Battery Tracker

BUCKEYE WILDCATS

Seth Gering
&
Scott Phelps

April 2022

OpenCV Spatial AI Contest: sponsored by Intel™ and Microsoft Azure™

intel

Microsoft Azure

LEGO mindstorms

LUX onjs

DEPTH

OpenCV

Our Team

- Home Base: Tucson, Arizona
- Met through adoption process
- Scott is Mechanical Engineer for Raytheon
- Seth is Mining Specialist for IMDEX
- Common Interests
  - International foods
  - Star Wars
  - Woodworking

Project Video: https://youtu.be/KqsggGiziQ4

Challenge Background

- **Why we entered**
  - Excited to test out the Oak-D Lite AI camera, playing with Legos, and having some fun solving problems.
  - Fascination with AI and wanted to test it out on practical application.
- **What problem we chose**
  - Focused on real-world problem experienced while making small batches of thermal batteries.
  - High Return on Investment.
  - Ability to achieve functioning proof of concept using OOTB software and hardware.
- **How to solve**
  - Minimum Viable Product (MVP) approach. Start small and scale with additional functionality over time.
  - Leverage existing software and technology from Microsoft Azure.
  - Divide and conquer (robotics and camera AI).

Business Problem

- ***Problem Summary**
  - Small quantity, custom thermal battery manufacturing requires stacking and accounting of individual metallic layers.
  - This manual process requires counting and tracking of the individual components.
  - Mistakes can lead to costly re-work and potentially unsafe conditions when the layers are not stacked properly.
- **Current Challenges with Small Batch Manufacturing**
  - Sample X-ray inspections can miss errors due to human element.
  - Potential for miscounts.
  - No material or defect tracking.
  - Manual process.
- **Proposed Solutions**
  - Use Oak D-Lite Spatial AI, Enterprise SaaS, and Robotics to automate the battery manufacturing and inspection process.
  - Take an inspect-as-you-go approach.

*Photos of actual process disallowed due to NDA and Proprietary

Project Goals

Phase 1 - Manual Stacking of Discs

1. Create User Interface GUI for production environment.
2. Make stackable discs.
3. Create “recipe” database.
4. Integrate Oak-D Lite camera spatial AI capabilities to distinguish between discs.
5. Integrate Oak-D Lite camera capabilities to distinguish between layers.
6. Create quality history record.
    a. Utilize Oak-D Lite video recording capabilities.
    b. Utilize Azure Media Services for video archive and streaming.
    c. Utilize Power BI for report generation for intranet or web-based oversight.

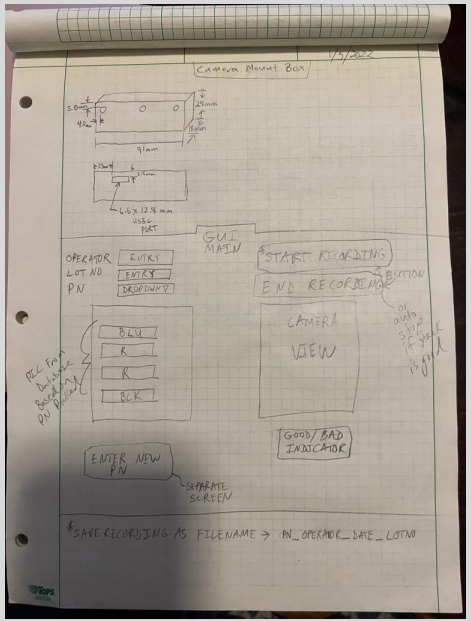
Phase 2 - Automate Stacking of Discs

1. Lego Mindstorm pick-n-place robot - Hardware.
2. Lego Mindstorm pick-n-place robot - Movement Code.
3. Integrate Phase 1 software to activate Mindstorm code.

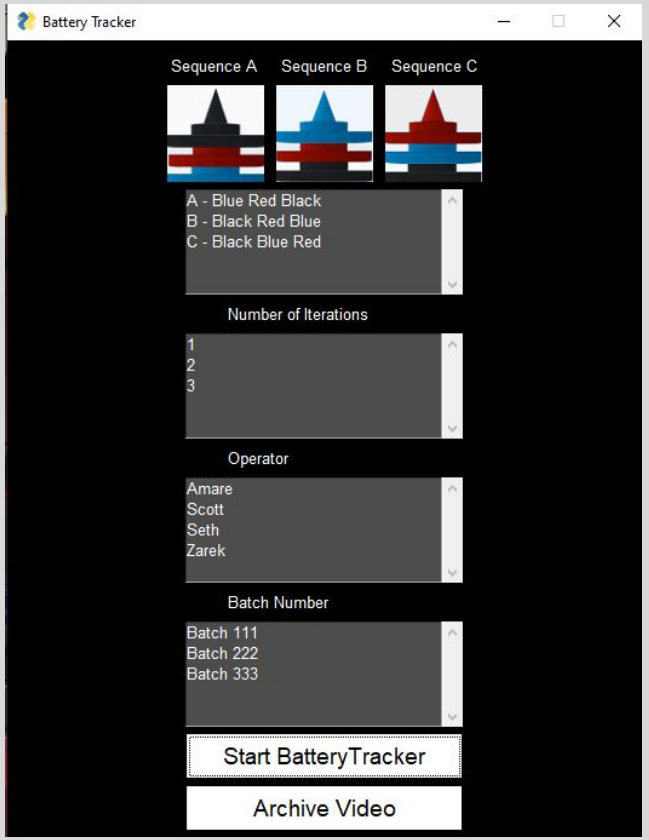
PHASE 1

User Interface GUI

- User picks part number from drop down.
- Database pulls in stack “recipe” based on part number chosen.
- “Recipe” shown on screen.
- Oak-D Lite camera view shown on screen.
- Good/Bad Indicator.



