MOBILE MANIPULATOR

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Project Title: Mobile Manipulator

Project Description:

The aim of this project is to build and simulate a mobile manipulator capable of performing various dexterous tasks autonomously.

The project is divided into two main components:
1. Manipulator Arm: Draw a circle on paper, Perform pick and place operations using object detection
2. Mobile Base: Perform SLAM for navigation.

Project Work :
1. Simulation(CoppeliaSim)
2. Designing
3. Manipulation
    a. Drawing a circle
    b. Object Detection and Classification
    c. Trajectory Planning
    d. Motion Planning
    e. Pick and Place
4. Navigation
    a. Omniwheel Drive

Hardware Selection :

1. Hardware Components:-
    - Selecting hardware, electronics based on requirements and finalising based on availability and ease of implementation
    - Selection of certain components such as batteries, grippers, wheels , etc. will be dependent on the following factors :
        - Power requirements

    - Accuracy and Precision requirements
    - Maneuverability
    - Load Capacity
- Primary focus was on achieving arm manipulation, object classification and navigation tasks. We plan to extend this project further into precision applications such as mobile assembly platform

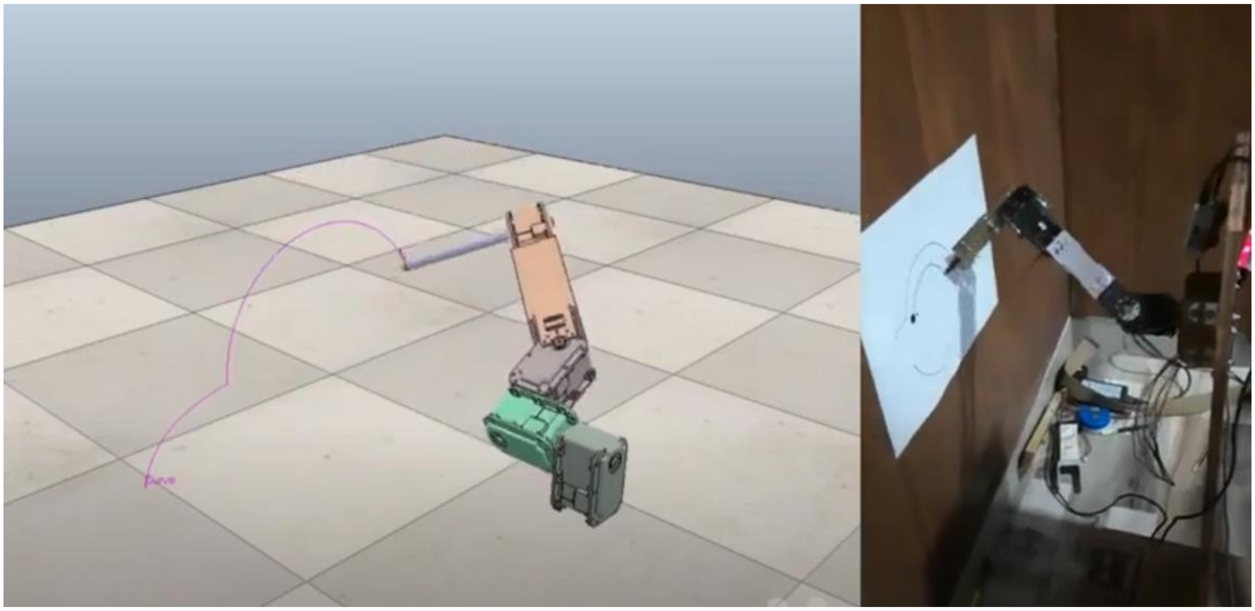
2. Testing and comparing Algorithms in Simulation :-
    - The mobile manipulator system can be divided into **2 core components : Mobile chassis** and **Manipulable arm**
    - Algorithms focusing on SLAM for Odometry and Navigation will be tested using a model of system and target environment in CoppeliaSim's student version software
    - The most efficient algorithm was further tested on the chassis of the mobile manipulator, and tuned before testing the final system i.e. arm + chassis in the target environment.
    - Algorithms focusing on using Inverse Kinematics based arm manipulation used and for trajectory planning we used QuinticTimeScaling, Feedforward control, and Point-to-Point trajectory Generation

Components :

