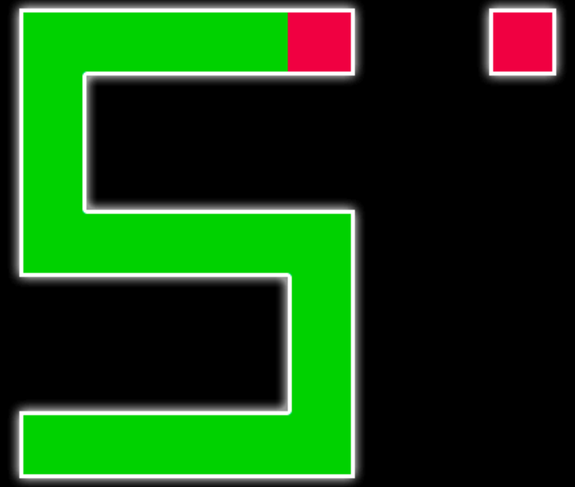
MetaBot Learning to Play

Reinforcement Learning Approach



Abdulwasay Mehar
Supervisors: Jessica Burgner-Kahrs & Reinhard Grassmann

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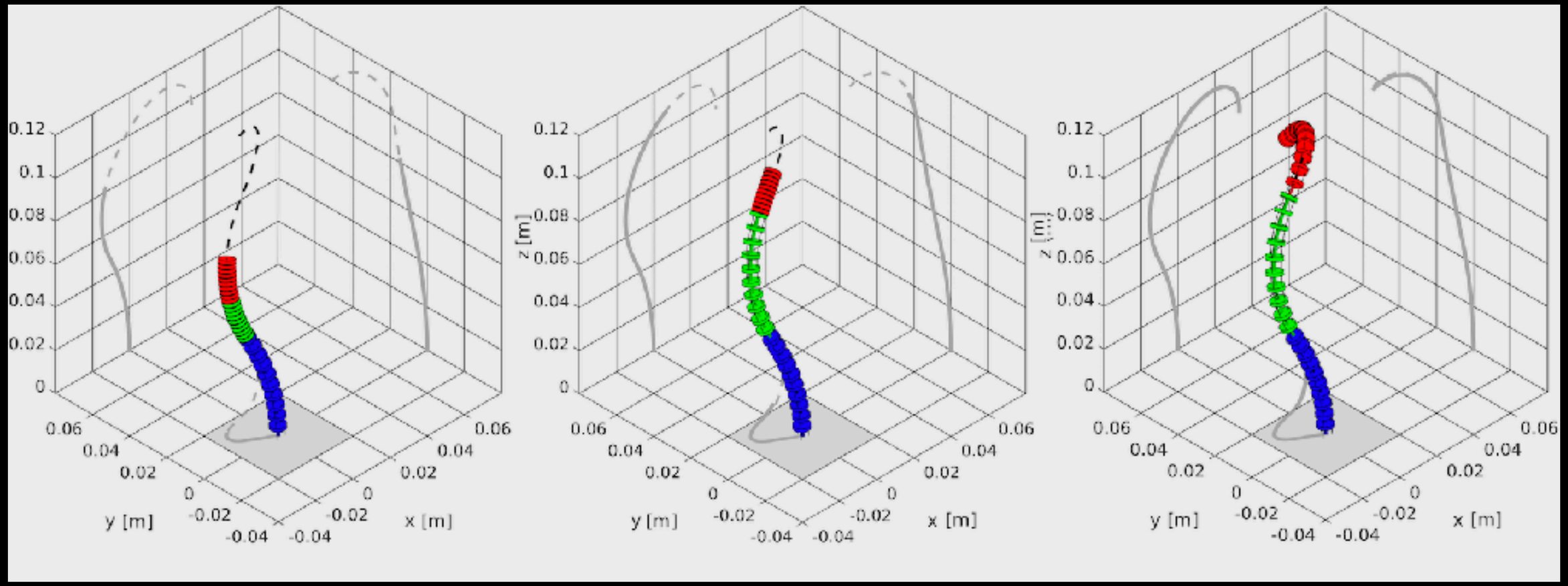
Motivation



Considerations for Follow-the-Leader Motion of Extensible Tendon-driven Continuum Robots
Maria Neumann and Jessica Burgner-Kahrs, Member, IEEE, May 2016

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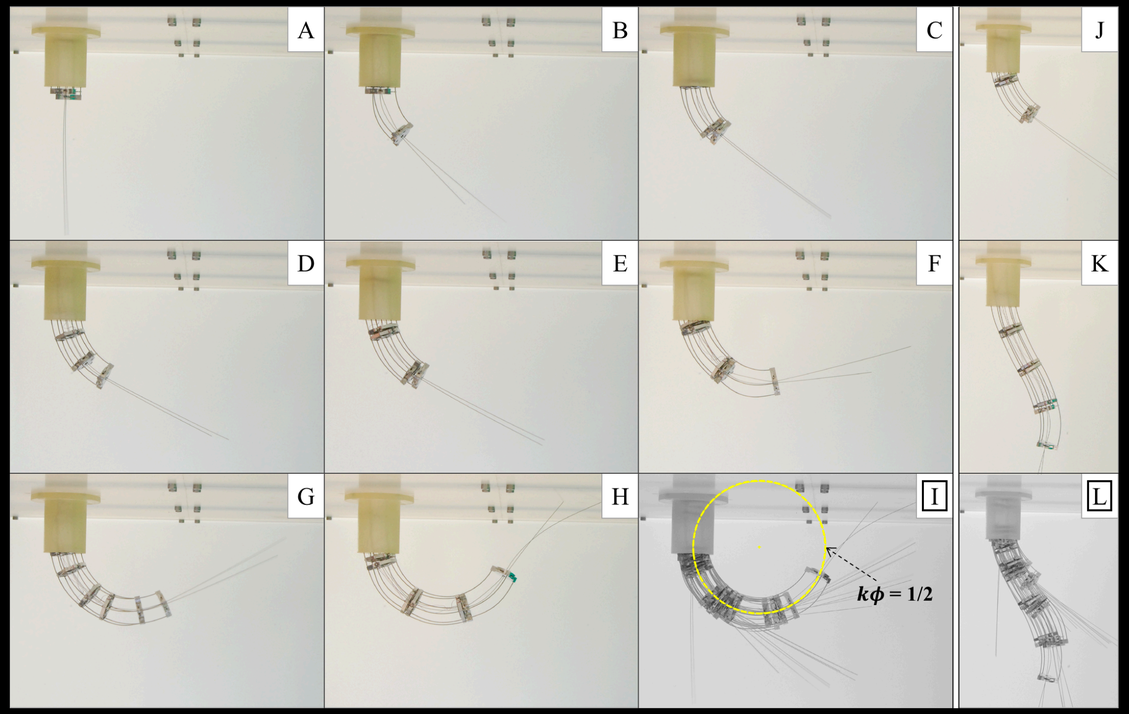
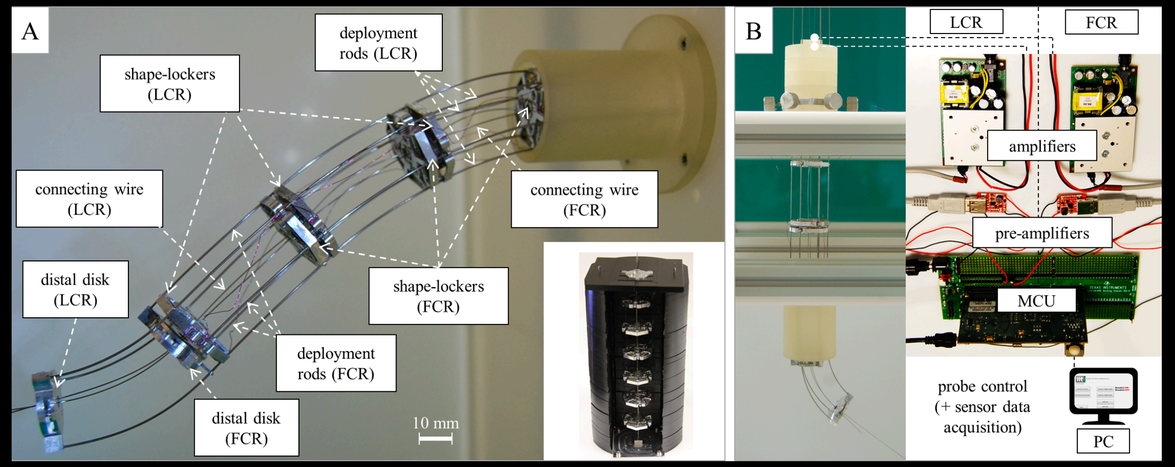
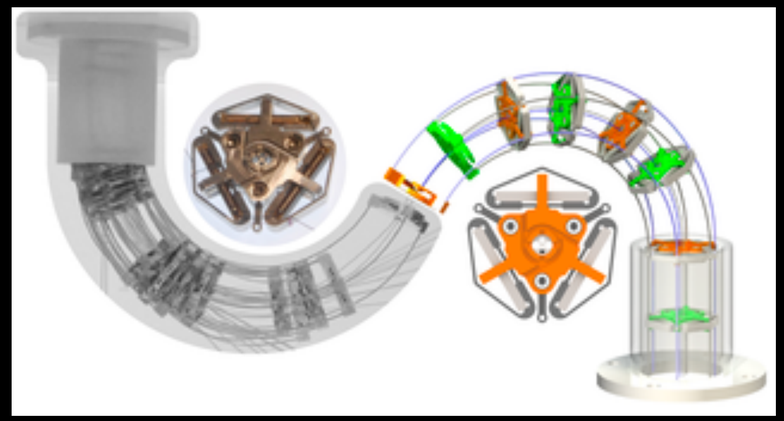
Motivation







