Anteater Dynamics

7 Degree-of-Freedom Robotic Arm

Department of Mechanical and Aerospace Engineering - Senior Design Project

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Industry Sponsor: ROBOTIS INC.

UCI Samueli School of Engineering

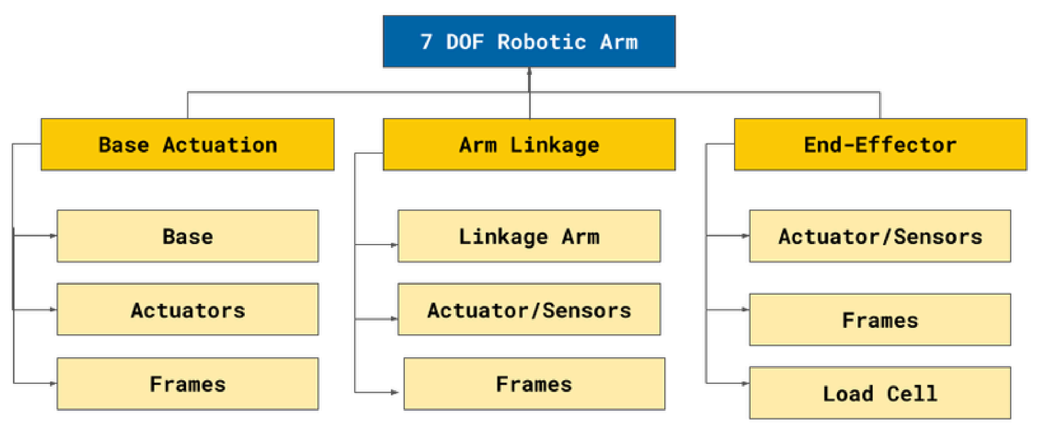
ROBOTIS

Executive Summary

The current machine learning research landscape is utilizing robotic systems to collect data on which AI models are trained. Companies such as our industry sponsor, ROBOTIS Inc., provide at-home robotics kits for enthusiasts to collect data and train AI models. The problem is that the available consumer options are either low budget, robot kits with low fidelity or high-end kits that may be unrealistic for many consumers.

Anteater Dynamics seeks to bridge the gap between existing market options by developing a mid-range robotic system capable of 7 degrees of freedom with integrated load sensors to collect critical data for AI training. Our solution is open-source, priced around $1000, and designed for additive manufacturing, allowing consumers to either purchase full kits from ROBOTIS Inc., or opt to manufacture their robot independently from any hobbyist 3D printer. The system is also designed to integrate ROBOTIS Inc. proprietary electronics for optimized linkage kinematics. Simulated kinematic analysis validates unrestricted 7DOF movement and if the 4DOF prototype demonstrates the system effectiveness, the Anteater Dynamics robotic arm could provide the robotics machine learning community with a robust and capable solution for AI training.

Structural Decomposition



Functional Requirements

(A) Base Actuator
FRA-1: The base actuator shall rotate 360 degrees to pick up objects around it
FRA-2 The base shall provide a stable and secure mounting platform for the arm linkage
FRA-3 The base shall support the mass of the robot and a load of 400g at the end effector

