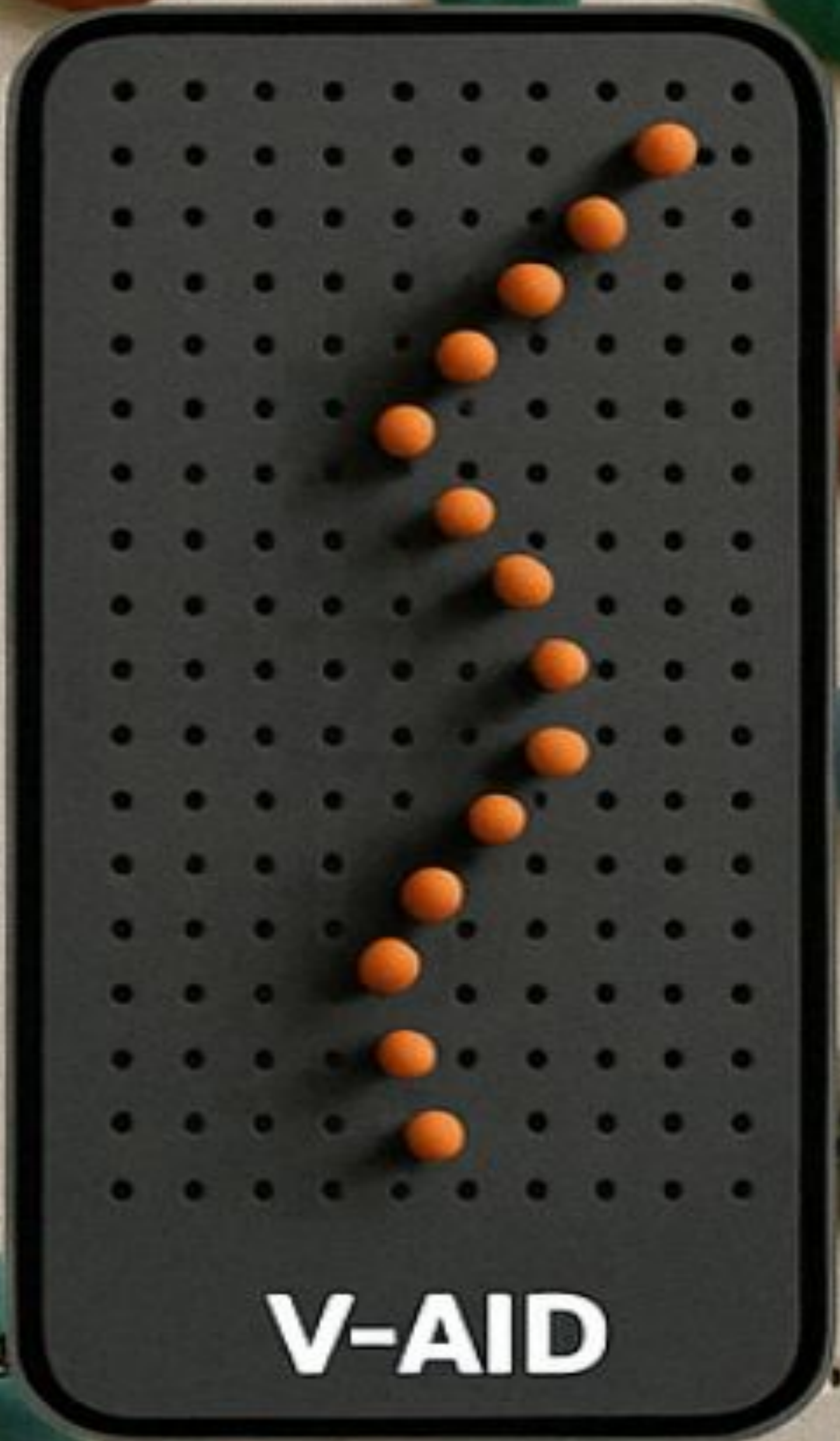
V-Aid Climbing

By: Timur Chukin, Ahmad Hassan, Tony Korycki, Mergen Ulziibayar, Brandon Kolodiy



Our Idea

An assistive device that supplements a visually impaired climber with a tactile display of the route paired with AI generated instructions read out loud.