The First Interlaced Continuum Robot, Devised to Intrinsically Follow the Leader
Byungjeon Kang, Risto Kojcev, Edoardo Sinibaldi | February 2016 (*Link*)

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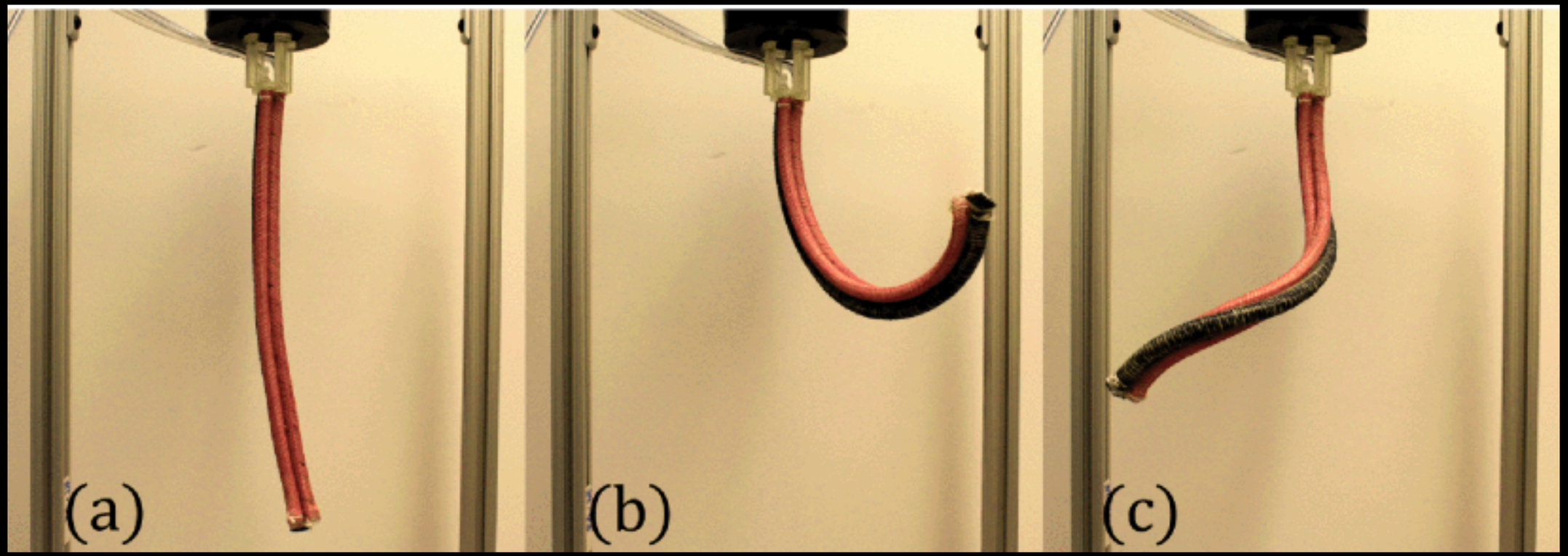
Motivation



Open Loop Position Control of soft continuum arms using Deep Reinforcement learning | ICRA 2019

Sreeshankar Satheeshbabu , Naveen Kumar Uppalapati , Girish Chowdhary and Girish Krishnan

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Problem

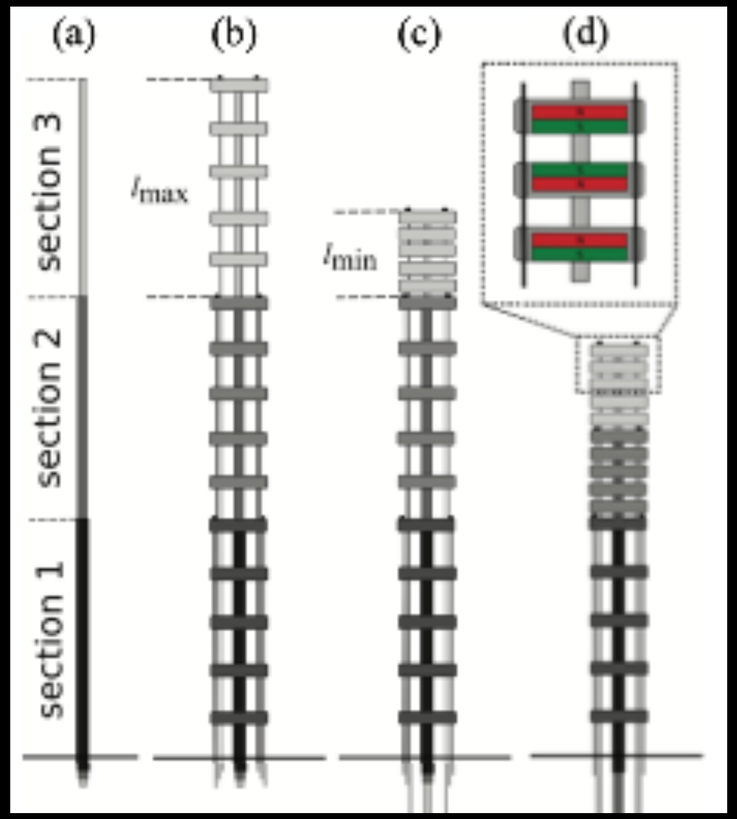
Designing an algorithm to achieve Follow-The-Leader behaviour is complicated

