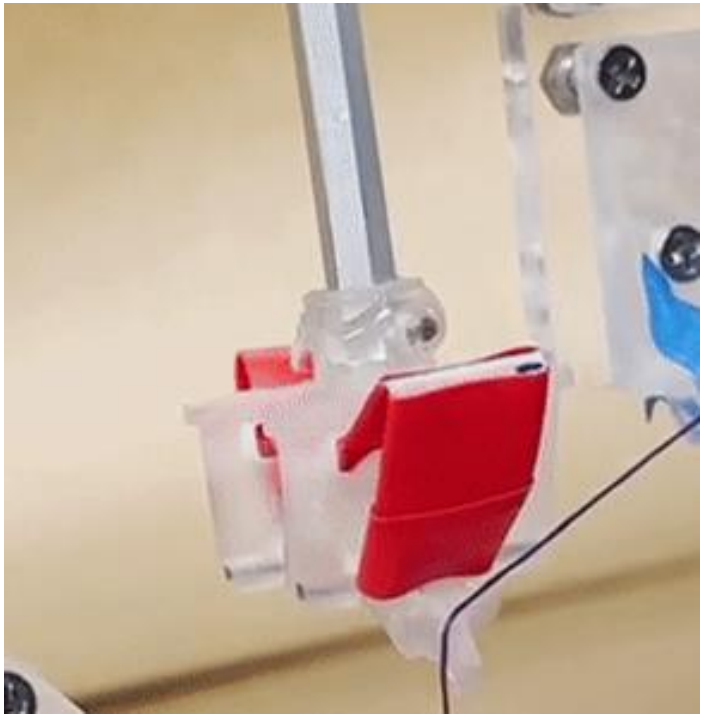
Looping 2

4 Housing & Integration

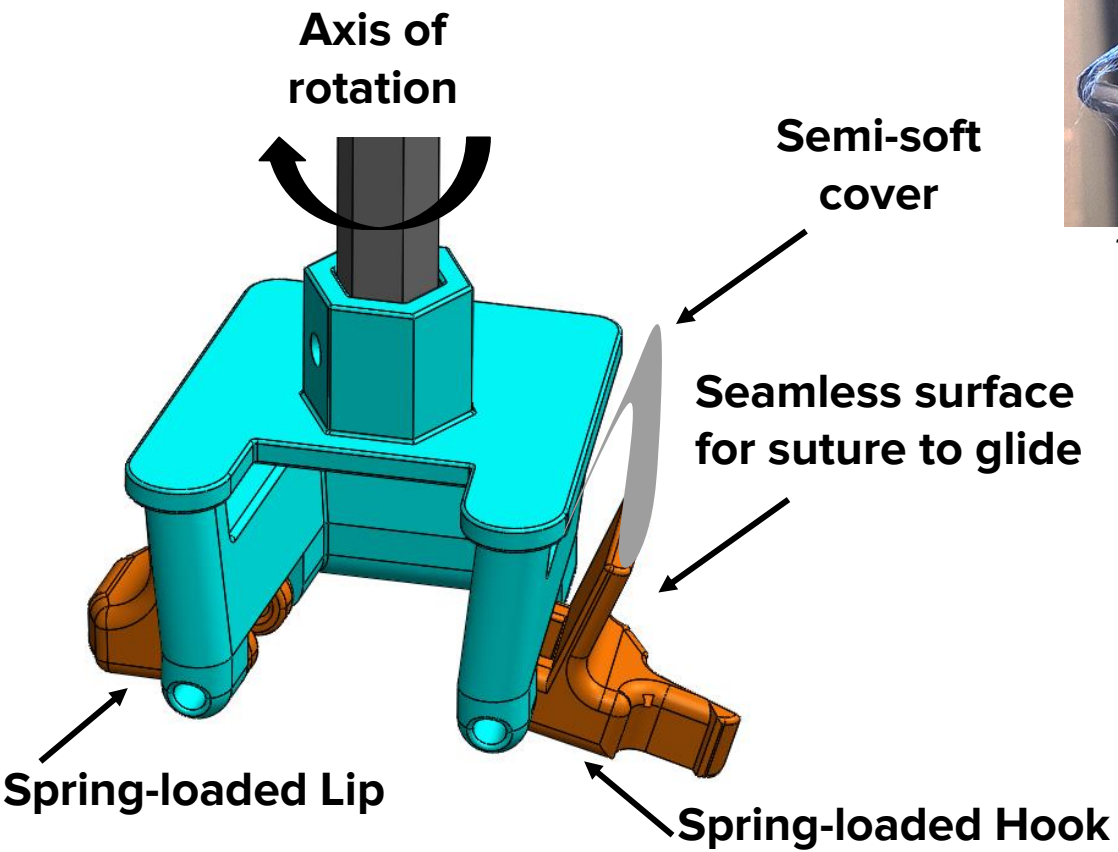
1 Needle Drive

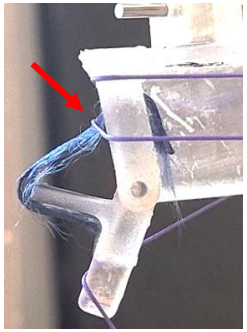
Hooks catch thread to make loops





Hook covers with optimal compliance

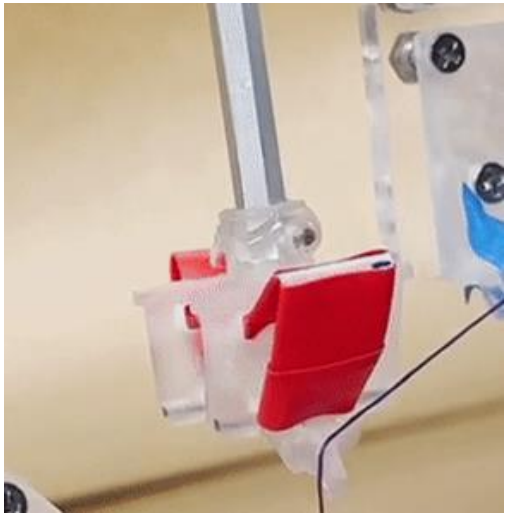




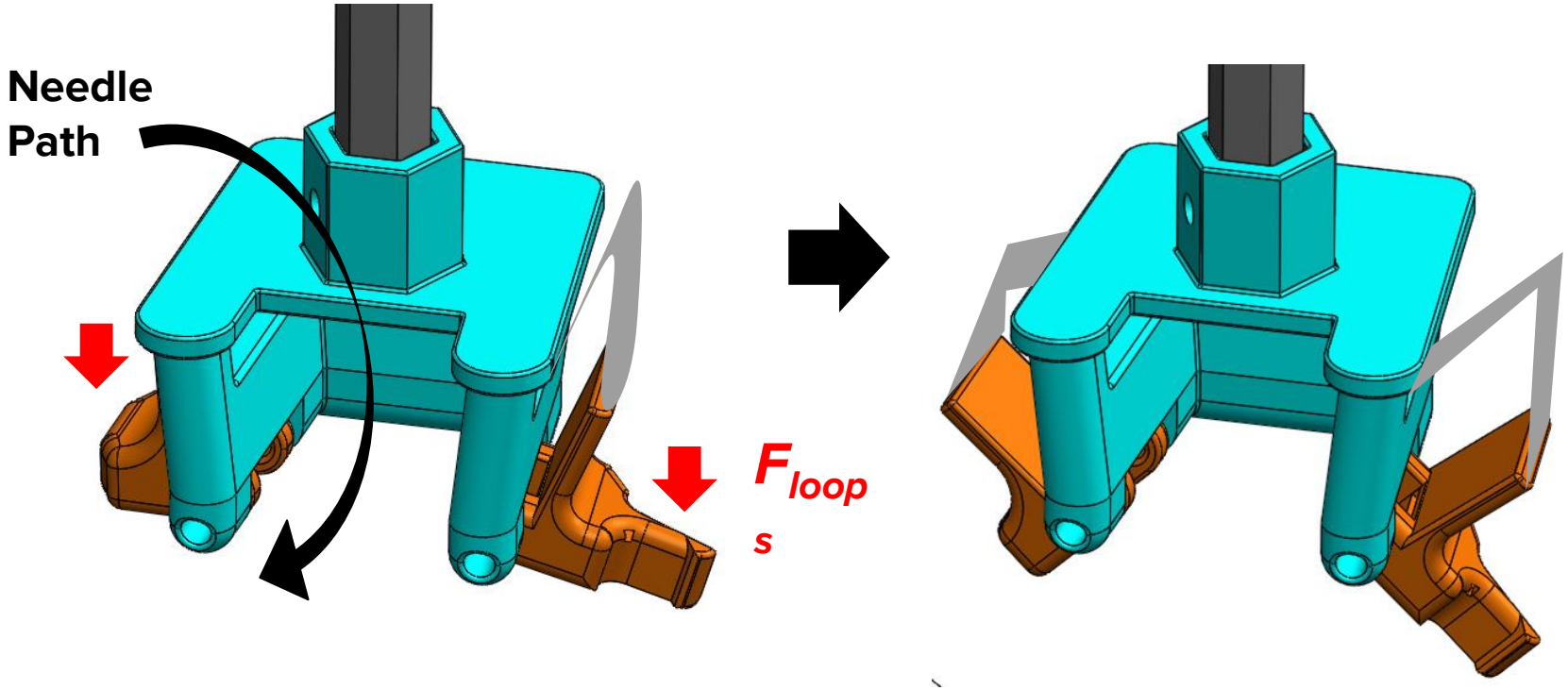
Too soft

Too hard