Meet the Team

Software Subteam

Antoni Korycki ‘27
Ahmad Hassan ‘27
Electrical & Computer Engineering, Undergraduate NYU Tandon

Hardware Subteam

Timur Chukin ‘27
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Electrical Engineering, Undergraduate NYU Tandon
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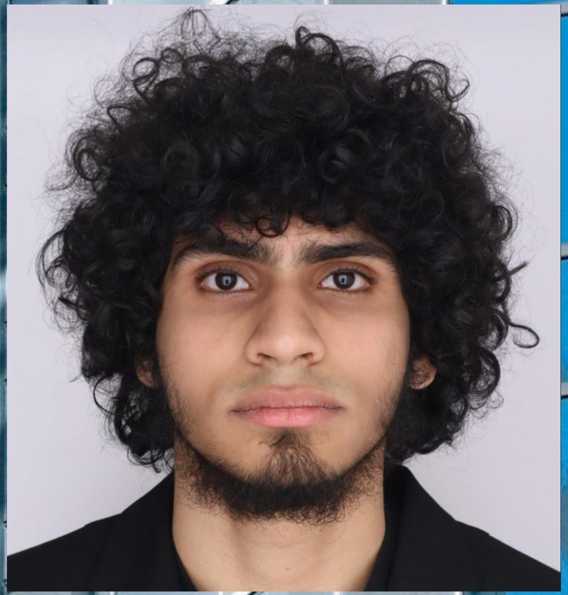
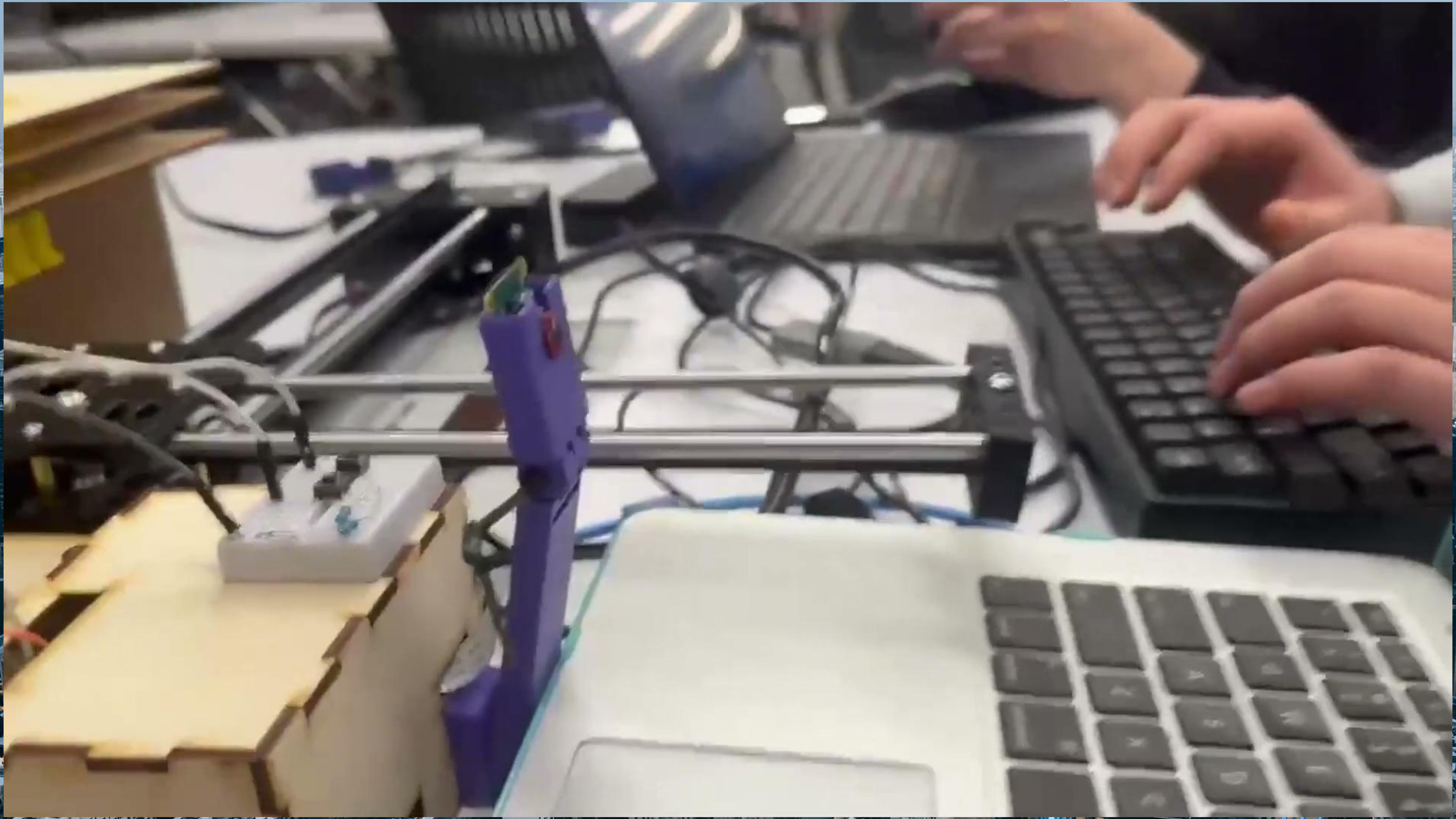


Our Motivation

Inspiration came to us when we come across a video from USA Climbing teaching proper “calling” techniques for visually impaired climbers, and another of a coaching tip which used lego bricks as a physical representation of a climb in addition to calls made.