Problem

Designing an algorithm to achieve Follow-The-Leader behaviour is complicated

So we will try learning the Follow-The-leader behaviour with Machine Learning

Solution



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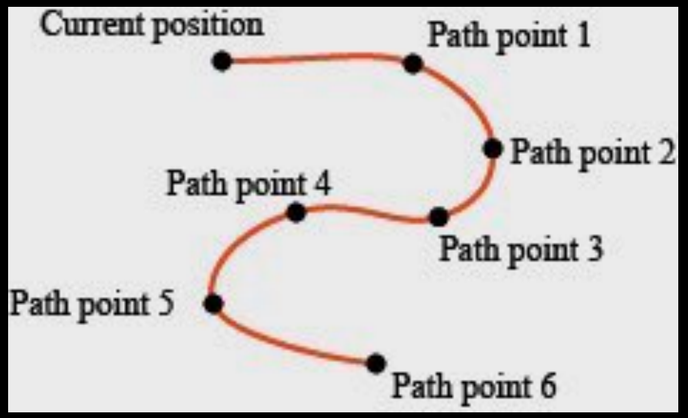

Existing Continuum Robot Models

Machine Learning

Follow the leader Model

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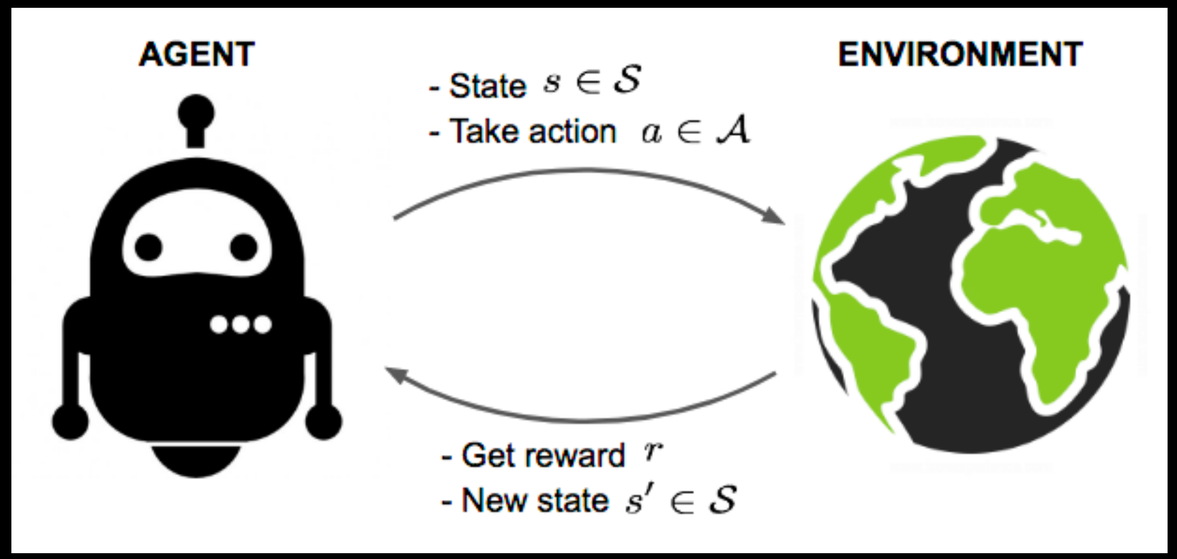
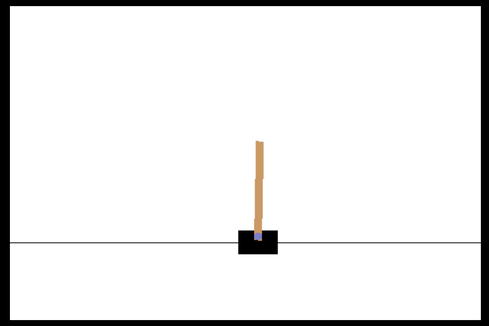
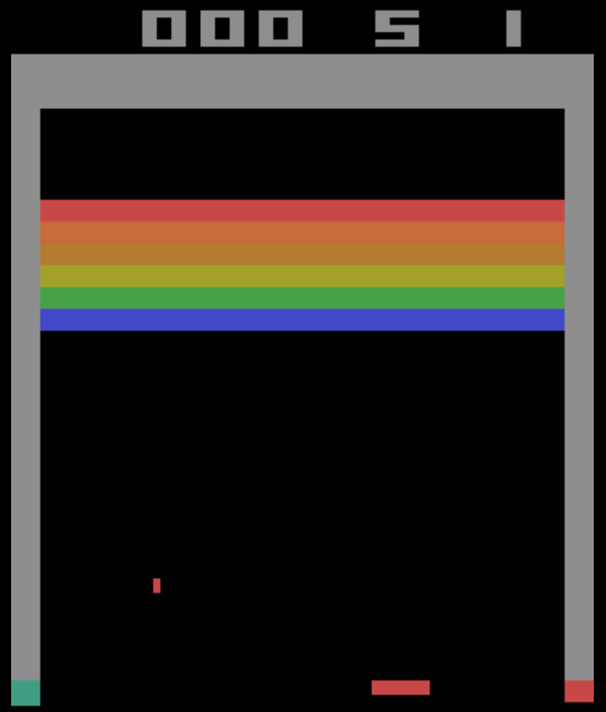
Solution

The Power of Reinforcement Learning (RL)