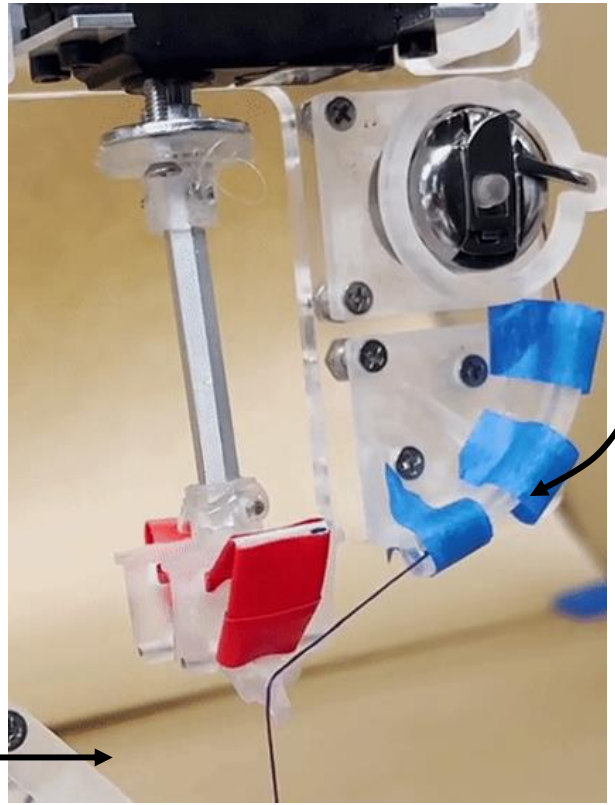
Just right



Hook and lip passively tilt down to release loops



Controlled suture release inspired by sewing machines

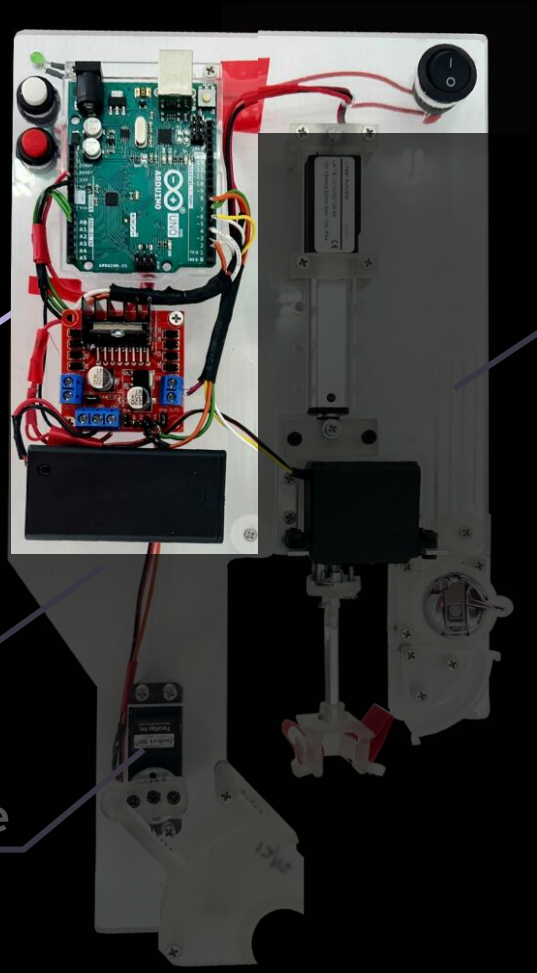


Retrofitted bobbin releases suture

Suture guide

released in tension

stationary



3 Electronics & Control

Looping 2

4 Housing & Integration

1 Needle Drive

