C.L.A.R.A.

Continuum Locomotive Alternative for Robotic Adaptive-exploration

Derik Pignone (Robotics Engineering), Blaise Schroeder (Robotics Engineering)
Advisor: Professor Cagdas Onal - Robotics Engineering (RBE)

Camera Module

One major goal of this robot is to aid in the inspection and exploration of pipe networks. To accomplish this, a camera module was added to provide a live feed to the operator. The module is an ESP32-CAM which hosts a live video web server via Wi-Fi. This server is accessible by the operator from the same laptop used to send commands to the robot.

Flexible Body

The origami flexible body of the robot is what provides its unique 3-dimensions navigation. This is the core of the CLARA robot, allowing for unique and useful motion profiles.

Compressed Flexible Body Length:

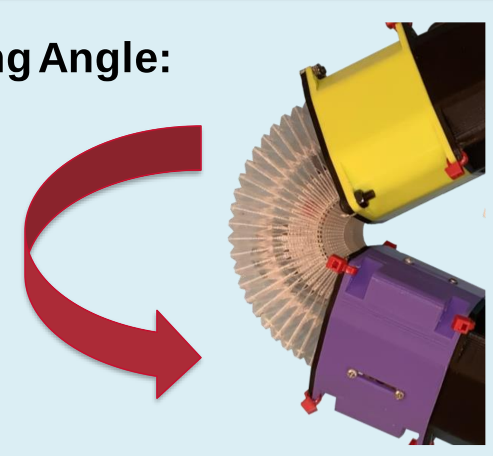
~ 1.5"

Extended Flexible Body Length:

~ 6"

Maximum Bending Angle:

~150˚

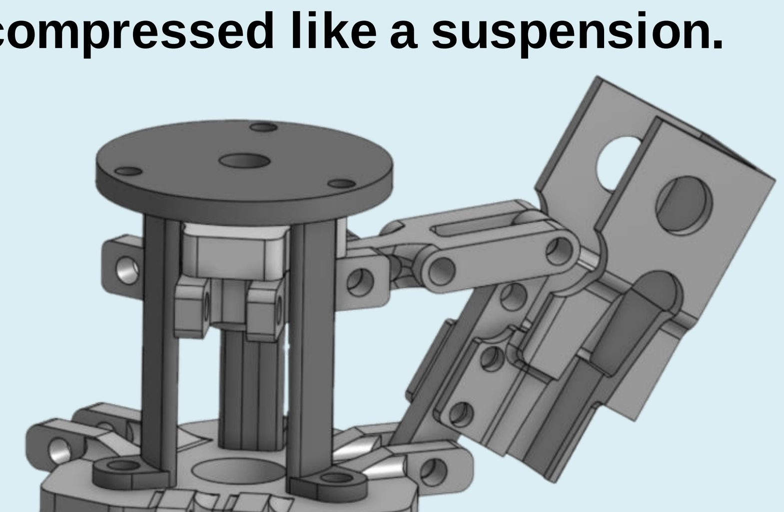


Body Profile / Casing Improvements

The first robot iteration had exposed wires and parts which could cause vital components to snag and break if the robot fell or encountered difficult geometry. To improve upon this and provide adequate protection, a standard casing profile was developed to keep the robot within a semi-standard frame, preventing snags and protecting vital components. This profile reduction also improved the maximum bending angle of the flexible body.

Actively Limited Passive Suspension

The driven wheels on the motorized ends of the robot are attached via a simple linkage connecting each motor arm to a central hub that passively rides along a lead screw. A compression spring sits between the hub and base plate, with a driven outer limiting plate to constrain extension. This mechanism allows the wheels to be actively pulled inward, but also to be passively compressed like a suspension.



