I'm not a Robotic Arm

Muratore Luigi s333098

Gennero Giorgia s333099

Akbarov Iskandar s329650

Muhammad Fatir Noshab s331898

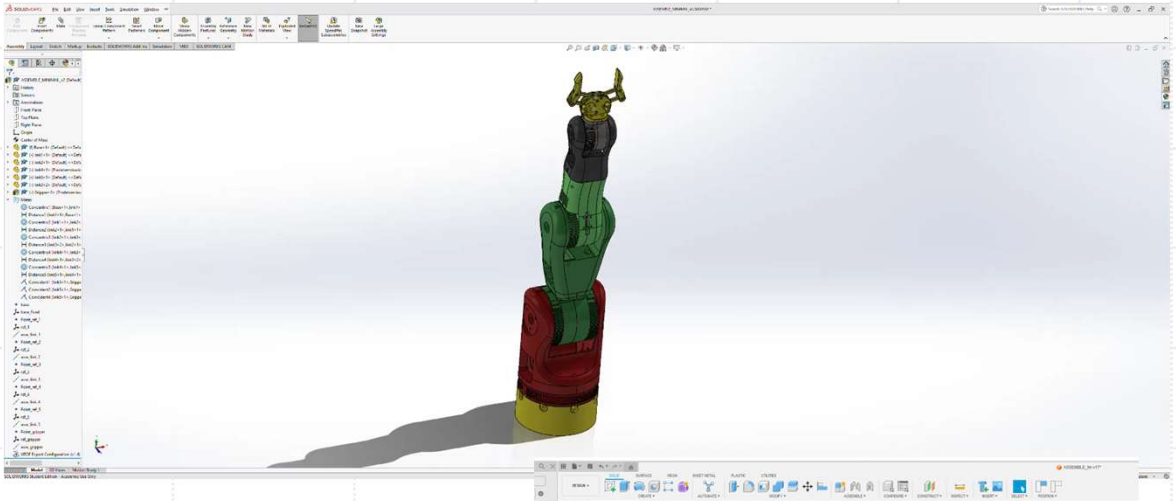
Moussa Swaidan s334402

Prof. : Alessandro Rizzo

TAs: David Pangcheng Cen Cheng
Andrea Usai

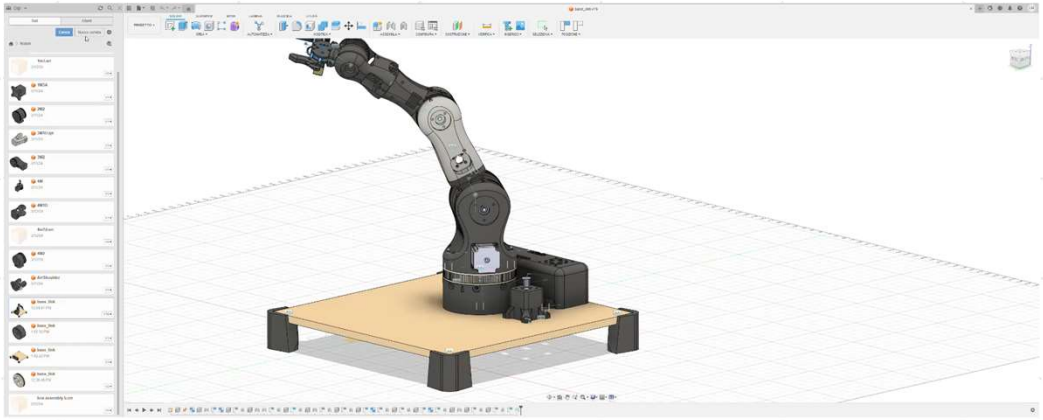
CAD

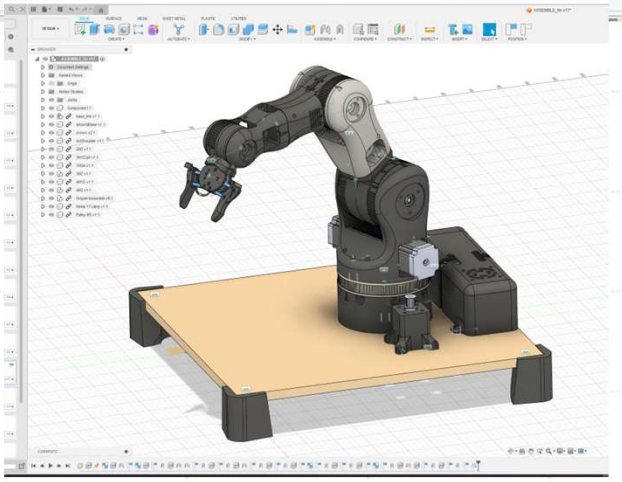
- SolidWorks
- Autodesk Fusion360



GOAL

- Pick and Place





- Requirements
- Limits

BOM

MOTORS:

- 2x Nema 17
- 1x Nema 14
- 1x Nema 17 1:5
- 2x Nema 23
- 1x Servo 20kg

DRIVERS:

- 6x TB6560

POWER SUPPLY:

- 24V 13A

CONTROLLERS :

- Arduino MEGA
- Raspberry Pi 4b

MOTORS

2x Nema 23

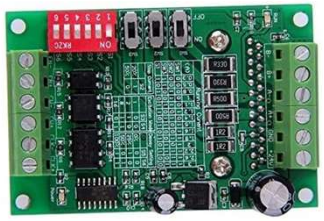
2x Nema 17

1x Nema 17 1:5

1x Nema 14

1x Servo 20kg

DRIVERS



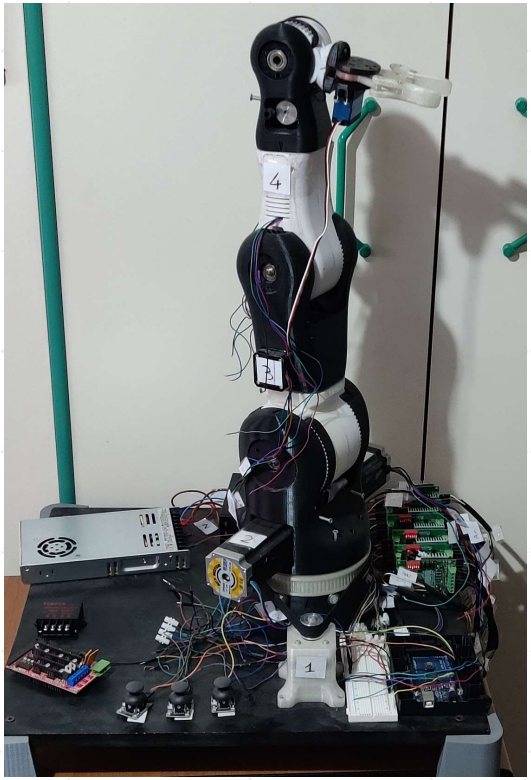
6x TB6560

POWER SUPPLY

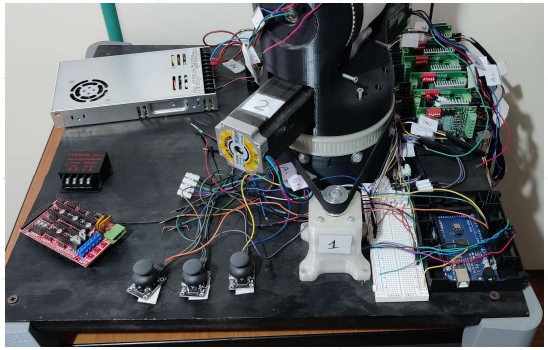
1x 24V 13A

PROGRESS

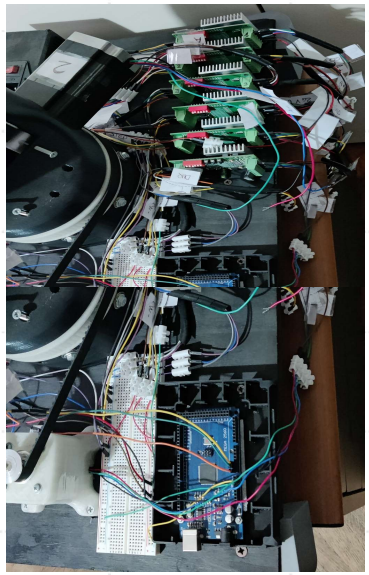
FINAL RESULT



- 3D Printing
- PLA Filament



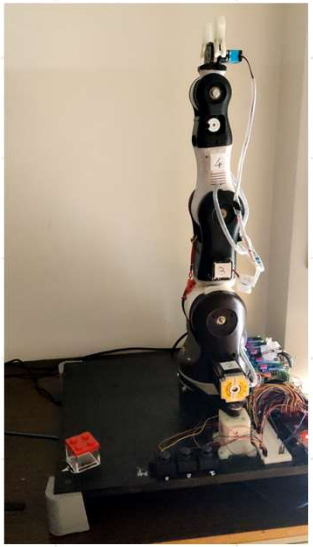
- Mechanical assemble
- Electronic assemble
- Electrical connections