Controls: Actuation Logic Flow

Looper forms loops
Servo 1

↓

Send looper down
Linear Actuator

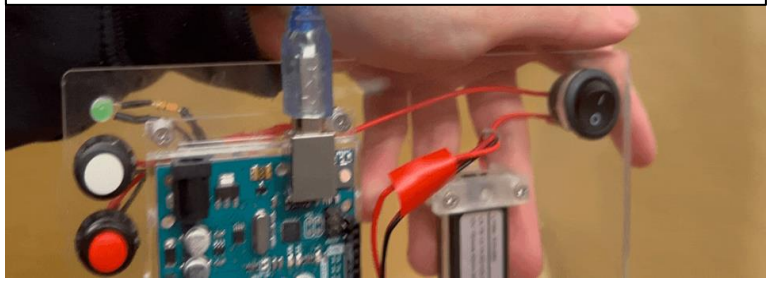
↓

Drive needle through loops
Servo 2

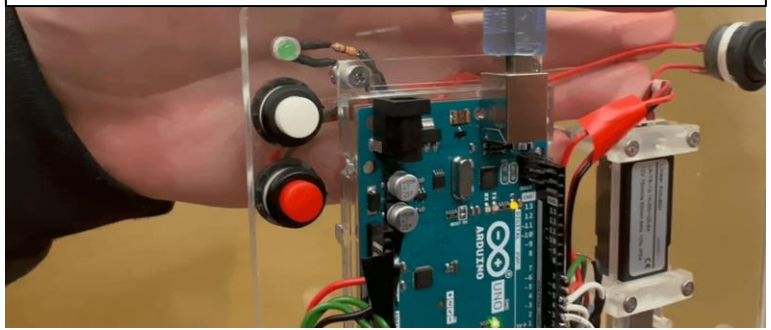
↓

Send looper up
Linear Actuator

On/Off Switch



‘Next Action’ Button
LED lights up when action completed and will not proceed until white button pressed.



