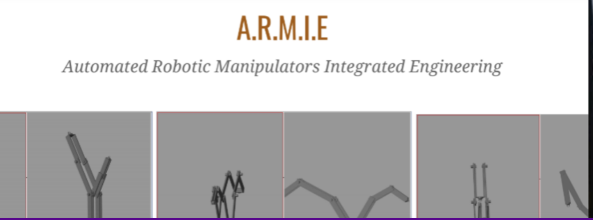


NYU TANDON SCHOOL OF ENGINEERING

ADVANCED MECHATRONICS PROJECT

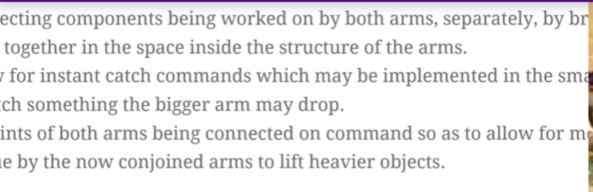
(Phase 3 - OpenCV integration)

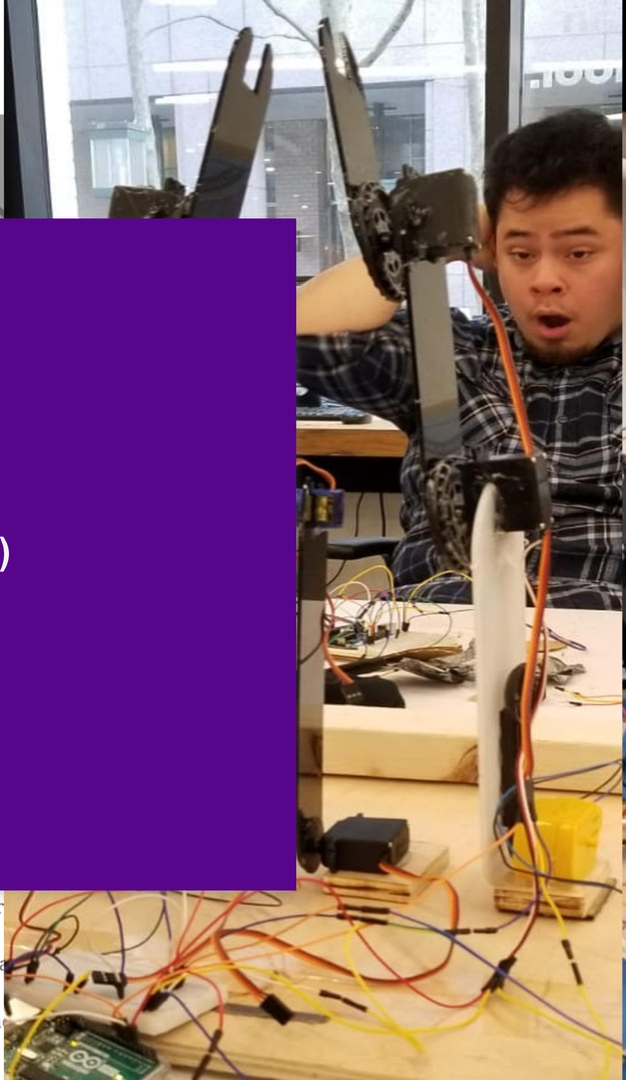
ME-GY 6933 A

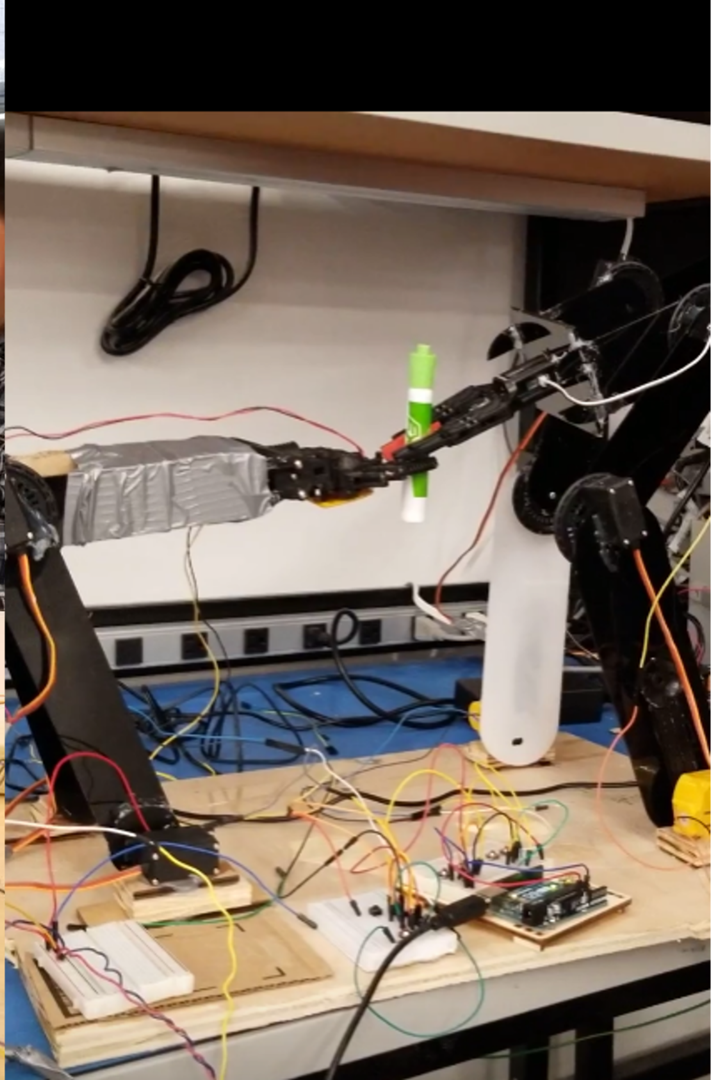
Guided by : Dr. Vikram Kapila

Armando Granado
Erdong Xiao
Sahil Kumar

16th Mayl 2019







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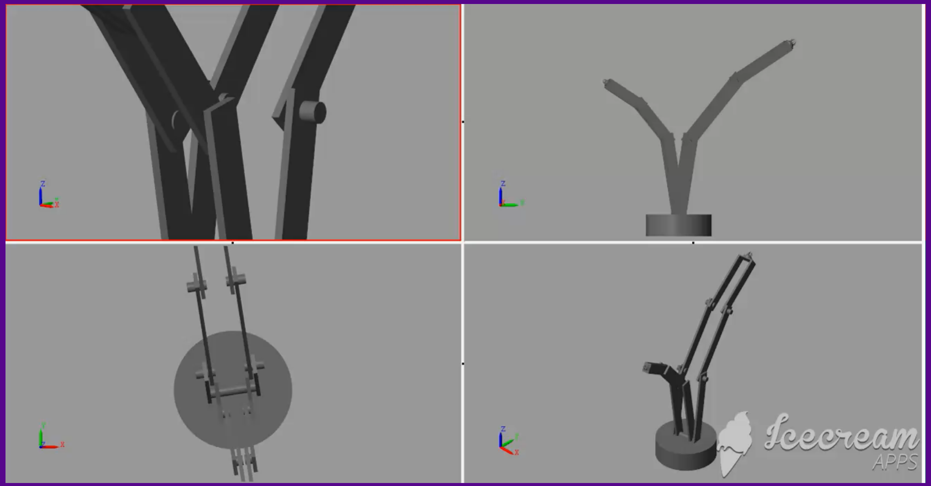
INDEX

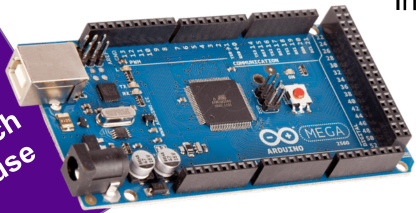
A . R . M . I . E .

Automated Robotic Manipulator Integrated Engineering



- Final Progress.
- Total Research.
- Forward Kinematics.
- Inverse Kinematics.
- Complete Point Cloud Workspace Model
- Object Recognition Using OpenCV
- Hardware.
- Torque
- Workflow.
- Videos.
- Problems Tackled By A.R.M.I.E
- Future Work.

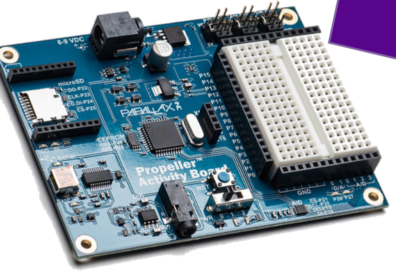
FINAL PROGRESS



In the arduino phase of the project:

- Research was conducted on prior art.
- Possible solutions and applications using A.R.M.I.E were discussed along with torque considerations.
- The basic structure of the arms was developed and kinematics computed.
