# Harnessing Plant Phenotyping for a Sustainable Future

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Project for NPEC

Problem Definition

- Increasing global demand for food and materials due to population growth and economic development.

- Sustainable approaches while boosting efficiency

- Lack of scalable methods to assess plant performance under varying environmental conditions.

- Necessity for advanced tools and techniques to bridge the gap between plant research and sustainable agricultural solutions.
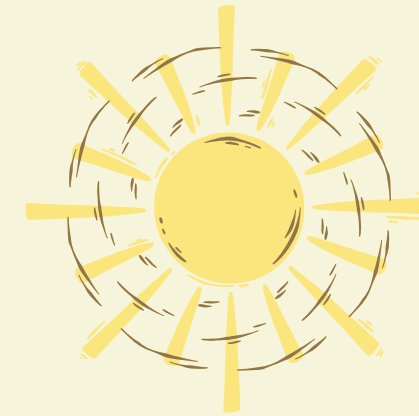
Overview of solution

- Automatic root architecture detection with ResNet

- Data Processing Pipeline for primary root measurement

- Reinforcement Learning for the inoculation of the root tips.
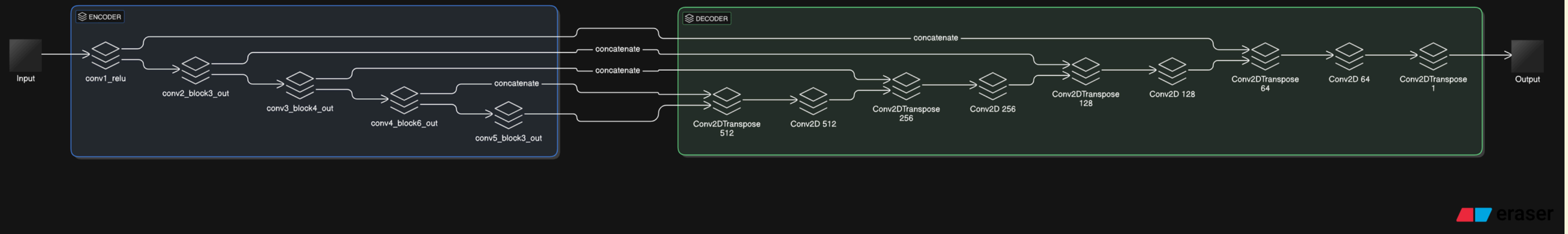
How??

