Lab-Assisting Robotic Manipulator (LARM)

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Project Background

Robotic arms prove useful in areas ranging from manufacturing to space exploration. However there is a distinct lack of cheap robot arms that can be used in medical and wet-lab settings. LARM aims to develop a robot arm that will perform dangerous tasks such as handling volatile chemicals and performing vaccine injections.

Motives

The design of LARM focuses on reach, stability, and accuracy. Each part of the arm is designed to allow the end product to achieve a target position with minimal error.

Goals:

- 6 Degrees of freedom to allow for 3-DOF positioning & 3-DOF orienting.
- Reach ≥ 0.6m (≈ 2ft).
- Payload capacity ≥ 1kg (2.2 lbs).
- End-effectors for syringe and beaker manipulation.
- Arm-Wrist Kinematic structure, which introduces a wrist joint at which precise end-effector motions are isolated.
- Intuitive tele-operation via a small-scale master arm.

Mechanical

Joints and Links:

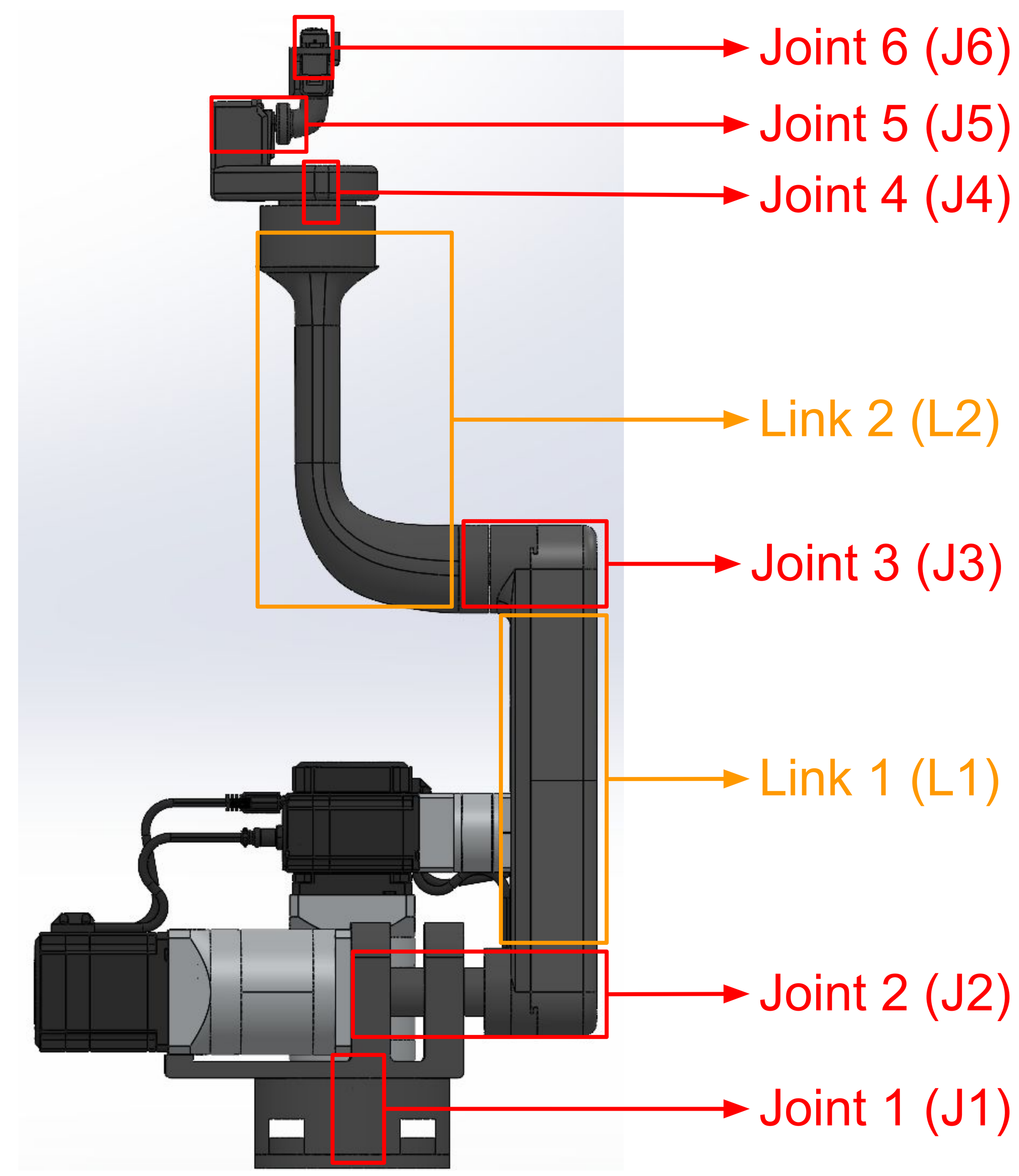

***Figure 1:** LARM Joints & Links*

- LARM consists of 2 arm linkages that support loads of 1 kg and allow a reach of roughly 75 cm.
- The base provides rotation about the Z-axis through a compact belt-and-sprocket system and also protects internal cabling.
- The arm links supply the robot's reach: Link-1 houses a belt drive that powers Link-2, and Link-2's curved geometry keeps the wrist aligned with the base rotation axis.
- The wrist contains three servos that provide full orientation control once the arm has positioned the end effector.