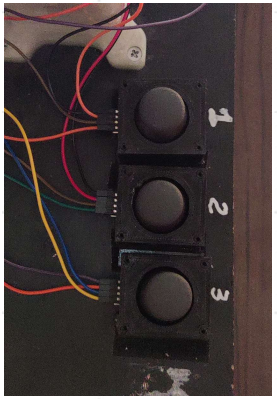


CONTROLLERS

Arduino MEGA 2560

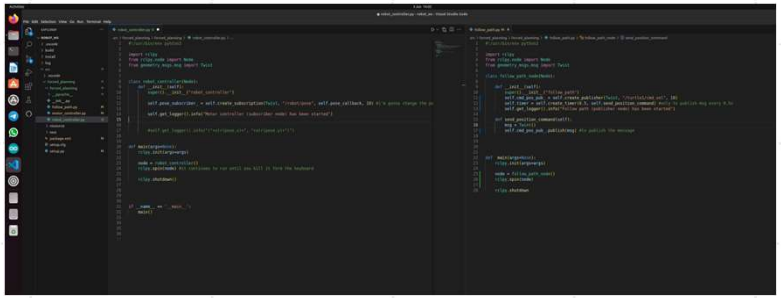
Raspberry Pi 4b



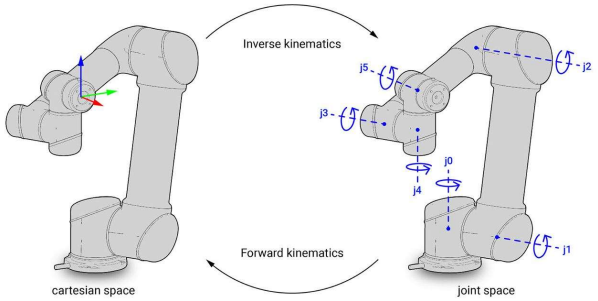


- Single task
- Joysticks -> 6 independent movements
- C++ scripts

- Linux Ubuntu 22.04 -> ROS2 Humble
- MoveIt
- Python scripts

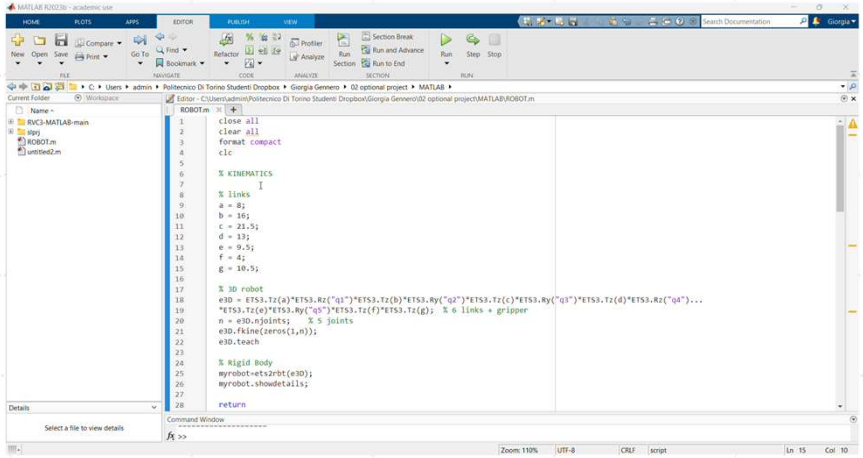


KINEMATICS



- Workspace volume
- Accuracy
- Repeatability

MATLAB computation

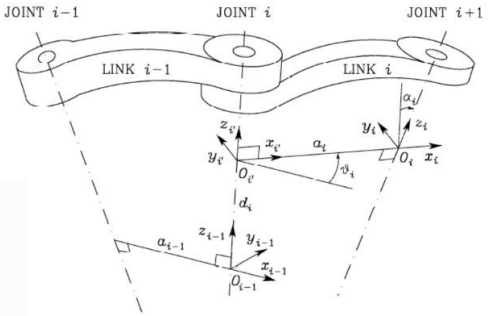


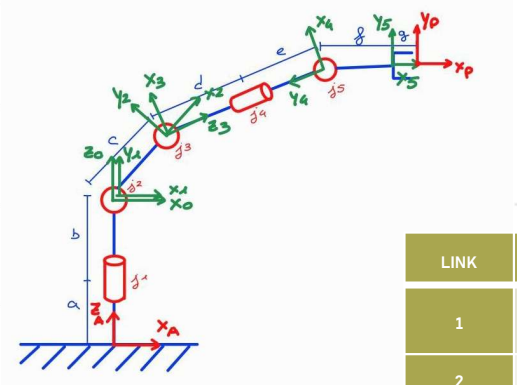
```
close all
clear all
format compact
clc

