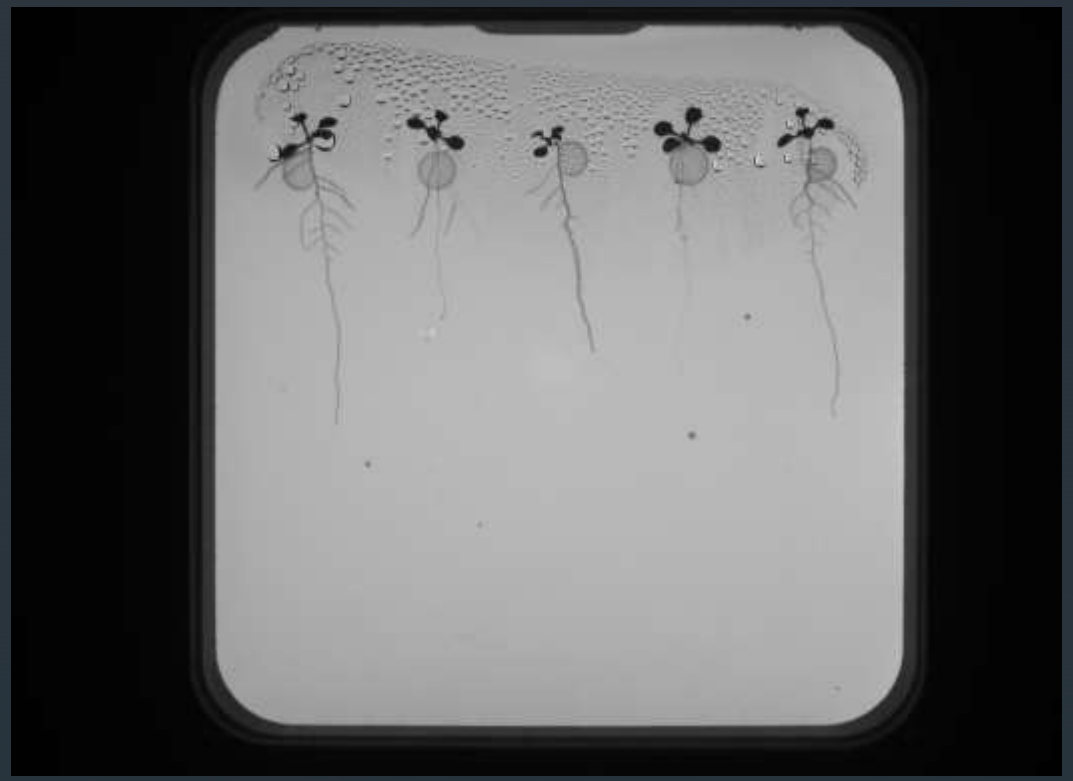
Computer Vision and Robotics

Presenter: Vladislav Stoimenov, 235030

Problem Definition

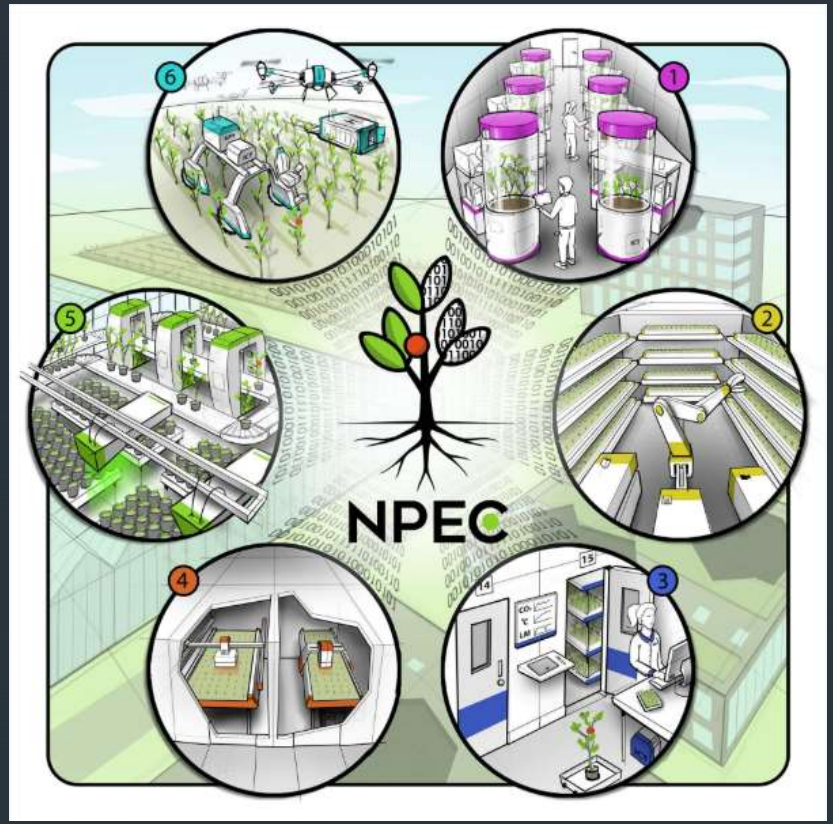
‘Arabidopsis thaliana’ grown in Petri dish