Mechanical Cont.

End effector

- A rack and pinion design allows for controlled injection of a syringe during vaccine administration.
- A ball bearing lined track minimizes friction and ensures smooth injections and accurate dosing.

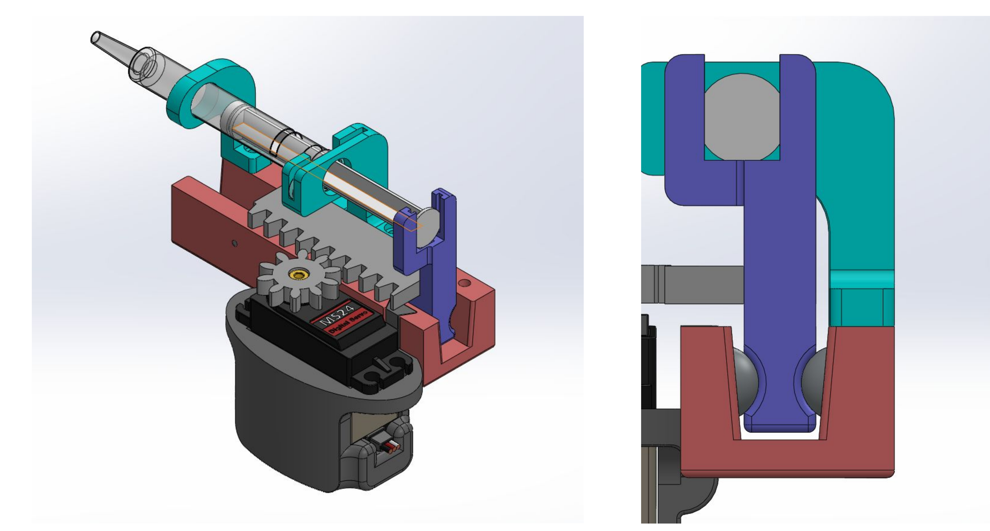

***Figure 2:** Vaccine End Effector*

Electrical

- 48V power supplies with ample current output power three stepper motors.
- Voltage is stepped down using buck converters to power four servos.

