UNIVERSITY OF LINCOLN

AgriFoRwArdS
EPSRC Centre for Doctoral Training in Agri-Food Robotics

Controller-based Reinforcement Learning in Robotics Manipulation

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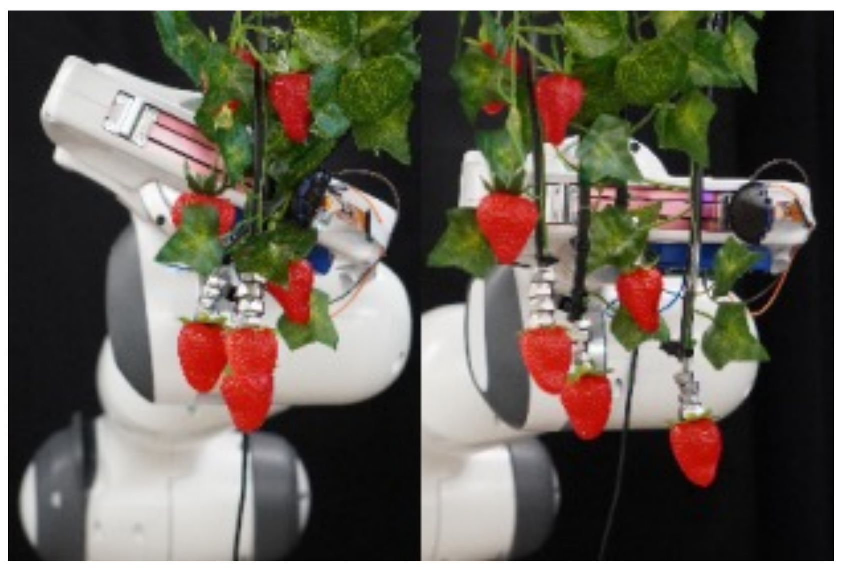
Introduction

- Consumption of soft fruits have increased 71% for the last two decades [1].
- The agricultural industry has faced significant challenges in recent years, including labour shortages stemming from aging workforces, Brexit, and the disruptions caused by Covid-19 pandemic [2].
- Addressing the specific issue of stable manipulation of soft fruits in clustered environments which has been studied in [3,4], this research focuses on the application of controller in Deep Reinforcement Learning (DRL).
- Aim to learn manipulation policies more efficiently in comparison to model-free RL methods. By incorporating an initially pre-tuned controller, we expedite the learning process through the acquisition of a controller first and then the exploration of better policies.
- To illustrate the concept, we address the problem of balancing a 2D inverted pendulum for its relevance as a sub-case of pushing obstructed objects within a clustered environment that requires stable manipulation.



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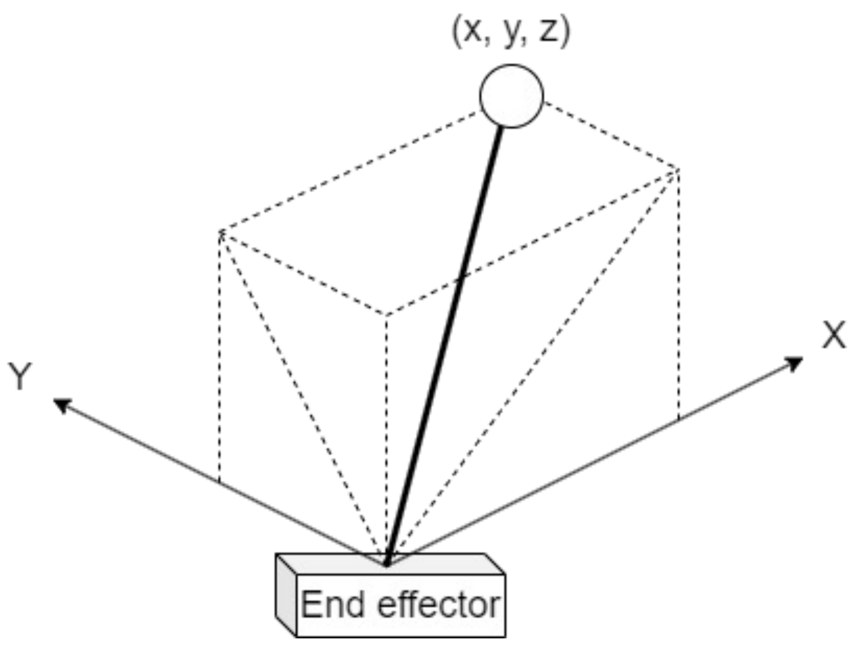