- Prototype constructed.

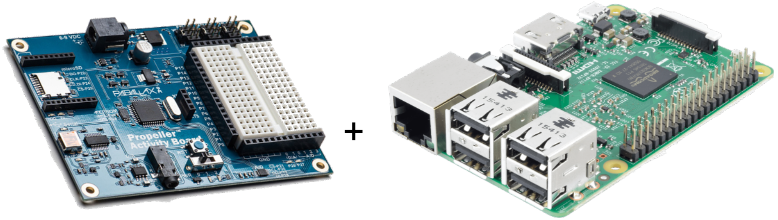
Using arduino, the movement was not synchronized which prompted us to use propeller.



In the Propeller phase of project:

- Research is furthered on improving the structural integrity and various aspects commonly used in research papers to prove a manipulator's legitima
- Workspace point cloud is completed.
- A demonstration setup is created using new weight sensors, grippers, etc.

Using arduino, the movement was not synchronized which prompted us to use propeller.

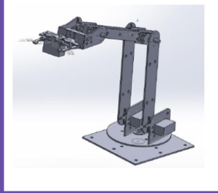


In the final phase of the project:

- The propeller would be used to synchronise different motors using cogs and computing inverse kinematics.
- Raspberry Pi is used for the PiCam and detecting where the object is kept.

Materials and Structure

Design, analysis and fabrication of robotic arm for sorting of multi-materials.



Physics Calculations

Design and development of a mechanism of robotic arm for lifting part5.

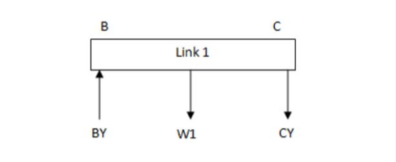


Figure 6. Force diagram of link 1.