% KINEMATICS

% links
a = 8;
b = 16;
c = 21.5;
d = 13;
e = 9.5;
f = 4;
g = 10.5;

% 3D robot
e3D = ETS3.Tz(a)*ETS3.Rz("q1")*ETS3.Tz(b)*ETS3.Ry("q2")*ETS3.Tz(c)*ETS3.Ry("q3")*ETS3.Tz(d)*ETS3.Rz("q4")...
*ETS3.Tz(e)*ETS3.Ry("q5")*ETS3.Tz(f)*ETS3.Tz(g);  % 6 links + gripper
n = e3D.njoints;    % 5 joints
e3D.fkine(zeros(1,n));
e3D.teach

% Rigid Body
myrobot=ets2rbt(e3D);
myrobot.showdetails;

return
```

FORWARD Kinematics

Denavit–Hartenberg convention

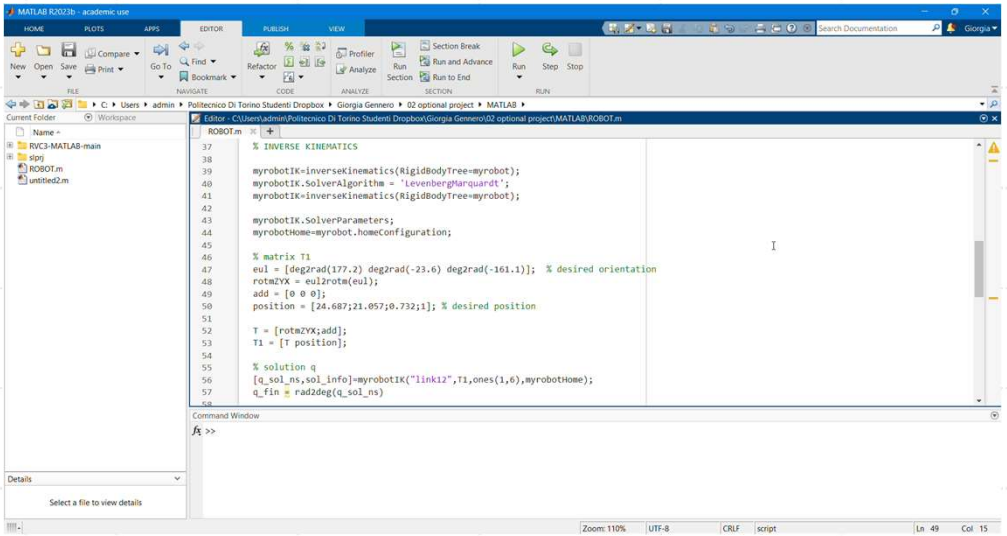
- a = link length
- α = link twist
- d = link offset
- θ = joint angle