Controls: Actuation Logic Flow

Looper forms loops
Servo 1

↓

Send looper down
Linear Actuator

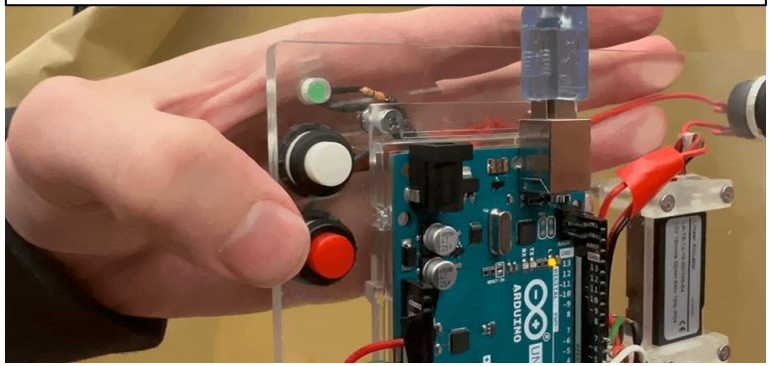
↓

Drive needle through loops
Servo 2

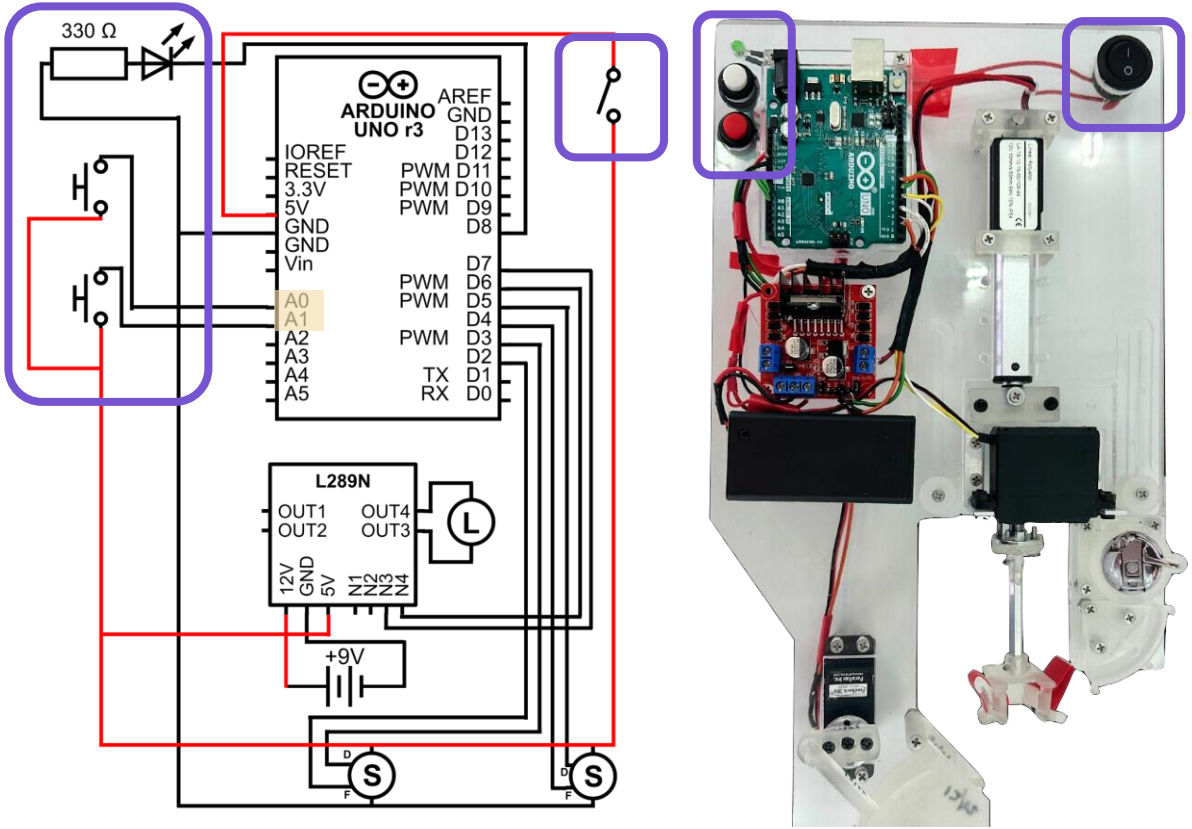
↓

Send looper up
Linear Actuator

Emergency Stop Button
Halt and retract needle if anything goes wrong.