Research

Design and Control of a Bio-inspired Human-friendly Robot. (Published in the International Journal Of Robotics Research)

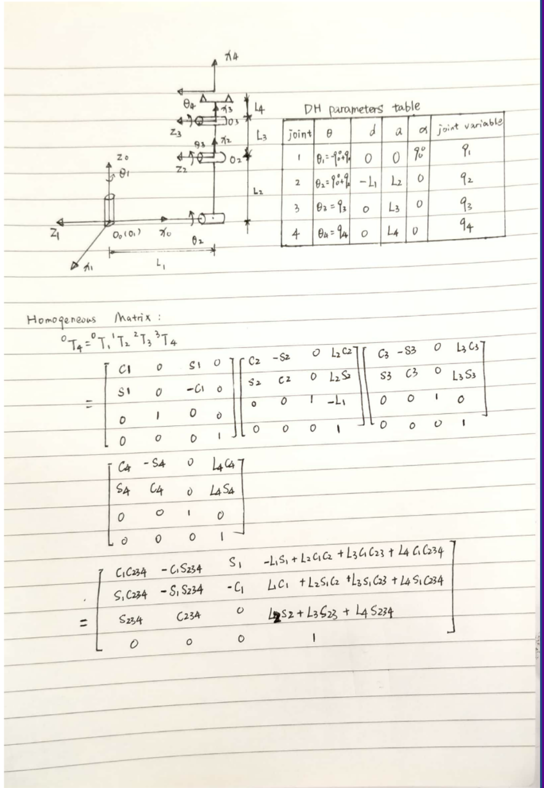
Development of lightweight dual arm robot by using hollow shaft servo assembly.

Stress
Motor Type
Material
Gravity Compensation Mechanism (Used in PR2)
Backshaft Encoder

Design Process

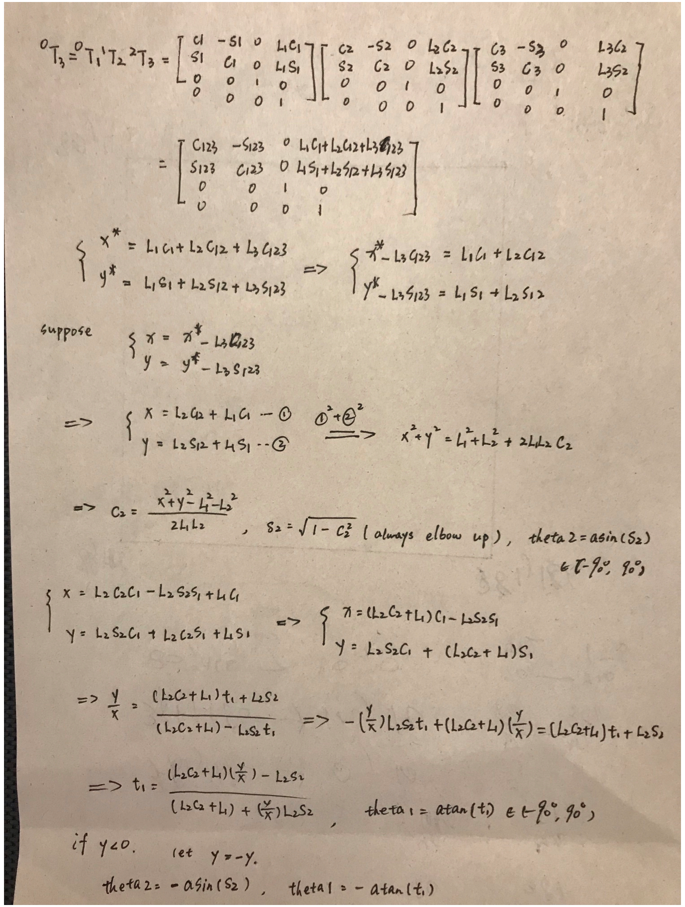
(Usually used by EMS companies and other product development departments. 2012 -2013)

- Gathering Design Information
- Design and Development
- Design Outputs
- Design Review (ANSYS)
- Approval Documents
- Prototype Construction.
- Testing and verification
- Design Transfer.



Similar to both angular robots and Puma 560

INVERSE KINEMATICS



$$^0T_3 = {}^0T_1\,{}^1T_2\,{}^2T_3 = \begin{bmatrix} C_1 & -S_1 & 0 & L_1C_1 \\ S_1 & C_1 & 0 & L_1S_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} C_2 & -S_2 & 0 & L_2C_2 \\ S_2 & C_2 & 0 & L_2S_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} C_3 & -S_3 & 0 & L_3C_2 \\ S_3 & C_3 & 0 & L_3S_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} C_{123} & -S_{123} & 0 & L_1C_1+L_2C_{12}+L_3C_{123} \\ S_{123} & C_{123} & 0 & L_1S_1+L_2S_{12}+L_3S_{123} \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{cases} x^* = L_1C_1 + L_2C_{12} + L_3C_{123} \\ y^* = L_1S_1 + L_2S_{12} + L_3S_{123} \end{cases} \Rightarrow \begin{cases} x^* - L_3C_{123} = L_1C_1 + L_2C_{12} \\ y^* - L_3S_{123} = L_1S_1 + L_2S_{12} \end{cases}$$

suppose $\begin{cases} x = x^* - L_3C_{123} \\ y = y^* - L_3S_{123} \end{cases}$

$$\Rightarrow \begin{cases} x = L_2C_{12} + L_1C_1 \quad \text{--①} \\ y = L_2S_{12} + L_1S_1 \quad \text{--②} \end{cases} \xrightarrow{①^2+②^2} x^2+y^2 = L_1^2+L_2^2+2L_1L_2C_2$$

$$\Rightarrow C_2 = \frac{x^2+y^2-L_1^2-L_2^2}{2L_1L_2}, \quad S_2 = \sqrt{1-C_2^2} \text{ (always elbow up)}, \quad theta2 = asin(S_2) \in [-90°, 90°]$$