Idea

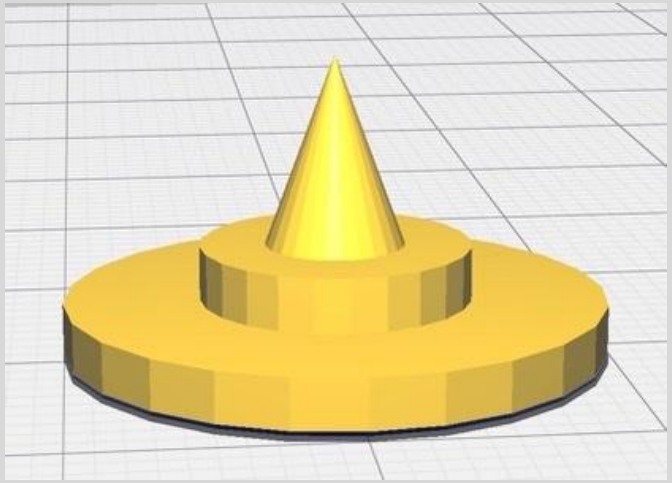


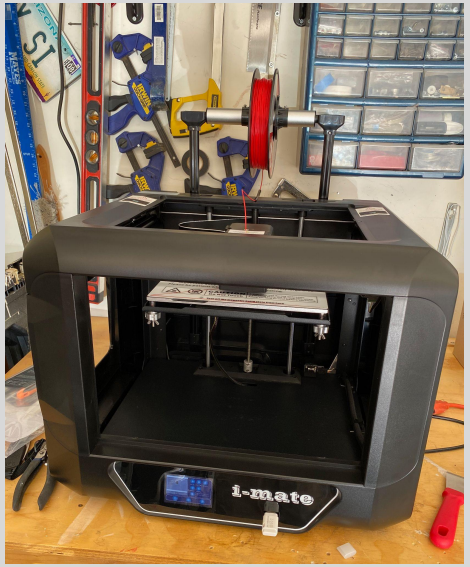
Proof of Concept

PHASE 1

Making Stackable Discs

- Proof of concept discs as actual are proprietary.
- Used TinkerCad to create model.
- Sliced model in Ultimaker Cura.
- Printed on Qidi i-Mate Printer using PLA filament.
- First batch printed were too small, scaled up and reprinted.