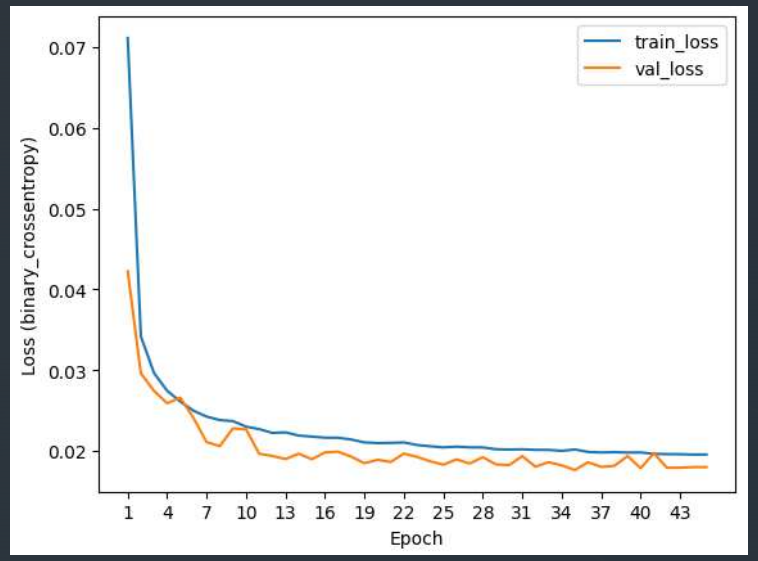
- Challenges
  - Challenge in automating the segmentation of plant roots from high-resolution images and controlling a liquid handling robot to inoculate plants in precise locations
  - Automate root segmentation and precision inoculation in the NPEC Hades system for efficient plant-microbe interaction studies.

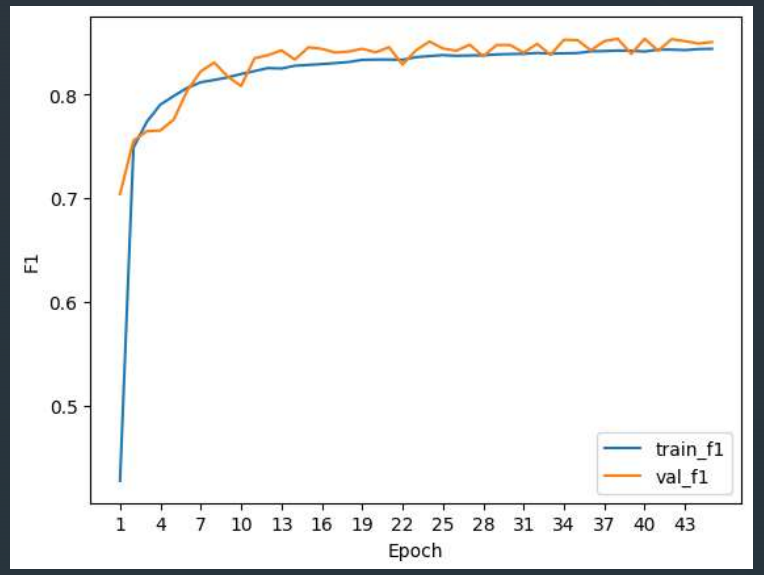
Overview

- Netherlands Plant Eco-Phenotyping Centre
- Implemented whole cv and robotics pipeline to inoculate the tip of the plants
- Reduce time & costs
- Automate the process of inoculating the plants