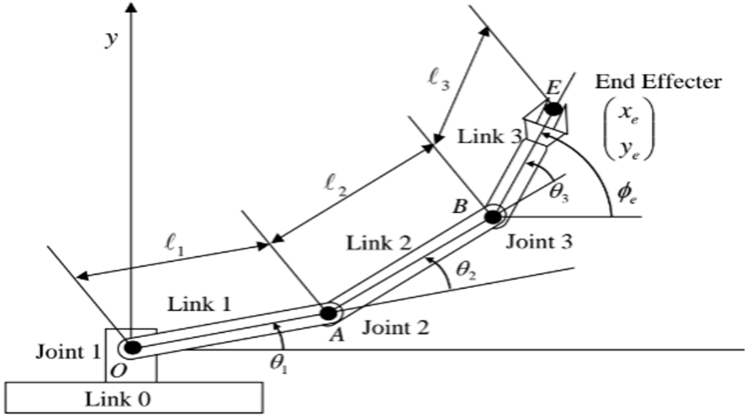
$$\begin{cases} x = L_2C_2C_1 - L_2S_2S_1 + L_1C_1 \\ y = L_2S_2C_1 + L_2C_2S_1 + L_1S_1 \end{cases} \Rightarrow \begin{cases} x = (L_2C_2+L_1)C_1 - L_2S_2S_1 \\ y = L_2S_2C_1 + (L_2C_2+L_1)S_1 \end{cases}$$

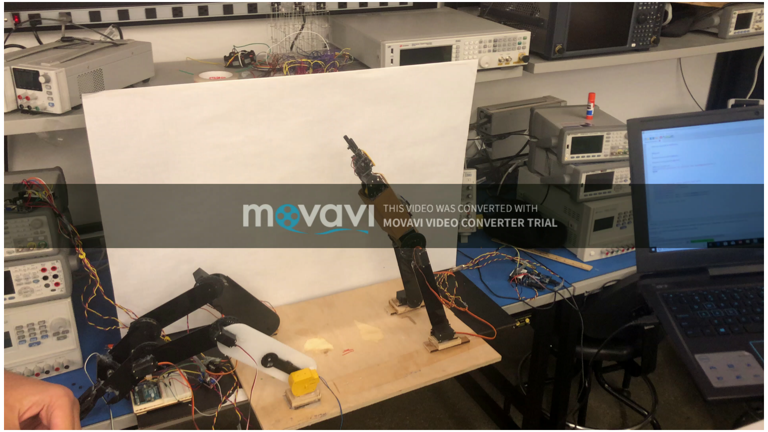
$$\Rightarrow \frac{y}{x} = \frac{(L_2C_2+L_1)t_1 + L_2S_2}{(L_2C_2+L_1) - L_2S_2t_1} \Rightarrow -\left(\frac{y}{x}\right)L_2S_2t_1 + (L_2C_2+L_1)\left(\frac{y}{x}\right) = (L_2C_2+L_1)t_1 + L_2S_2$$

$$\Rightarrow t_1 = \frac{(L_2C_2+L_1)\left(\frac{y}{x}\right) - L_2S_2}{(L_2C_2+L_1) + \left(\frac{y}{x}\right)L_2S_2}, \quad theta1 = atan(t_1) \in [-90°, 90°)$$

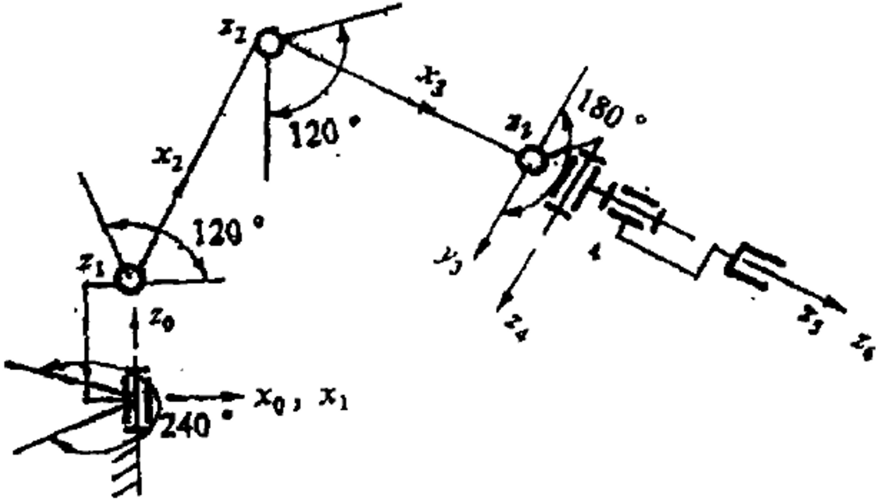
if $y<0$, let $y = -y$.

