Mask R-CNN Based King Flowers Identification for Precision Apple Pollination

Xinyang Mu and Long He

The Pennsylvania State University

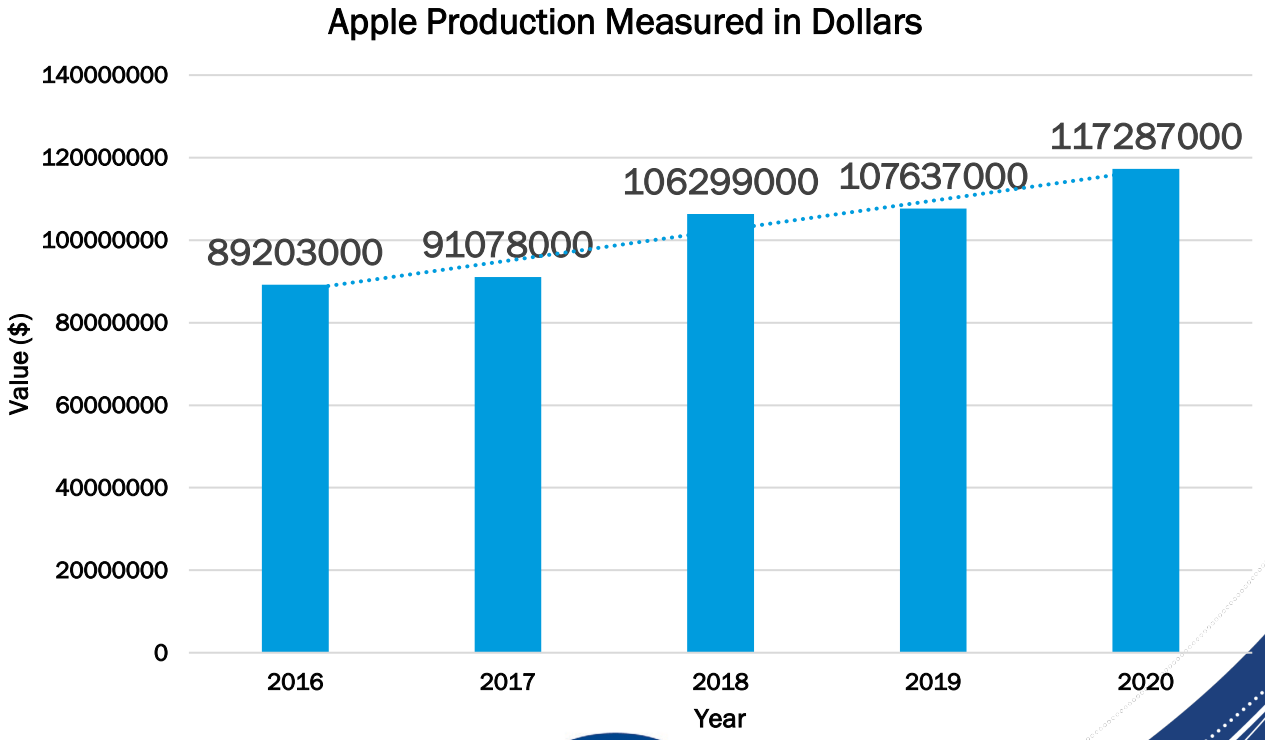
2022 Mid-Atlantic Fruit and Vegetable Convention