Hardware: Circuit Diagram



LED

Digital OUTPUT, 5V

330Ω Resistor

Momentary Push Buttons
Continue, Emergency Stop

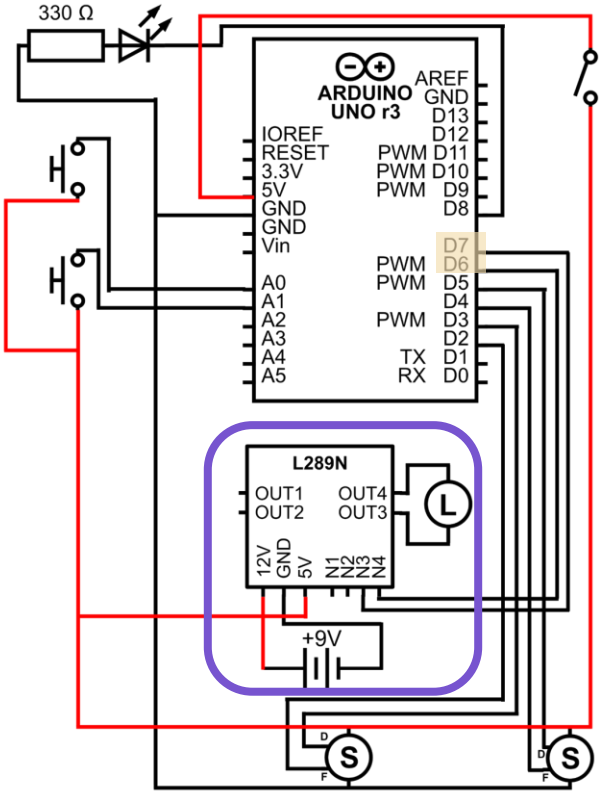
'Main circuit' 5V DC

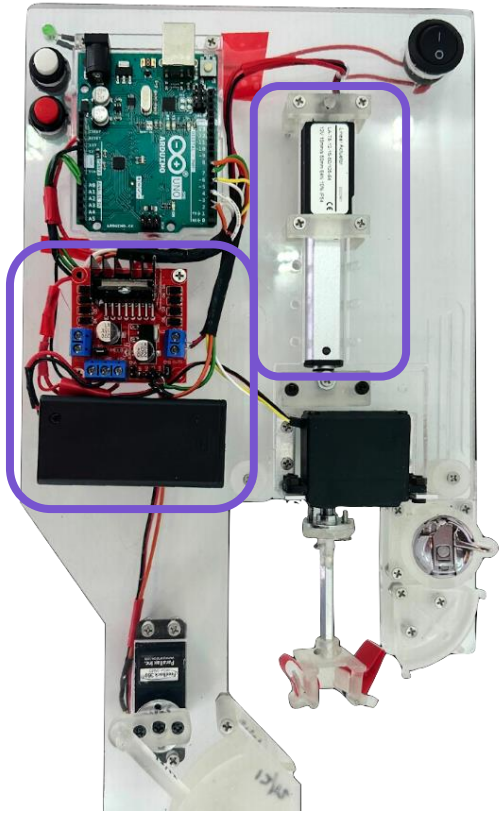
Ground: Analog INPUT

On/Off Switch

In series with 'Main circuit' 5V DC

Hardware: Circuit Diagram





L289N Motor Driver

‘Main circuit’ 5V DC

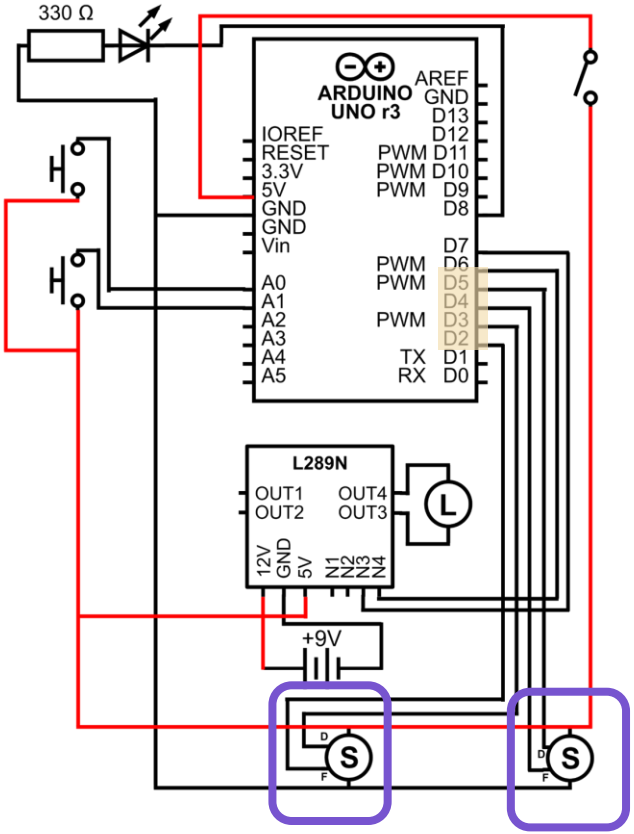
- Power motor driver

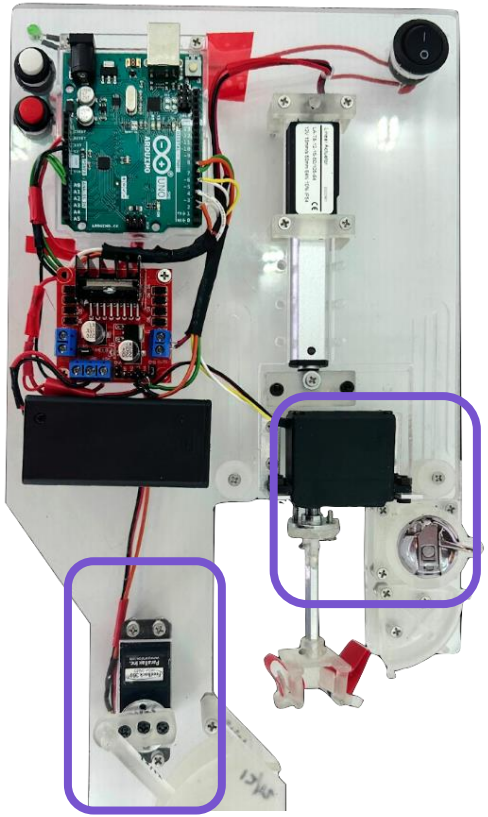