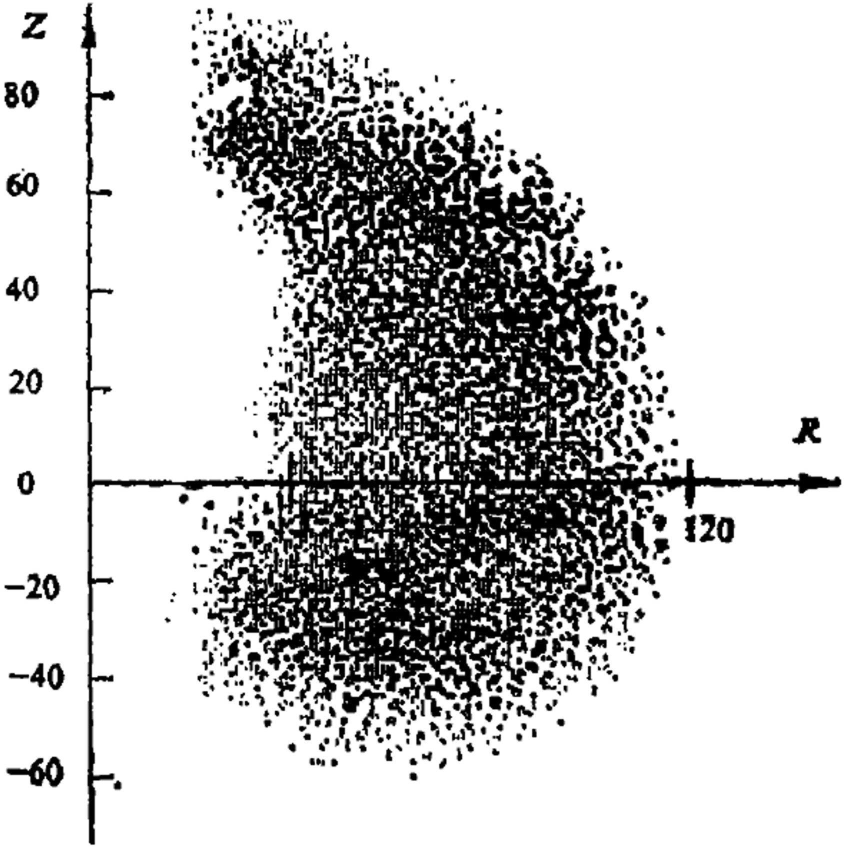
$theta2 = -asin(S_2)$, $theta1 = -atan(t_1)$



