Rapid Identification of Strawberry Runners Using AI Techniques

Xue Zhou[1,2], Liyike Ji[1,2], Xu Wang[1,2]

[1] Gulf Coast Research and Education Center, University of Florida, Wimauma, FL, USA.

[2] Department of Agricultural and Biological Engineering, University of Florida, Gainesville, FL, USA.

INTRODUCTION

- Strawberry runners, also known as “stolons”, are long, horizontal stems that extend from the main strawberry plant, or mother plant (Fig. 1).
- Runners can be used for vegetative propagation, which is a cost-effective and efficient method for expanding strawberry production.
- Runners can also cause overcrowding in the patch, which can reduce overall strawberry yield and make it difficult to manage and harvest the fruit.
- Runners take energy away from the mother plant, which can reduce the size and quality of the fruit produced.
- Traditional methods of visually identifying runners in the field is a time-consuming, labor-intensive, and costly process.
- An automated and accurate technique is needed to streamline the selection of runner-related traits for breeding and for automated runner management for growers.

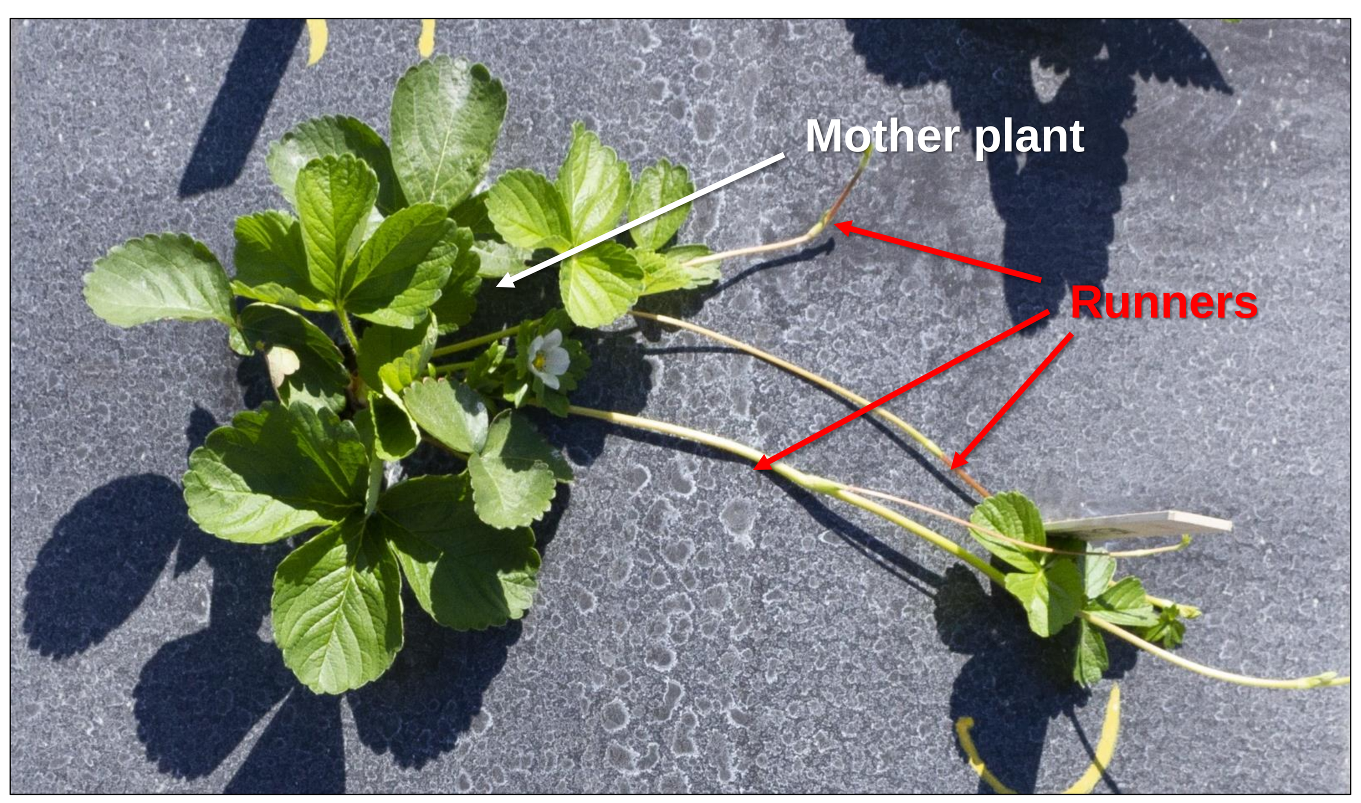


Figure 1. A strawberry plant with runners on the plastic mulch

OBJECTIVES

- Identifying and quantifying strawberry runners in large-scale trials in a timely and cost-efficient manner.
  - Characterizing strawberry trials in high throughput.
  - Identifying runners from various plant tissues.
  - Quantifying numbers of runners accurately.

MATERIAL

- Advanced-stage strawberry breeding trials
  - 400 cultivars, 5 replications, 2,000 selections in total.
  - Planted on Oct. 14th, 2022, at the University of Florida IFAS, Gulf Coast Research and Education Center, Wimauma, FL.

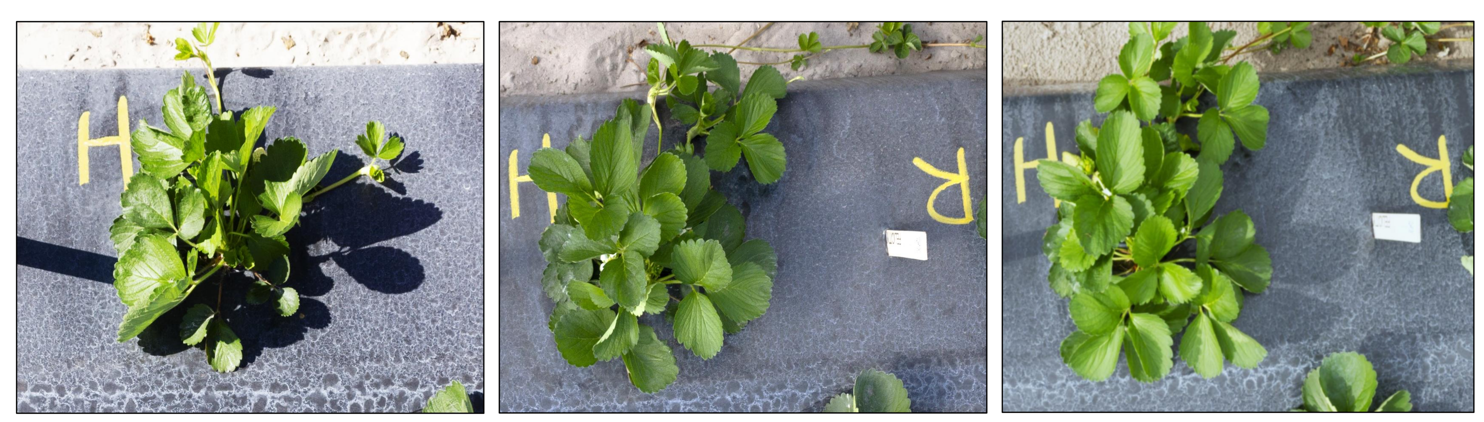
HIGH-THROUGHPUT IMAGING

- A ground imaging system comprises an electric vehicle, a GNSS receiver, and 6 DSLR cameras positioned at various angles (Fig. 2).
- 1 image/sec/camera, weekly collection for 400 varieties.