- Precise root architecture analysis

- Minimized human error during root annotation process

- Support for Sustainable Agriculture Goals

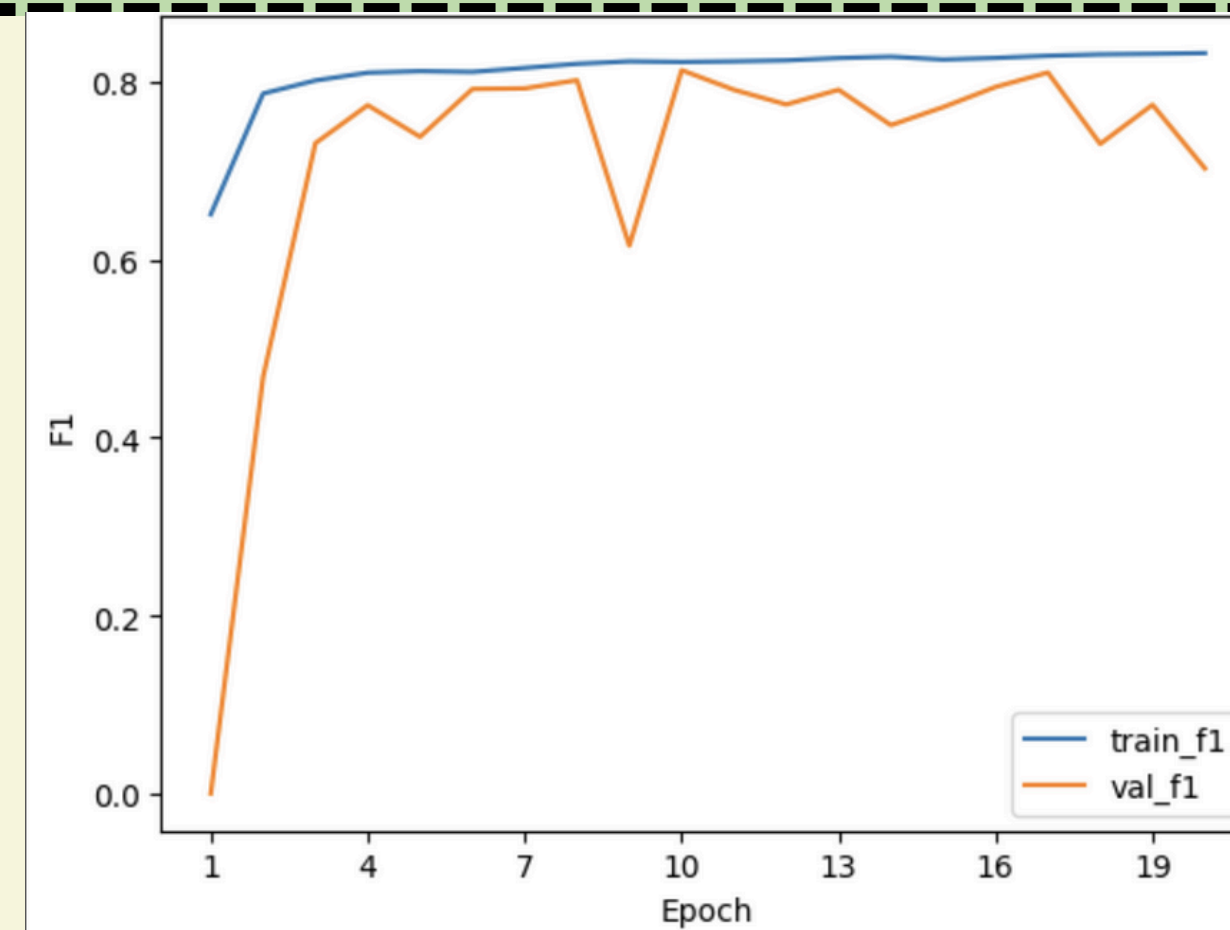