2/2/2022

PennState

Introduction

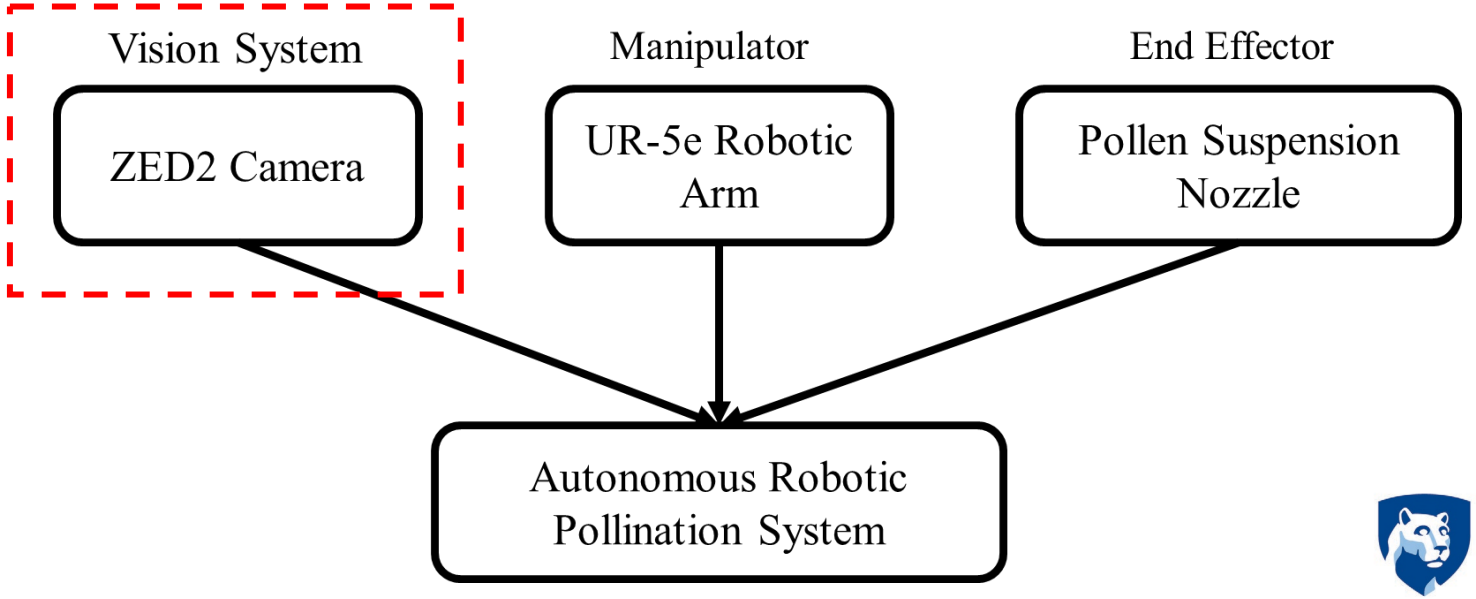
- **Importance of Apple Production**
  - Economic impact
- **Ensure Product's Quantity and Quality**
  - Optimal pollination



PennState

Introduction

- **Product Quantity and Quality**
  - Precision pollination during flowering stage
- **Challenges in Achieving Optimal Pollination**
  - Insect pollinators – dying off rapidly
  - Environmental conditions – huge uncertainty
- **Autonomous Robotic Pollination System**



PennState

Study Objectives

- ❑ Establish a flower cluster image dataset throughout the flowering growing stage.
- ❑ Develop a machine vision system to identify the king flowers on apple canopies.
- ❑ Compare the results of vision system with manually-counted ground truth.

PennState

Artificial Intelligence based Vision System

❑ Image Acquisition System

- ZED 2 camera
- Kubota utility vehicle
- Aluminum supporting frame
- Cultivars: Gala / Honeycrisp
- 800 images were collected