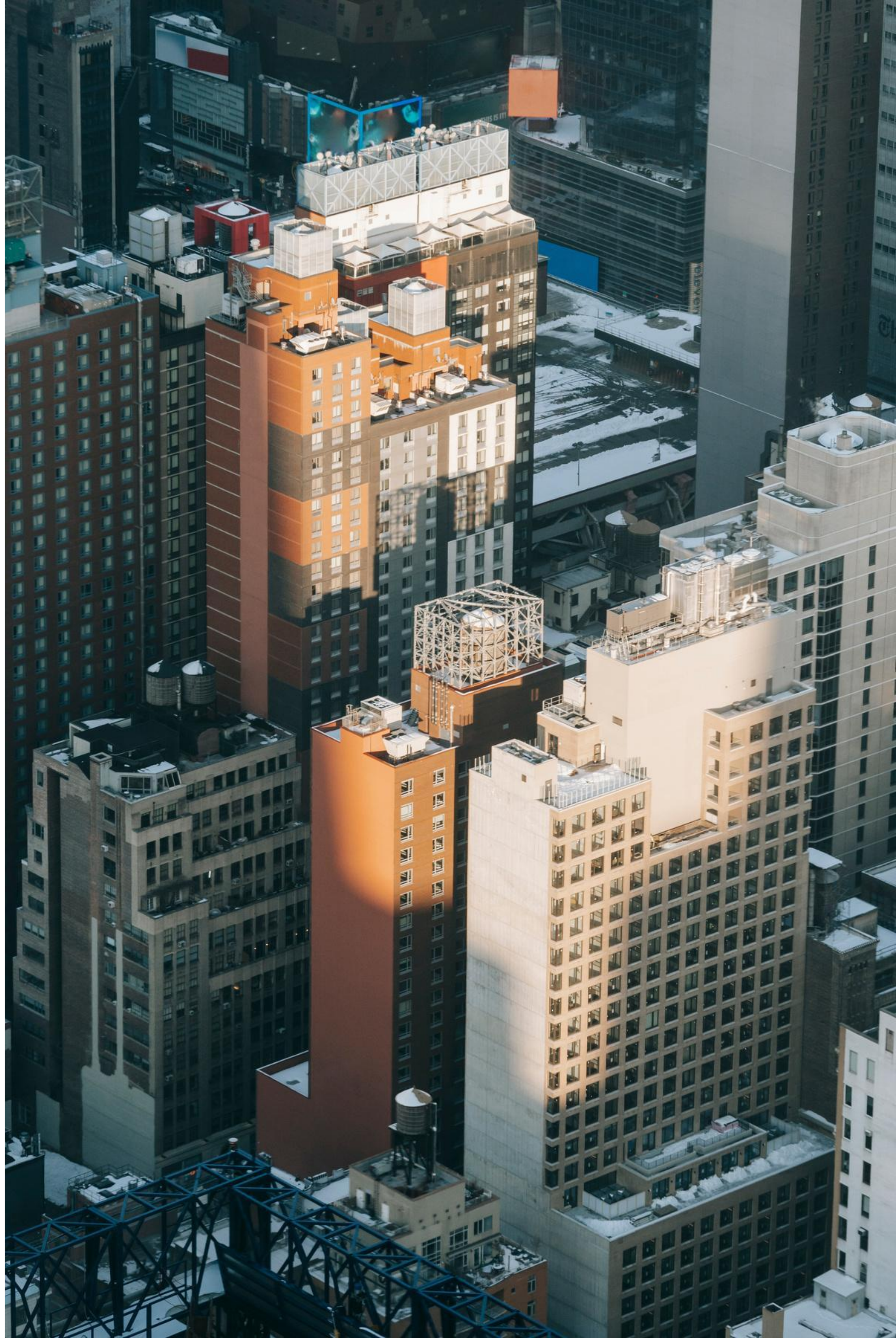
As climbers ourselves, we realized the reliance of visually-impaired climbers on friends and callers, as well as the inefficiency of the lego system, and began brainstorming a device that would increase their independence when climbing at the gym.



Our Prototyping Process

Main Challenges:

- **Hold Detection and Classification**
- **Tactile Display Design and Pi Integration**
- **Communication with Tactile Display**
- **Integration of the XY Plotter to push Tactile Display pins.**



MARKET RESEARCH

Calling Efficiency

Climbing is exhausting, and losing energy waiting for better communication can be crucial

User Experience

Controlling the device with accessibility in mind is as vital as making an accessible device in the first place

Pin Prototyping Process

TECA014 - Tactron: A Low Cost Tactile Graphics Display

A project by Jerry Yao for the Regeneron Competition seemed like the perfect opportunity when we began our project. We had come up with a very similar idea, but reaching out to Jerry allowed us to obtain a prototype for the pin design that boosted our progress meteorically.