‘Additional circuit’ 9V DC

- Power linear actuator

N3, N4: Digital INPUT

Hardware: Circuit Diagram





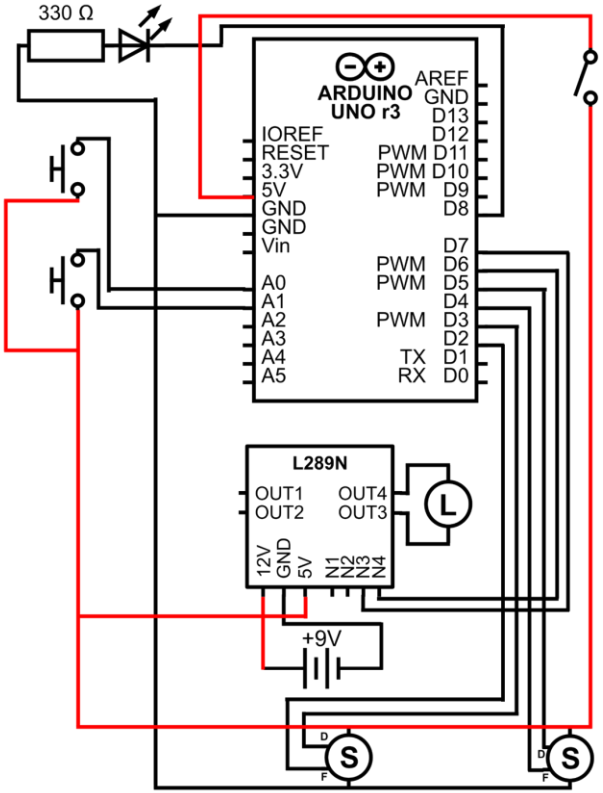
Servo Motors

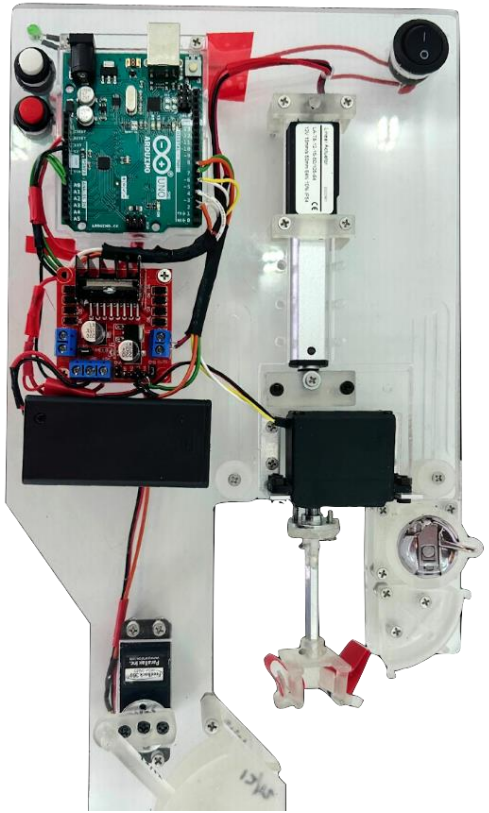
‘Main circuit’ 5V DC

Feedback: Digital INPUT

Driver: Digital OUTPUT

Hardware: Circuit Diagram

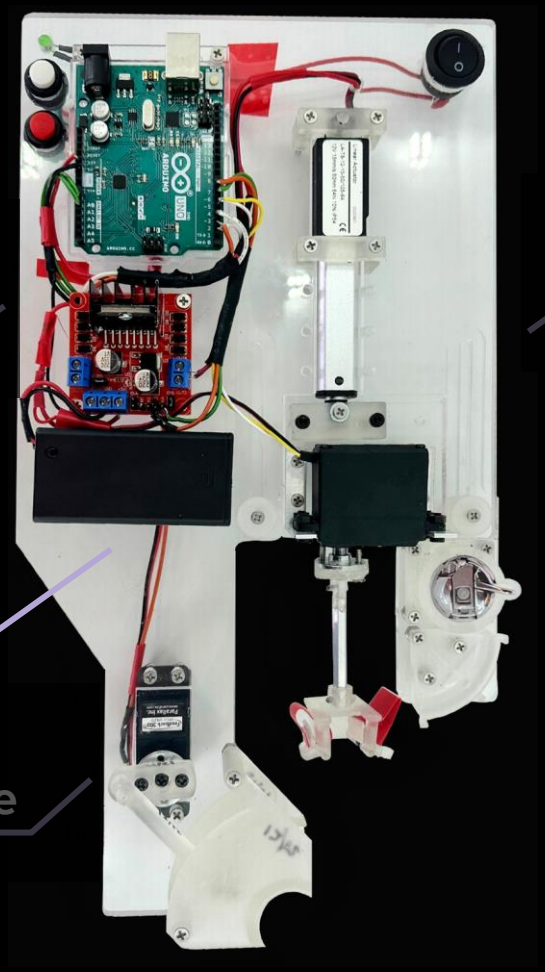




Power Consumption

5V, Max Draw: 0.032A

Ideal for miniaturization and untethered handheld devices.