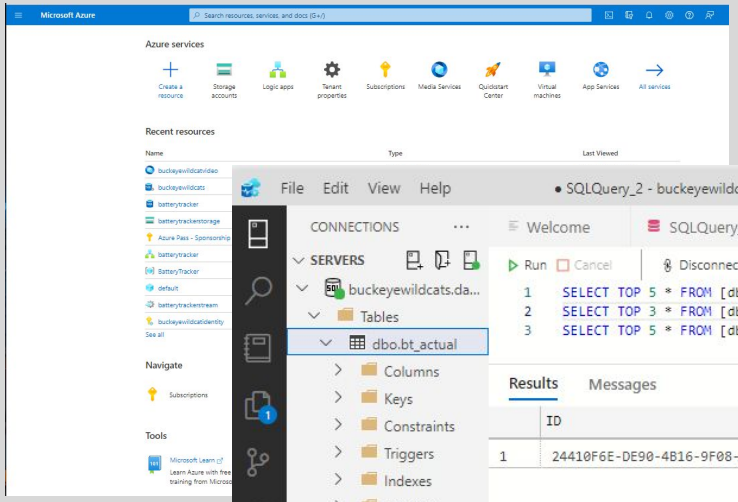


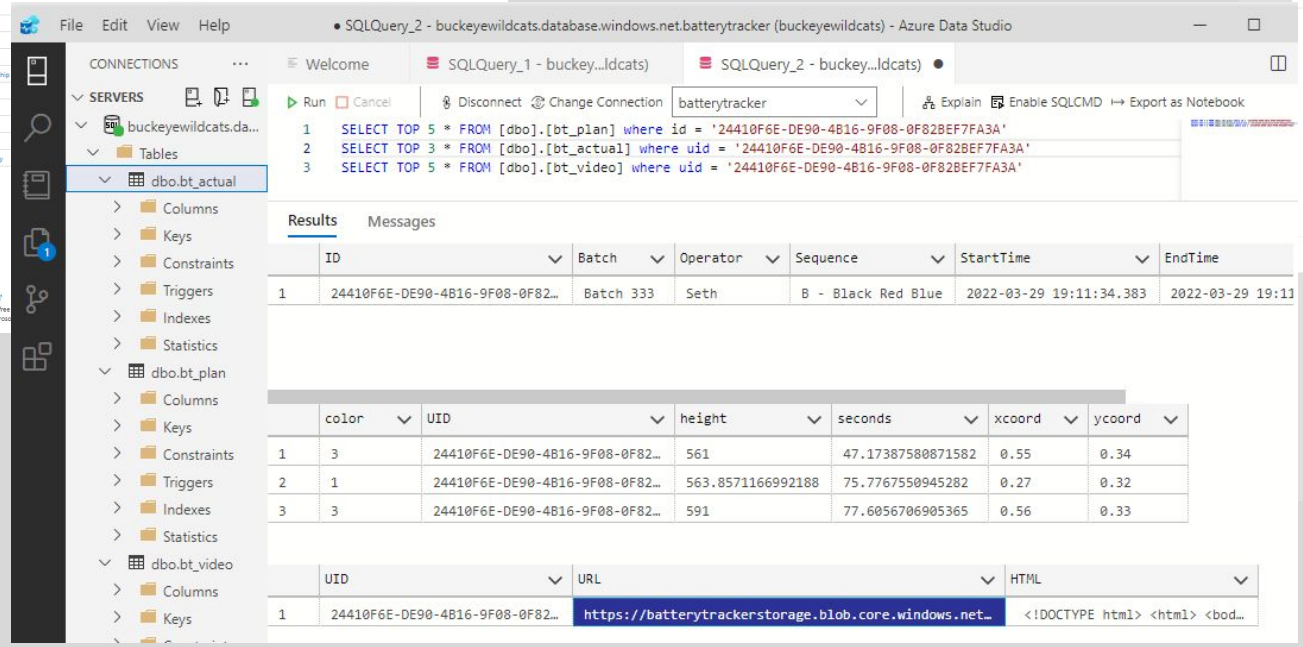


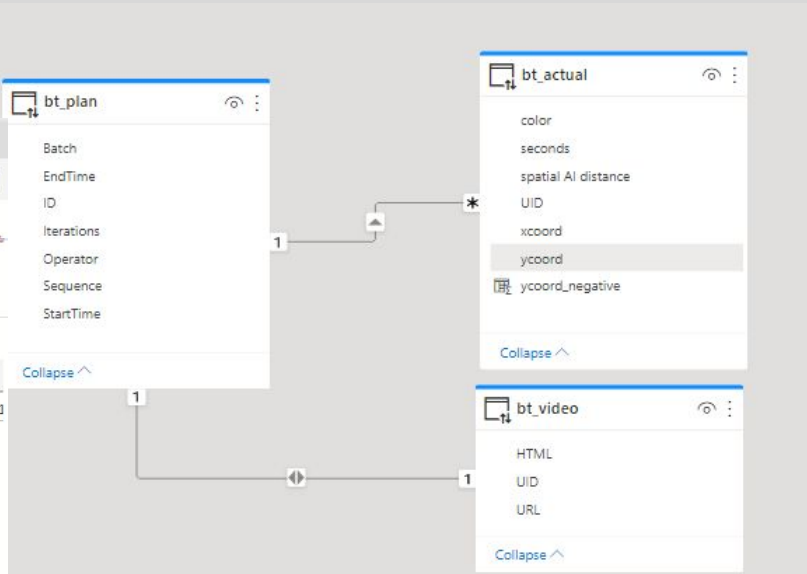
PHASE 1

Create “Recipe” Database

- Design recipe, actual Spatial AI data collection, and video archive all stored in SQL relational database.
- Microsoft Azure SQL Database linked to UI to pull in correct stack layer “recipe” based on part number chosen.
- Database stores video link to Azure Media Service of recorded of stack process.





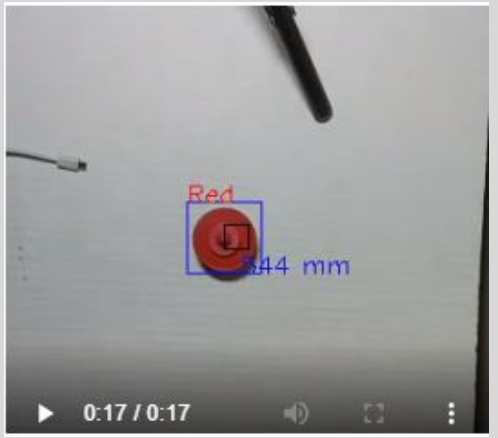


Integrate Oak-D Lite Camera Spatial AI Capabilities to Distinguish Between Discs and Layers

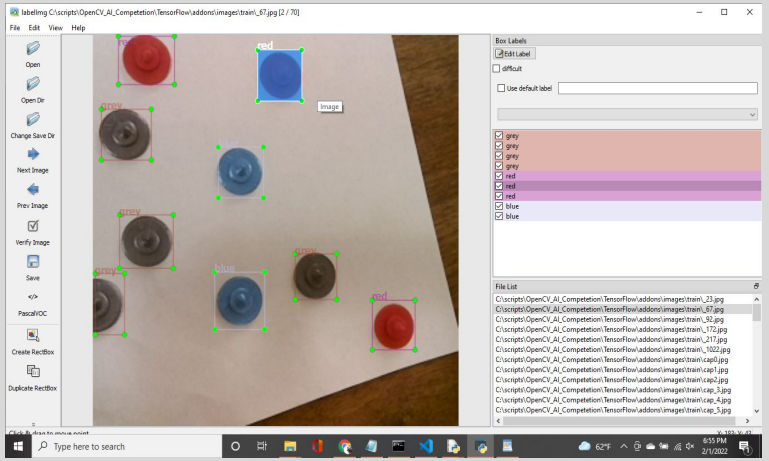
PHASE 1

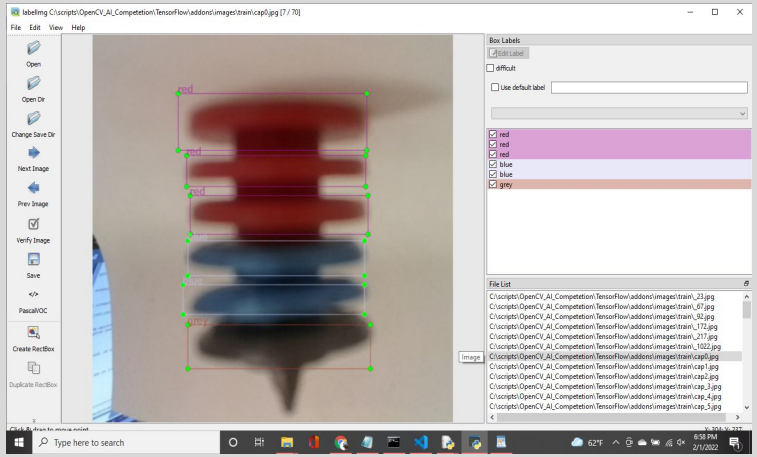
- Custom Feature Detection using Mobilenetv3.
- Utilized Luxonis Custom Training Tutorial.
- Training process
  - 20 Testing Images
  - 80 Training Images
- Two Views
  - Top View
    - Color + height
  - Side View
    - Color + count