Aim and Objectives

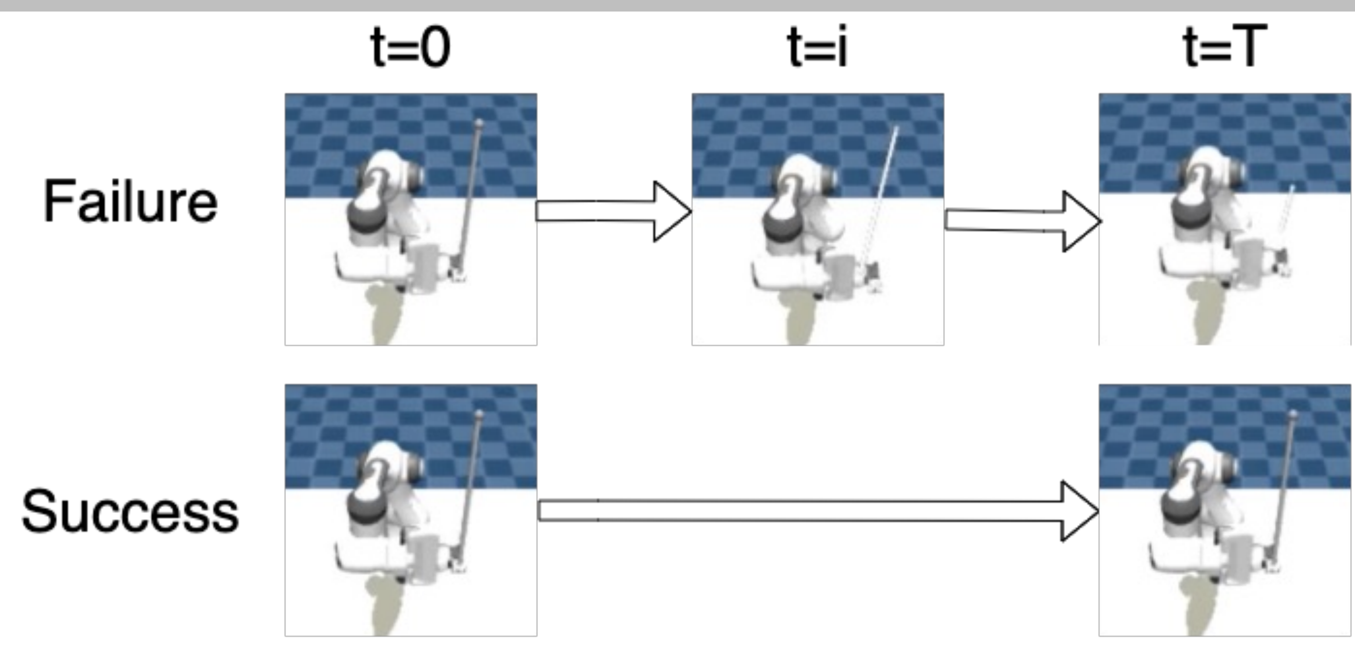
Aim: Inverted Pendulum Balance with controller-based deep RL
To address limitations in model-free RL and model-based control, this study aims to enhance model-free RL efficiency by incorporating task knowledge (pre-tuned controller) in the action selection process.

Objectives:

1. **Custom Gym environment** establishment featuring Franka Emika Panda robot and Xela tactile sensor.
2. **Data collection and neural network design** for generating more realistic Xela tactile sensor reading in simulation.
3. **Controller-based reinforcement learning algorithm design.**
4. **Benchmark and Validation** on controller-based deep RL algorithm. Performance will be compared with model-free RL and traditional controllers.