Results and Evaluation



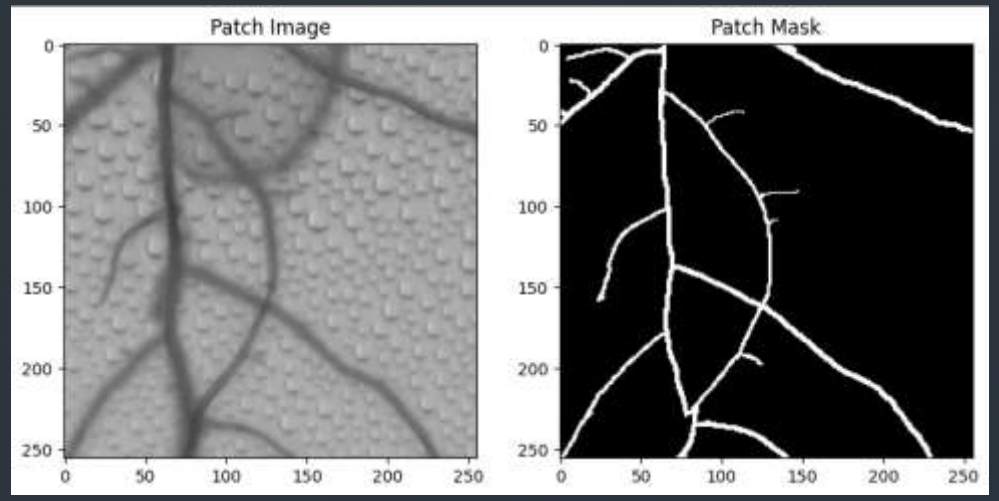


- Both Y23 and Y24 datasets
- Patch_size = 256
- Simple U-Net model
- Model best val_f1 = 0.853
- Model best val_loss = 0.0176

```
Best validation loss: 0.017617942765355 11
Best validation f1: 0.8537212610244751
```

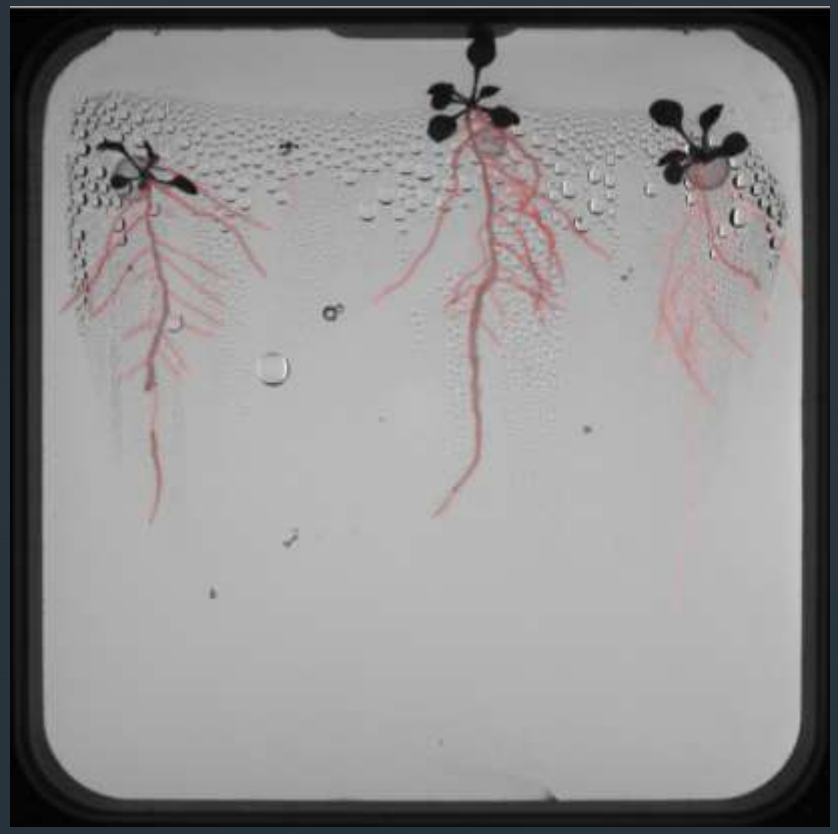
Results and Evaluation

Patch Image and Mask



Task 5 Test Mask

Overlay of the Test Mask

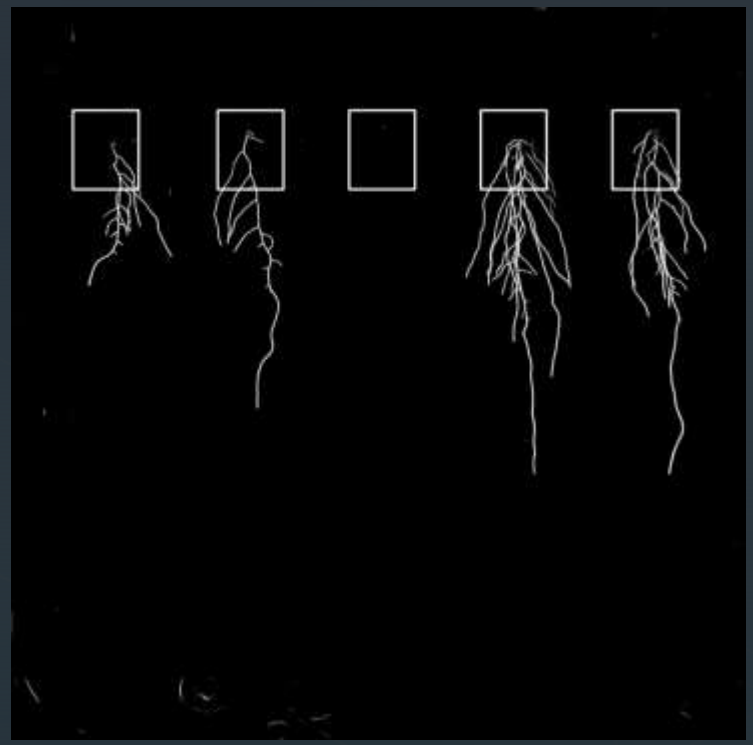


Best Iteration

- Patching the Dataset
- Filtering
- Training
- Inference
- Individual Plant Segmentation
- Main Root Extraction

