



Introduction: Precision Apple Pollination

- ❖ Supplies of pollination services (honeybees) do not match the increasing demands.
- ❖ Robotic pollination system provides promising solution.
- ❖ An autonomous robotic pollination system consists of a vision system, a manipulator, and an end effector.
- ❖ A vision system that can accurately locate king flowers is necessary.
- ❖ The success of this study will improve the efficiency of pollination and reduce labor cost.

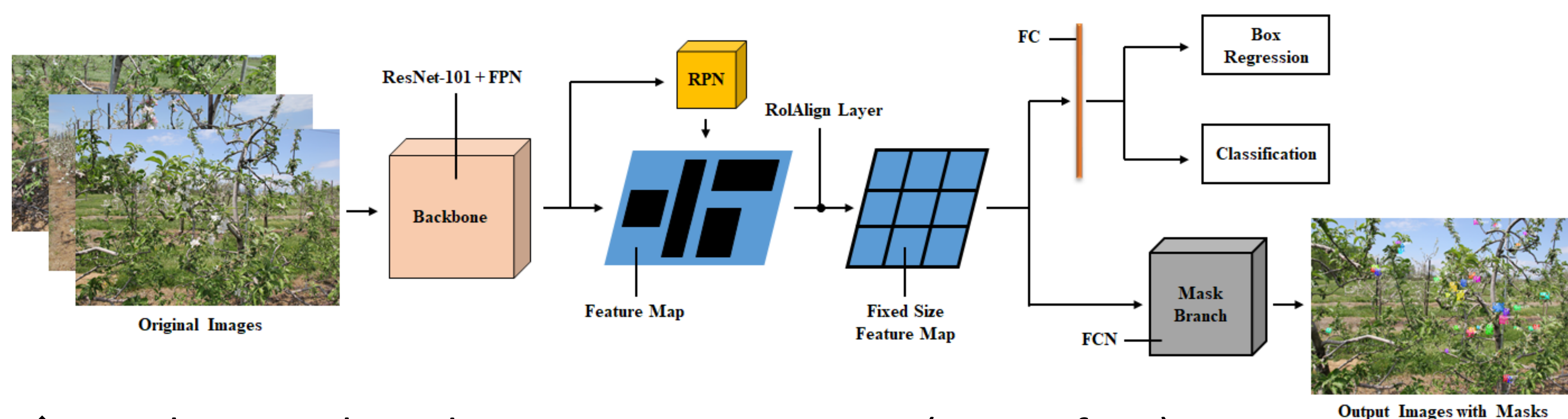


Image Acquisition System

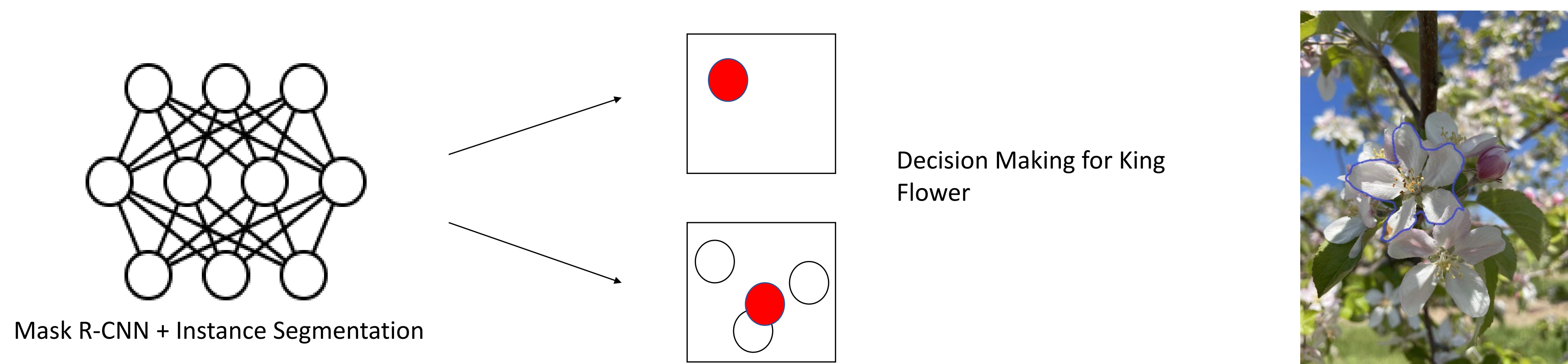


- ❖ Materials:
 - ZED2 camera
 - Kubota utility vehicle
 - Aluminum frame
- ❖ Cultivars: Gala / Honeycrisp
- ❖ 800 images were collected