"What we want is a machine to learn from Experience" - Allan Turing

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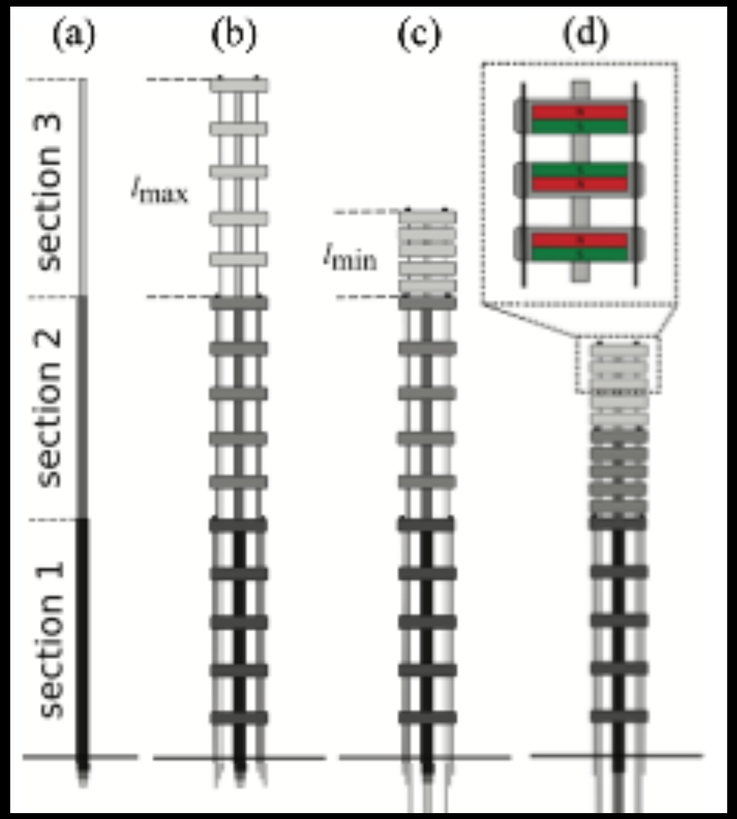
Solution



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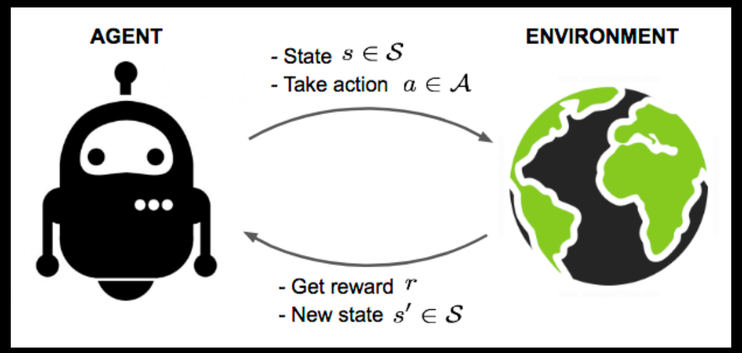

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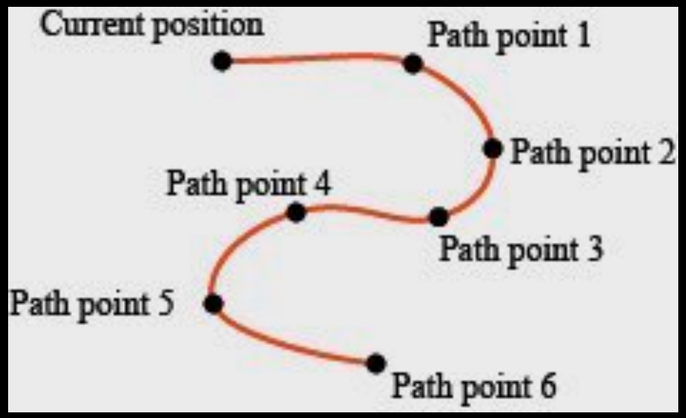

Existing Continuum Robot Models

Reinforcement Learning

Follow the leader Model

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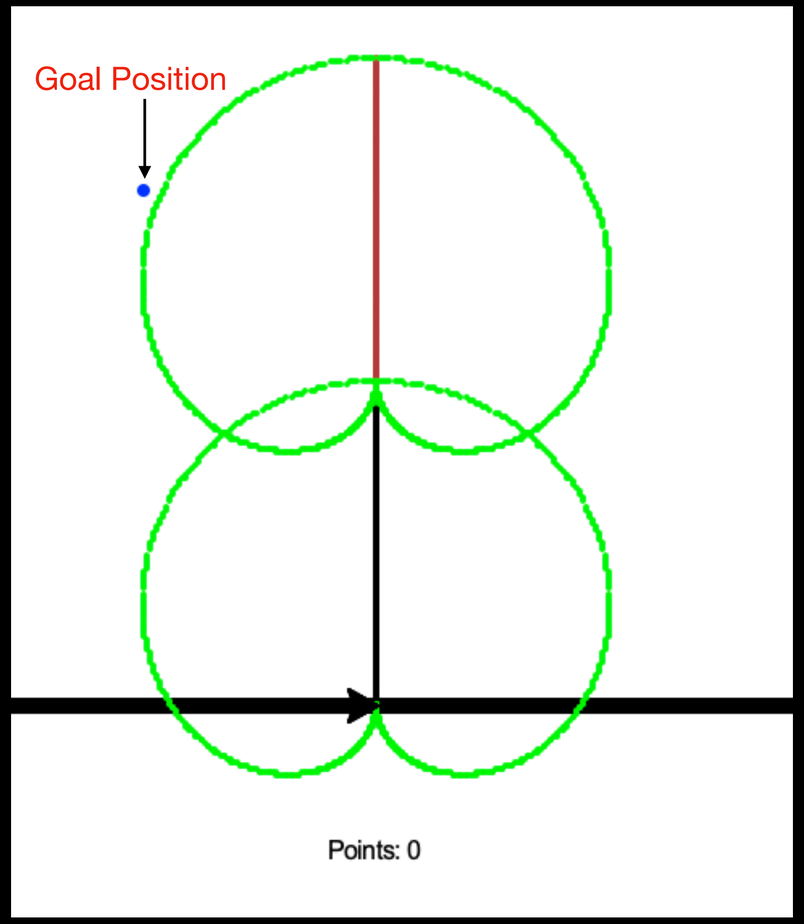
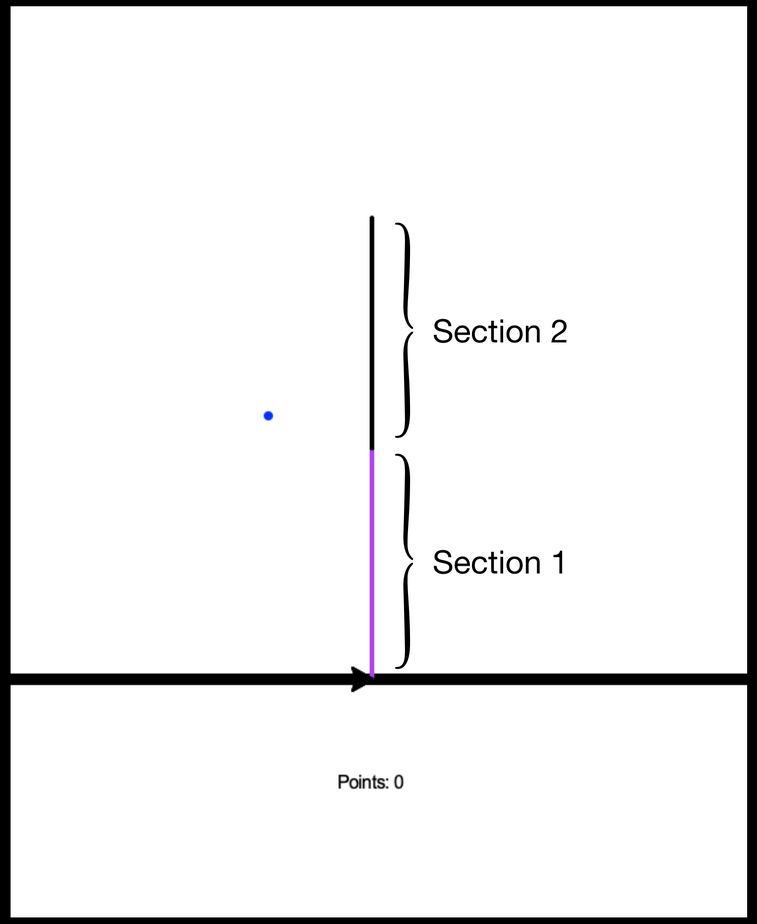
Project Implementation