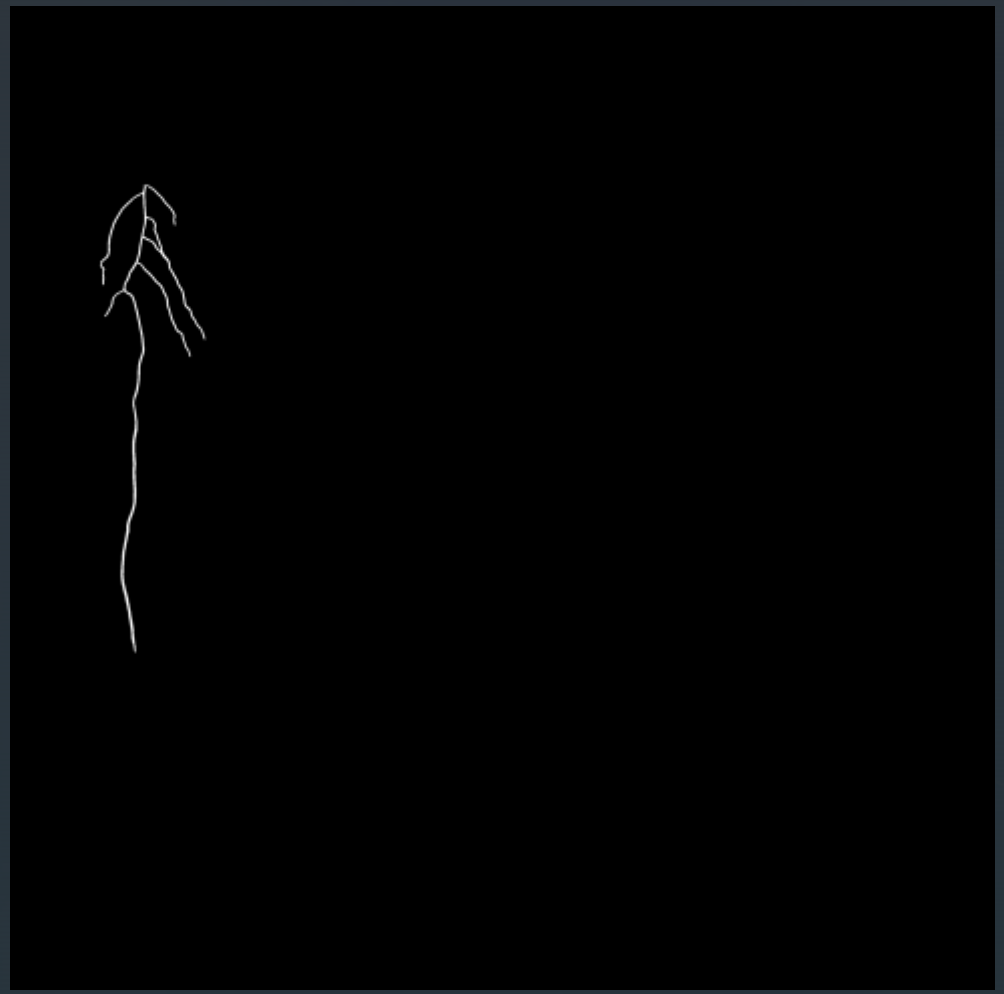
Private SMAPe Score: 8.539

Plant Segmentation Method



Best Iteration

Individual Plant Segmented



Main Root Length Measure

Error Analysis and Iteration

- Removing masks containing only black pixels, leading to better model performance
- Improve the segmentation of the individual plants
- Measure the main root length by getting the distance between the first and the last node of the skeleton