Looping 2

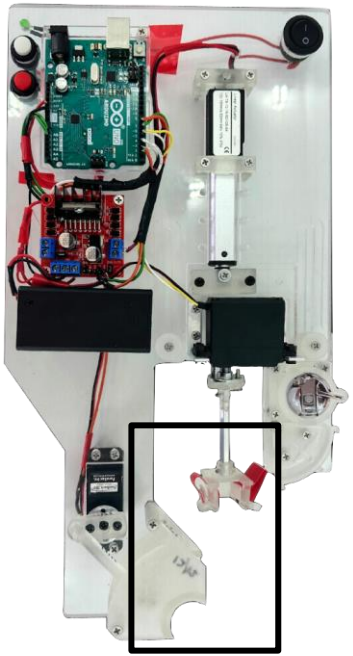
3 Electronics & Control

4 Housing & Integration

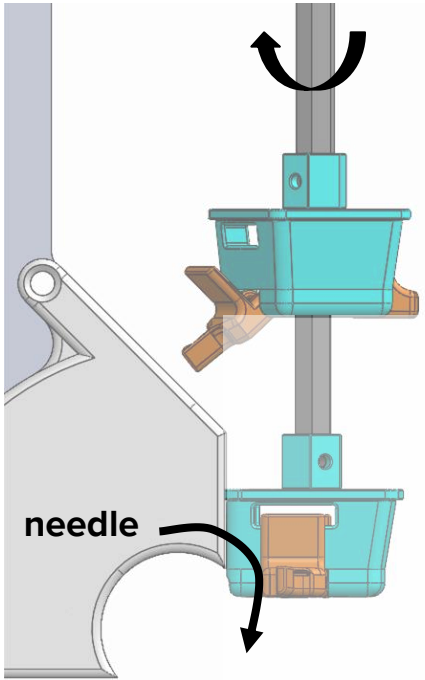
1 Needle Drive

Vertical looper movement to enter/exit needle path

Laser Cut Mount Board



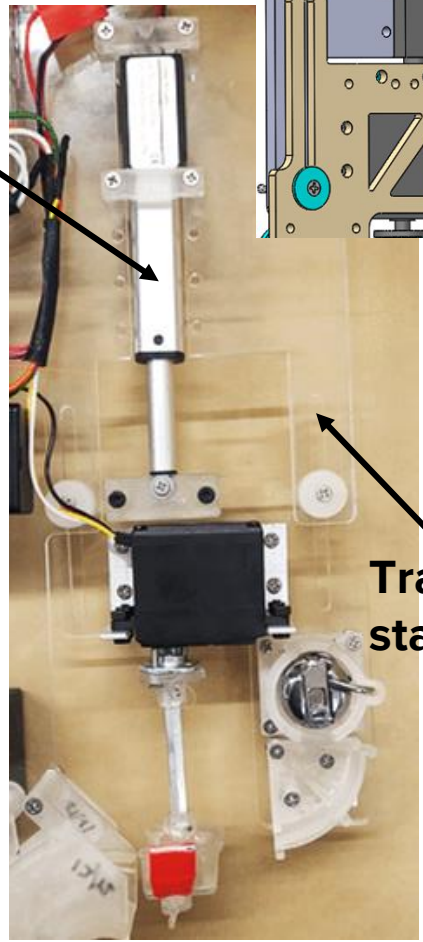
Lateral Alignment