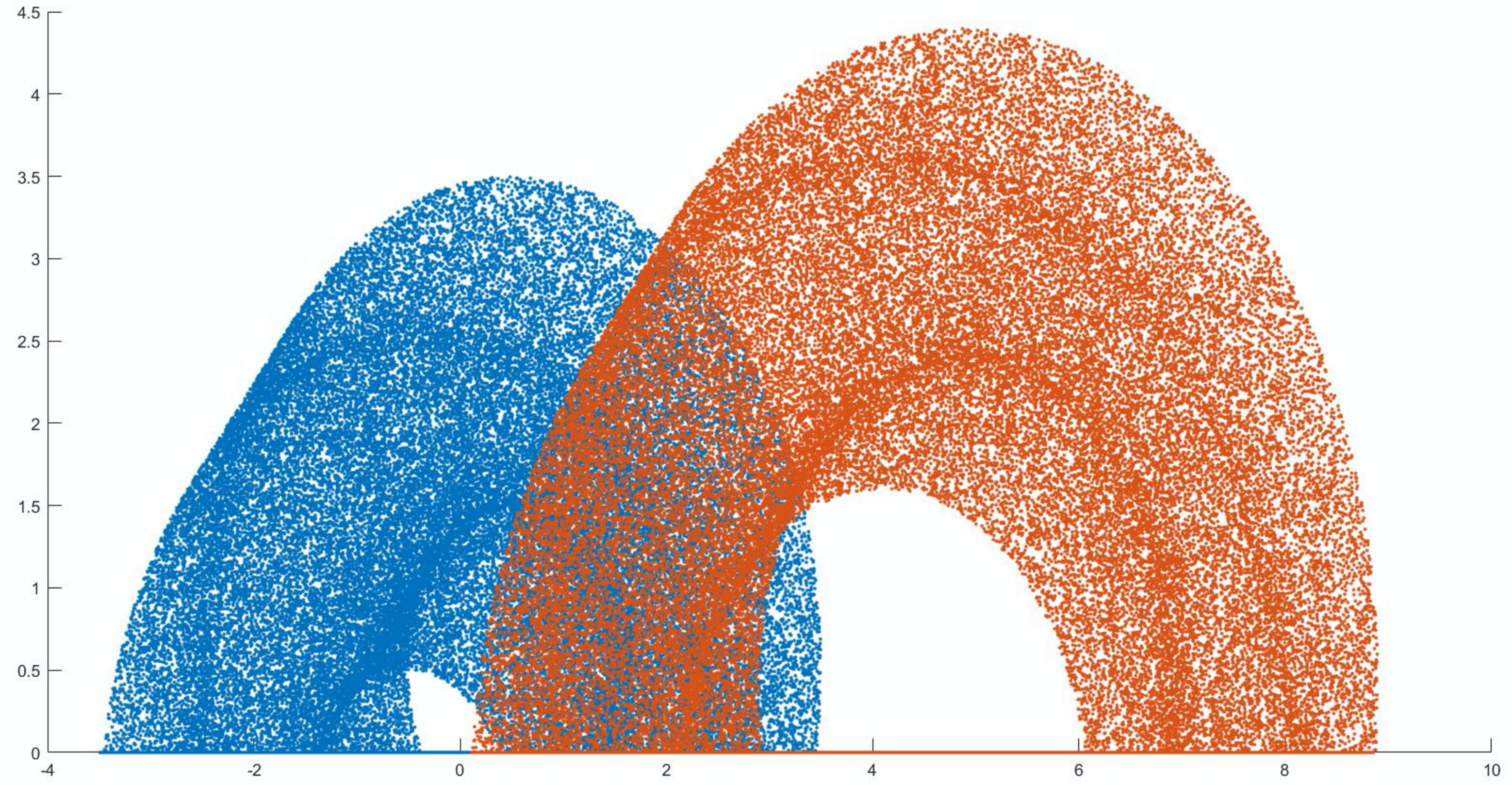


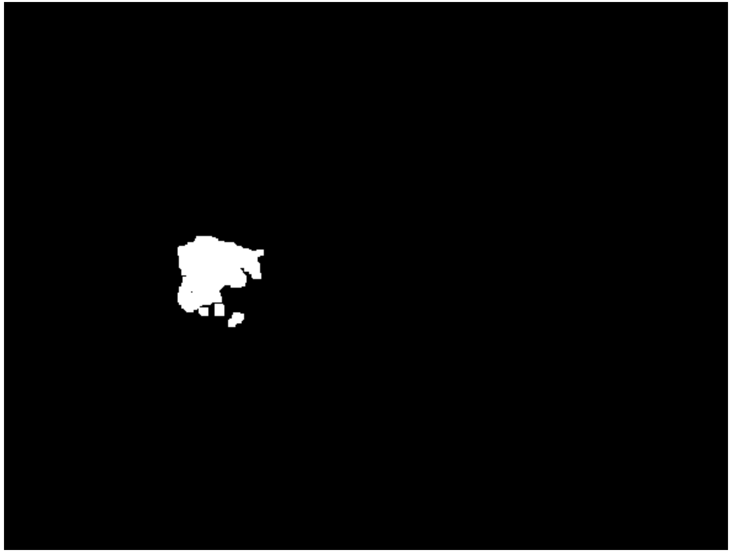
COMPLETE POINT CLOUD WORKSPACE MODEL

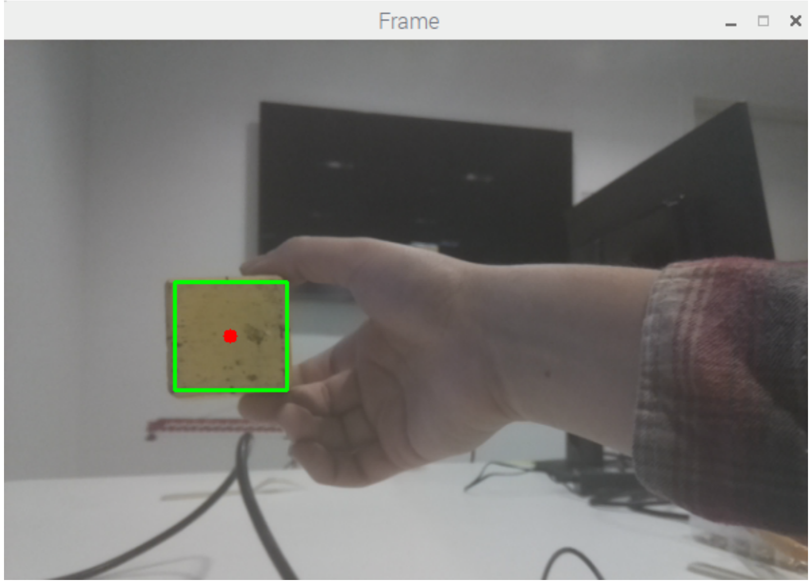




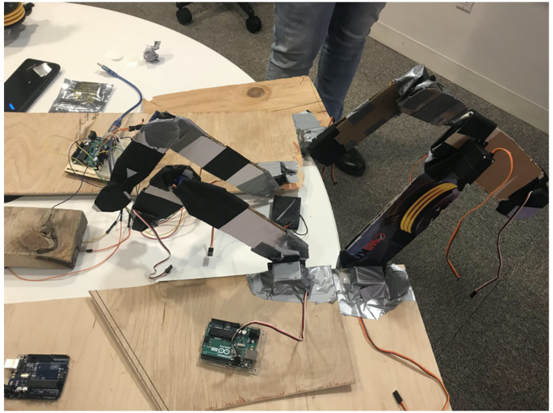
COMPLETE POINT CLOUD WORKSPACE MODEL

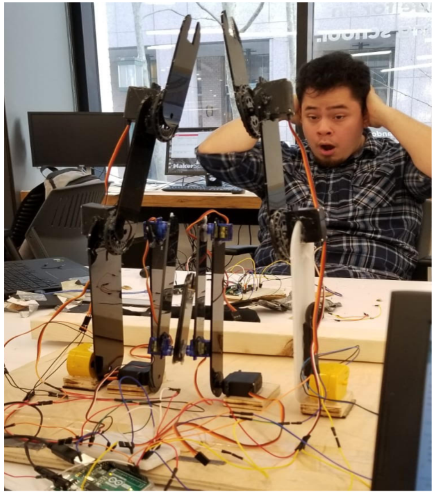


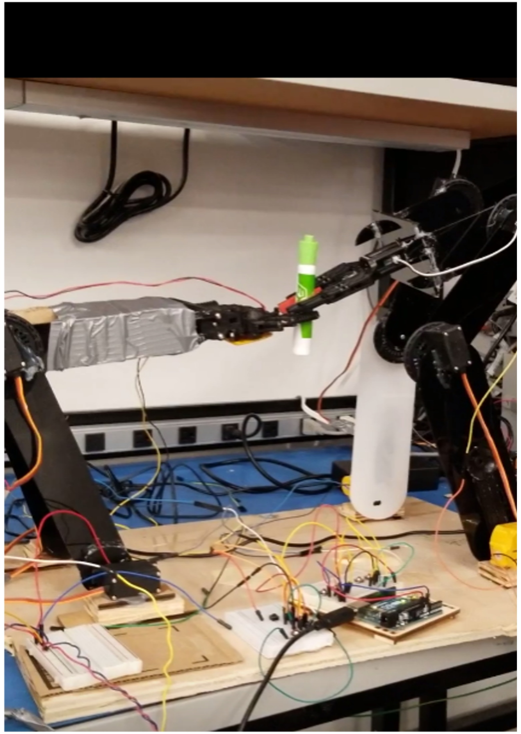



Frame

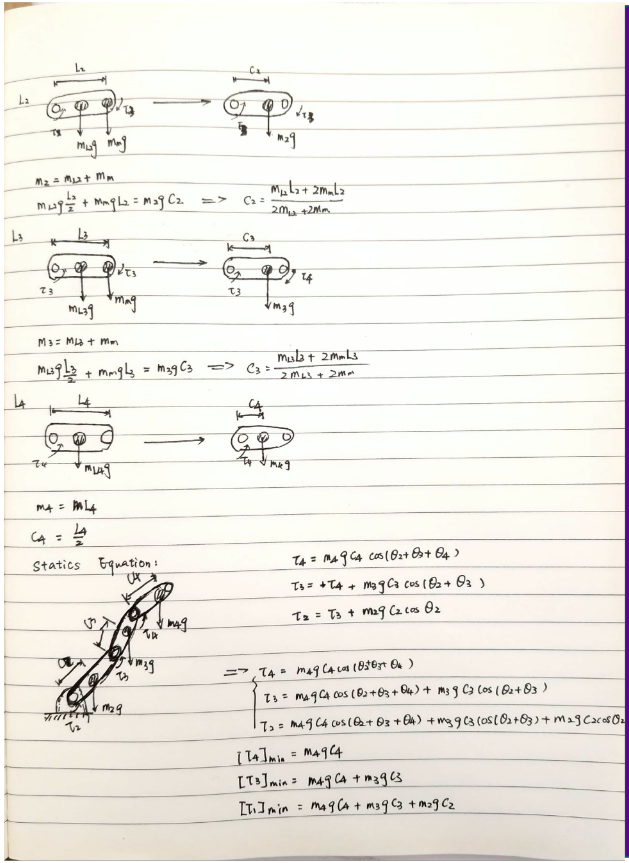