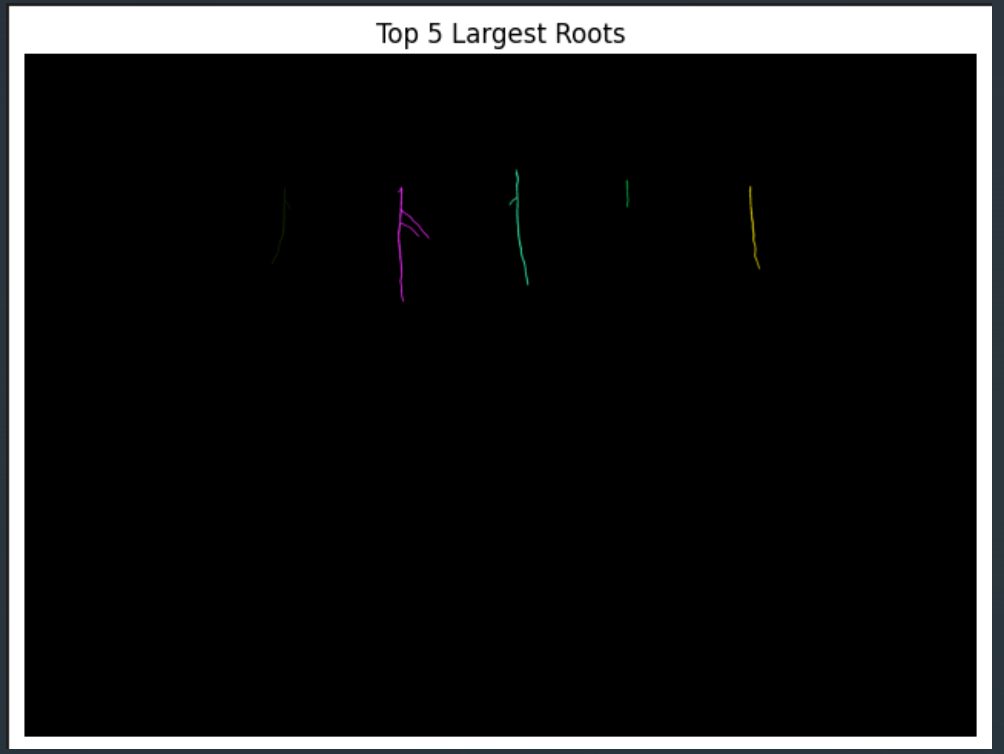


Image 18, Plant 4

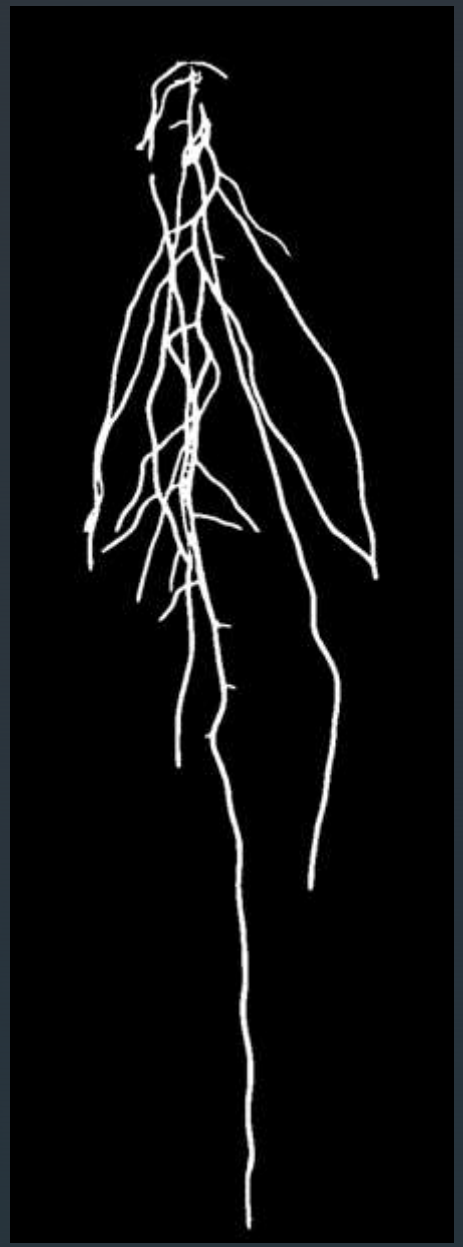
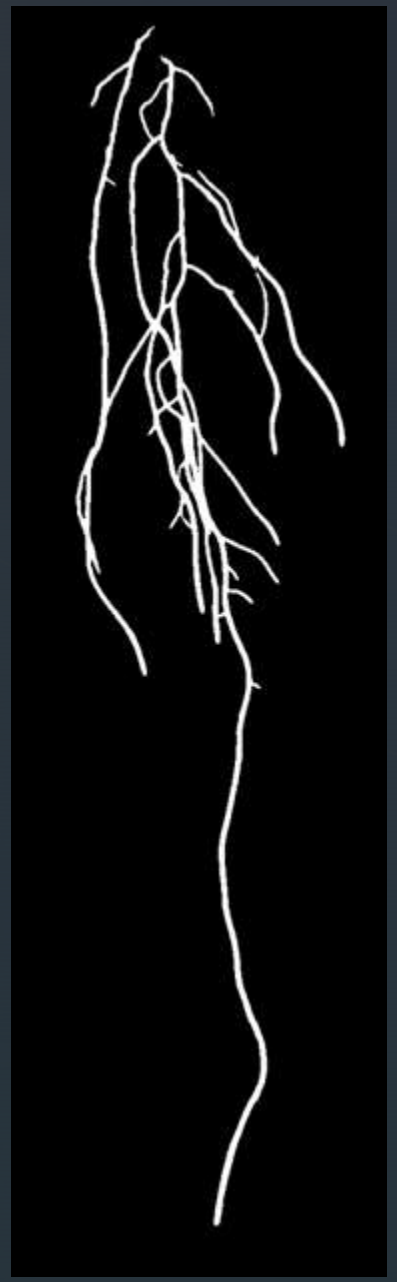
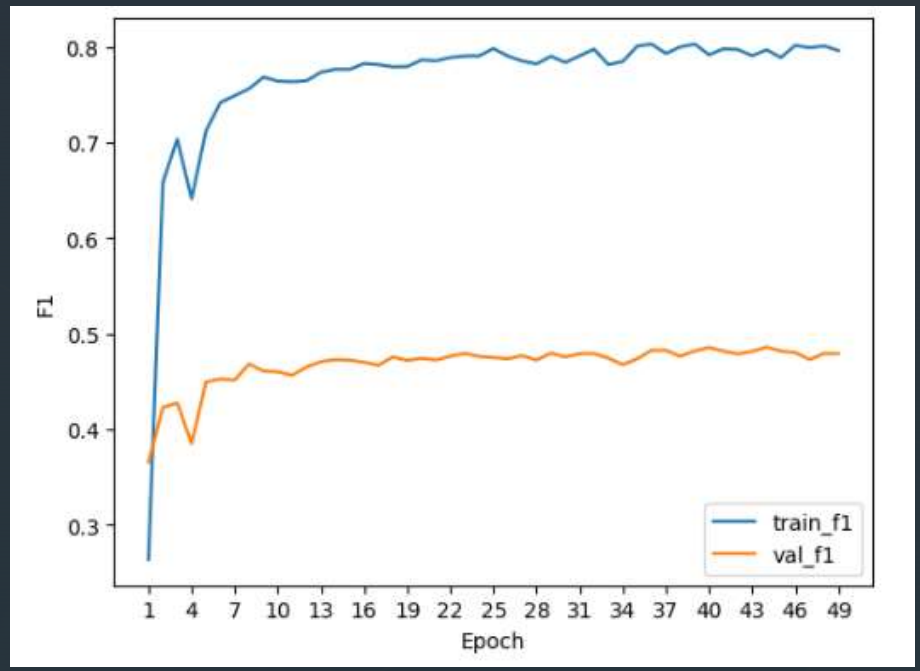