Top View



Side View



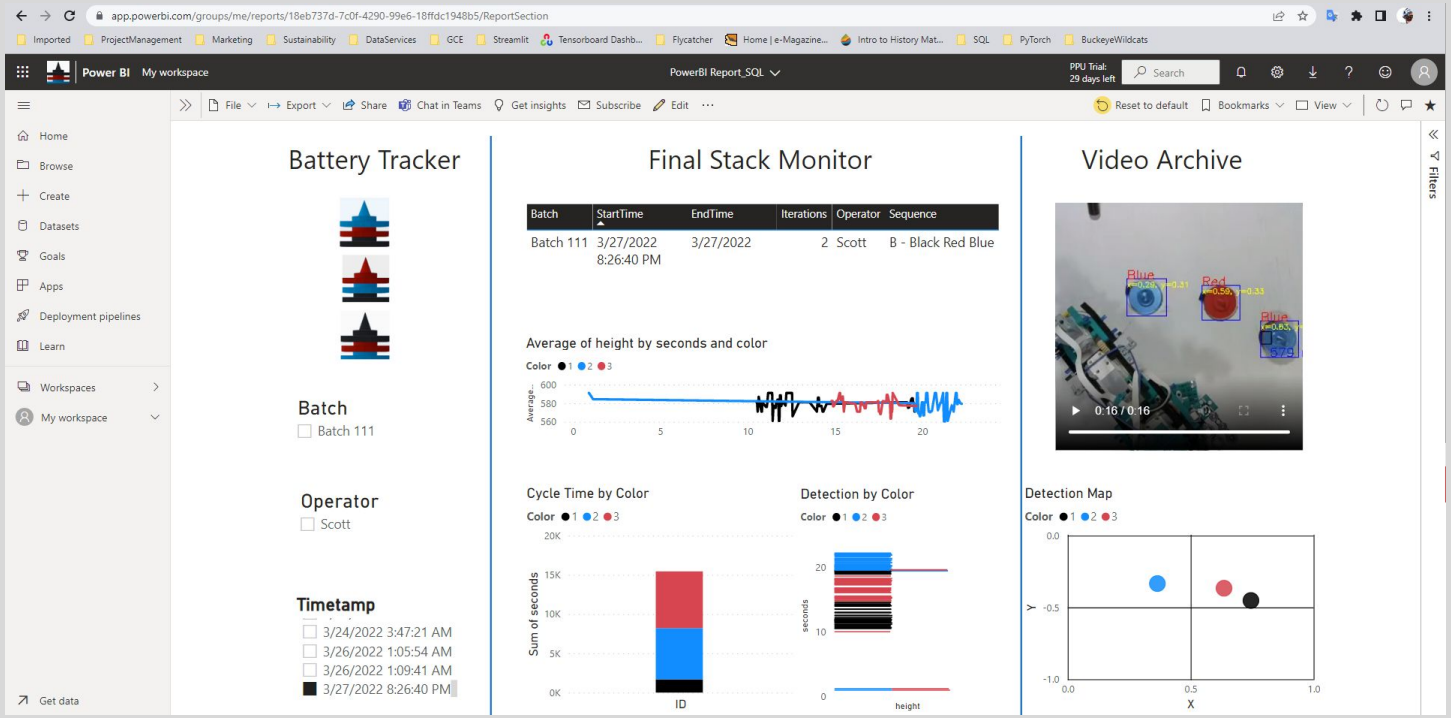


https://blog.roboflow.com/tips-for-how-to-label-images/

PHASE 1

Integrate Oak-D Lite Camera Video Recording for Quality History

- Create quality history record.
  - Utilize Oak-D Lite video recording capabilities
  - Utilize Azure Media Services for video archive and streaming
  - Utilize Power BI for report generation & intranet or web-based oversight
- Quality record can be accessed remotely (web or mobile) for presentation to customers.