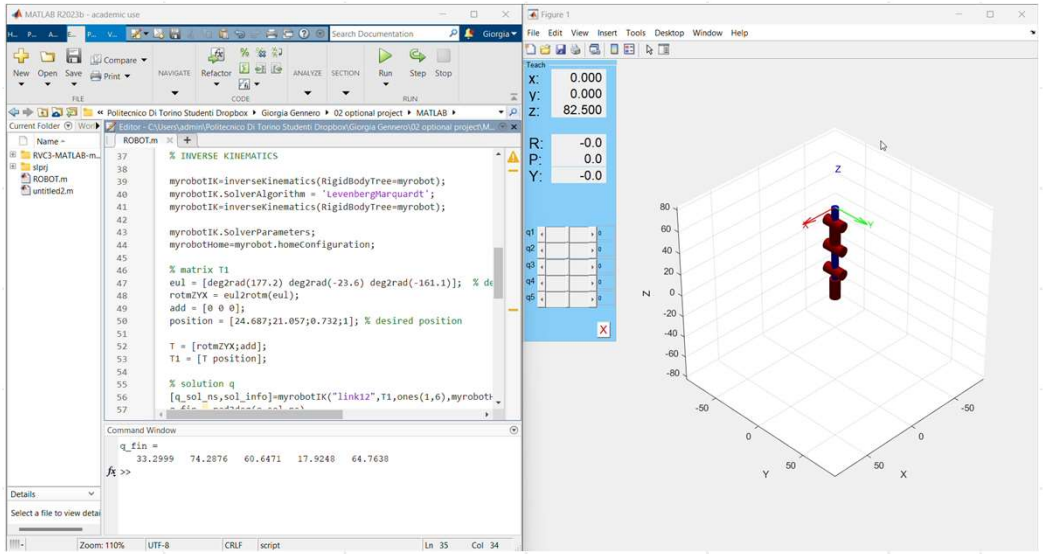
LINK	a_i	α_i	d_i	θ_i
1	0	$\frac{\pi}{2}$	0	θ_1
2	c	0	0	θ_2
3	0	$\frac{\pi}{2}$	0	θ_3
4	0	$-\frac{\pi}{2}$	d + e	θ_4
5	f	0	0	θ_5

INVERSE Kinematics in MATLAB



- **Numerical solution** instead of analytical one

- Best solver **approximation** solution



URDF – Unified Robot Description File

final_mod.urdf

0 URDF > ROS1 > Gigi > final > urdf > final_mod.urdf

```
<robot
  <link
    </collision>
  </link>


  <link
    name="link_1">
    <inertial>
      <origin
        xyz="9.1411E-05 1.439E-05 0.08307"
        rpy="0 0 0" />
      <mass
        value="1.5994" />
      <inertia
        ixx="0.006851"
        ixy="-3.0652E-05"
        ixz="4.1042E-07"
        iyy="0.0083058"
        iyz="3.7857E-07"
        izz="0.0063085" />
    </inertial>
    <visual>
      <origin
        xyz="0 0 0"
        rpy="0 0 0" />
      <geometry>
        <mesh
          filename="package://final/meshes/link_1.STL" />
      </geometry>
      <material
        name="">
        <color
          rgba="0.79216 0.81961 0.93333 1" />
      </material>
    </visual>
    <collision>
      <origin
        xyz="0 0 0"
        rpy="0 0 0" />
      <geometry>
        <mesh
          filename="package://final/meshes/link_1.STL" />
      </geometry>
    </collision>
  </link>


  <joint
    name="joint_0"
    type="revolute">
    <origin
      xyz="0 0 0.066"
      rpy="0 0 0" />
    <parent
      link="base" />
    <child
      link="link_1" />
    <axis
      xyz="0 0 1" />
    <limit
      lower="-1.6"
      upper="1.6"
      effort="100"
      velocity="100" />
  </joint>
```

Links

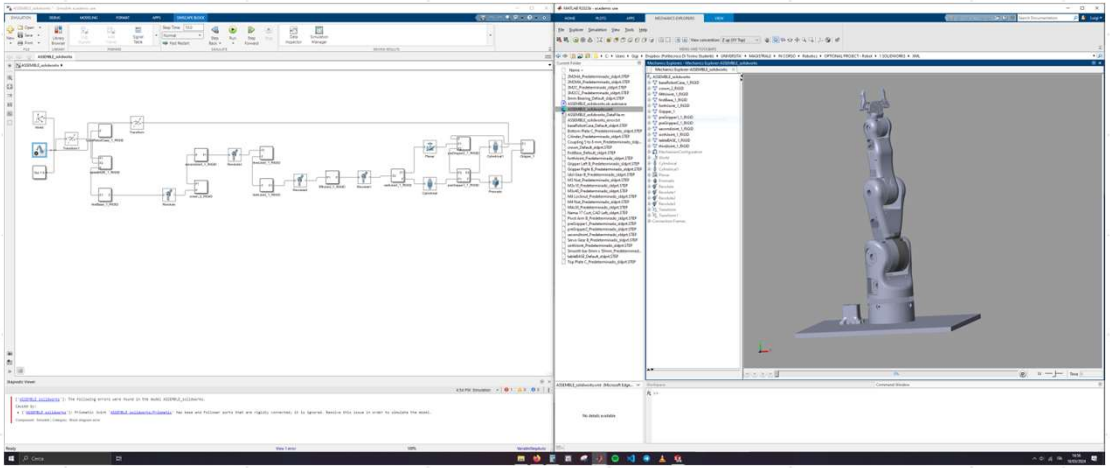
- Origin
- Mass
- Geometry
- Inertia
- Material
- Collision