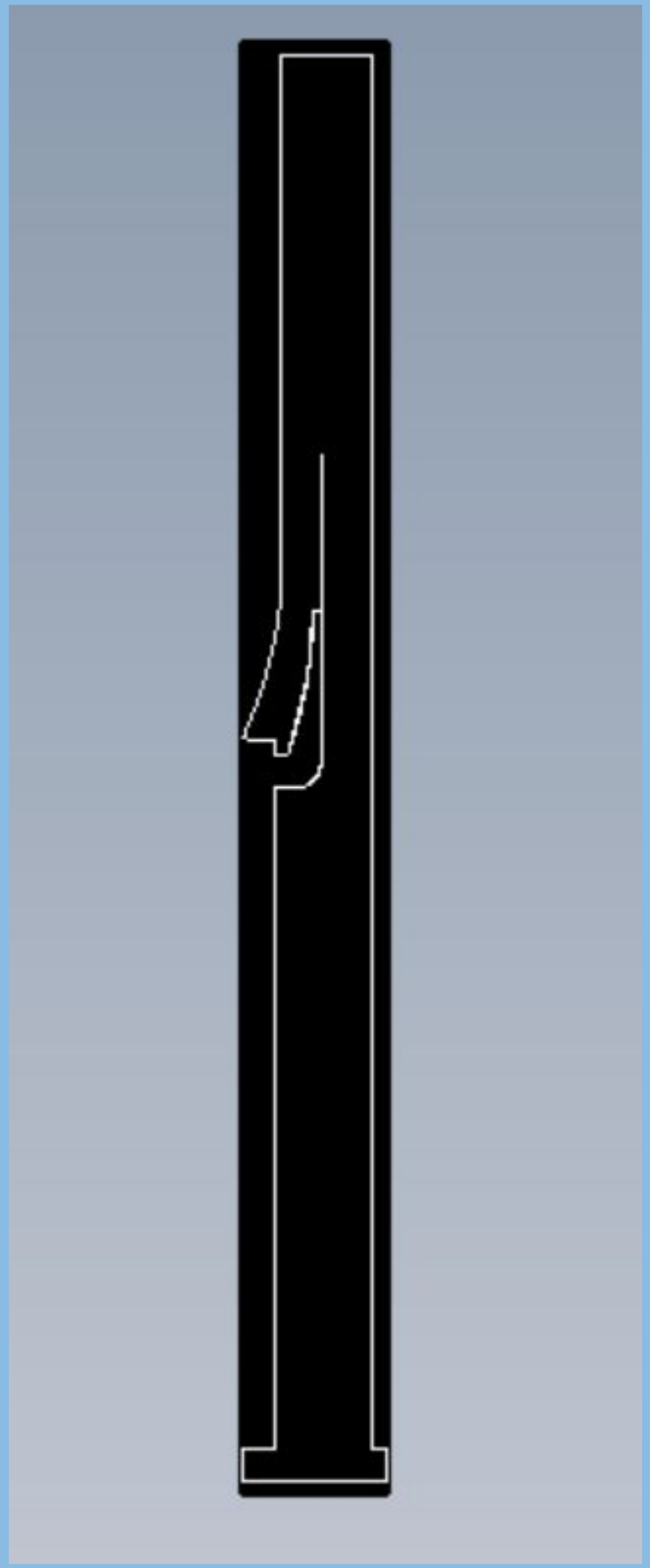
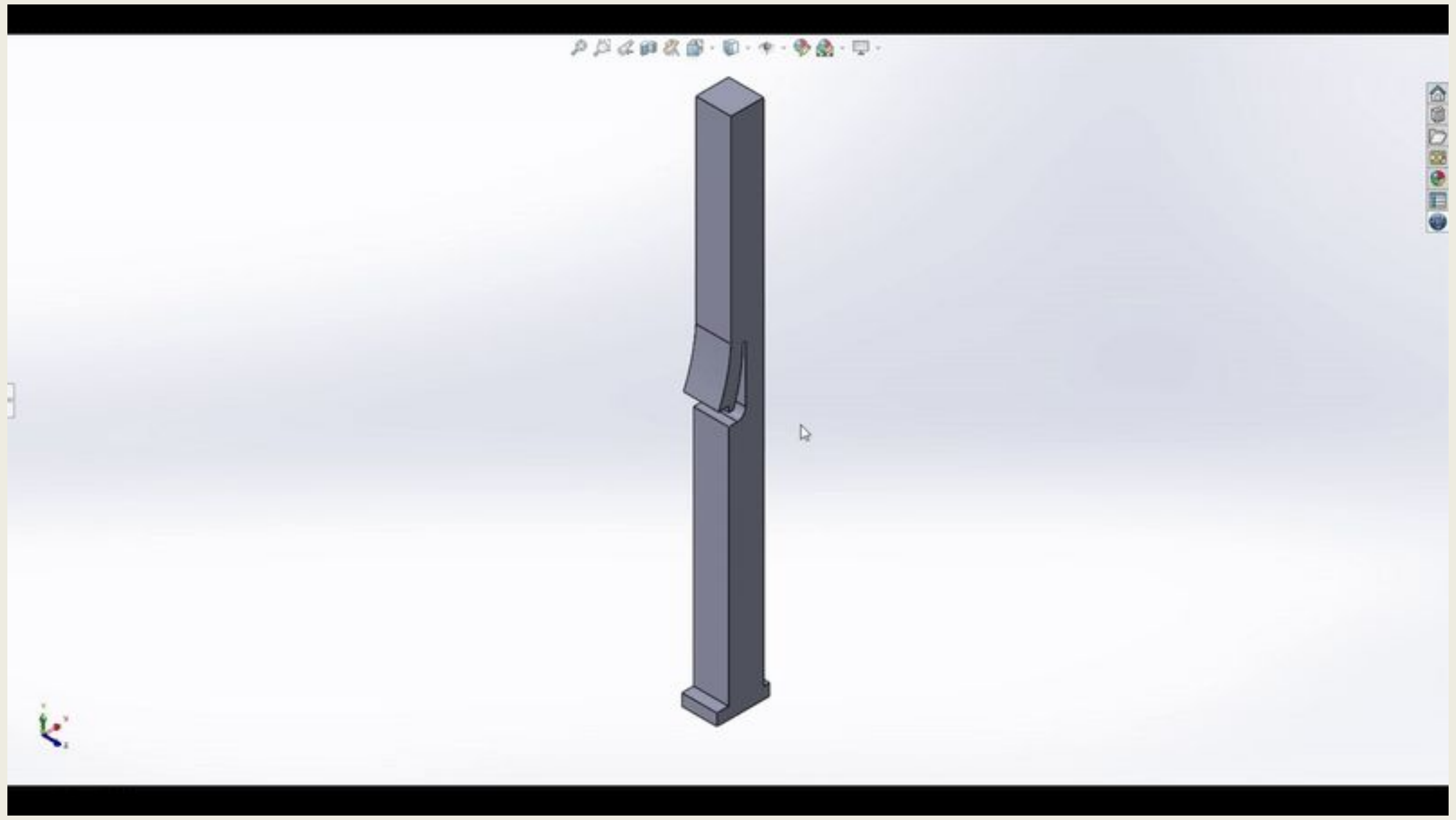