Figure 2. A ground imaging system for strawberry phenotyping

RUNNER IDENTIFICATION

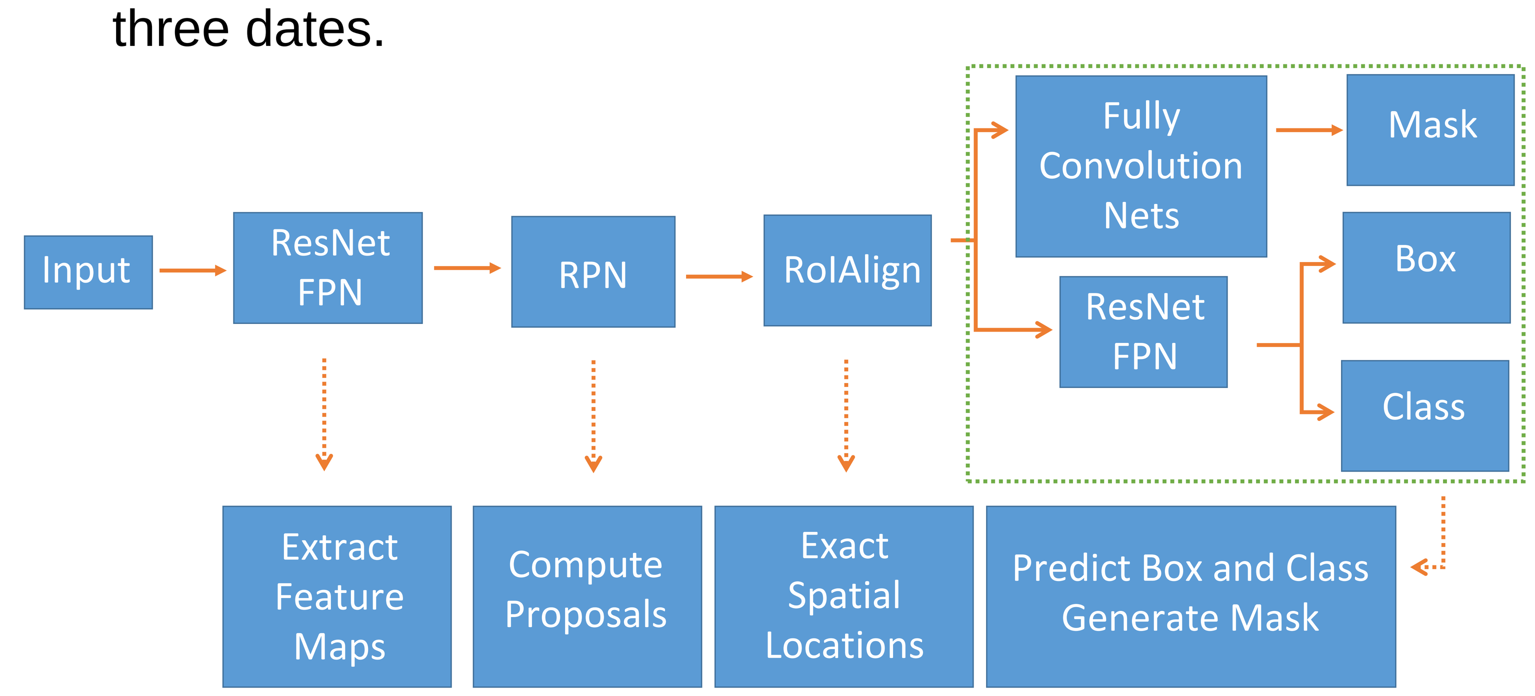
- In this project, high-resolution RGB images collected at early growth stage (on Dec. 1st, 14th, and 21st, 2022) were used to train and test an image-based deep learning model for runner identification.



(a) 12/01/2022 (b) 12/14/2022 (c)12/21/2022

Figure 3. Canopy top-view of the same strawberry cultivar on three dates

- Following the same Mask R-CNN architecture (Fig. 4), two models were trained using two datasets for performance comparison: 1) images from Dec. 1st, 2022, and 2) images from Dec. 1st and 12th, 2022.
- The two models were tested separately on images from all three dates.



FPN: Feature Pyramid Network RPN: Region Proposal Network RoI Align: Region of Interest Align

Figure 4. The Mask R-CNN architecture used for runner identification

PRELIMINARY RESULTS

- Trained by a small number of images (from 3 dates only), the Mask R-CNN model could reach the runner identification accuracy of 84%.
- Larger training data led to a better performance (Table 1).