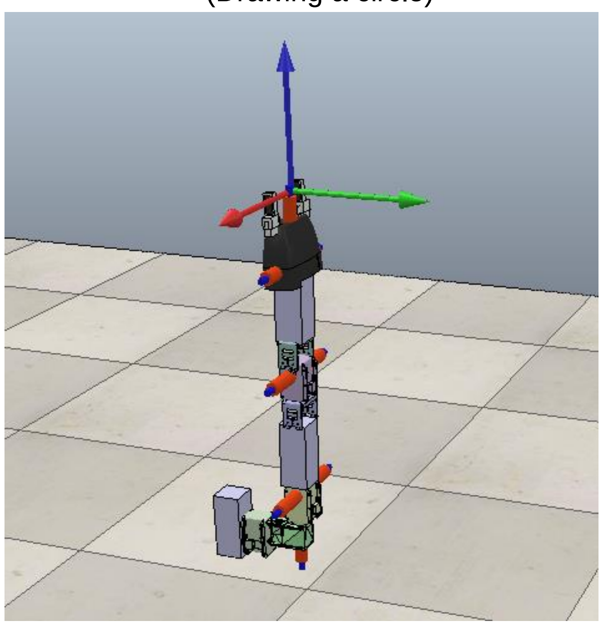
Part Name	Quantity
AX-12A DC Servo	7
3D printed joints	6
PCB Prototypes and Components	6
Lipo Battery	2
MPU 9250	5
Intel Realsense T265	1
OAK -D	1
Jetson Nano	1
LMS-111 Lidar	1
Mecanum wheels	4
Gripper + Servo	1

Outputs :

1. Drawing a circle with a 5 DoF manipulator : (Video Link)

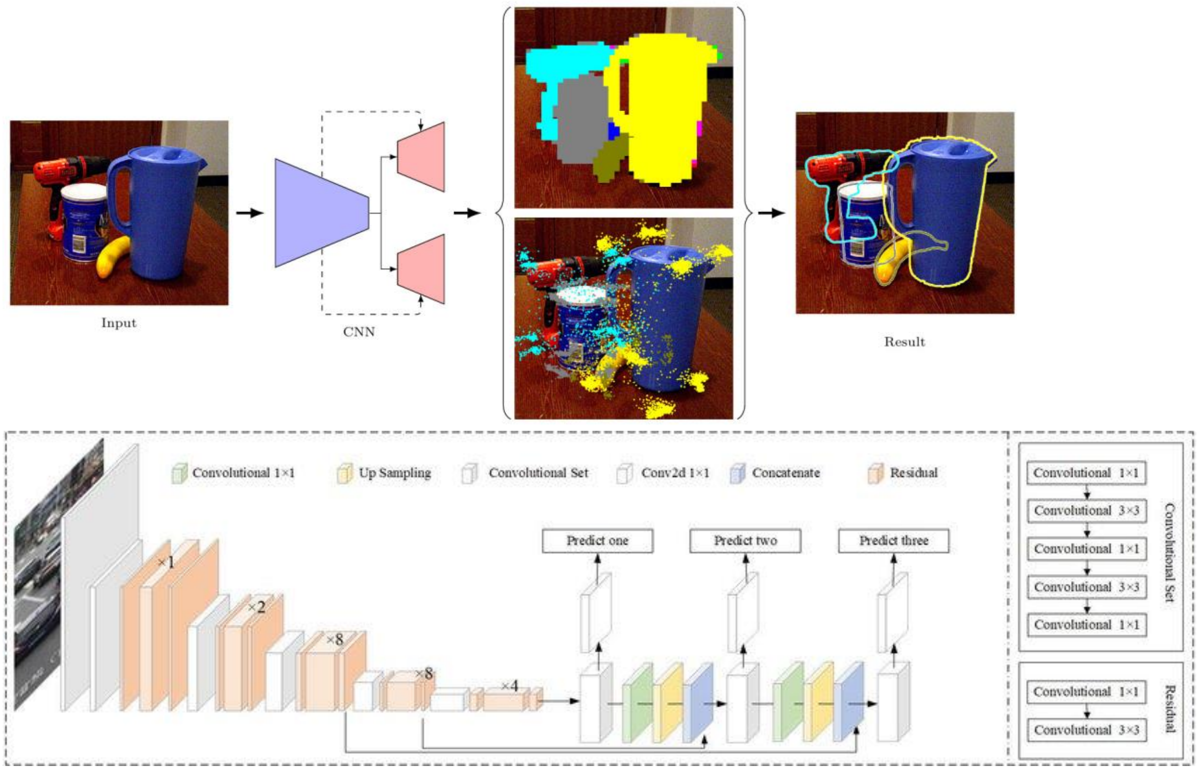


(Drawing a circle)



(Arm Design)