HARDWARE







TORQUE CONSIDERATIONS



To find capabilities of manipulator with different materials as well as total torque required for motors.

Weight of Parallax standard servo motor = 44gm

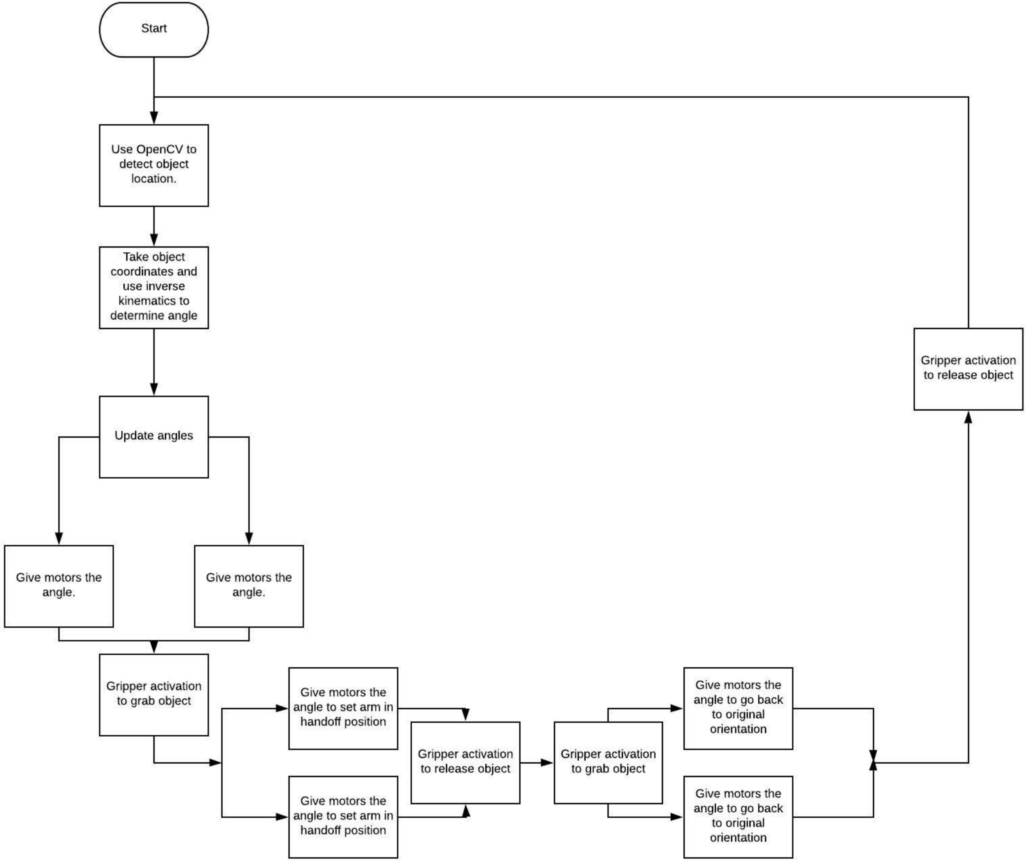
Link 1-
25.4*7.62*0.35*1.18=79.93g= Weight of link 1
17.78*5.08*0.35*1.18=37.3g= Weight of link 2
13.97*5.08*0.35*1.18=29.3g= Weight of link 3