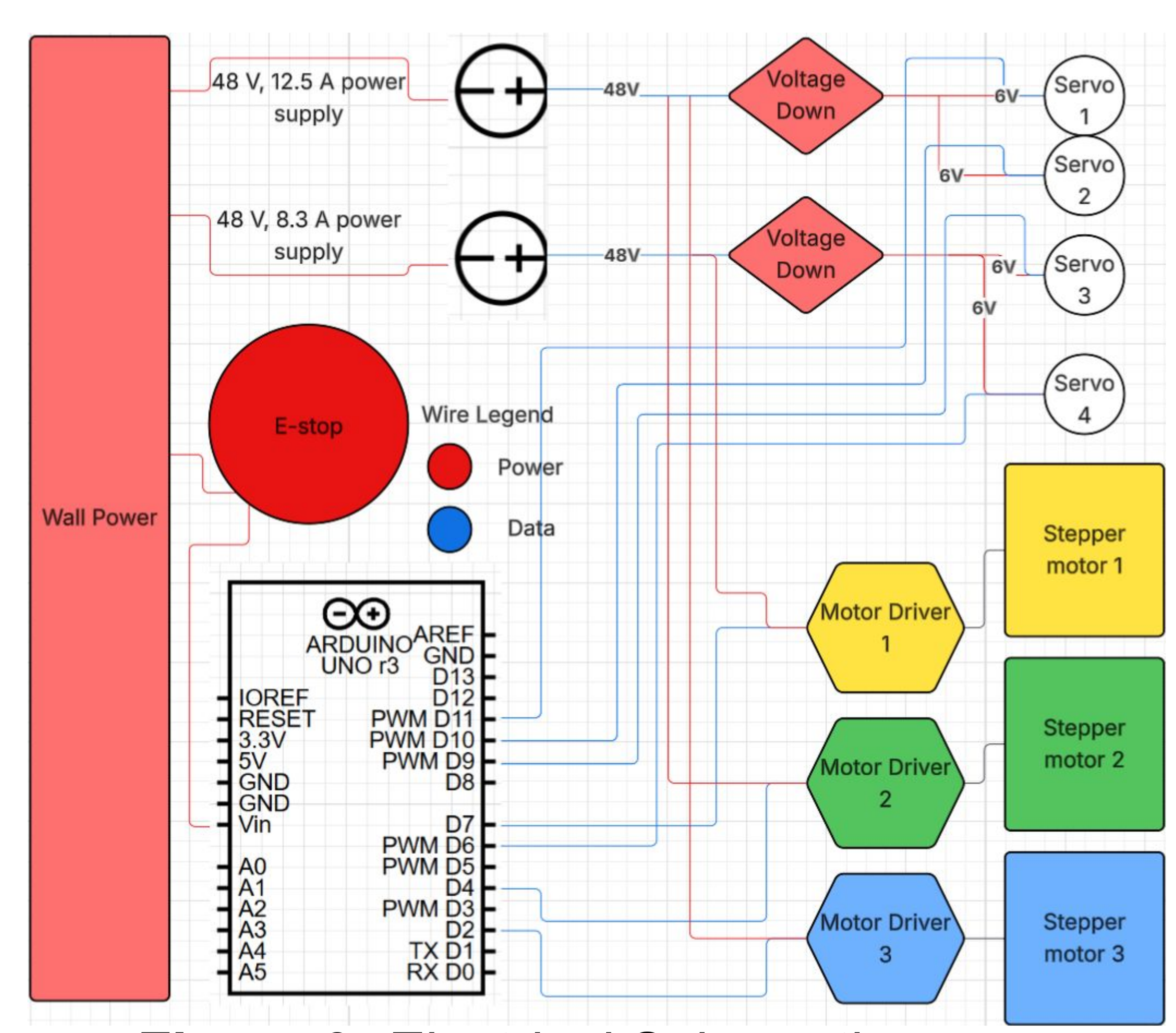

***Figure 3:** Electrical Schematic*

Teleoperation

- LARM is tele-operable using a small-scale, kinematically similar controller. This allows intuitive, real-time positioning of the arm, reducing collision and increasing maneuverability.
- A set of Dynamixel servos send their position data at a high frequency to an Arduino through serial communication. The joint positions are then transmitted to LARM's stepper and wrist motors.

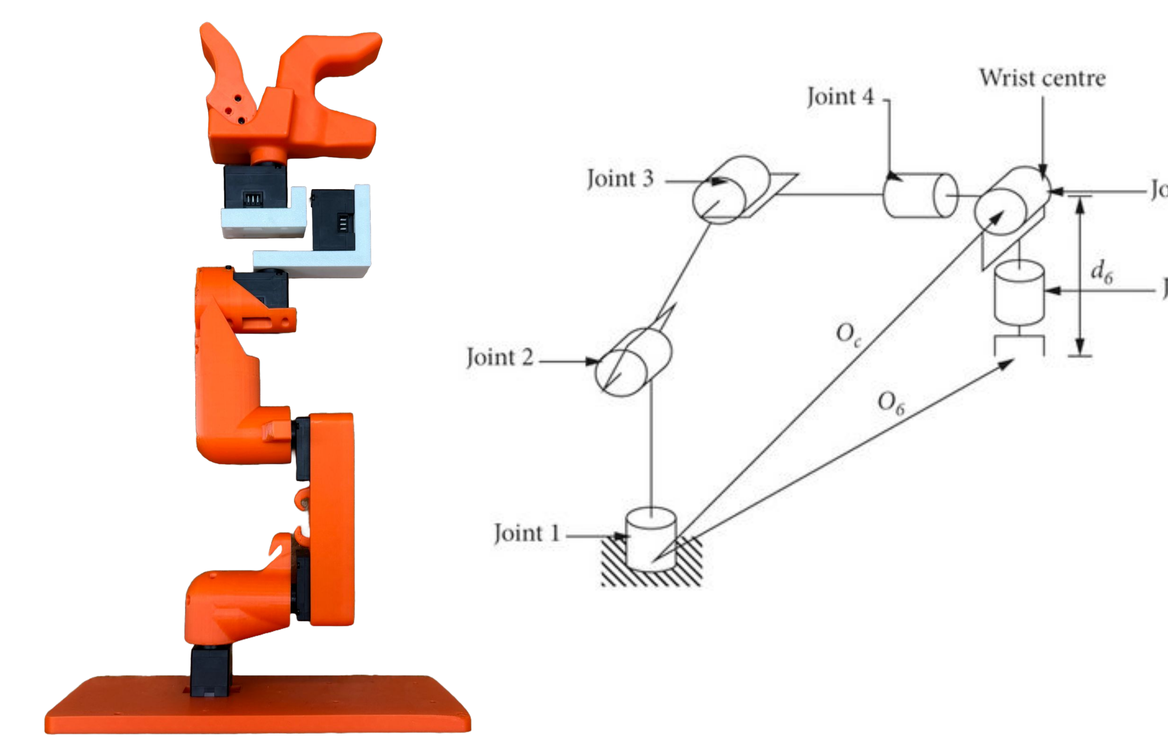

***Figure 4:** Arm controller and Kinematic Diagram*

Next Steps

- Add a Raspberry Pi to interface with the Arduino and run motion planning, controls, and computer vision.
- Redesign links for greater strength.
- Modularize end-effectors for efficient task switching.
- Add haptic feedback to remote operation.

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