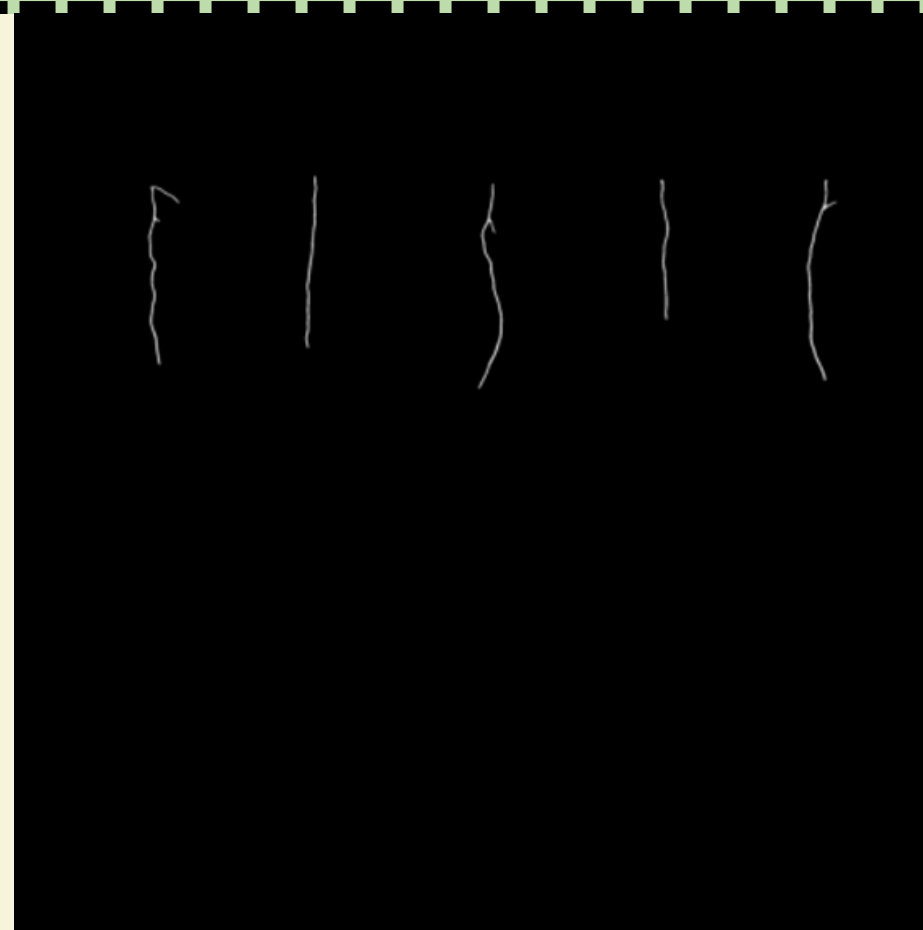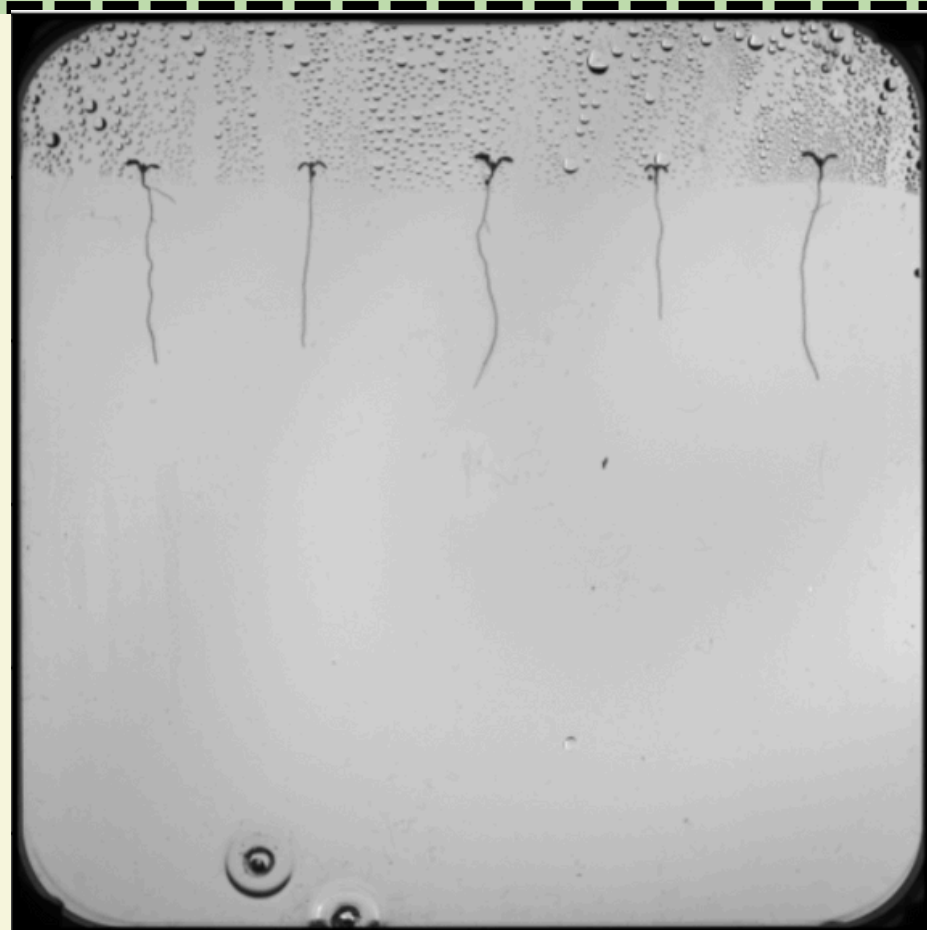- Integration of state-of-art technologies in plant science
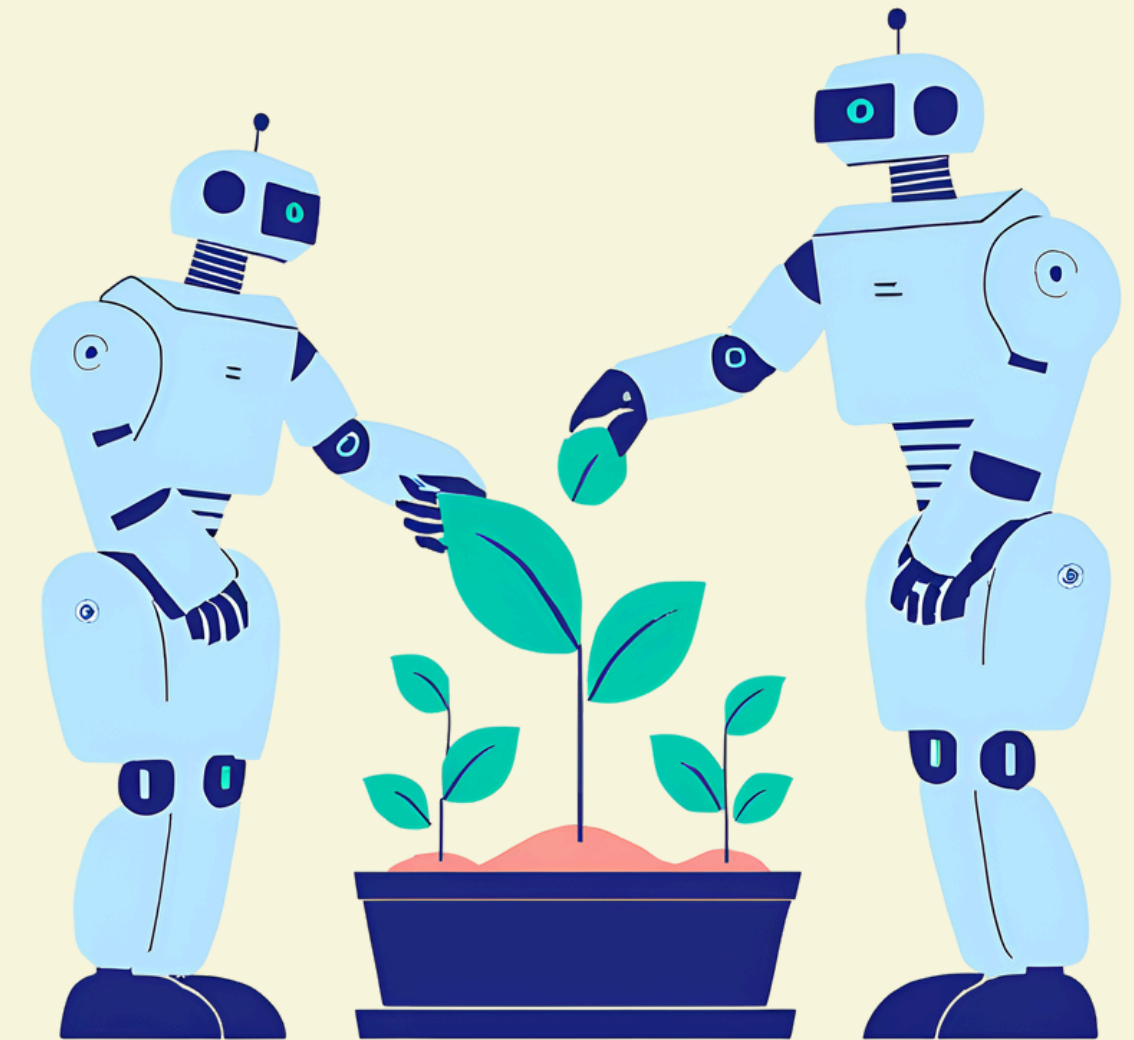
ResNet architecture