Silicone Wheels

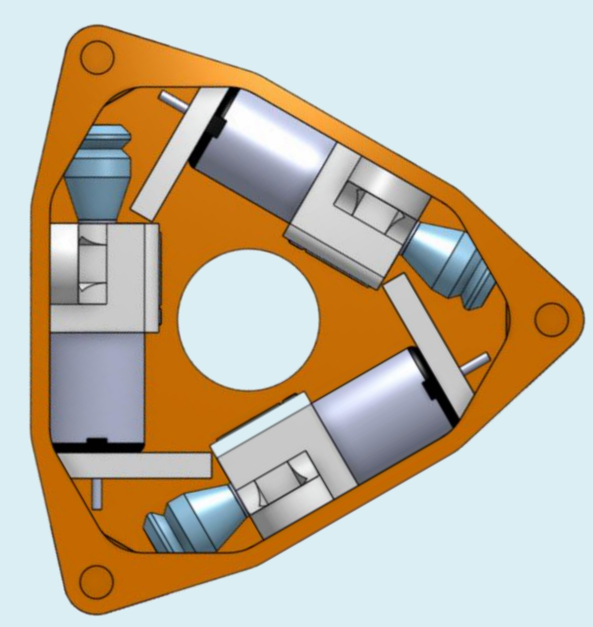
Custom silicone wheels were molded to replace the stock wheels and provide adequate grip to the inner surface of a pipe. A shore hardness of 30 was selected to provide a balance between compliance to provide grip, and sturdiness to resist damage.

Abstract & Motivation

This project continues the development of a salamander-inspired soft robot for use in inspecting and exploring pipe networks and is capable of maneuvering in a variety of pipe shapes, sizes, and configurations. Our work focused on implementing various mechanical and functional improvements for overall robustness and performance. The robot features an origami body segment following a Yoshimura crease pattern. The pattern allows deformation and bending, controlled by three cable winch mechanisms. Locomotion is achieved with a three-segment wheeled mechanism on a suspension-based linkage. The segments expand and contract to provide variable force on the interior surface of the pipe, allowing for variable grip. Our work further developed numerous systems to provide added functionality, robustness, and a low-profile design. New wheels were cast in silicone for better grip. A new casing structure was introduced to enhance rigidity and protection of vital components, as well as reduce the overall robot profile. The upgraded system uses an ESP32-CAM module to provide live footage to the operator. Relocation of actuators increased the maximum bending angle to ~150 degrees, a ~60% increase over previous iterations. This project expands upon the previous project's foundations, providing further support, functionality and recommendations for future research and applications in pipe network exploration and inspection, and possible payload integration.

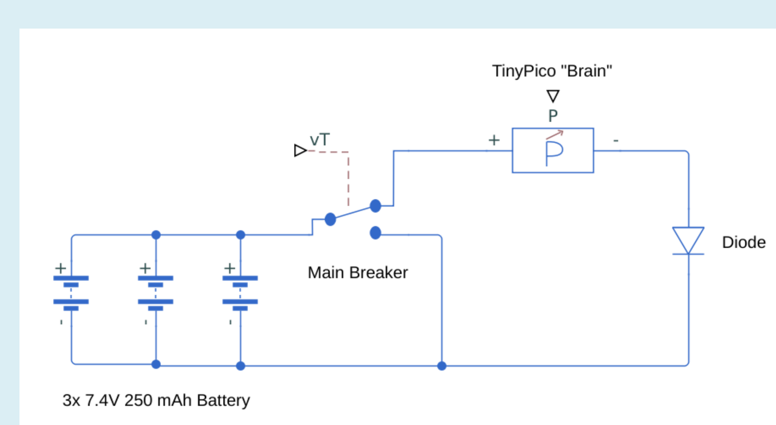
Winch Segment

The new winch segment places the 3 winch motors on the sides of casing to allow them to fit within the new profile. Additionally, the new orientation of the winches aligns the winch drums with the cable channels of the flexible body. This layout prevents issues discovered in previous iterations in which the friction between the cable and flexible body would cause damage to the origami body.



Battery Changes

To fit within the new body profile, a 1000 mAh LiPo was swapped out with three 250 mAh batteries of the same 7.4V. The batteries were wired in parallel to increase maximum current, and a main breaker was added for safety and operation purposes.



Suggested Future Work

- Design of modular wheel segments for different environments
- Waterproofing of body casing to protect from moisture in pipes
- Advanced control schemes for enhanced network navigation
- IMU implementation for orientation and live mapping of pipe networks
- Uniform segment connection design for possible modular configurations
- Hold / Release segment for possible payload transport