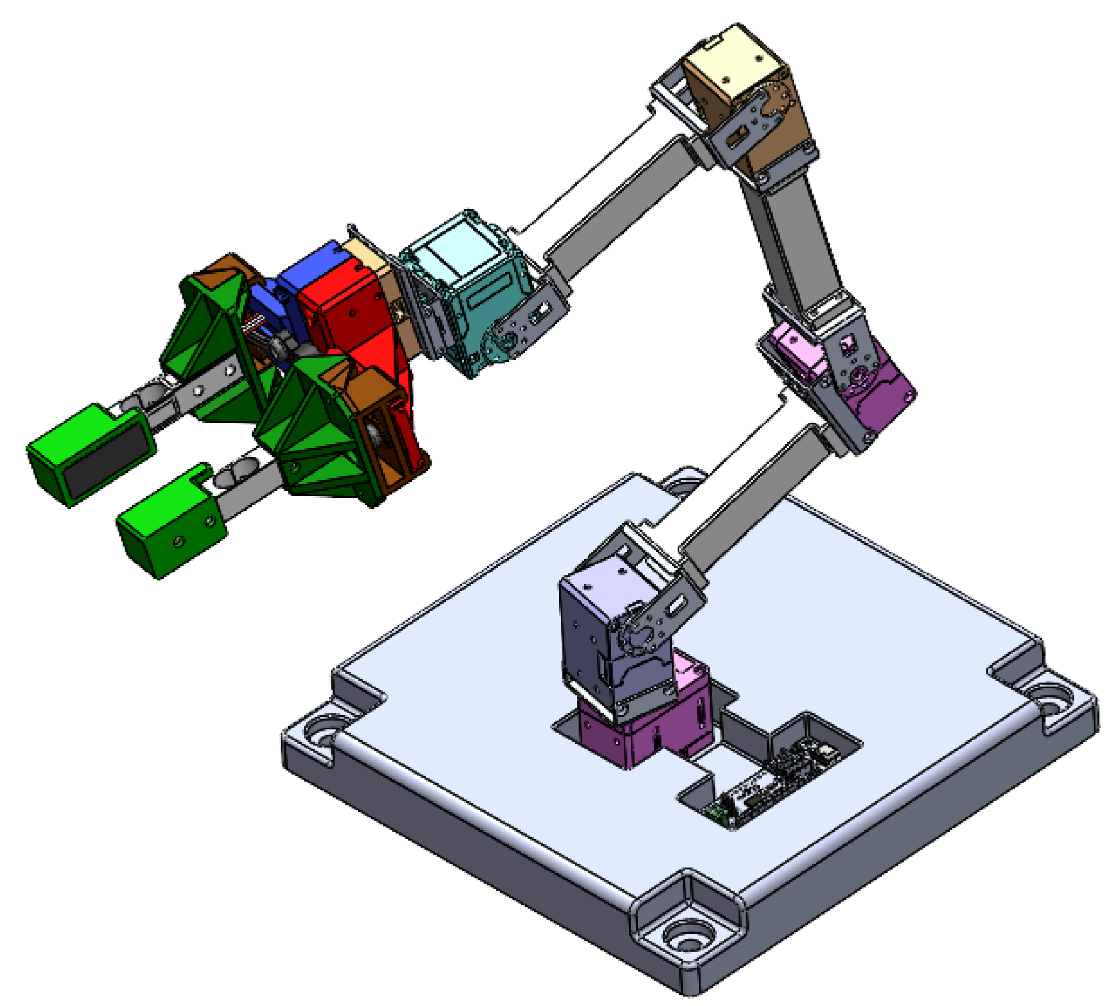
(B) Arm Linkage
FRB-1: The arm linkage shall provide the reach to pick objects at a distance of 500mm away
FRB-2: The servos in the arm linkage shall support the load of 400g at the end effector
FRB-3 The arm linkage shall articulate to move around obstructions

(C) End Effector
FRC-1: The end effector shall pick up small household objects
FRC-2: The end effector shall sense gripping forces
FRC-3: The end effector shall be able to grip the expected loads of 400g

References and Awknowledgements

Our team would like to thank our sponsor ROBOTIS, for providing feedback and guidance, as well as supplying Anteater Dynamics with DYNAMIXEL servos and other ROBOTIS components. We would also like to thank our MAE151A instructors, Professors David Copp and Mark Walter, and our TA Abdelrahman ElMaradny.

CAD Assembly



Existing Solutions

Fig 1. Koch v1.1 Robot Arm
$237
Low Fidelity
4 DOF

Fig 2. OpenManipulator-X Robot Arm
$1,416
High Fidelity
6DOF

Future Improvements

Shortcomings	For the Future
Expensive Servos	Servo Optimization
Torque requirements	Servo Torque Control
Complex Control Algorithms	AI Integration and Control
	Interchangeable end effectors

Robotic Linkage

Overview:

5 Total ROBOTIS Servo Actuators
- One 2-axis servo for wrist joint
- Arm has 6 Degrees of Freedom (DOF)
  - 4 Angle joints; 2 revolute joints
- Bolted or Clamped base for stability
- Integration of Open-RB150 control module
- FEA Optimised linkage arms
- Overall reach ~600mm

Construction:
- Injection molded linkage arms, able to be 3D printed
- Metric Hardware for Joints
- ROBOTIS aluminum frames for joints

Proof of Concept:
- Simplified linkage to allow for easier programming and to identify areas for improvement

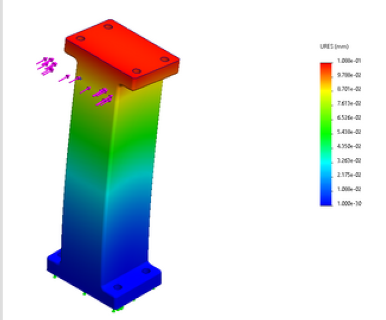


Fig. 1. Linkage Arm FEA

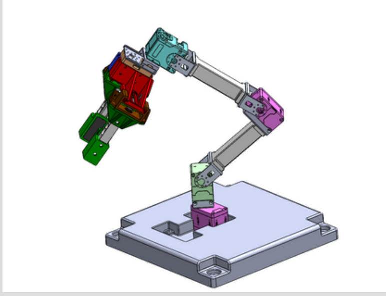


Fig. 2. Simplified POC Arm

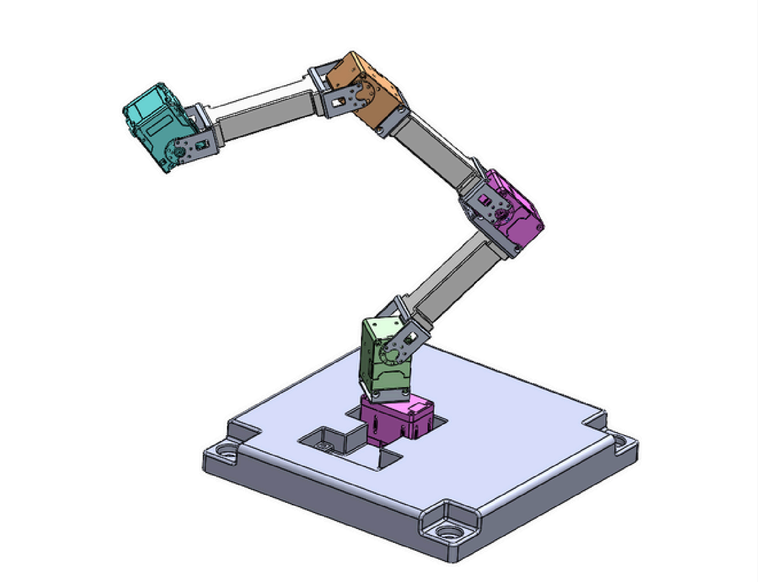


Fig. 3. Full 6 DOF Linkage Arm

End Effector

Overview:

ROBOTIS XL430-W250-T Actuator
- Max Jaw Width; 50.5mm

Construction;
- Injection Molding
- 3D Printing

Active Grip Control;
Each "finger" of the claw is equipped with a 1kg Load Cell. Allowing for machine learning to actively control its applied grip force.

Modularity;
Fingertip pads can be easily swapped for specific applications.

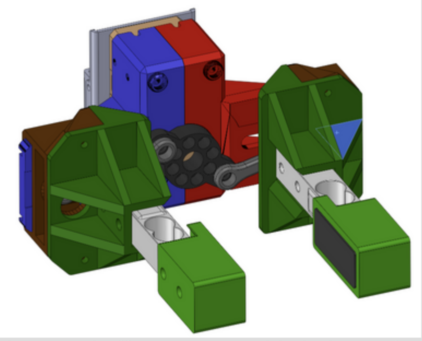


Fig. 4. End Effector - Assembled View Left

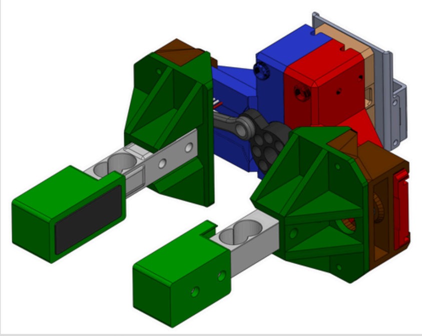


Fig. 5. End Effector - Assembled View Right

Assembled & Exploded Views:

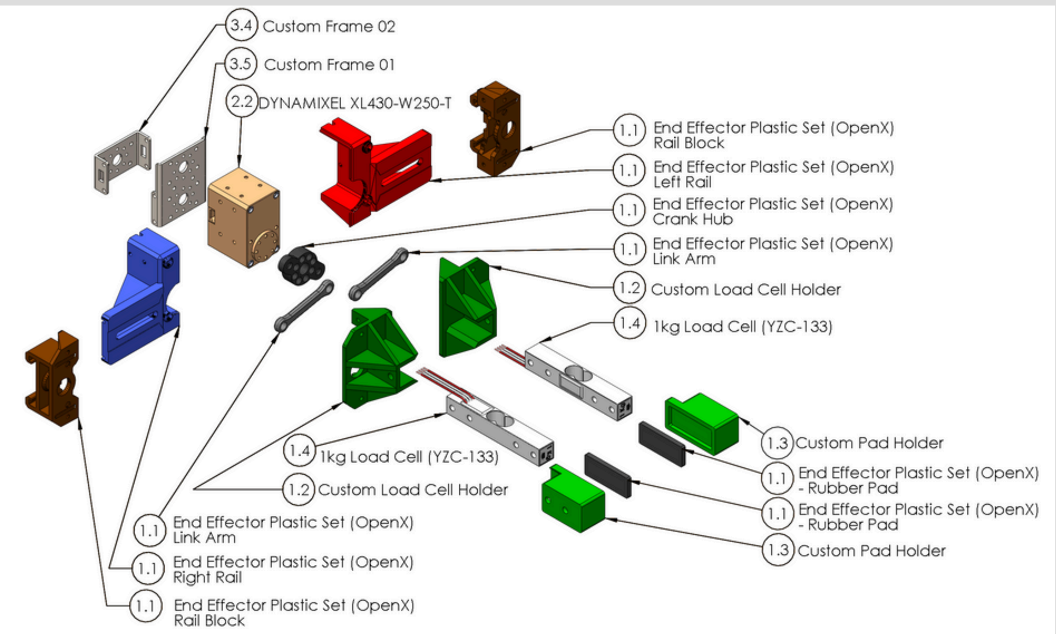


Fig 6. End Effector - Exploded View

Controls/Software

Pseudocode Flowchart

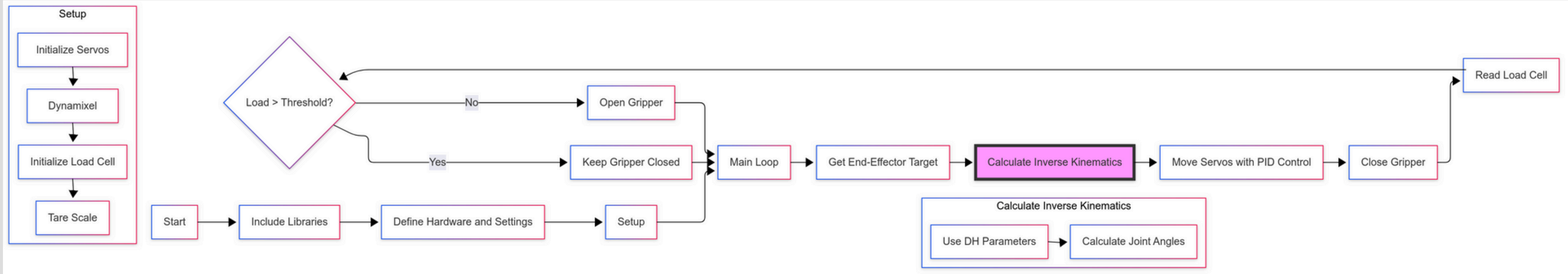


Fig 7. Flowchart of the Robotic Controls Code