Joints

- Type
- Origin
- Axis
- Parent
- Child
- Limits

- Extensible Markup Language (XML)
- Robot description
- Visual representation
- Collision model
- Extensible

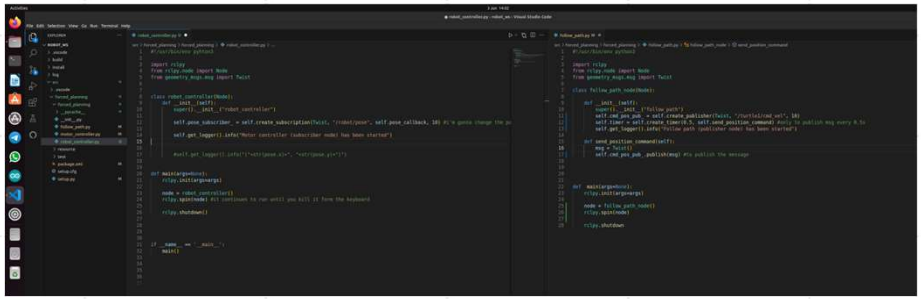
MATLAB/Simulink Simscape Multibody Link



ROS2 - Humble

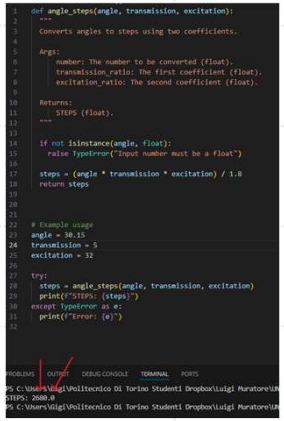
Subscriber

Publisher