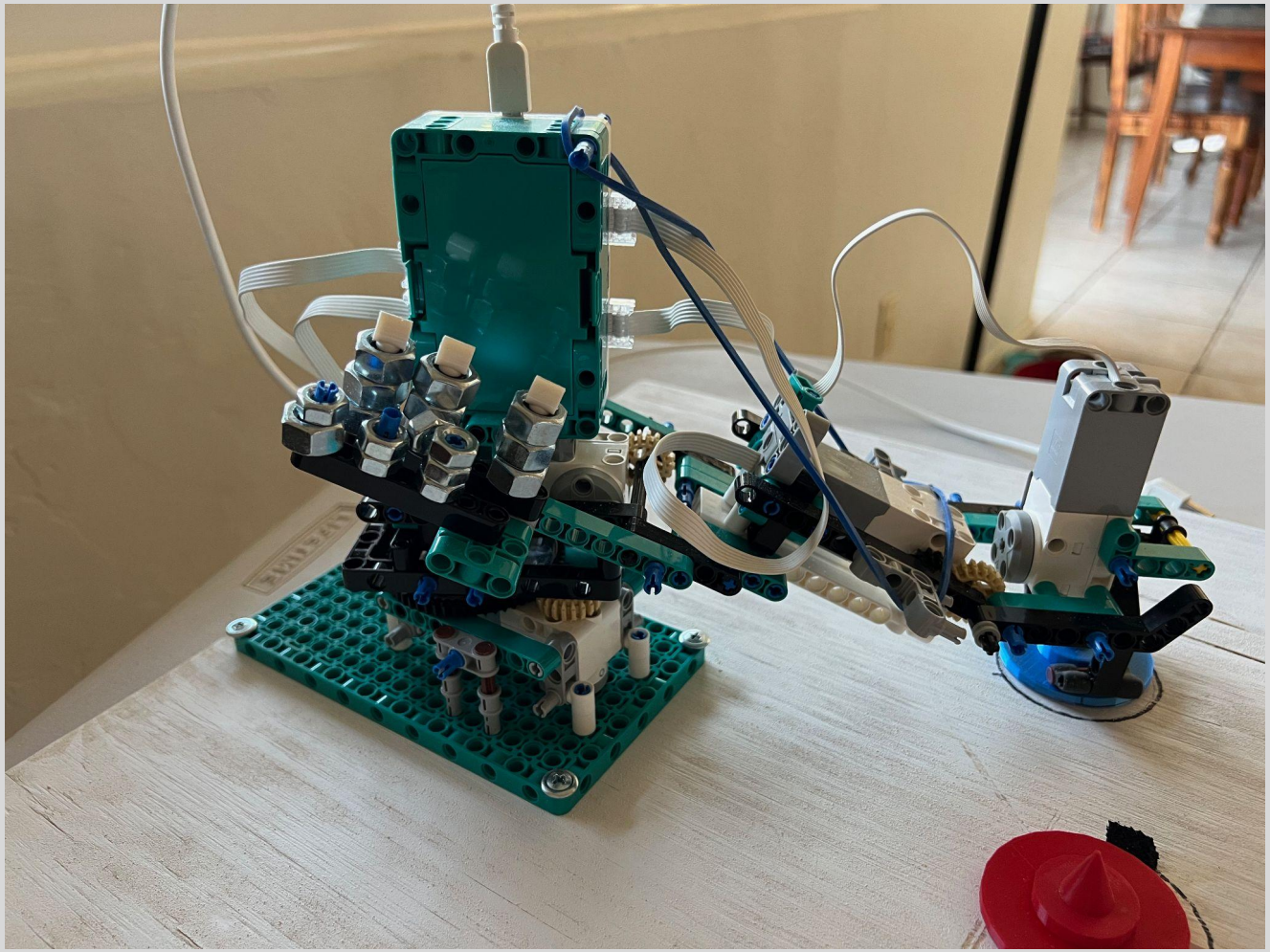


Lego Mindstorms Pick-N-Place Robot - Hardware

PHASE 2

- Custom design.
- Uses 4 motor modules.
  - Rotate base
  - Primary arm
  - Secondary arm
  - Grippers
- Motors too weak to hold weight of arms and gripper.
  - Integrate custom counterweights and rubber band “dampers”
- Repeatability insufficient to reliably pick-n-place discs.
- Proof of Concept.

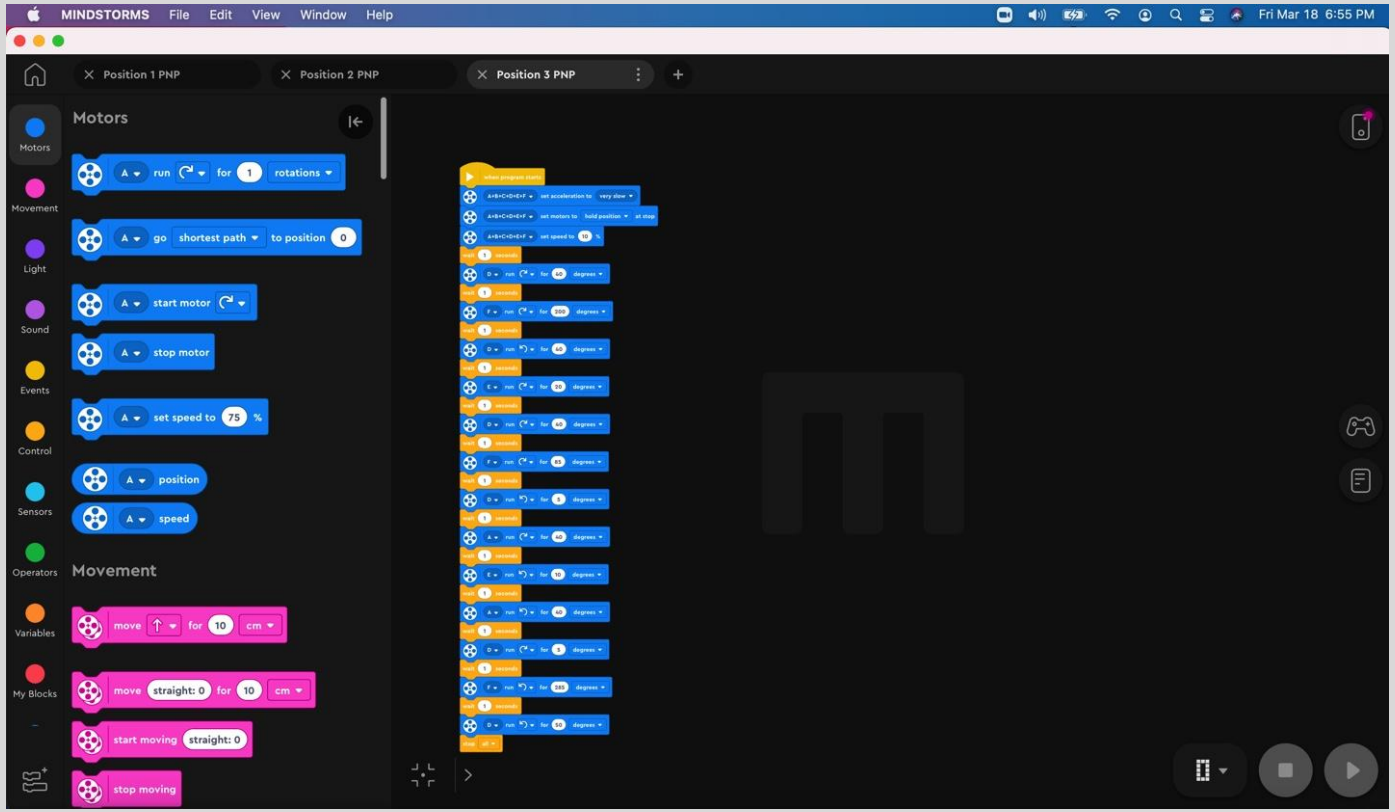
https://youtu.be/WJeU1hslt1E



PHASE 2

Lego Mindstorm Pick-N-Place Robot - Movement Code

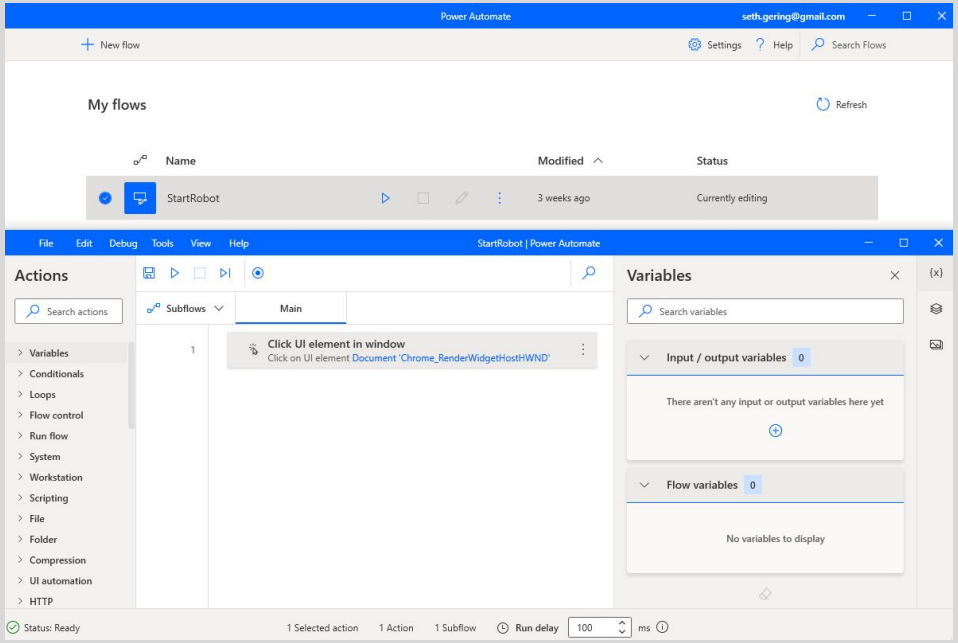
- Small testing programs used for each of the 4 motors.
  - Rotate base
  - Primary arm
  - Secondary arm
  - Grippers
- 3 programs created for stacking of disc.
  - one for each disc position
- Mindstorm coding software easy enough even a Mechanical Engineer can use it.