Simulation

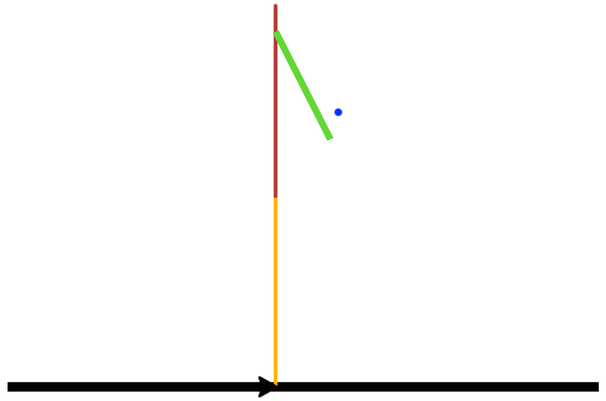
- 2D Dimension
- Dual Sections
- Point Based System
- Constant Curvature
- Actions
  - Left, Right, Extend, Contract





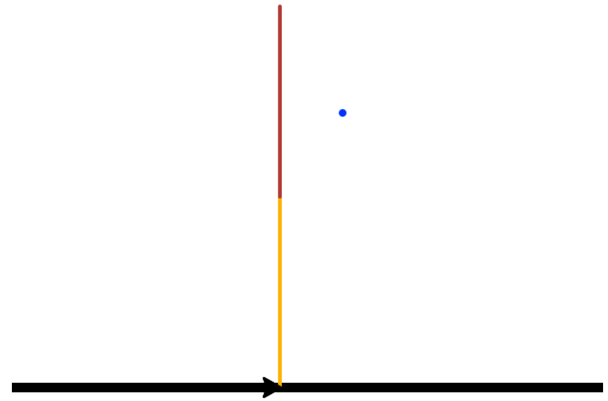
Project Implementation

Reward Policy



Negative distance Reward:

Negative Distance from Tip Position to Goal as the reward for each action



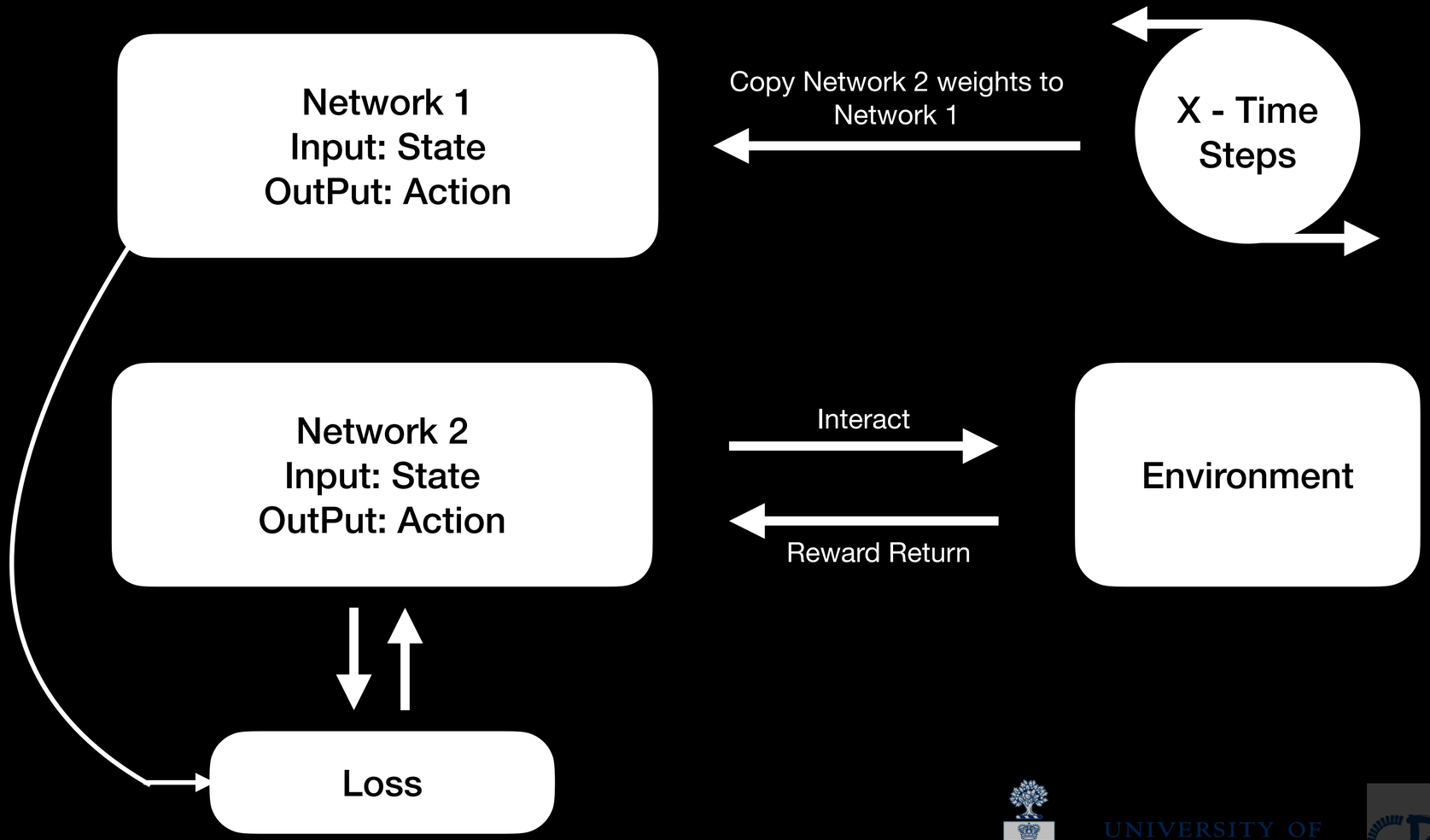
Constant Reward:

Distance Decreased: +1
Distance Increased: -1
Reaching Curvature Limit: -2

Project Implementation

Model 1: Double Deep Q Network (DDQN)