PennState

Mask R-CNN based Instance Segmentation

❑ Mask R-CNN Network Flowchart

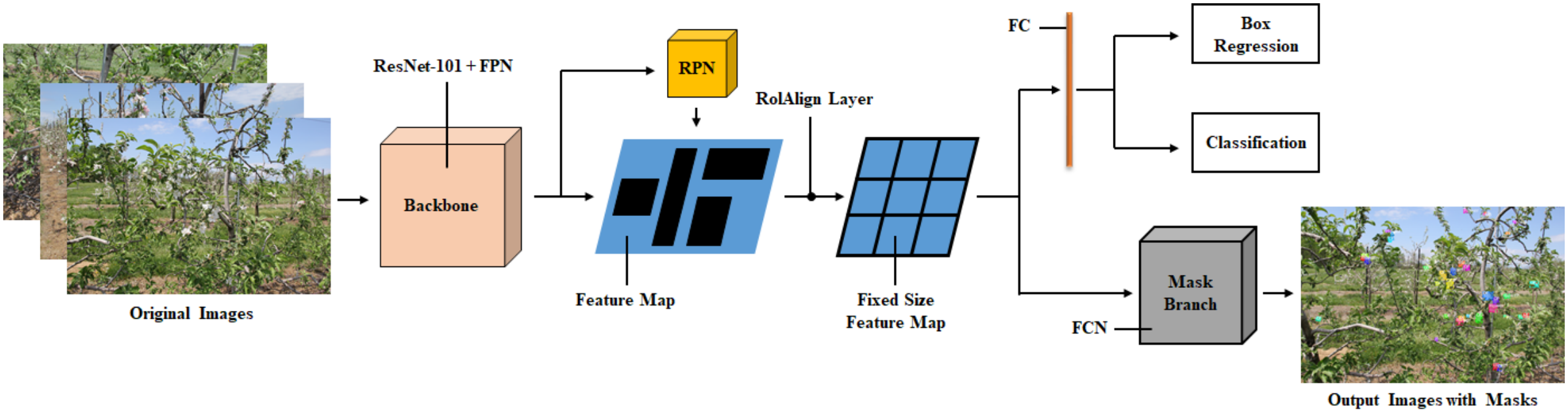


Image Segmentation Results

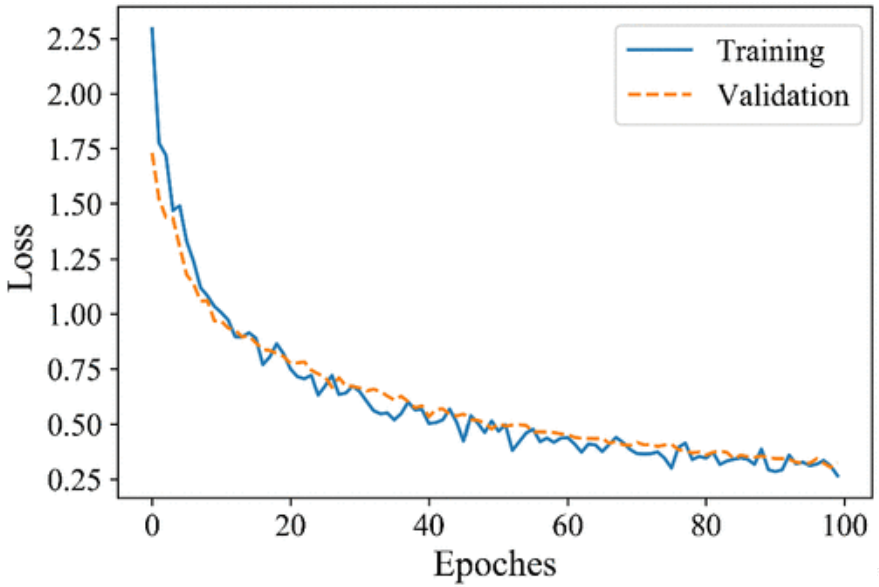
- Flower Segmentation Result

PennState

Image Segmentation Results

❑ Flower Segmentation Evaluation

Evaluation parameter	Exposed Flowers	Occluded Flowers	Overall
Precision (%)	78.73	68.39	73.56
Recall (%)	70.31	58.83	64.57
F1 Score	74.28	63.25	68.77



PennState

King Flower Detection

- King Flowers Detection

PennState

King Flower Detection

- King Flowers Detection Accuracy for Gala Apple Trees

Date	Counted flowering stages (ground truth)	Detected flower stages (algorithm)	Accuracy of king flower detection (%)
4/15/2021	5%	4.6%	92%
4/16/2021	10%	8.5%	85%
4/17/2021	20%	16.6%	83%
4/18/2021	30%	23.7%	79%
4/19/2021	40%	29.6%	74%
4/20/2021	75%	46.5%	62%
4/21/2021	100%	60%	60%

PennState

King Flower Detection

- King Flowers Detection Accuracy for Honeycrisp Apple Trees

Date	Counted flowering stages (ground truth)	Detected flower stages (algorithm)	Accuracy of king flower detection (%)
4/15/2021	0%	0%	100%
4/16/2021	3%	2.7%	90%
4/17/2021	13%	11.4%	88%
4/18/2021	20%	16.8%	84%
4/19/2021	50%	39.5%	79%
4/20/2021	75%	56.3%	75%
4/21/2021	100%	69%	69%

PennState

Conclusion

- A novel approach for apple king flowers detection was developed using Mask R-CNN based instance segmentation.
- The detection target focused directly on the king flowers, which are the most critical blossoms to perform precision pollination.
- The detection accuracy was ranged from 91% to 60% with the development of flowering stages.

PennState

Thank you!

USDA AMS-Specialty Crops Program No. K3055
State Horticultural Association of Pennsylvania (SHAP)
Northeast Sustainable Agriculture Research and Education (SARE) Graduate Student Grant GNE22-293
Special thanks to Dr. James Schupp for ground truth information.