Figure: Original Tactron Pin

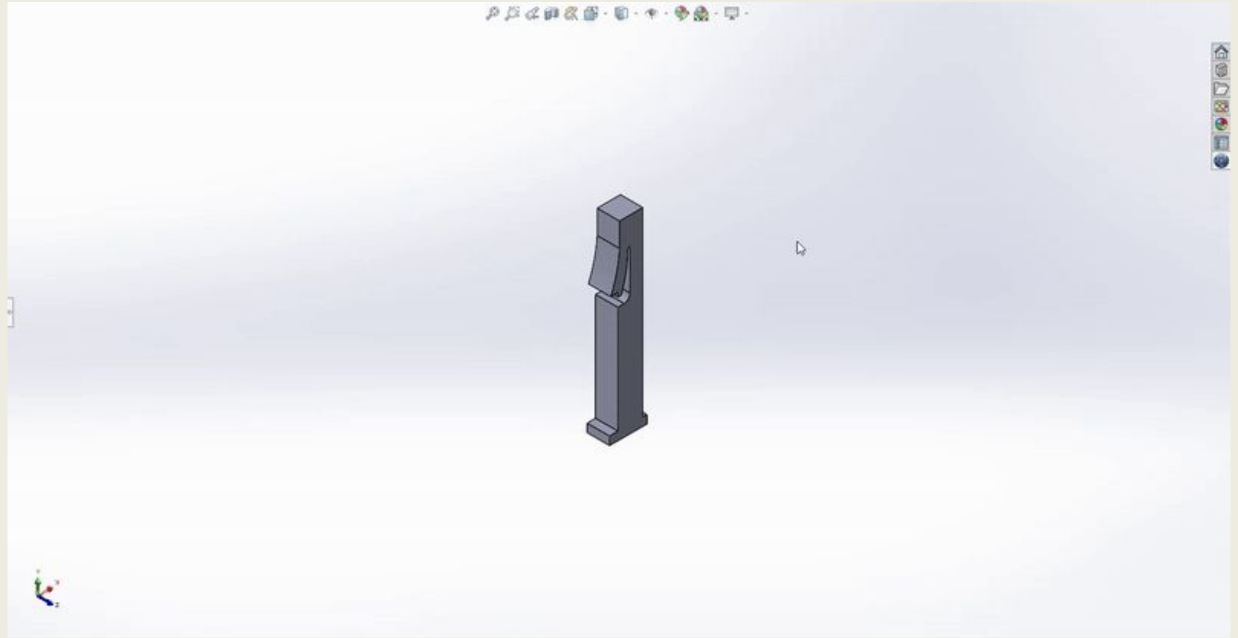
Yao, M. (2024). TacTron: A low-cost tactile graphics display. Society for Science: ISEF 2024. https://isef.net/project/teca014-tactron-a-low-cost-tactile-graphics-display