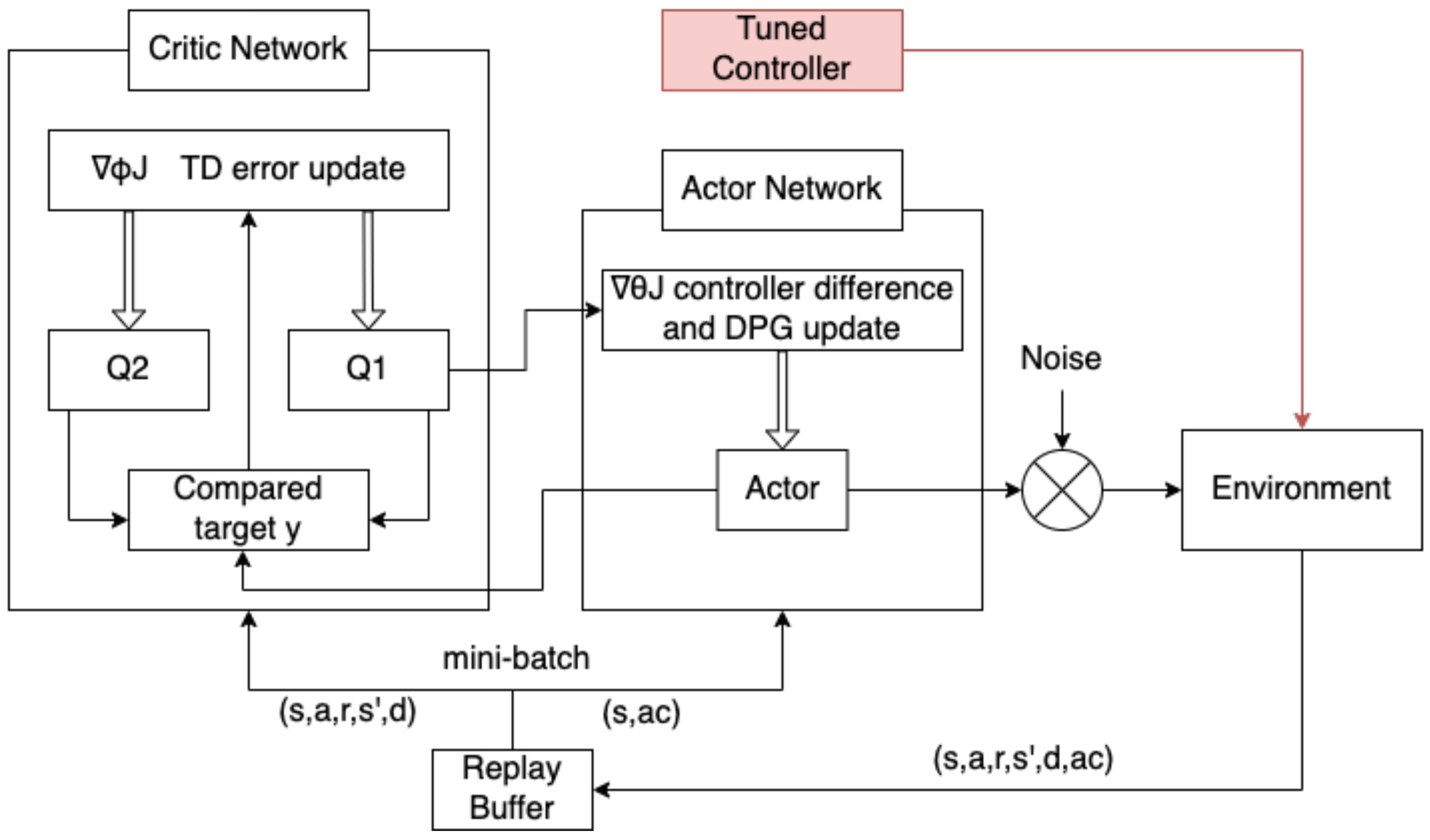
Summary

Using controller-based Reinforcement Learning methods, we tackle the complex and nonlinear control problem in robotic strawberry harvesting where strawberries are in a cluster. To address this issue, we solve a similar problem from the control field: balancing a 2D inverted pendulum. Our approach involves developing a simulation of the problem in Mujoco and designing a deep RL algorithm combined with a controller to expedite the learning process.



Controller-based Reinforcement Learning

A modified TD3 algorithm is designed to enable learning from both controller and experience collected through interacting with the environment.



Outlook

- Faster policy improvement using a given controller is expected at the beginning stage of the learning.
- Additional learning from experience should be stable, i.e., does not cause large sudden shift in policy and expected reward evaluation.
- Improvement of the method for efficient deployment in real-world.

References

[1] Department for Environment, Food & Rural Affairs (2023).
[2] John Pelham, Andersons Midlands (2017).
[3] Elijah Almanzor, University of Lincoln (2021).
[4] Kiyanoush Nazari *et al.,* IROS2023(2008).

Acknowledgement

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