

Soft Robotic Fish

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Background

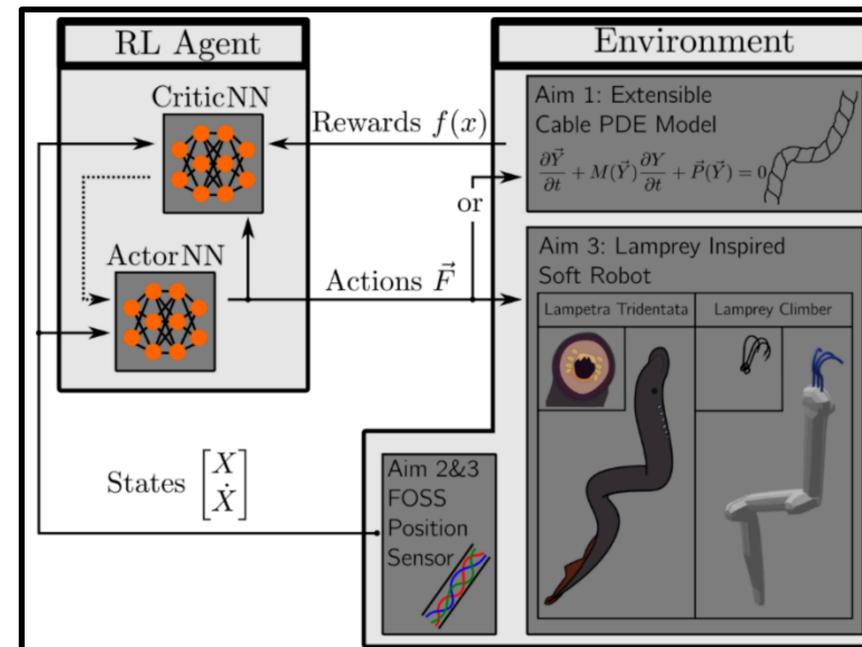
- We want to understand and explore the effects of reinforcement learning algorithms on the movements and propulsions of a soft robotic fish. More specifically, in environments not suitable for rigid, segmented robots.
- Soft robots are challenging due to the infinite degrees of freedom possible, and ML algorithms aim to train that in this study.
- Research conditions causing different tail maneuvers, to better understand how RL adapts to complex soft-robot dynamics.
- Our goal is to contribute to aquatic research and prosthetic models used for underwater exploration by improving soft-robot locomotion.
- Aim to advance robot control with Deep Reinforcement Learning (DRL) agents for soft robots, as they have shown promise in walking swimming, etc. in simulations.
- Traditional robots implement ODEs, but PDEs are deemed more appropriate, and thus used to model the robots movements for soft robots.

Methods

- Literature reviews and data analysis in terms of findings. Understand how previous RL algorithms attempted to control movements of robot with different algorithms.
- Reading through past XML codes, client tests, and server tests, studying them and deciphering them.
- Elevated our understanding of how the programs and algorithms worked greatly, and will make it easier for us to work on future XML programs.
- DRL applies pressure across body of robot, allowing for movement (i.e. tail, head, etc.).
- Supporting systems such as a FOSS sensor allow us to collect data of the robots exact position and movement, to feed to the Neural Networks controlling the robot to further propagate its control over robot.



Soft robot navigating dynamic environment.



Sample communication of an Reinforcement Learning Algorithm.

Reinforcement Learning

- Soft robot system controlled by Actor and Critic Neural Networks
- Actor NN advised robot on what actions to take, and Critic NN evaluated how good actions were.
- These actions are evaluated based on a reward function, which gives separate reward per action. This tells robot if its performing the appropriate action.
- A supplementary FOSS sensor is used to provide exact feedback of robots movements, allowing NN to adjust according; modeling an input-output relationship.
- An XML algorithm is used for the communication; sending and receiving the state of the action as well as the rewards as needed.
- PDE-based modeling used for robots movement, which are more complex and computationally expensive than ODEs used for rigid robots.

XML-RPC

- The XML-RPC (Extensible Markup Language Remote Procedure Call) is a remote protocol that allows communication between different systems.
- Made procedure calls to allow programs written in different languages, such as C, MATLAB, Fortran, and Python, to interact and communicate.
- Server proxy is an interface, for a remote XML-RPC server, facilitating requests and responses between the client and server.
- The client initiates a request to the server, which executes a function and returns the result.
- Establishes communication between separate codes by using XML-RPC to pass data and function calls across different languages.
- In the RCC, a script defines tasks for the system, or *jobs*, retrieving running or pending job statuses, and managing workflows. This allows interoperability between the running jobs, ensuring efficient coordination of data.
- Connecting back to this study, this is the communication method for the robot, able to send things such as rewards for fitting movements, or the exact action of the robot through the FOSS sensor.

Results

- It appears the algorithms will have significant control over the tail, and the maneuver.
- Our environment is the surrounding fluid, and we observe how to move the tail to try to learn as it goes through different environments such as behind a stone. We observe things such as where to get maximum velocity and such.
- The reinforcement learning will be a better algorithm to use in comparison to other machine learning models such as supervised and unsupervised, due to the ability to detect patterns.
- And by leveraging DRL in simulations, we were able to receive better movements in the soft robot.
- Soft robot learned proper control policies and maneuvers like walking, swimming, crawling.
- PDE model allowed for more precise and environmentally appropriate movements.
- It is about recognizing the patterns of obstacles to see, and this information that is fed to the robot after each encounter will improve its maneuverability.

References