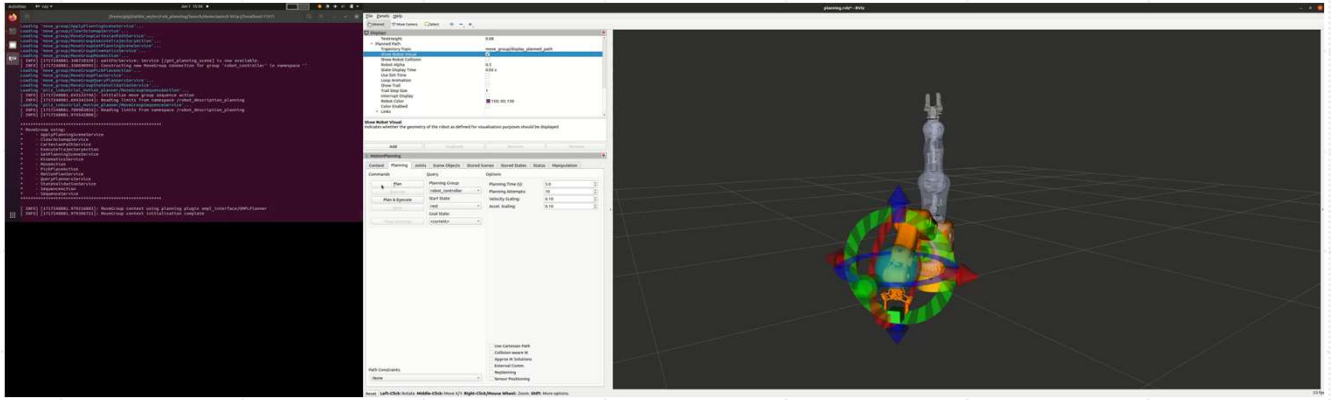
Python

- Converter angle-steps
- Motors script



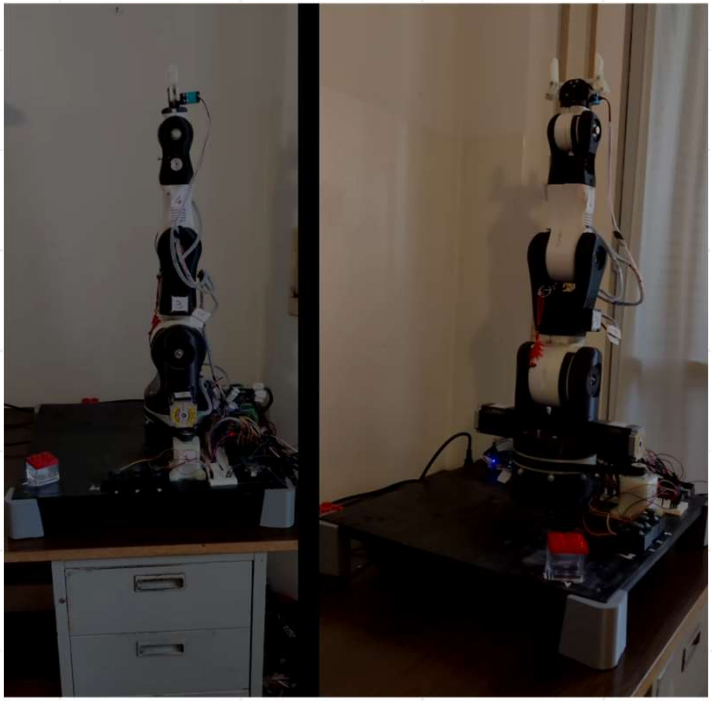
MoveIt

- OMPL – RRT planning library
- Plan trajectories
- Inverse Kinematics
- Angles

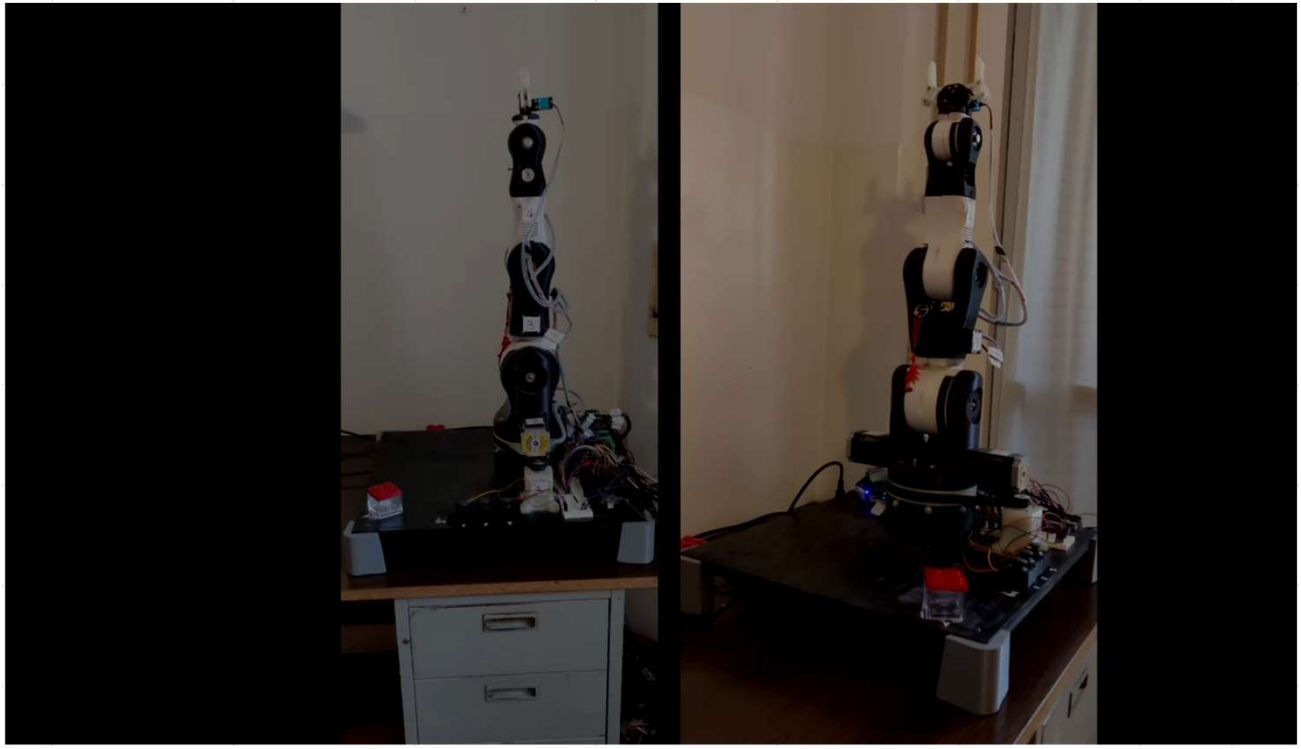


TESTS

Pick and Place with a cube



I'm not a Robot



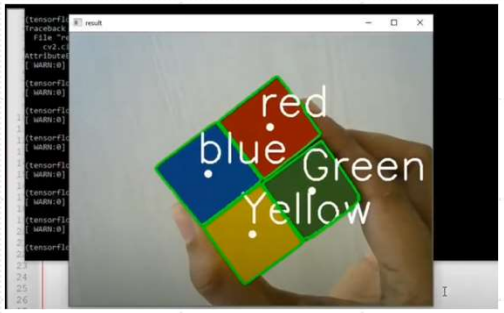