Optimizing Pin Length and Tactile Experience

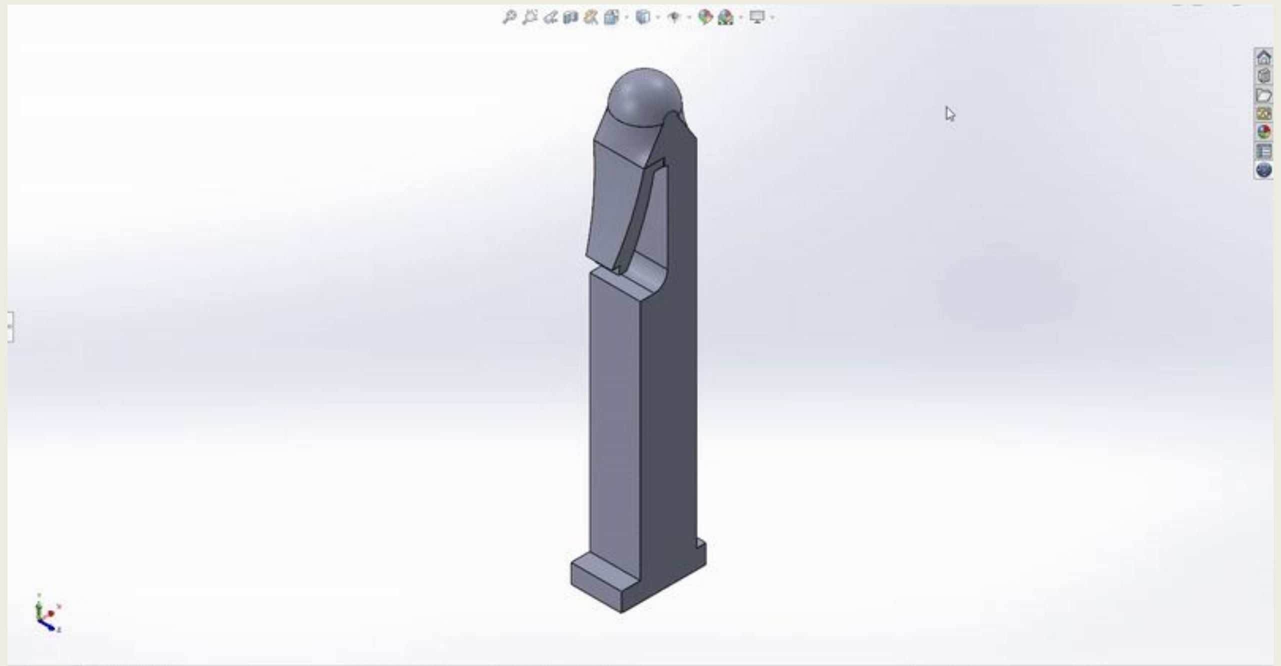
Pin Iterations



Iteration 2:
Shorter pins for easier pressing and less drastic height difference between activated and unactivated pins.



Iteration 3:
Smoother tops for less rough gliding when feeling full grid. Further adjusted heights.