Table 1. Performance of runner identification on different dates using two Mask R-CNN-based models

Model	Date for model testing	No. of Runners (TP+FN)	No. of Detected Runners (TP+FP)	No. of Correctly Detected Runners (TP)	Precision (TP/ (TP+FP))	Recall (TP/ (TP+FN))	F1 Score (2*(precision*recall)/ (precision+ recall))
Trained by 12/01	20221201	95	119	59	0.50	0.62	0.55
	20221214	140	98	68	0.69	0.49	0.57
	20221221	174	78	60	0.77	0.34	0.48
Trained by 12/01 and 12/14	20221201	95	191	83	0.43	0.87	0.58
	20221214	140	122	90	0.74	0.64	0.69
	20221221	174	128	107	0.84	0.62	0.71

TP: true positives, the positive class is correctly predicted as the positive class
FP: false positive, the negative class is predicted to be a positive class
TN: true negative, the negative class is correctly predicted to be a negative class
FN: false negative, the positive class is predicted to be a negative class

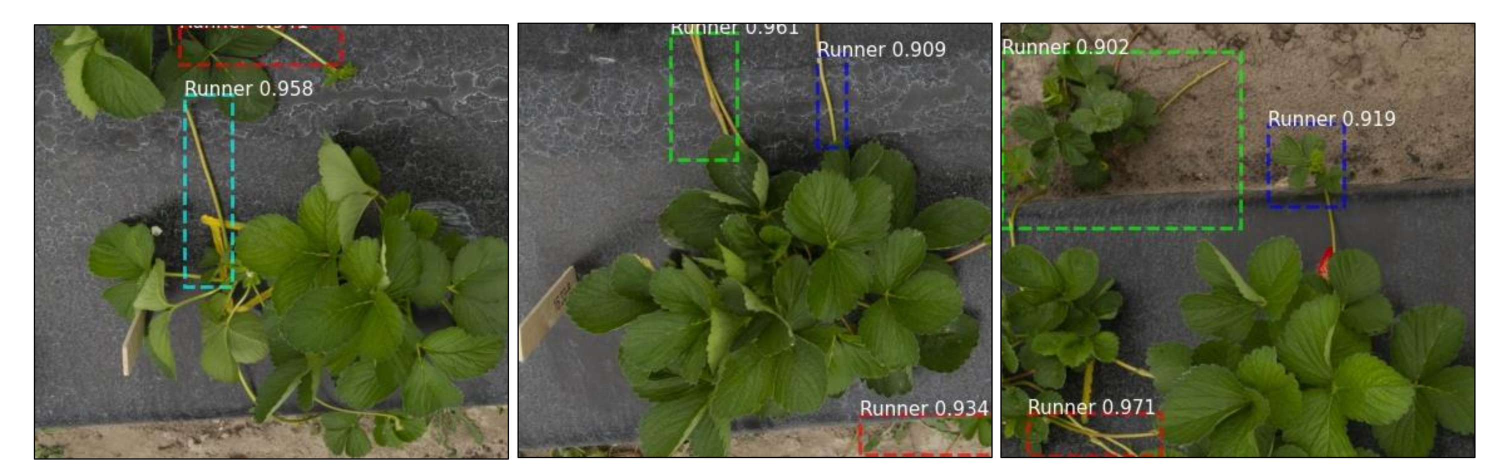


Figure 4. Output examples from the Mask R-CNN display dashed bounding boxes to show identified runners

CONCLUSIONS

- Preliminary results from this study successfully proved the concept of runner identification using machine vision.
- AI-powered machine vision technique has great potential to identify complex plant tissues for crop breeding, management, and production applications.
- Future efforts will focus on enhancing the identification accuracy, expanding the system’s capacity in larger-scale strawberry trials, and evaluating the efficacy of this method across multiple cultivation periods.

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