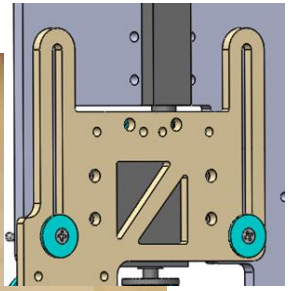


Retracted:
Waiting, Looping

Extended:
In needle path

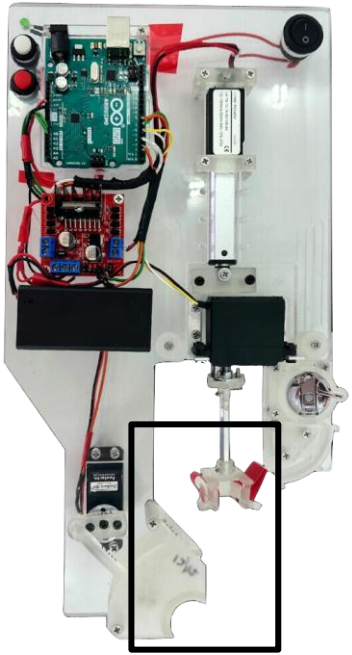
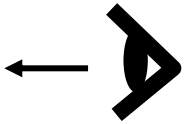
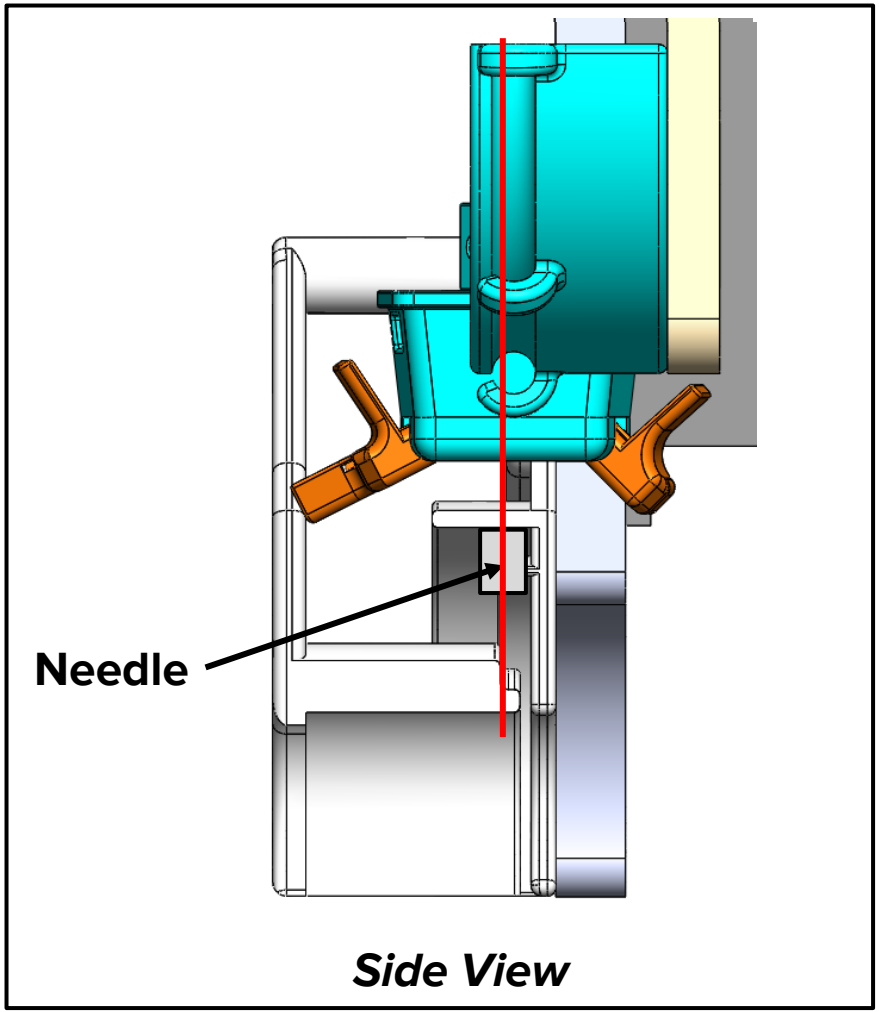
Linear actuator





Back

Tracks for stability

Side view alignment

Laser Cut Mount Board