Plotter Integration - Grid Design - Servo/Actuator Design

Grid Design Prototyping Process

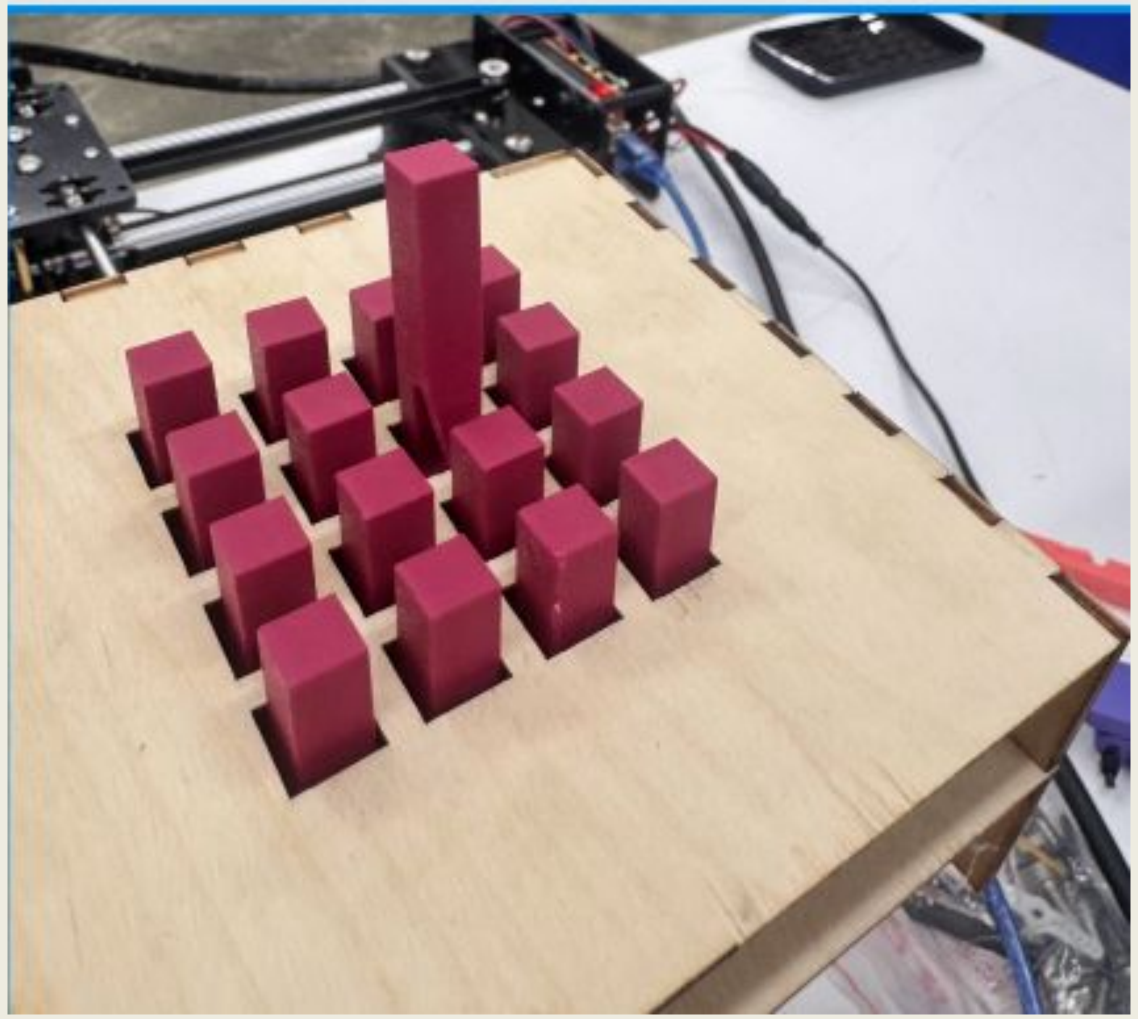


Figure: First Full Pin Prototype

Color Correction - Image Cropping - Hold Detection - LLM Communication

Computer Vision Learning Process

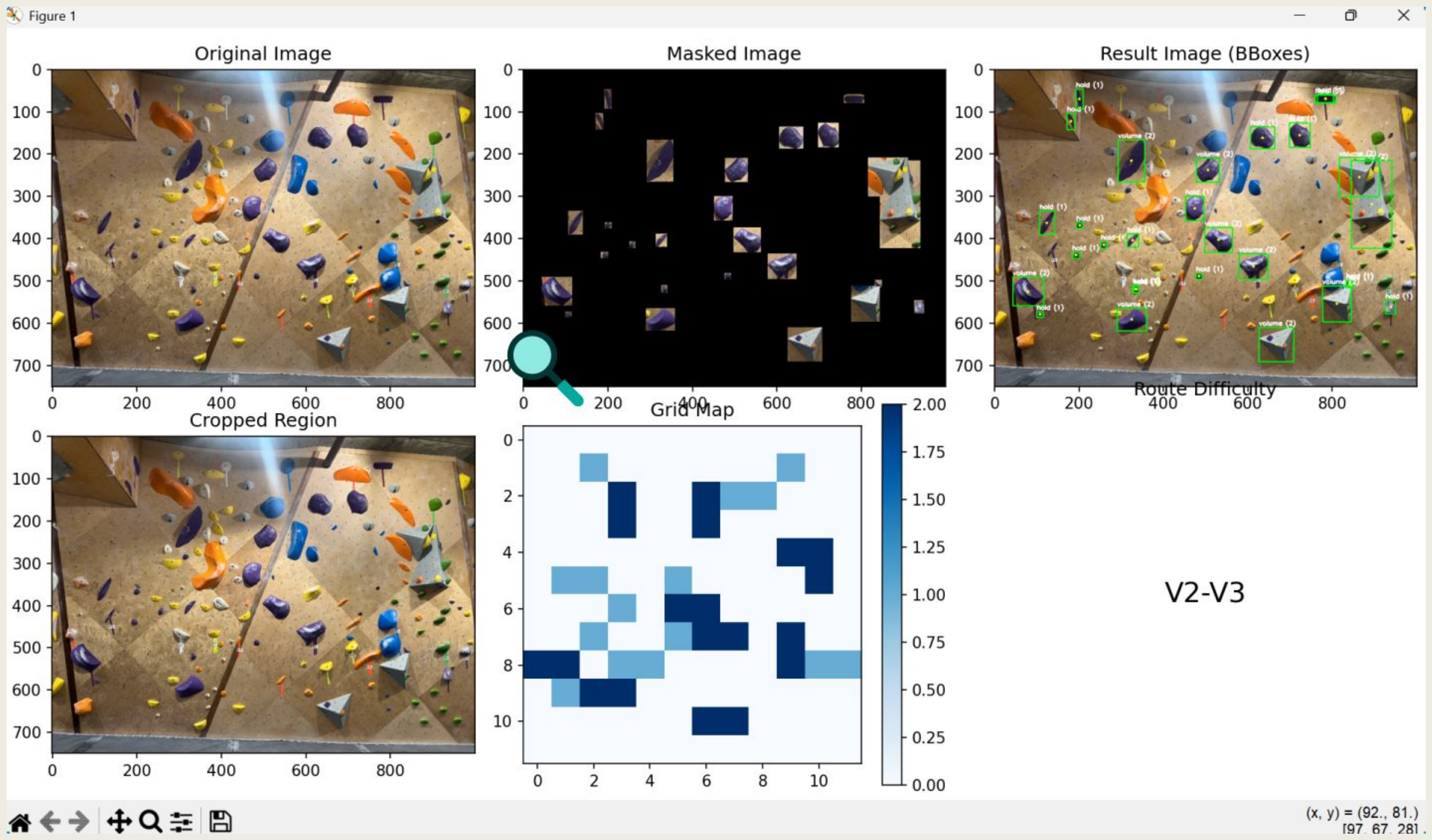


Figure: Climb Analysis

Computer Vision Learning Process Cont.

- **Used a You Only Look Once (YOLO) object detection model to get bounding boxes for all holds**
- **Cropped image to only include analyzed route and adjusted color ranges based on image brightness**
- **Filtered out holds in the right color range and assessed which volumes belong to the route**

```
#run YOLO on the full image
results = yolo_model.predict(source=image, conf=0.25)
if len(results) == 0 or len(results[0].boxes) == 0:
    print("No holds detected by YOLO.")
    return [], np.zeros((12, 12), dtype=np.int32), image, image, (0, 0, orig_w, orig_h)

# define HSV color ranges with adaptive sensitivity
v_base = 50 - sensitivity // 4
s_base = 100 - sensitivity // 4

color_ranges = {
```

Compute Vision Learning Process Cont.

- **Mapped each hold on a 12x12 array to define an accurate map**
- **Used Mistral-7B to generate natural language route descriptions**
- **Utilized google text to speech to read a description of the route**

```python
for box in results[0].boxes:
    # Extract bounding box coordinates (x1, y1, x2, y2)
    x1, y1, x2, y2 = box.xyxy[0].tolist()
    x1, y1, x2, y2 = map(int, [x1, y1, x2, y2])

    box_area = (x2 - x1) * (y2 - y1)
    if box_area < min_area:
        continue

    # Clip coordinates to image boundaries
    x1 = max(0, min(orig_w - 1, x1))
    x2 = max(0, min(orig_w - 1, x2))
    y1 = max(0, min(orig_h - 1, y1))
    y2 = max(0, min(orig_h - 1, y2))
    if x2 <= x1 or y2 <= y1:
        continue

    # Get predicted class from YOLO
    pred_class = int(box.cls[0].item()) if hasattr(box, 'cls') else 0
```

Figure : Cropping image based on found bounding boxes

```python