Image 18, Plant 5



Iteration 1 (val_f1 = 0.48)



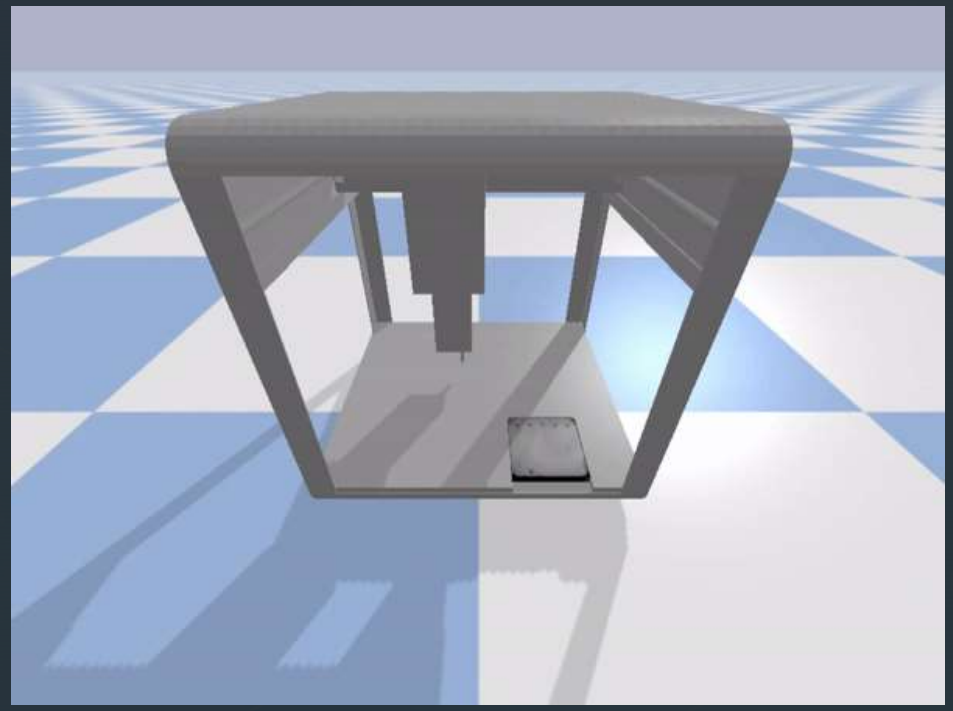
Reinforcement Learning

RL Implementation

- 3 models for different rollout steps – 2048, 4096, 8192
- Threshold – 0.001m (1mm)