2. Multi-Object Detection:

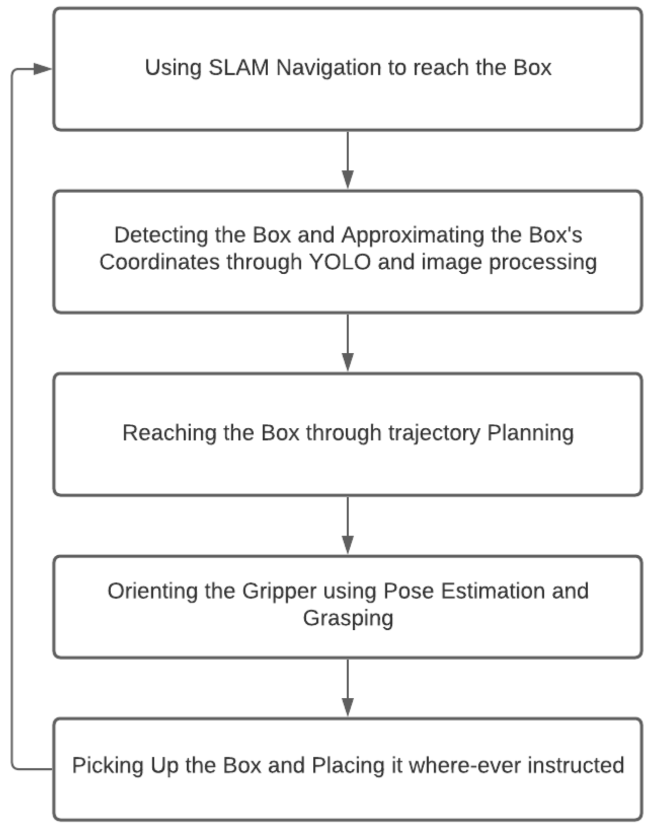


A brief description of the network

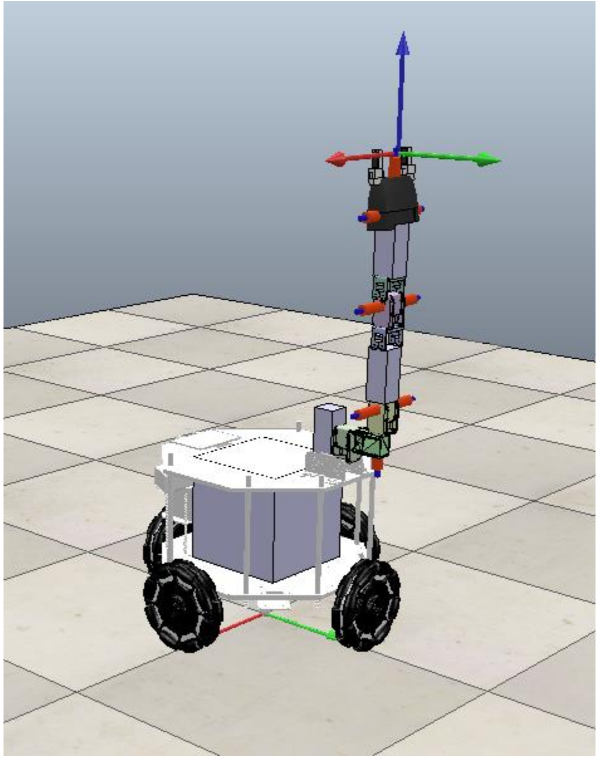
a. The input to the network is a simple RGB image.
b. The network has an encoder of Darknet-53 from YOLOv3, which is used for feature extraction of input images.
c. The network, then, has two streams :
    i. Segmentation stream: to produce the output segmentation masks (pixel-wise object classification).
    ii. Regression stream: to get 2D key points corresponding to the 3D key points of the object in the world (object) frame. Usually, the key points are 8 vertices of the 3D bounding box.
d. The output 2D keypoints are used to solve a 2D-3D correspondence problem with the 3D keypoints, using RANSAC-based PnP to get object pose (extrinsic), knowing the camera intrinsics. Also, segmentation masks are used to define object class.

3. Omniwheel Drive :
    - An Omniwheel Drive controller was developed for the 4-wheeled mobile chassis. ([Video Link]())

4. System Design:



5. Mechanical Design:



(CAD Model of the Finished Bot)

Timeline:

Month	Objective Achieved
July 2021 - August 2021	• Studying about the concepts related to modern robotics, SLAM, CV • Completing the assembly of the mobile manipulator
September 2021	• Testing the motion of the bot and the arm attached to it in simulation
October 2021	• Trying out SLAM Algorithms for bot motion in an unknown area in the simulation
November 2021	• Implementing Computer Vision Algorithms for detection of objects
December 2021	• Testing out arm motion for orienting it for picking up objects
January 2022	• Gripper testing

	• Finalizing the simulation part of the project
February 2022	• Looking upon the mechanical motion of the mobile manipulator
March 2022	• Testing Trajectory Planning on the physical bot
April 2022	• SLAM navigation testing with Mecanum
May 2022	• Operating the visual devices for testing out the detection of physical objects
June 2022	• Testing Out the Fully Assembled Bot
July 2022	• Documenting the Project implementation

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