King Flower Detection Algorithm

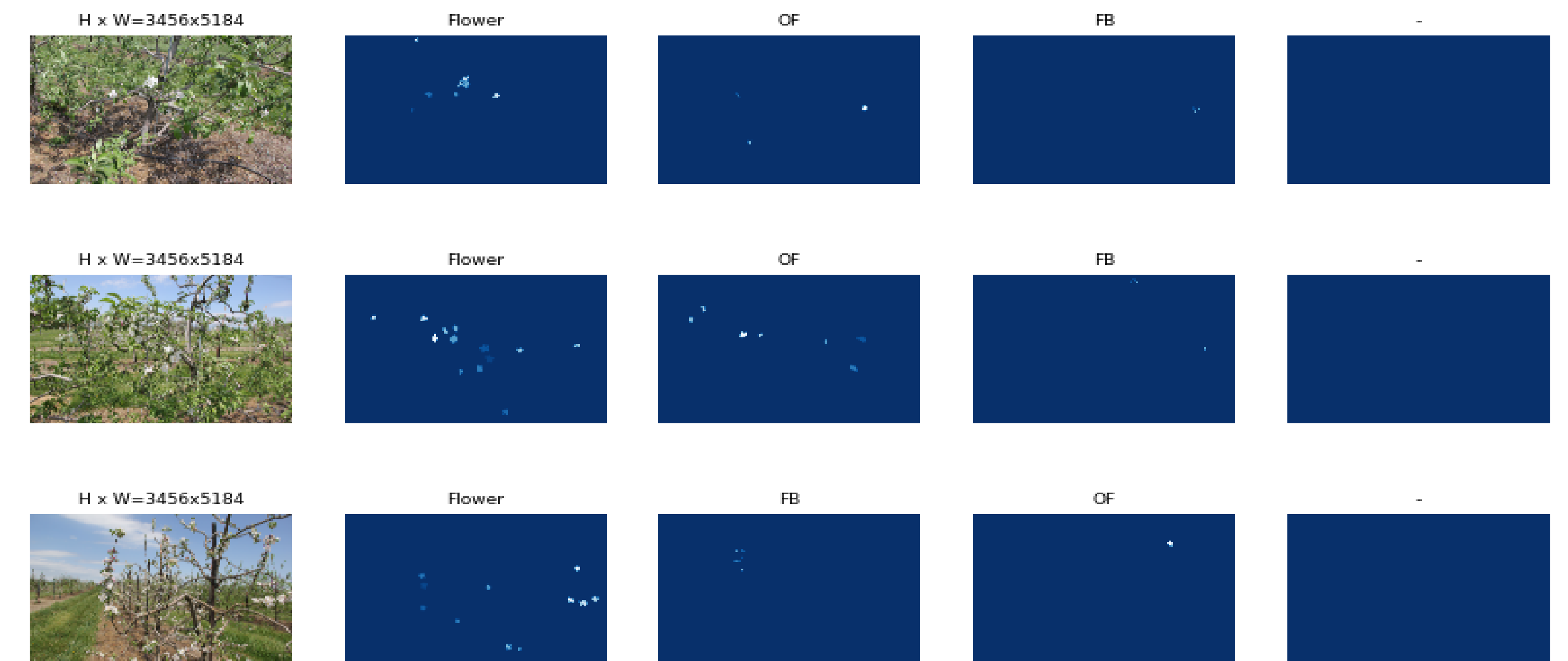


- ❖ Mask R-CNN based instance segmentation (state-of-art)
- ❖ Transfer learning using COCO dataset



Apple King Flowers Detection Results

- ❖ Four classes were identified including flower, occluded flower (OF), flower buds (FB), and background.



- ❖ All the apple flowers and flower buds were detected with an average precision rate of 73.56% (left figure).
- ❖ The king flowers within each cluster were selected using image processing algorithm (right figure).



- ❖ Comparison between flower detection results and manually counting.
- ❖ The accuracy of king flower detection kept decreasing as the development of flowering stage.
- ❖ Multiple factors: occlusion by other objects / orientation of king flowers

Date	Counted flowering stages (ground truth)	Detected flower stages (algorithm)	Accuracy of king flower detection (%)	Date	Counted flowering stages (ground truth)	Detected flower stages (algorithm)	Accuracy of king flower detection (%)
4/15/2021	5%	4.6%	92%	4/15/2021	0%	0%	100%
4/16/2021	10%	8.5%	85%	4/16/2021	3%	2.7%	90%
4/17/2021	20%	16.6%	83%	4/17/2021	13%	11.4%	88%
4/18/2021	30%	23.7%	79%	4/18/2021	20%	16.8%	84%
4/19/2021	40%	29.6%	74%	4/19/2021	50%	39.5%	79%
4/20/2021	75%	46.5%	62%	4/20/2021	75%	56.3%	75%
4/21/2021	100%	60%	60%	4/21/2021	100%	69%	69%

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

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