- ResNet50 base model (with ImageNet weights)

- Trained on 407 images (high quality 7066 patches) + data augmentation

- Residual Blocks

- Adam optimizer

ResNet50 architecture

Best validation f1: 0.813
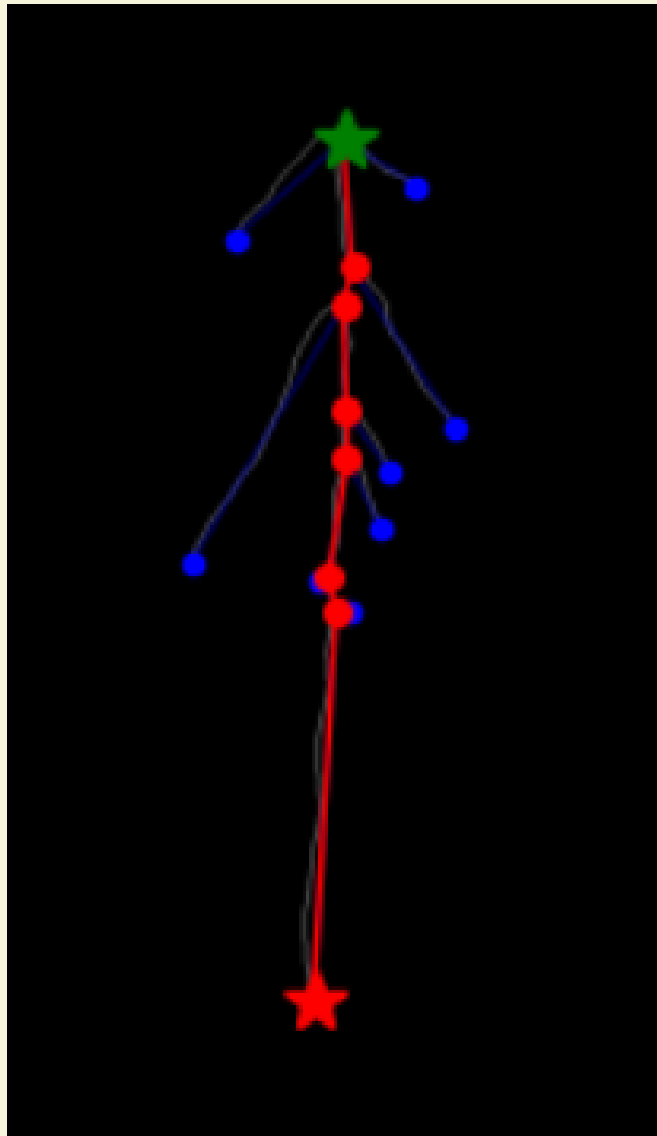
SMAPE score public: 3.484

