GLOBAL RESEARCH IMMERSION PROGRAM FOR YOUNG SCIENTISTS

Identification of Potential Pruning Points in Tomato Plants Using Deep-Learning for Robotic Pruning

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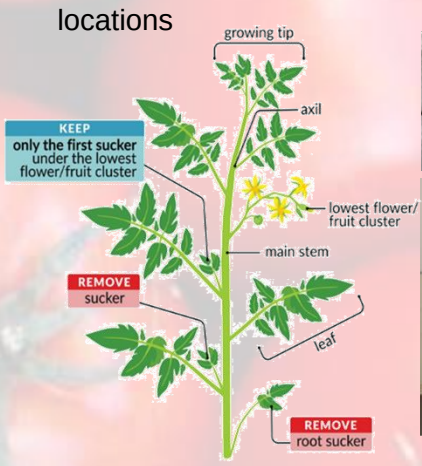
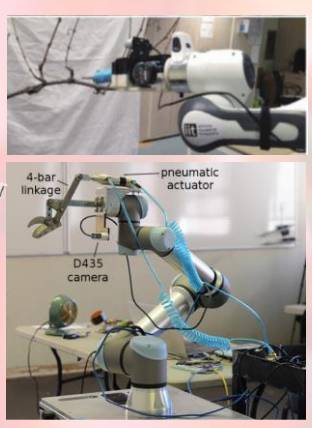
Background

- Removing tomato suckers (axillary shoots) and withered leaves is essential for increasing yield and reducing the risk of disease infestation
- Currently performed manually – very time-consuming and arduous process
- Vision-guided robotic pruning – efficiency is heavily reliant on the performance of the machine-vision algorithm for identification of the pruning locations



Identification of suckers on a tomato plant



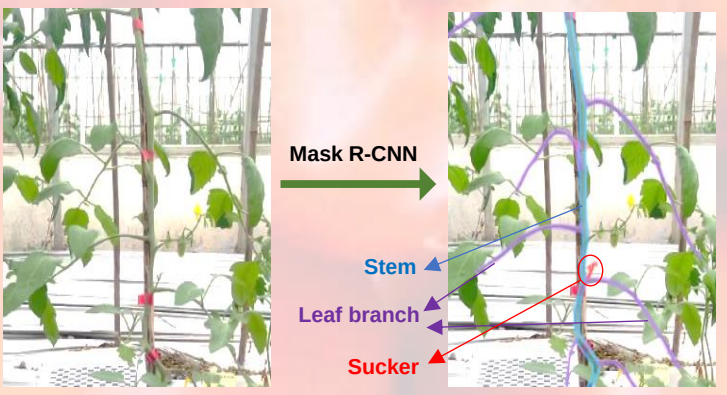
Vision-enabled robotic pruning systems

Research objectives

- Develop a deep-learning-based instance segmentation model to accurately identify suckers and branches in tomato plants
- Estimate optimal pruning points based on the identified instances of suckers and branches

Methodology

- Instance segmentation was performed using Mask R-CNN deep-learning algorithm to identify (i) stem, (ii) sucker, (iii) leaf branch



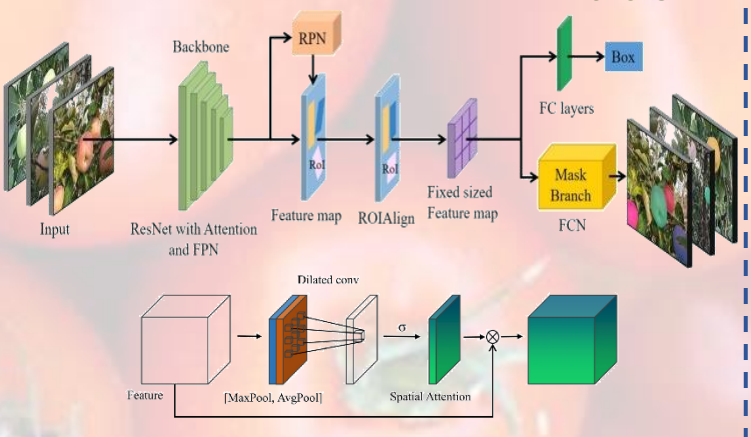


Illustration of the Mask R-CNN model and the attention mechanism developed for identifying the stem, suckers, and branches of the tomato plant

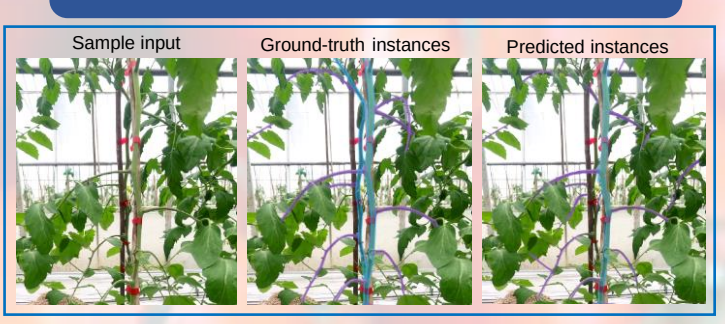
Dataset

- The dataset consisted of 150 images of tomato plants at different growth stages – acquired in parallel to the rows of the greenhouse
- Images were annotated using hasty.ai software – polygon annotations performed to cater instance segmentation task

Sampling stage | Flowering stage | Green-fruit stage

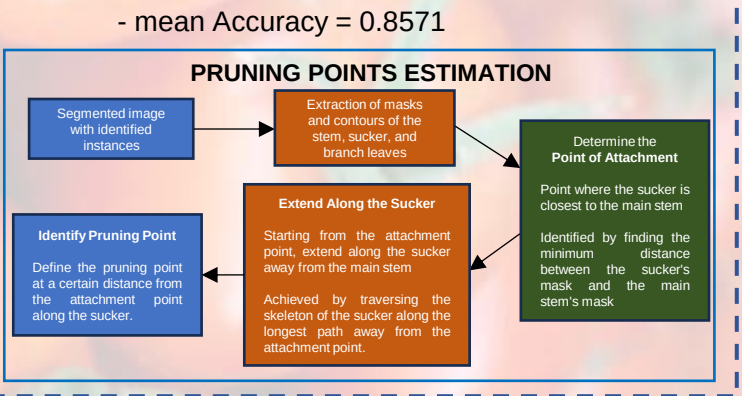
Sample images from the greenhouse tomato dataset

Results & Discussion



Training loss, precision, recall, and mAP curves of the Mask R-CNN network observed on the validation dataset

- The following statistical results were observed:
  - mean Intersection over Union = 0.8045
  - mean boundary F1-score = 0.6352
  - mean Accuracy = 0.8571



Conclusions

- Mask R-CNN was effective in identifying the stem, suckers, and branches of the plant
- An efficient pruning point estimation algorithm was developed for robotic pruning

References

- M. Fernandes et al., (2021). Grapevine Winter Pruning Automation: On Potential Pruning Points Detection through 2D Plant Modeling using Grapevine Segmentation. 2021 IEEE 11th Annual International Conference on CYBER Technology in Automation, Control, and Intelligent Systems (CYBER), Jiaxing, China, 2021, pp. 13-18.
- D. Borrenpohl & M. Karkee, (2023). Automated pruning decisions in dormant sweet cherry canopies using instance segmentation. Computers and Electronics in Agriculture, 207, 107716.