- Pipette Working Envelope:
  - X-axis : [-0.187; 0.253]
  - Y-axis : [-0.1705; 0.2199]
  - Z-axis : [0.1196; 0.2905]

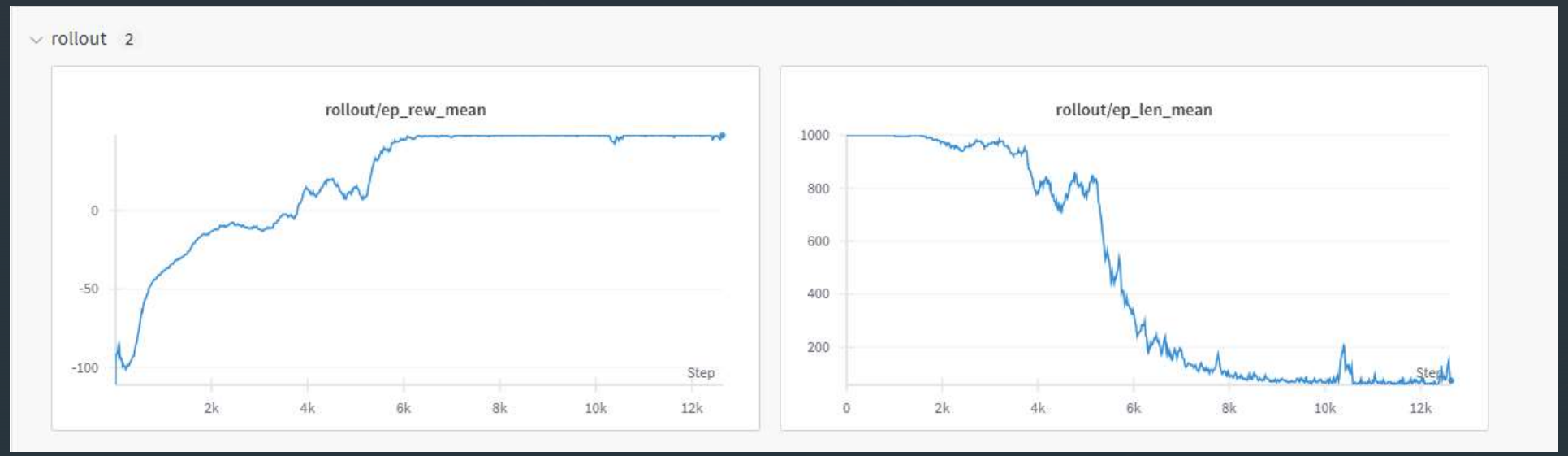
Moving the pipette to all 8 corners



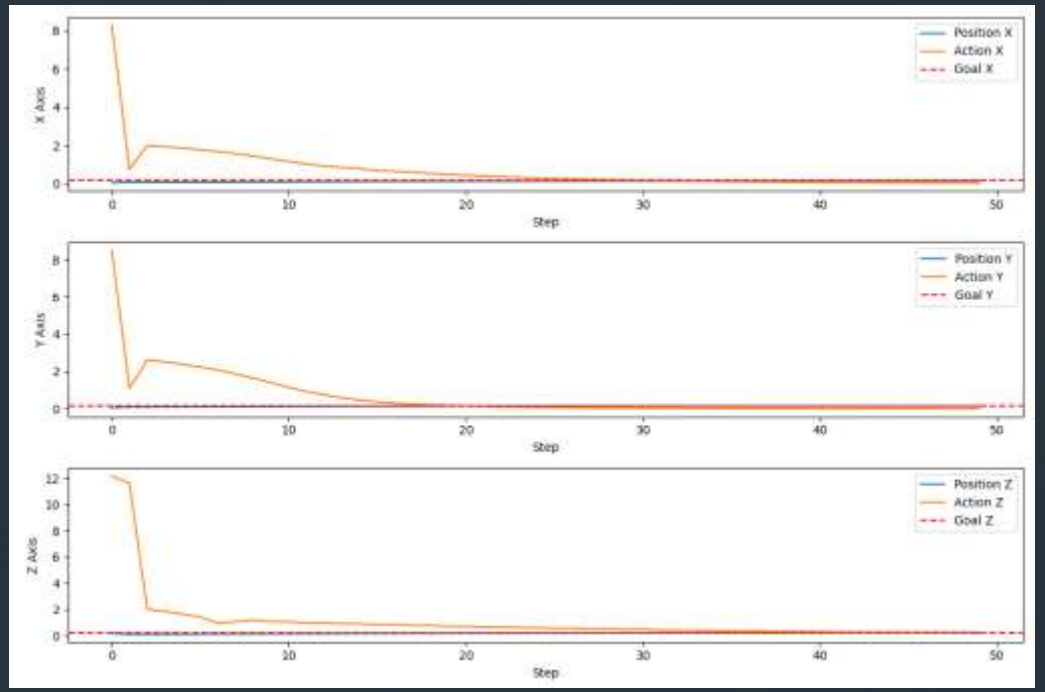
RL Implementation

Model Performance

- Best model – 4096 Rollout Steps
- Group best hyper parameters
  - Learning_rate = 0.0001;
  - Discount_factor=0.99;
  - Rollout_steps = 4096



Implemented PID Controller

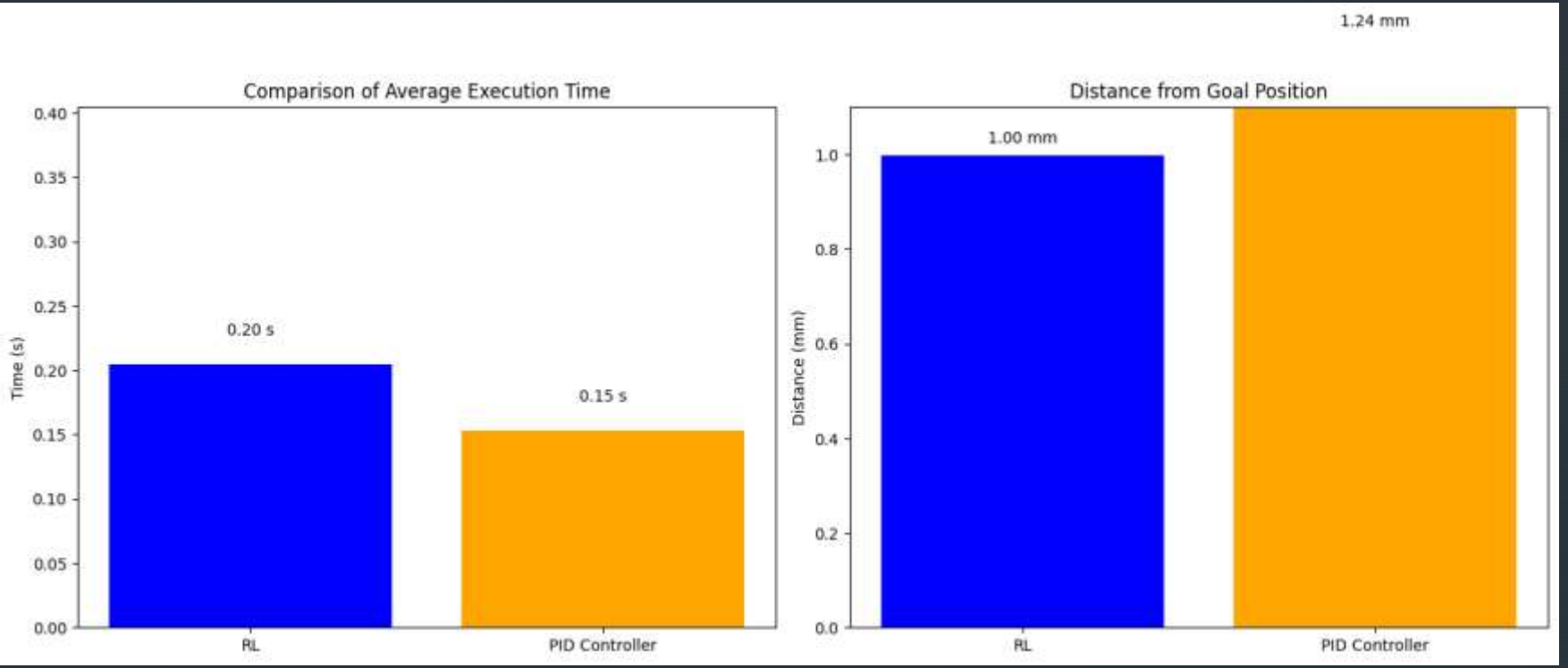


PID Controller

- PID Gains for the x, y, z axes
  - X = 27, 0.5, 2.8
  - Y = 45, 0.1, 2
  - Z = 18, 2.8, 7.8
- Overshooting the goal position

Benchmarking

- Comparison between the average speed and distance to the goal position for both RL and Controller
- Average speed: RL – 0.21, PID – 0.16
- Average Distance From Goal Position: RL – 1mm, PID – 1.24mm



Next Steps for Improvement

- Train better model and RL
- Improve image pre-processing
- Experiment with different strategies of measuring the main root length
- Optimize the gains of the PID Controller
- Combine all steps of the pipeline in one code

Thank you!

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