Best validation loss: 0.027

SMAPE score private: 11.982

ResNet50 architecture

Example of calculating the primary root length

Green Star = start of primary root

Red Star = end of primary root

Red Dot = start lateral root

Blue Dot = end lateral root

PID Controller

Example of the PID controller

PID Controller:
- Limited adaptability
- Not suitable for complex scenarios
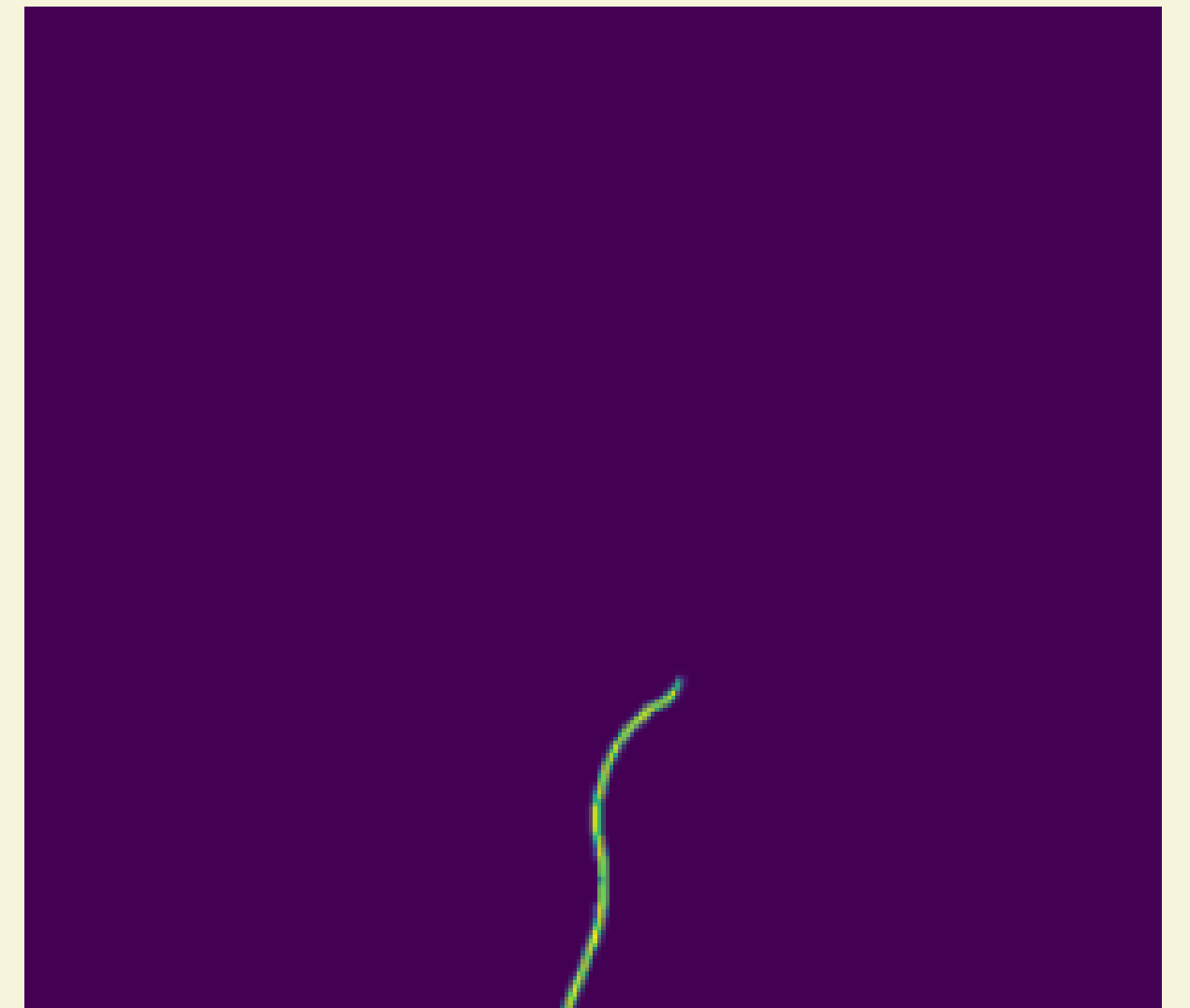- Suboptimal long-term performances

Reinforcement Learning:
- Can adapt to different scenarios
- Scalability
- Optimal for long-term performances
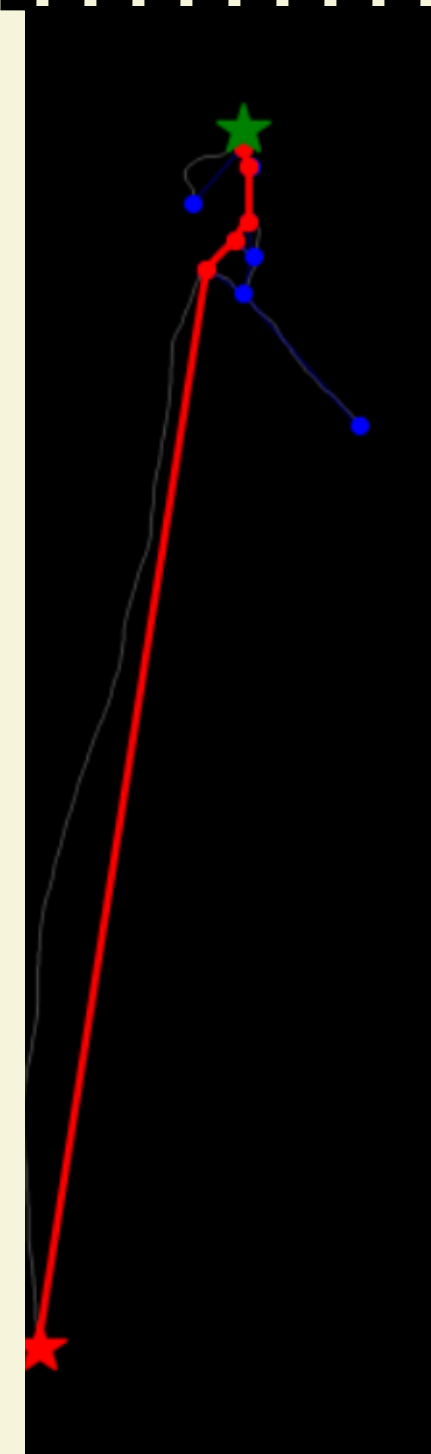
Error Analysis and Iteration

Iteration 4:

- Private SMAPE: 73.584
- Public SMAPE: 49.230
- Incorrect root measurement
- Minimal postprocessing
- Ungerminated root detection

Error Analysis and Iteration

Iteration 10:

- Private SMAPE: 18.469
- Public SMAPE: 4.100
- Changed logic for largest component (with biggest height)
- Automatic plant segmentation
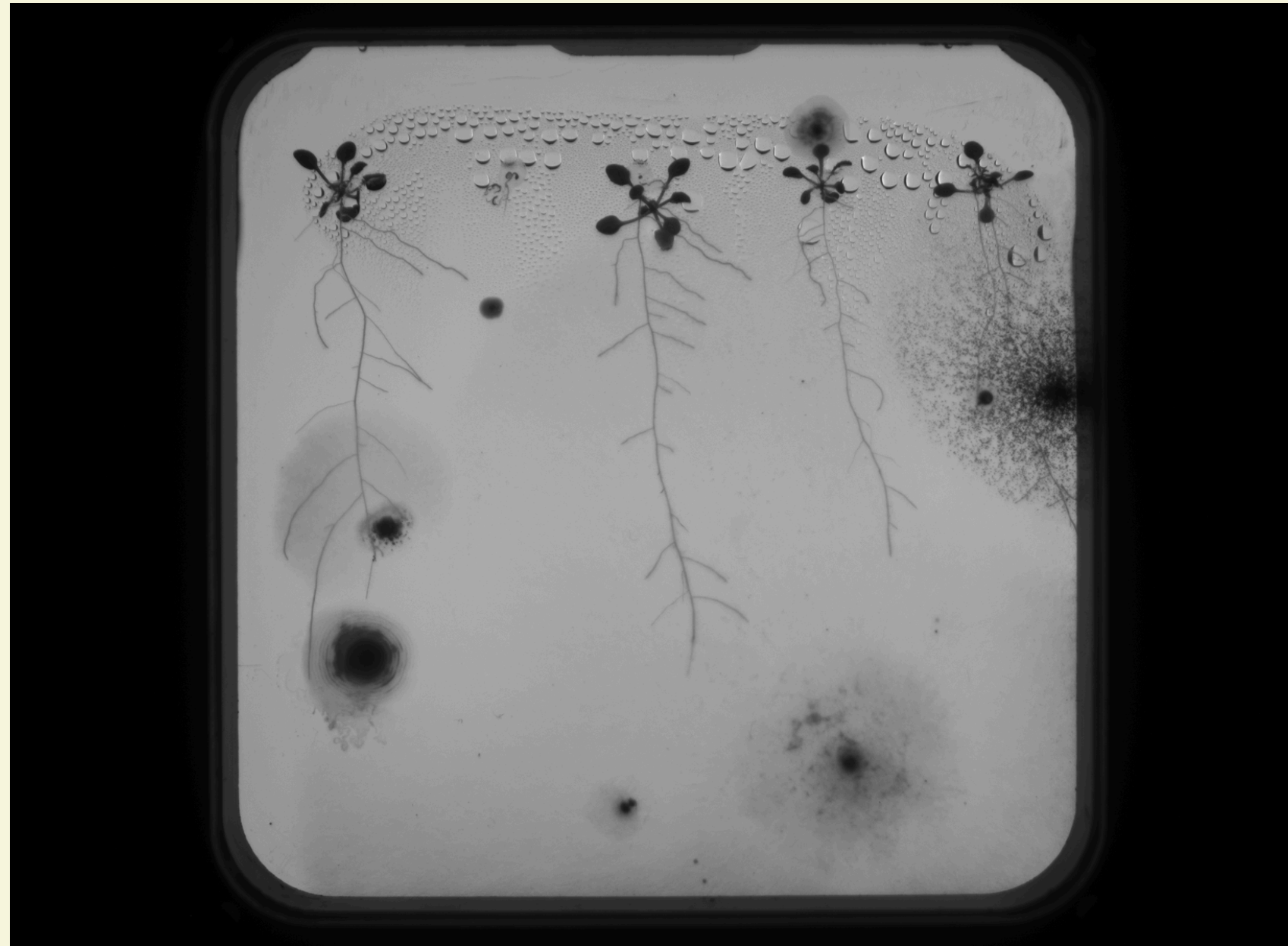- Correct measurement of the primary root

Error Analysis and Iteration

Iteration 17:

- Private SMAPE: 11.982
- Public SMAPE: 3.484
- Removing noise in postprocessing
- Changed threshold for obtaining the hard to classify roots
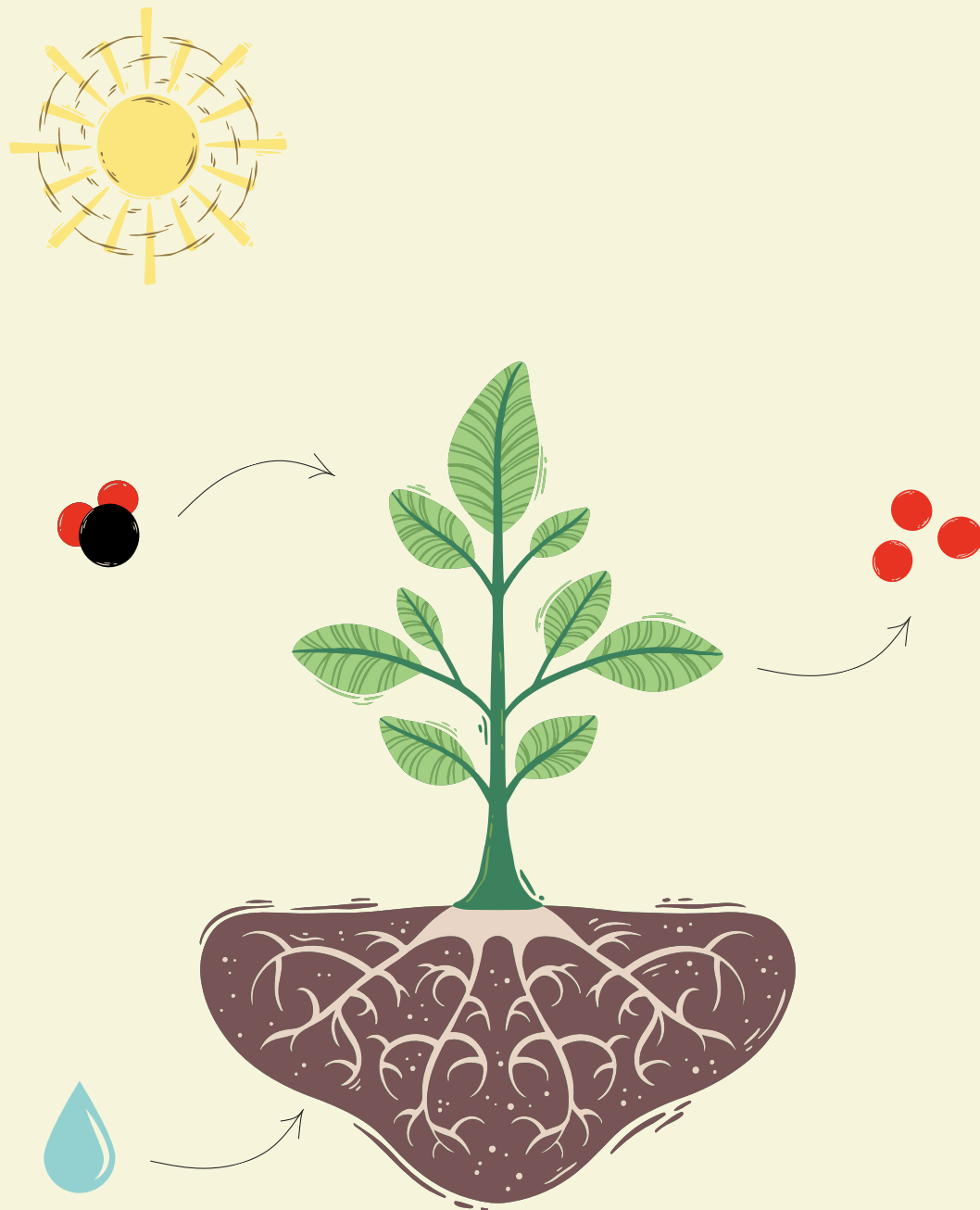- Comparing the largest component based on verticality
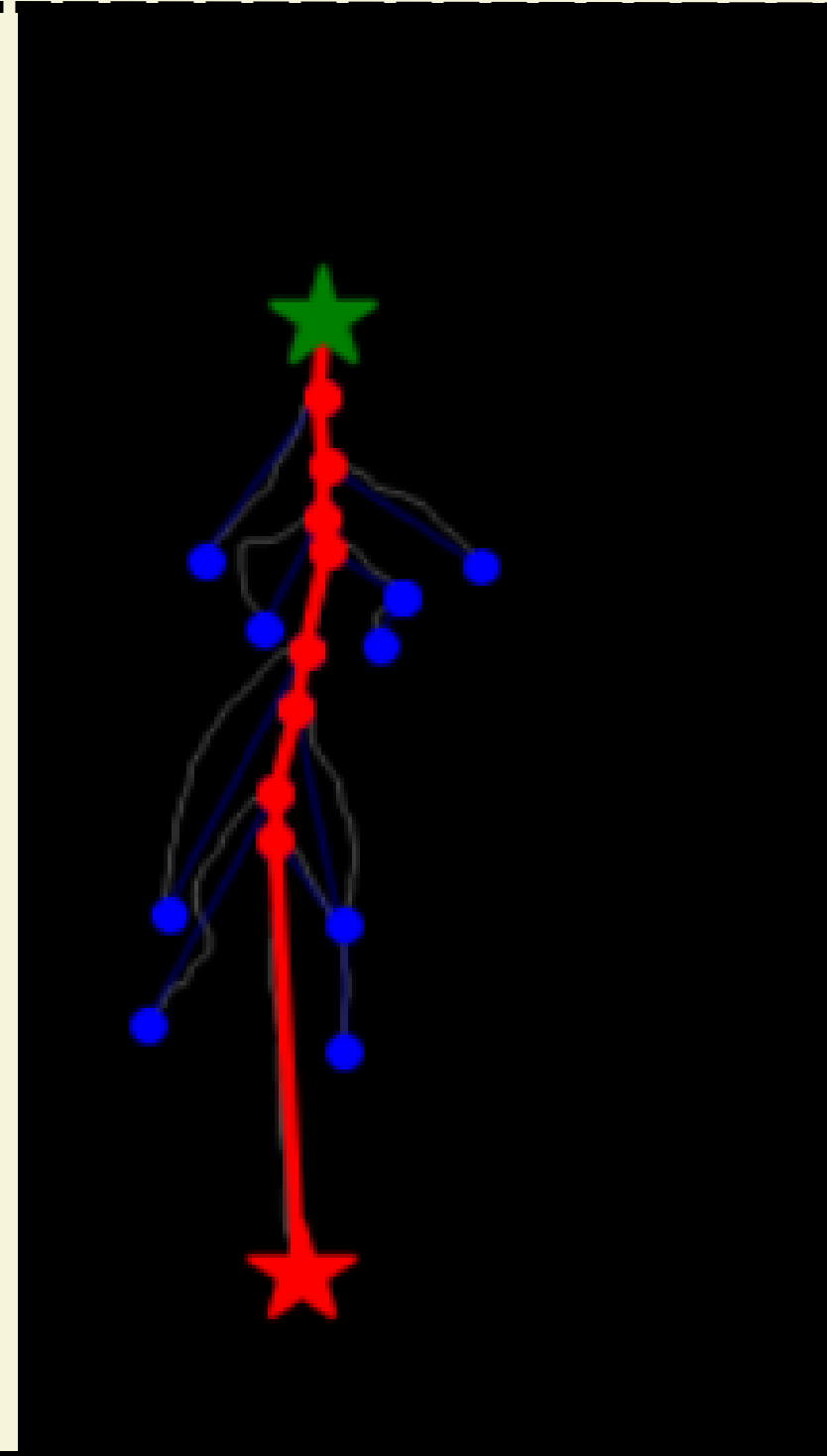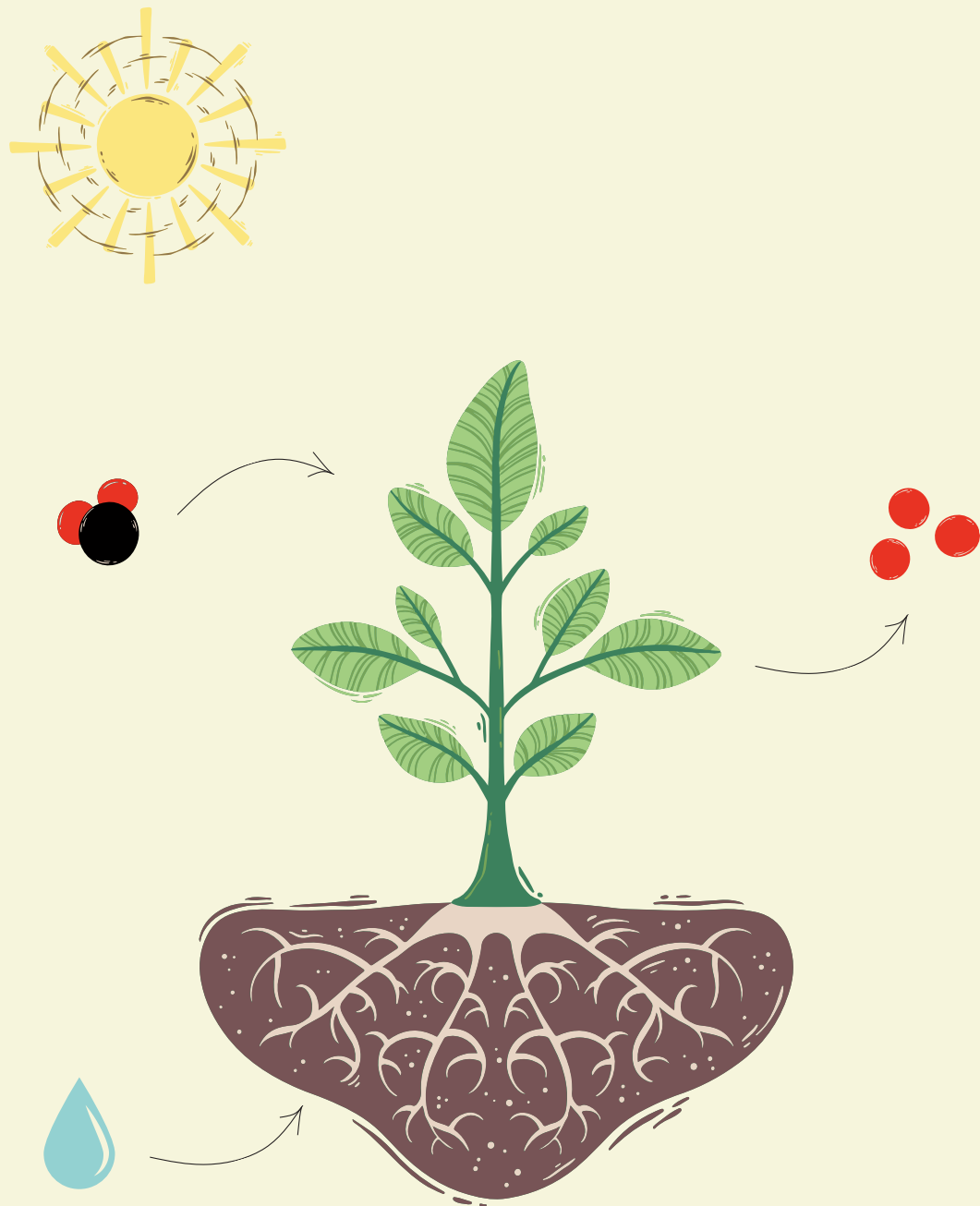
Assumptions

- 5 plants per image

- Non-overlapping roots

- No fallen plants

Limitation

- Root Nav 2.0 technical problems

- Time constraint

- ResNet50 limitations

- Lateral roots exceeding the primary root

Next Steps

- Reinforcement Learning with pipeline implementations

- Root Nav 2.0

- ADOPT optimizer

- Focal Loss

Thank you for listening!!
Questions?