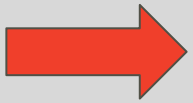


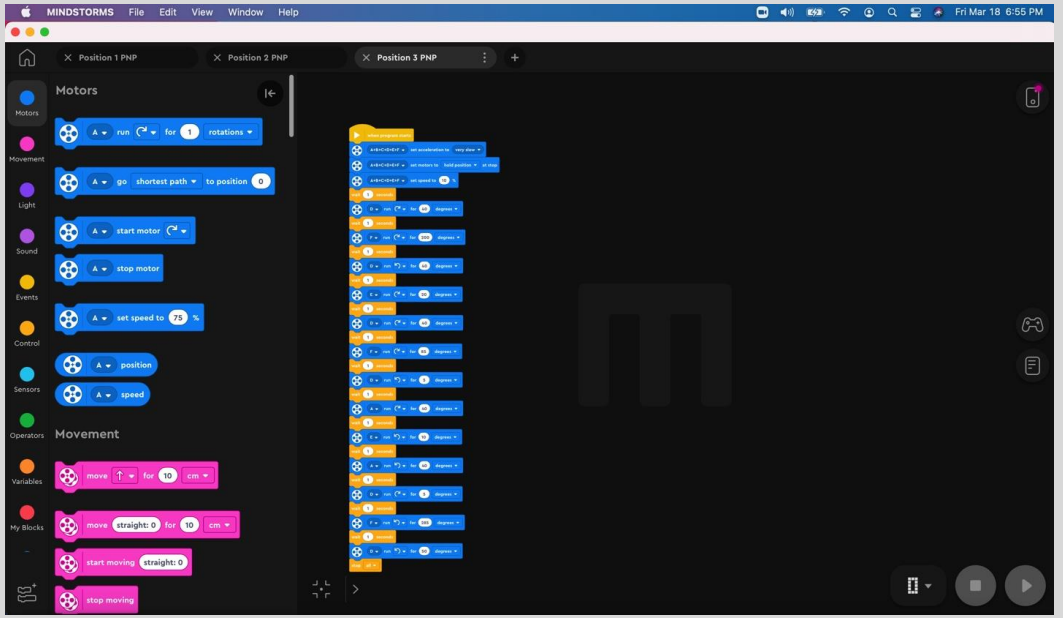
PHASE 2

Integrate Phase 1 software to activate Mindstorm code

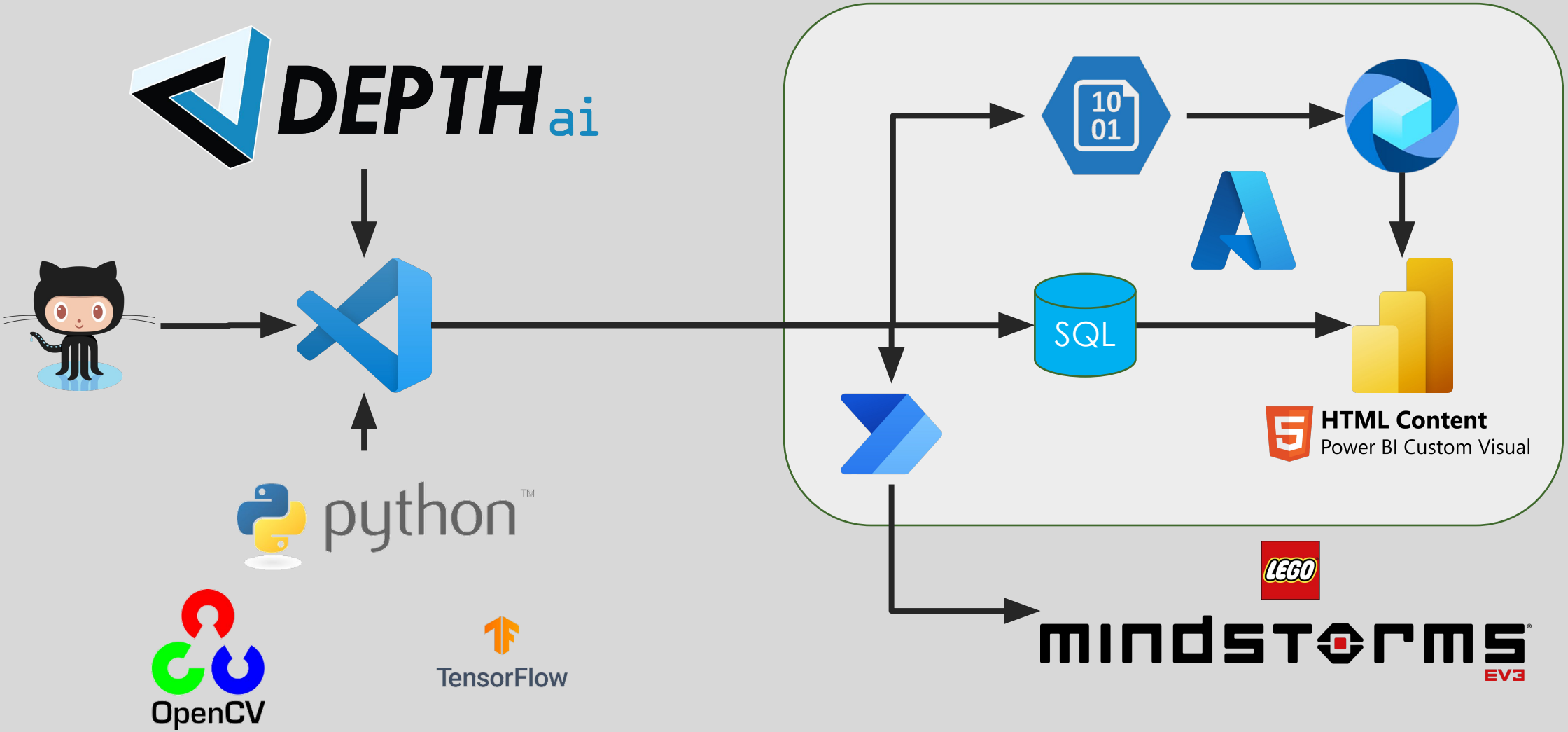
- Microsoft Power Automate used to interact with Lego Mindstorm software.
- The “recipe” chosen by operator dictates the order of the Lego Mindstorm position pick-n-place codes.