# Send request to the API
try:
    print(f"Sending request to Mistral API...")
    response = requests.post(api_url, headers=headers, json=payload)

    if response.status_code == 200:
        result = response.json()
        if isinstance(result, list) and len(result) > 0:
            return result[0].get("generated_text", "No text generated")
        return str(result)
    else:
        print(f"API error: {response.status_code} - {response.text}")
        return generate_generic_description(grid_map, difficulty)

except Exception as e:
    print(f"Error using API LLM: {e}")
    return generate_generic_description(grid_map, difficulty)
```

Figure : Generating description with an LLM

Key Learnings:

Integrating Arduino-GRBL-Pi

Throughout our process we learned a lot about combining processes. While getting the individual test scripts to work was straightforward and quick. Working through errors created through migrating the code to the Pi and physically integrating the components was challenging.

Reaching out for External Help

We initially set upon creating our own pin design; however, through reaching out and obtaining permissions from similar projects we were able to save weeks of 3D modeling work. By communicating with others that could forward our progress we could devote more time towards debugging and constructing the housing body.

Final Key Learning: Project Organization

When starting out, we planned out an elaborate project schedule. With component shipping dates and exam dates interfering, our personal and project schedules drifted prompting readjustments of our plans. A key learning moving forward is to create plans holistically while staying flexible to not lose sight of the goal of the project

V-Aid-Climbing Next Steps

- All in One Pin Dropping System
- App and Bluetooth Integration for Ease of Use and Project Overhaul
- Reducing the size of the V-Aid Climbing Plotter and creating a quicker pin activator.

Thank You!

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