UNIVERSITY OF GEORGIA

Performance Evaluation of Single-Shot Detection Models for Weed Identification on Open-Source Datasets

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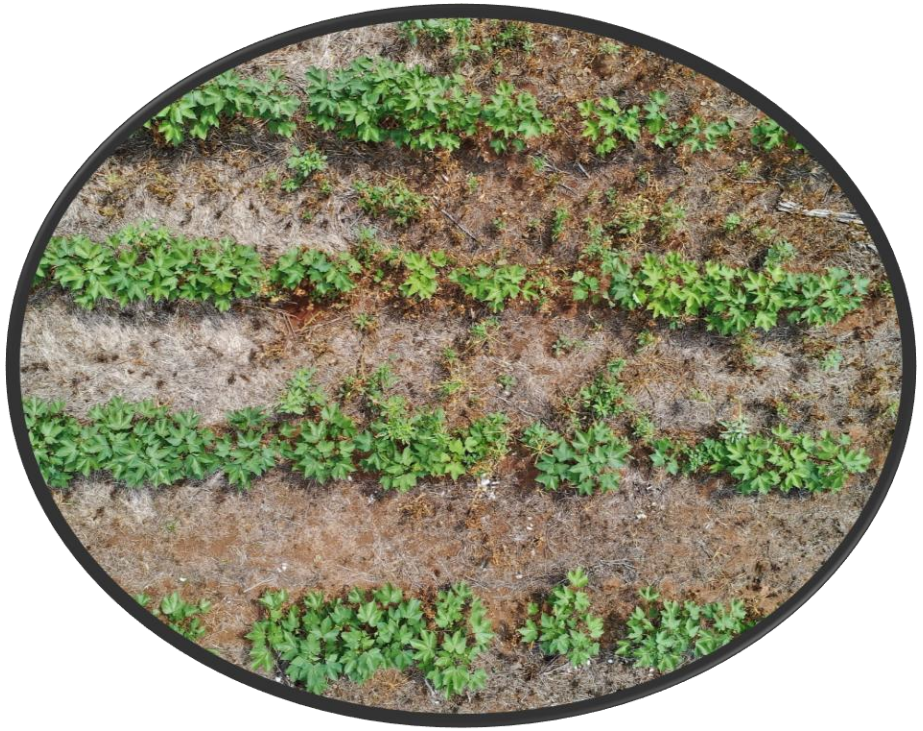
Introduction: Hazards of Weed Plants

- Weeds cause $138 Billion annual loss in the USA [1]
- Weed management accounts for more than 30% of production costs in specialty crops [2]
- Weeds degrade the quality of specialty crops by competing for essential nutrients
- Critical to control weeds within the first 4-6 weeks of crop plantation [3]



Weeds in cotton field at J. Phil Campbell Sr. UGA Research Center, Watkinsville, GA

Introduction: Challenges In Conventional Weed Management

Manual Weeding

Manual weed removal [8]

- **Time consuming**
- **Labor intensive**
- **Damaging to healthy vegetation**
- **Inefficient**

Herbicide Application

Chemical weed control [9]

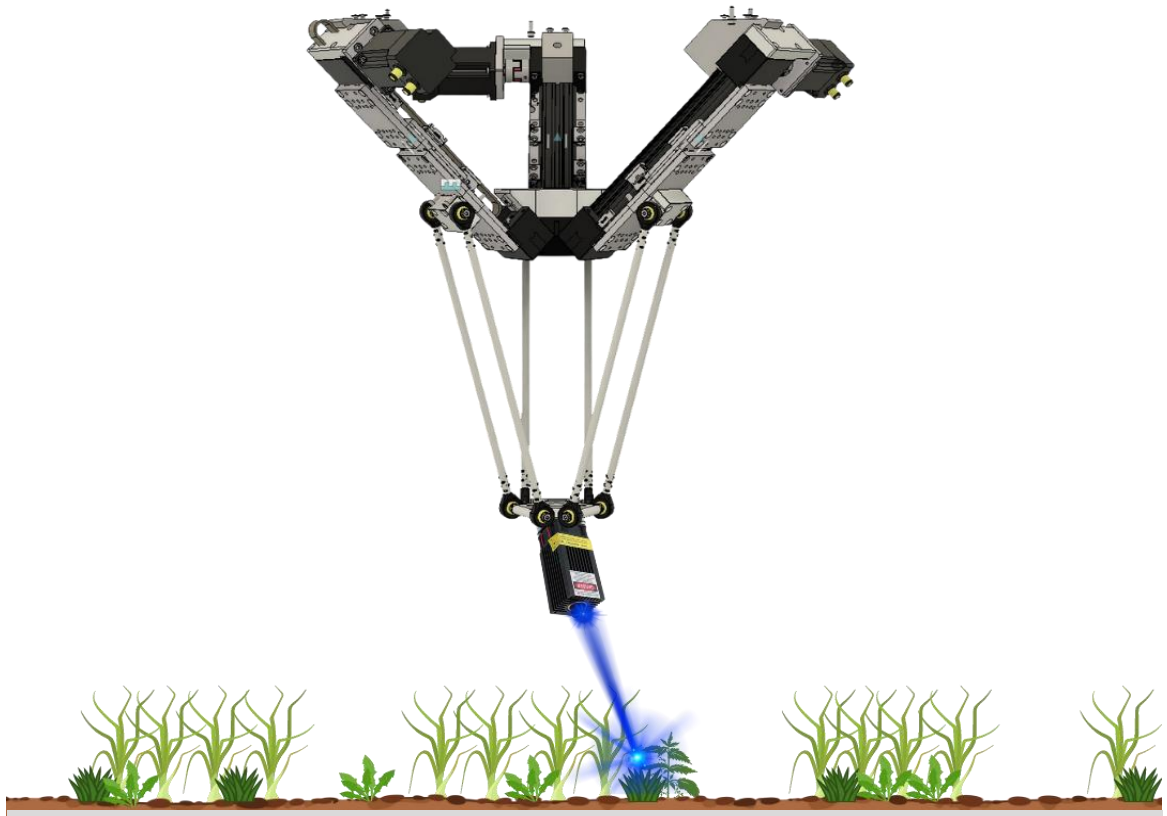
- **Weed resistant plants**
- **In-organic**
- **Crop injury**
- **Negative impact on environment**