Solution Architecture



Challenges

- AI object recognition was difficult between black and blue discs.
  - Mitigated by increasing the number of training images and training with varied lighting conditions.
- Lego Mindstorm servo strength led to repeatability issues of pick-n-place issue.
  - Attempts to mitigate using counterweights partially successful.
- Collaboration due to COVID.
  - Mitigated by working remotely and division of tasks utilizing strengths of team.

Current vs. Future State Features

Feature	Current Manual Process	Additional Value with Microsoft Azure and Spatial AI
Manual stacking	X	X
Automatic consumable tracking		X
Video process auditing		X
Dynamic reporting		X
Alerts		X
Cloud-based Archive		X
Scalable solution		X
Configurable object detection		X
Spatial analysis for distance		X
Archivable Quality History Record		X
Remote Qualty History Retrieval		X

Project Success

Project Video: https://youtu.be/KqsggGiziQ4

Phase 1 - Manual Stacking of Discs

1. Create User Interface GUI for production environment	SUCCESS
2. Make stackable discs	SUCCESS
3. Create "recipe" database	SUCCESS
4. Integrate Oak-D Lite camera capabilities to distinguish between discs	SUCCESS
5. Integrate Oak-D Lite camera capabilities to distinguish between layers	SUCCESS
6. Create quality history record	SUCCESS
a. Utilize Oak-D Lite video recording capabilities	SUCCESS
b. Utilize Azure Media Services for video archive and streaming	SUCCESS
c. Utilize Power BI for report generation and internet or web-based retrieval	SUCCESS

Phase 2 - Automate Stacking of Discs

1. Lego Mindstorm pick-n-place robot - Hardware	PARTIAL SUCCESS
2. Lego Mindstorm pick-n-place robot - Movement Code	SUCCESS
3. Integrate Phase 1 software to activate Mindstorm code	SUCCESS

What We Are Excited About

- Real-time operator feedback of accuracy of build.
- Ability to create a quality history record utilizing Oak-D Lite + Microsoft Azure + Microsoft Power BI that can be accessed remotely.
  - Can save days of effort accessing quality data to exonerate hardware when failures happen in the field.
  - Video record increases confidence in hardware over data record.
  - Increase in repeatability of energetics build process.
  - System would be a best value, single source differentiator when choosing suppliers.
- Ease of use of Oak-D Lite + Microsoft Azure + Microsoft Power BI enabled new users to create a proof of concept quickly with no training, solving a real world manufacturing problem.

Backup Material

Project Costs

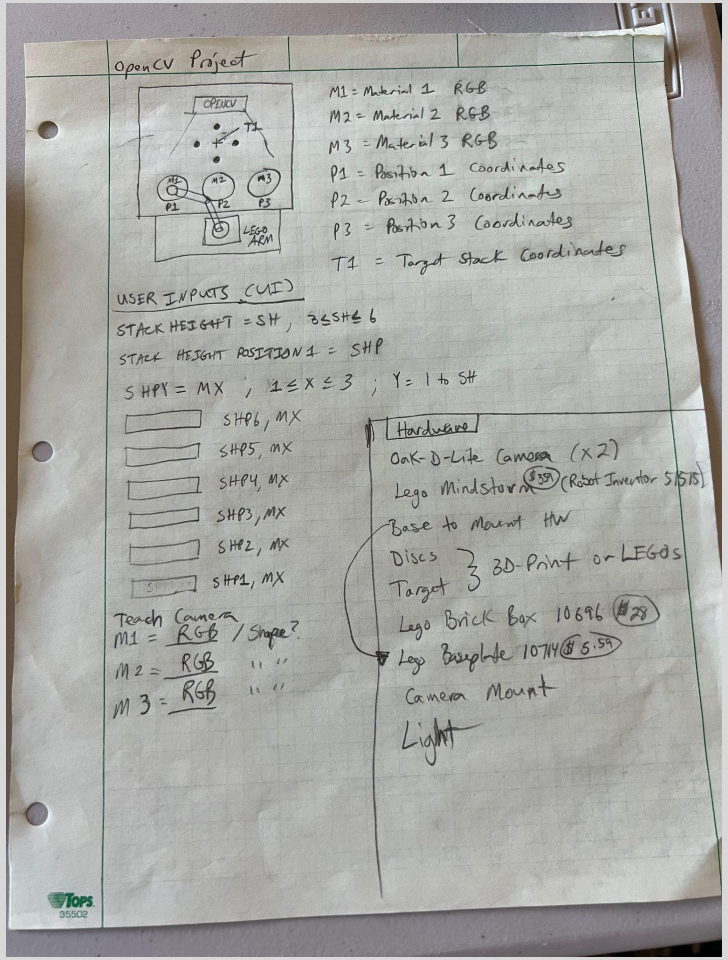
Item	Description	Cost
Azure Services*	Media Services	$36.00
	SQL Database	$1.00
	Media Services	$1.00
Spatial AI Camera*	Oak D Lite	$149.00
Lego*	Lego Mindstorm	$399.00
Camera Accessories	Lights x 2	$40.00
Camera Accessories	Tripod	$17.00
Total Project Cost		$643.00