- Future Action Estimation
- Avoids Overestimation
- Replay Buffer



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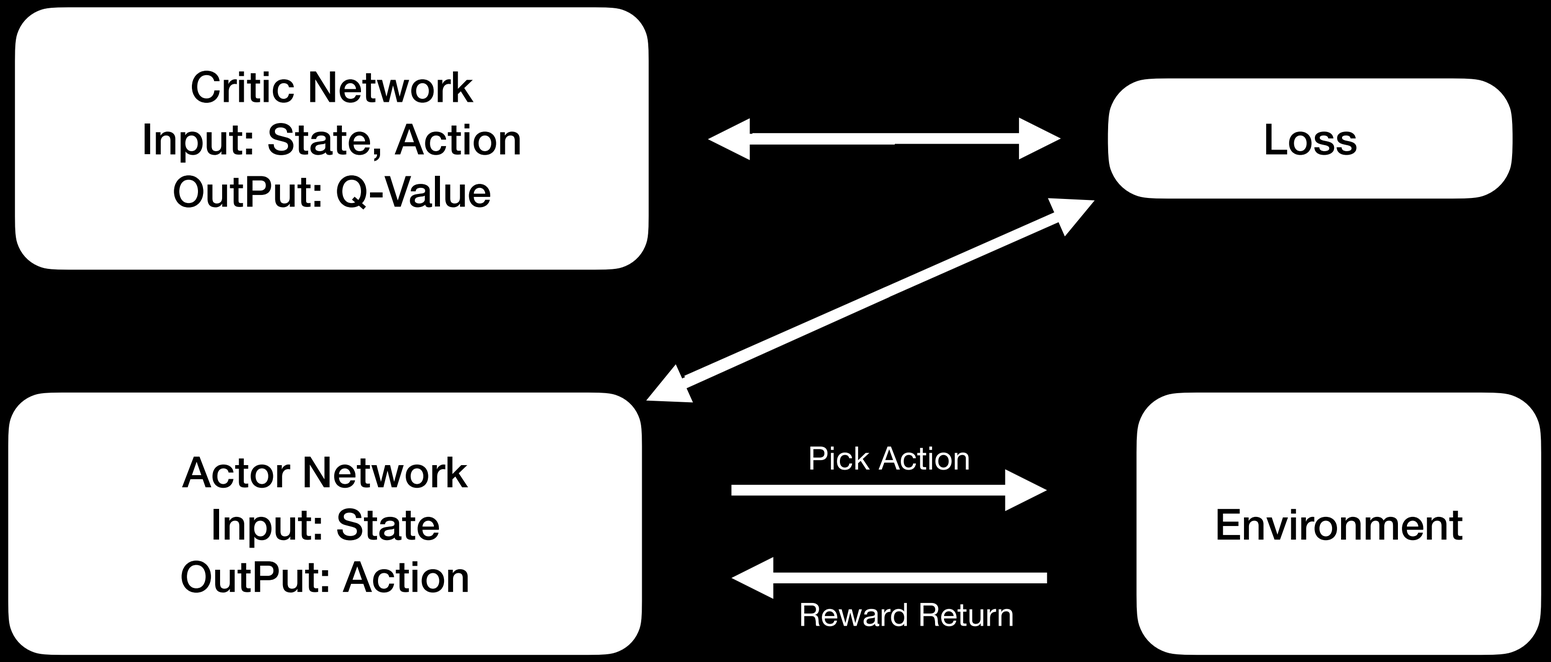
Project Implementation

Model 2: Actor Critic (A2C)

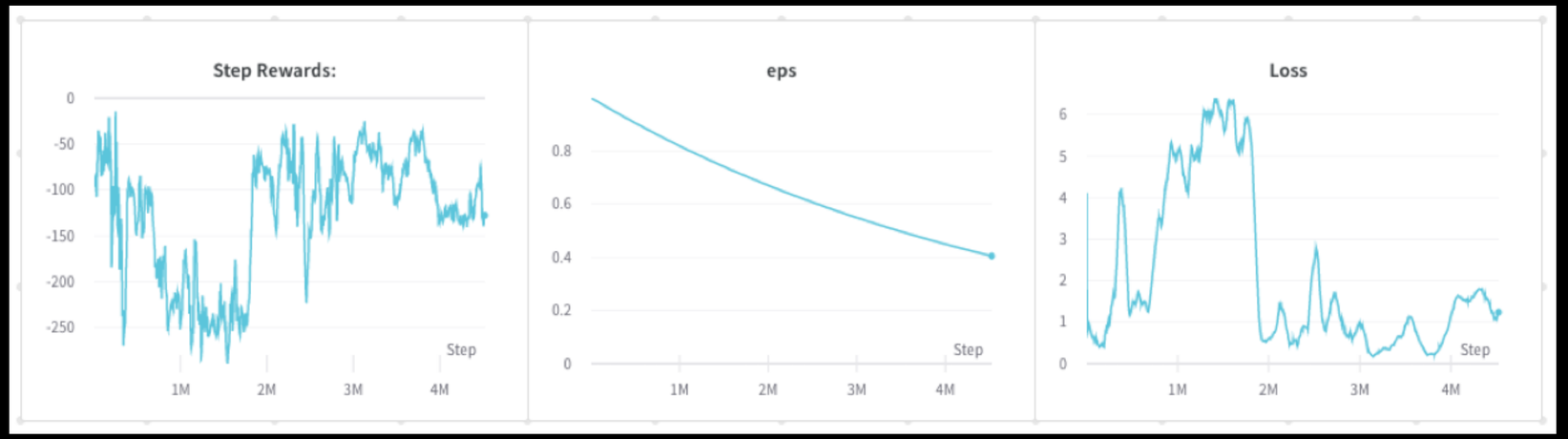
- Continuous Task Efficient
- Action Criticism