Link 2 -
10x1.75 = 25.4*4.44*0.35*1.18=46.57g=Weight of link 1
7x1.5=17.78*3.81*0.35*1.18=27.97g=Weight of link 2
4.5*1.5=11.43*3.81*0.35*1.18=17.98g=Weight of link 3

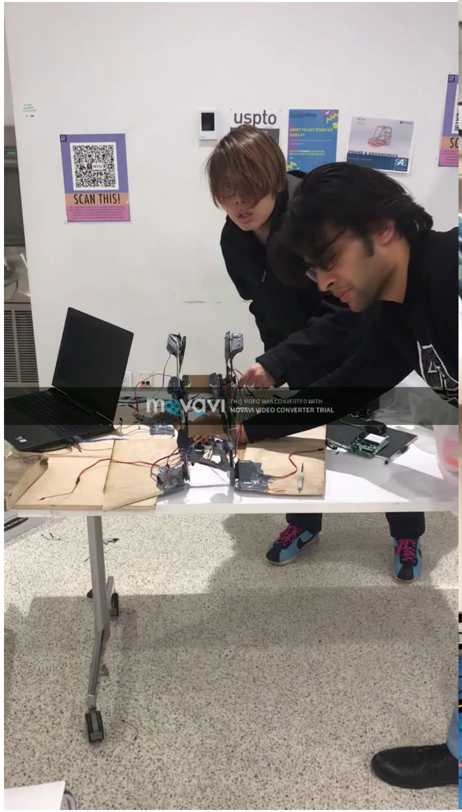
Acrylic Load bearing capacity = 400,000 Psi
Tensile strength is load/area

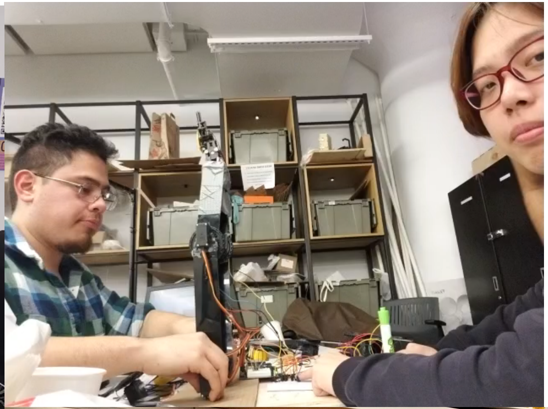
Other motors considered -
Tower Hobbies
SG5010 MOTOR
mg996r servo

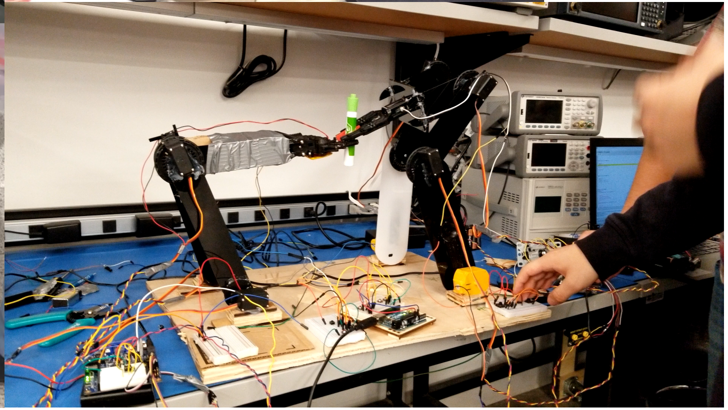
WORKFLOW


Start
Use OpenCV to detect object location.
Take object coordinates and use inverse kinematics to determine angle
Update angles
Give motors the angle.
Give motors the angle.
Gripper activation to grab object
Give motors the angle to set arm in handoff position
Give motors the angle to set arm in handoff position
Gripper activation to release object
Gripper activation to grab object
Give motors the angle to go back to original orientation
Give motors the angle to go back to original orientation
Gripper activation to release object

VIDEOS


uspto
SCAN THIS!
movavi
THIS VIDEO WAS CONVERTED WITH
MOVAVI VIDEO CONVERTER TRIAL





PROBLEMS TACKLED BY ARMIE

4 Things Commonly Needed In All Robots

Required Mobility (KUKA Omnirob),
Required Precision (Da Vinci Surgical Robot),
Quality and quantity of work for low cost,
Low power consumption.

Possible Applications

Surgical robots - Doctor Nurse Pair.
Some applications might require just speed (Smaller arm), some just strength (Bigger arm) and some both, with precision.

FUTURE WORK

- Making it structurally sound.
- Further research on applications and parts.

REFERENCES

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