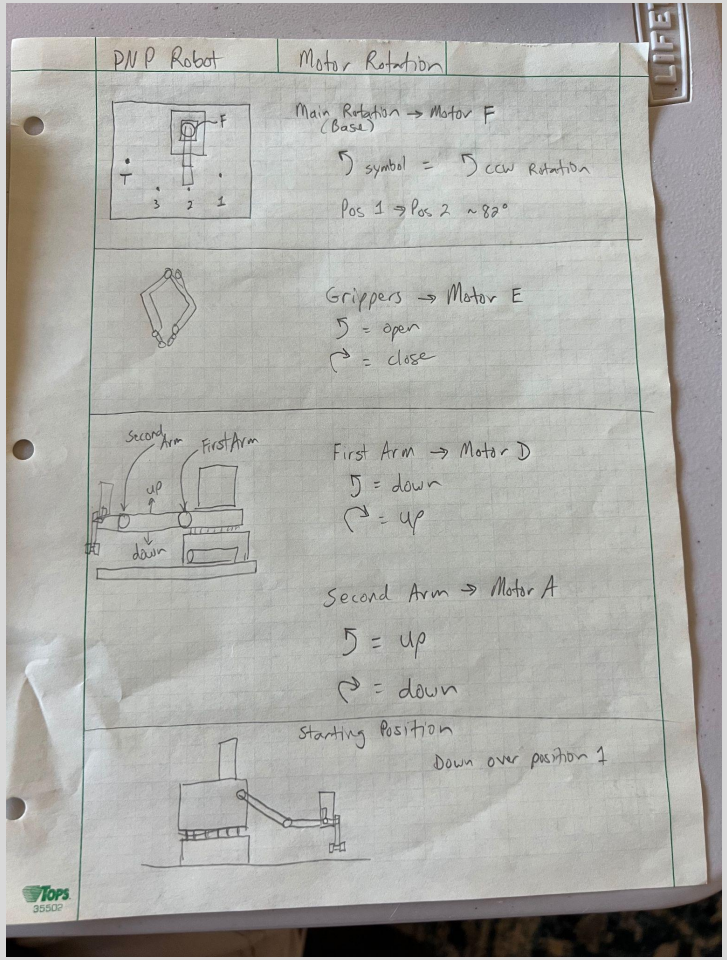
*Indicates items provided through sponsorship

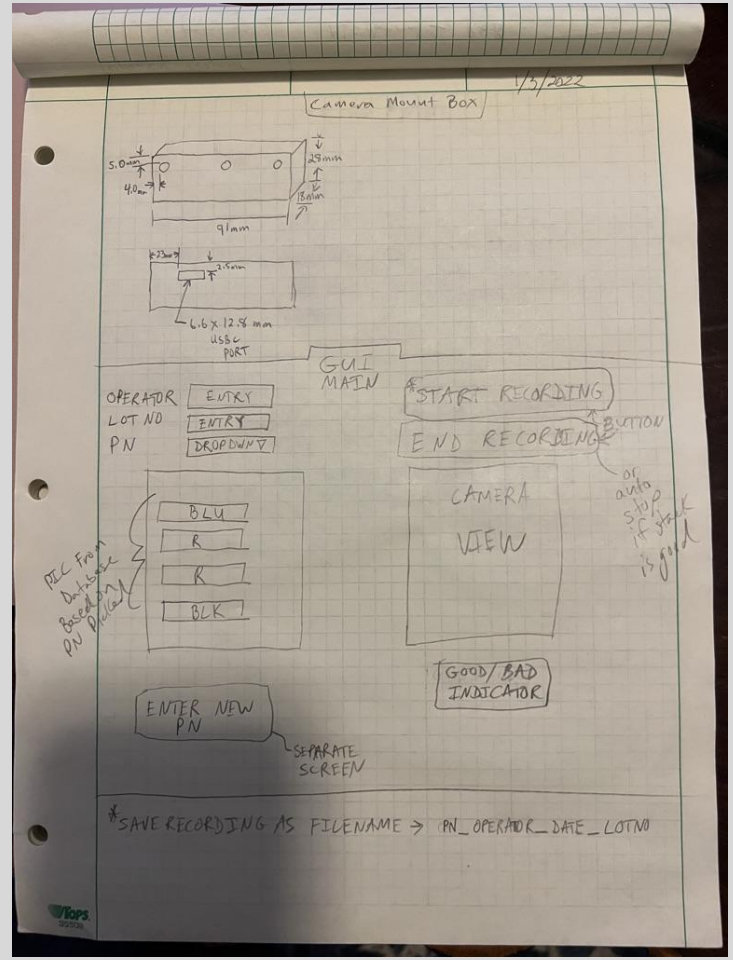
Documentation

Proposal	https://github.com/sgering/project/blob/master/SupportingDocuments/OpenCV%20Proposal.pdf
Scripts	https://github.com/sgering/project/blob/master/bt_user_input.py https://github.com/sgering/project/blob/master/bt_custom_model_spatial.py https://github.com/sgering/project/blob/master/bt_upload_video_store_db.py
Lego Mindstorm Control Files	https://github.com/sgering/project/tree/master/Mindstorms
User Interaction and Logic	https://github.com/sgering/project/blob/master/SupportingDocuments/Open%20CV%20Project%20RAIL.pdf
Sketches / Project Notes	
Model /Images	https://github.com/sgering/project/tree/master/Model https://github.com/sgering/project/blob/master/Images.zip
UI Workflow	https://github.com/sgering/project/blob/master/SupportingDocuments/OpenCV%20Project_Flow%20Chart.pdf
SQL Database Definition	https://github.com/sgering/project/blob/master/create_db.sql
PowerBI Report	https://github.com/sgering/project/blob/master/PowerBI%20Report_SQL.pbix

Project Notes







Putting it All Together