Future Upgrades and Implementations

- Vacuum gripper

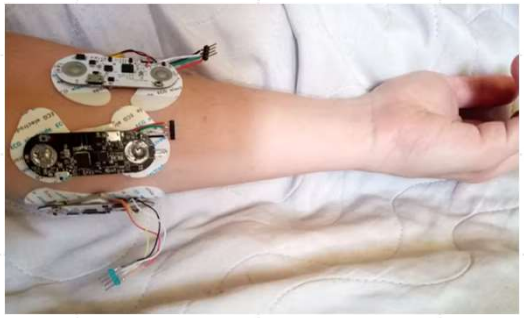
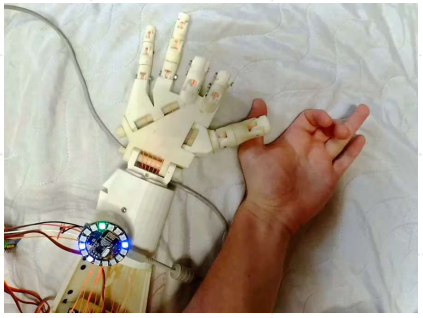



- Stereo camera

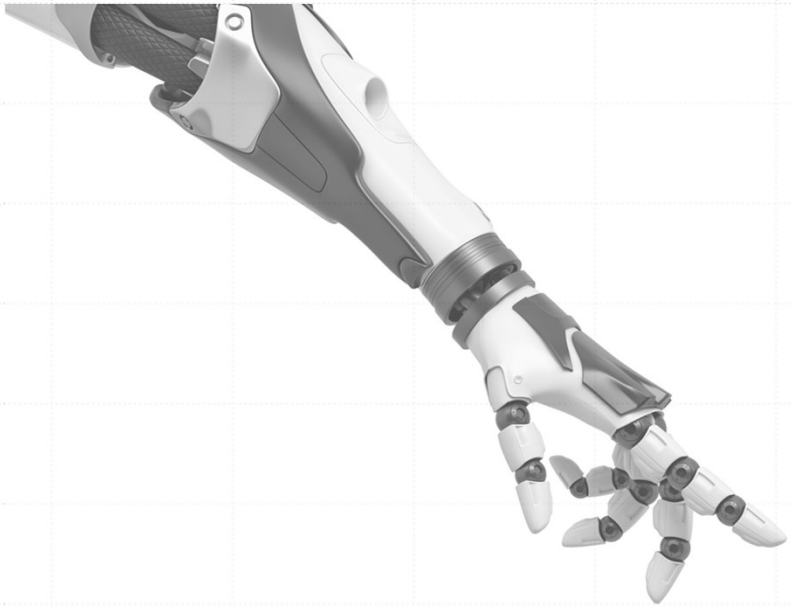
- Artificial Intelligence:
  - Voice control
  - Code generator



- EMG control

THANK YOU FOR YOUR ATTENTION



I'm not a Robotic Arm