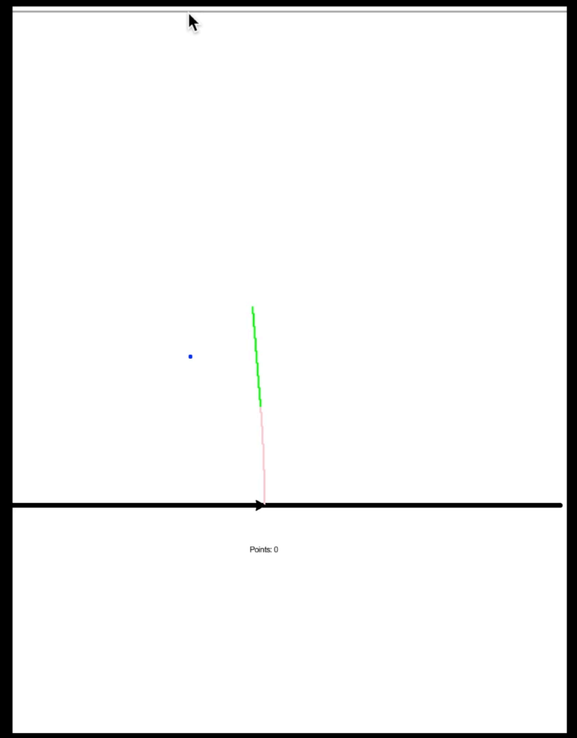


Results

Model 1: DDQN

- Negative Distance as Reward
- 6000 Epoch/Model Updates



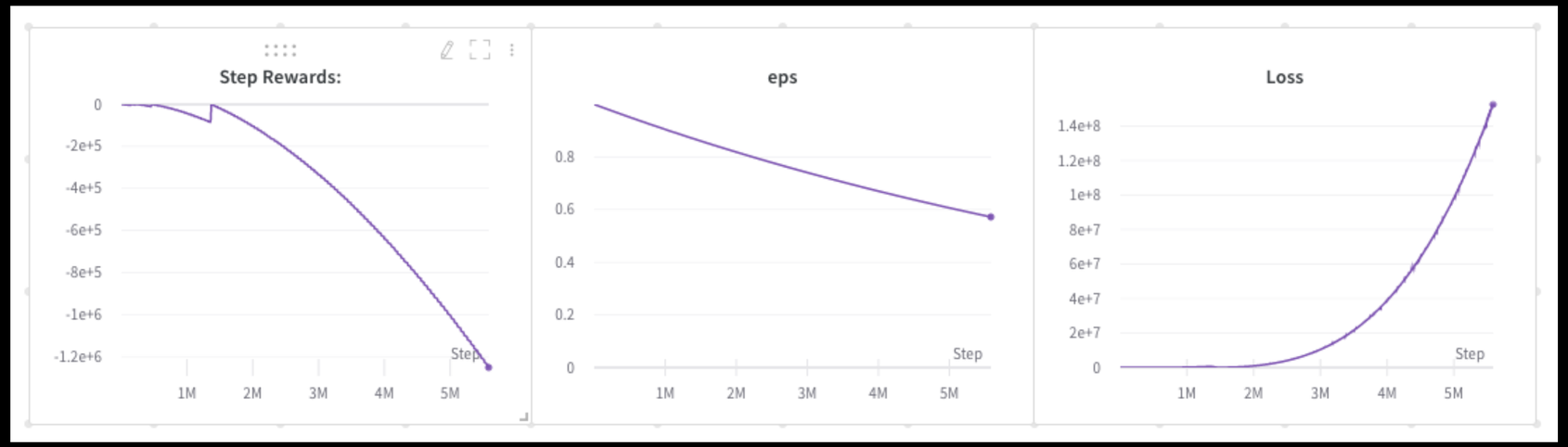


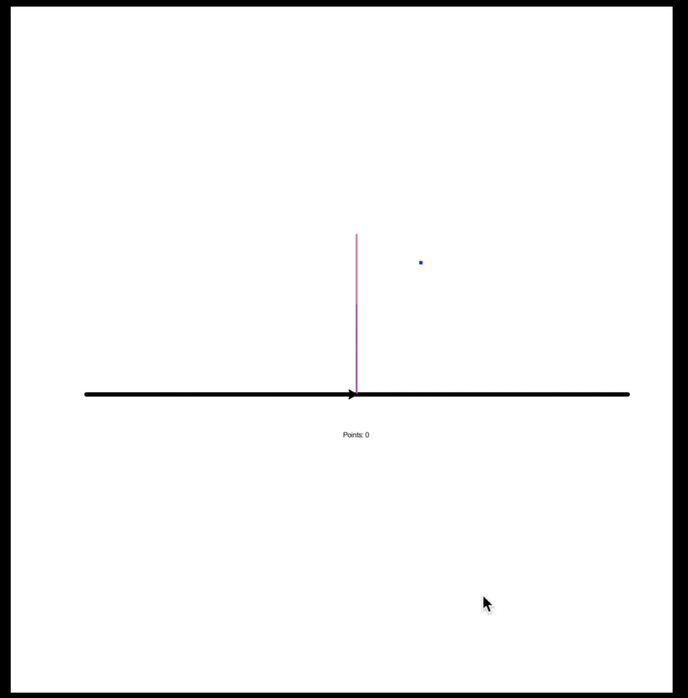
Issue: Taking too long to converge

Results

Model 1: DDQN

- Constant Reward
- 7000 Epoch/Model Updates





Possible Issue: Calculating expected reward too far into the future

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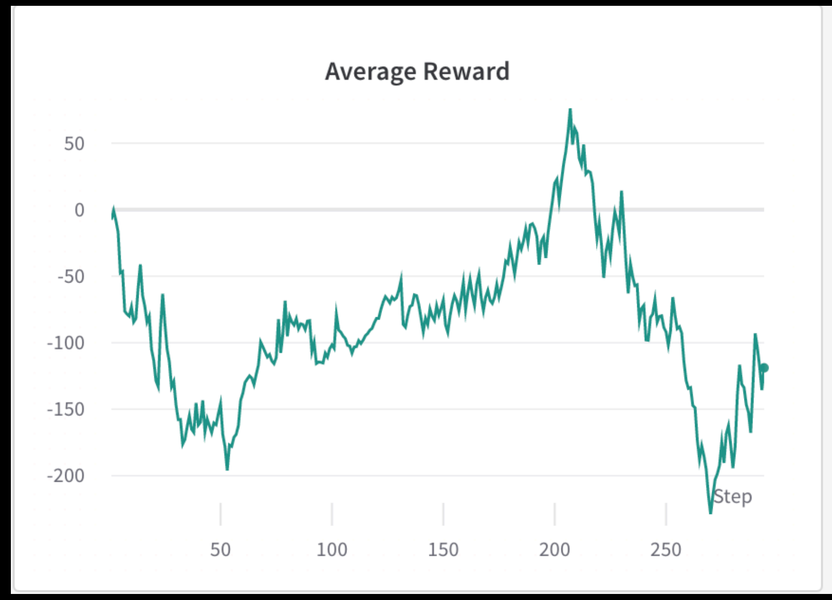
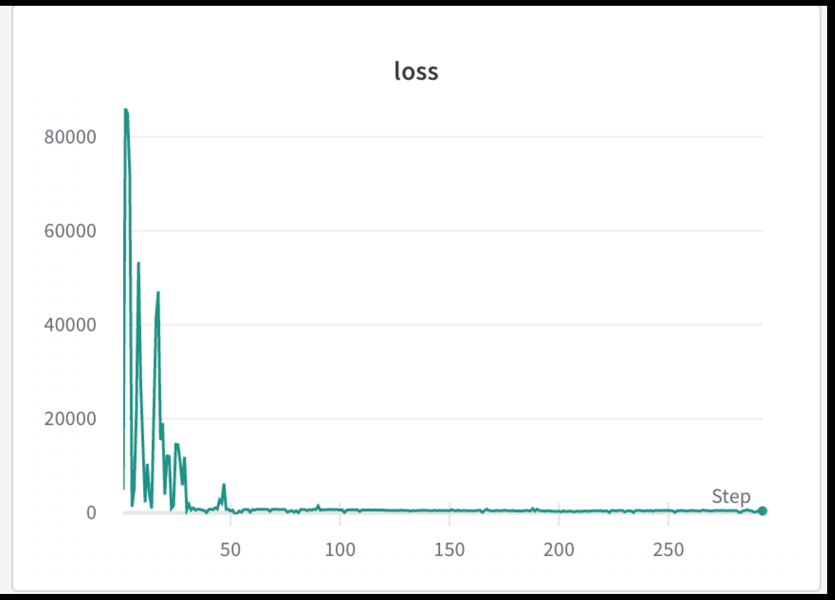
Results

Model 2: Actor Critic

- Constant Reward
- 250 Episodes

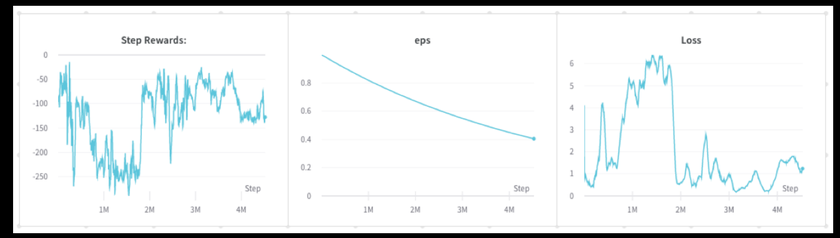


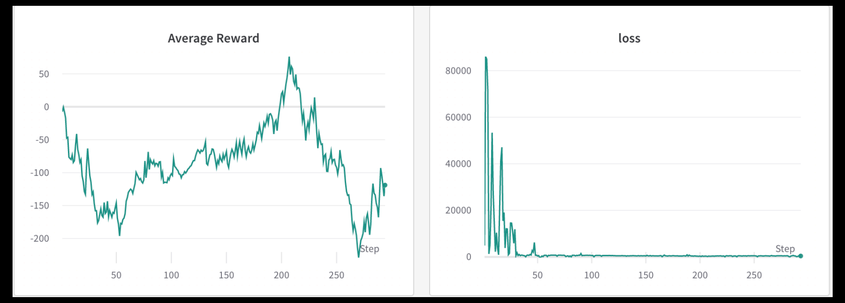


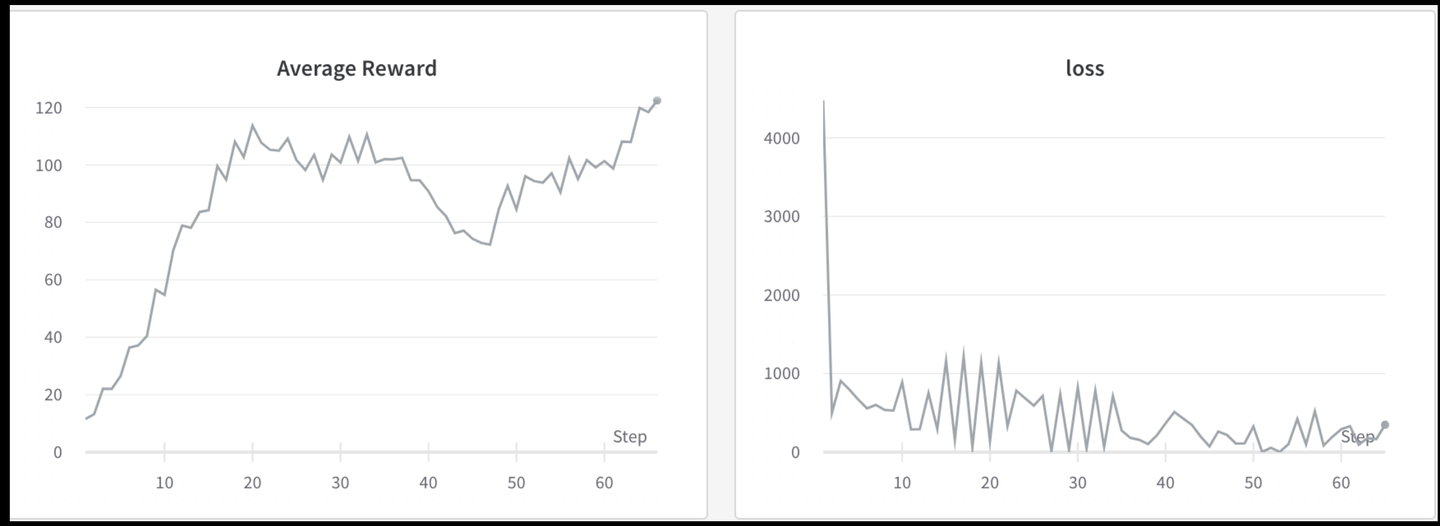
Issue: Numerical Errors

Discussion

- DDQN vs Actor Critic
  - Actor Critic
- Negative Distance vs Constant Reward
  - Constant Reward overall
- NaN Error



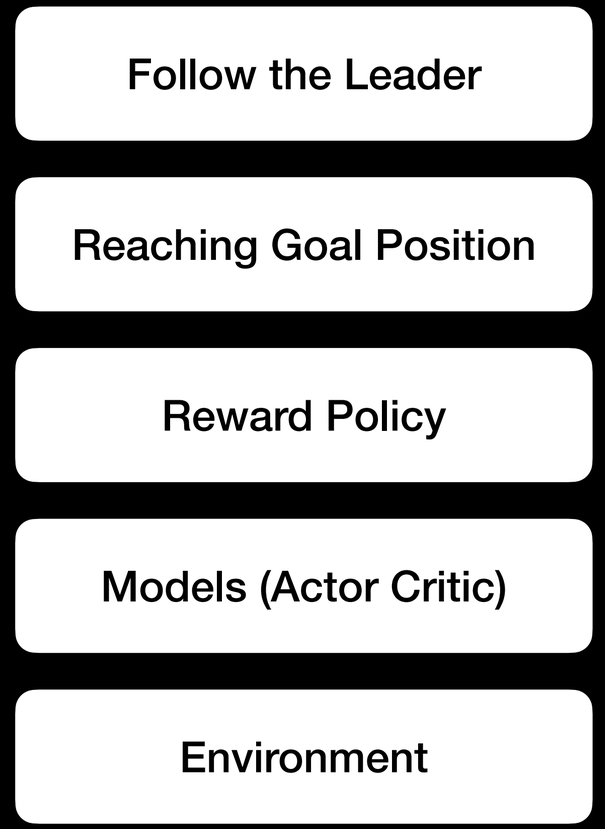




Actor-Critic | Step-Wise Reward System | Normalized Inputs

Conclusion

- Base Foundation is Complete
  - Model Structures and Base Reward Systems
- Sub Goal: Reach a Goal Position from an initial position
- Reward System Modifications

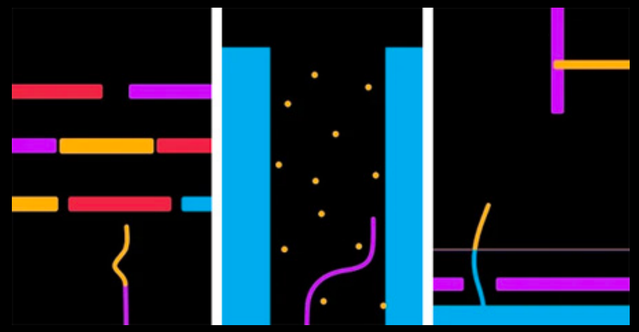


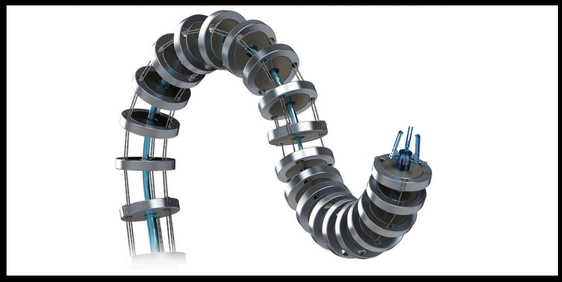
Next Steps

- Resolving NaN issue
- Reward Function Optimization
- Environmental Complexity
- 3D Simulation

DDQN | Negative Distance Reward

DDQN | Constant Reward





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Thank You for Listening

Q/A

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