Robotic Laser Weeding

1. Organic process
2. Reduced risk of crop damage and increased weeding efficiency
3. Reduction in Soil Disturbance
4. Precise operation
5. Cost effective
6. Automation and labor savings

Goal and Objectives

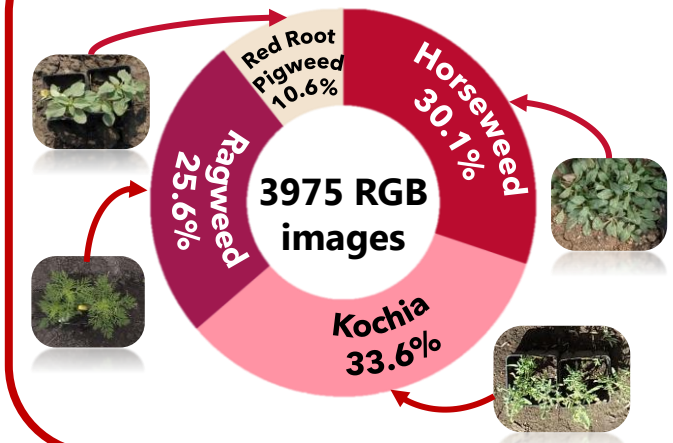
Enhancing weed detection under variable lighting conditions using advanced deep learning models



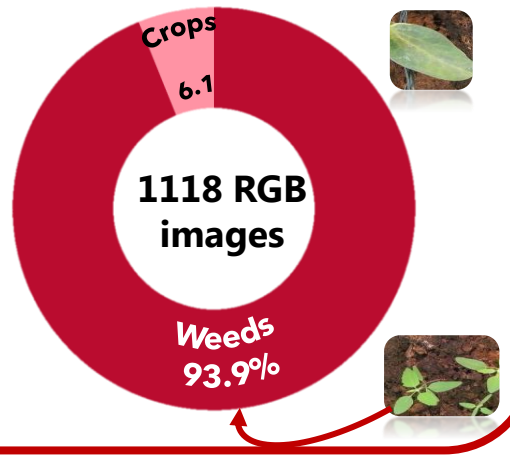
Methodology

Data Acquisition

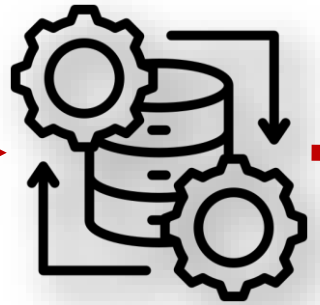
Dataset A [4]



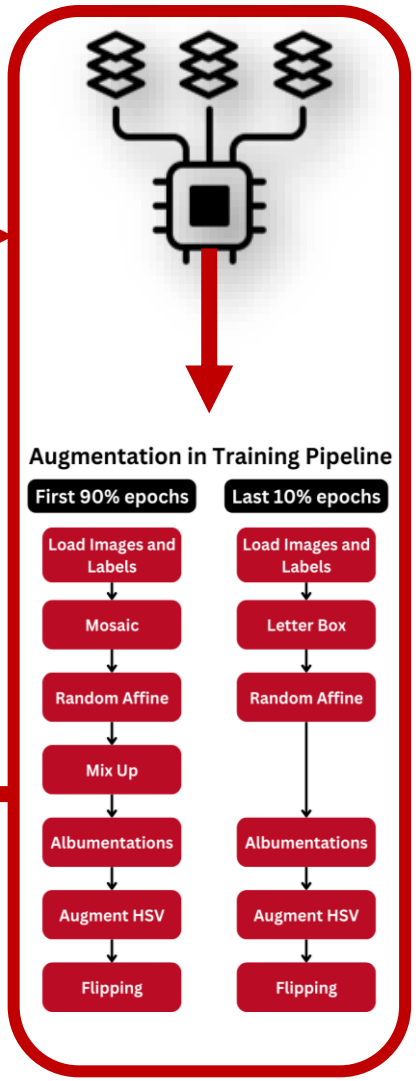
Dataset B [5]



Pre-processing



Train Yolov9, RT-DETR, Yolo-World and Yolov8

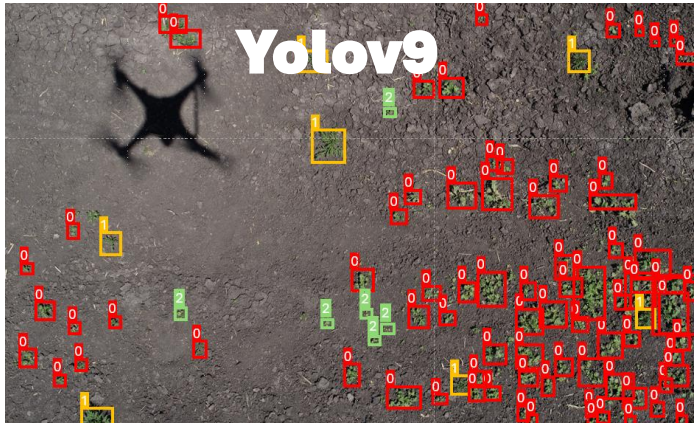


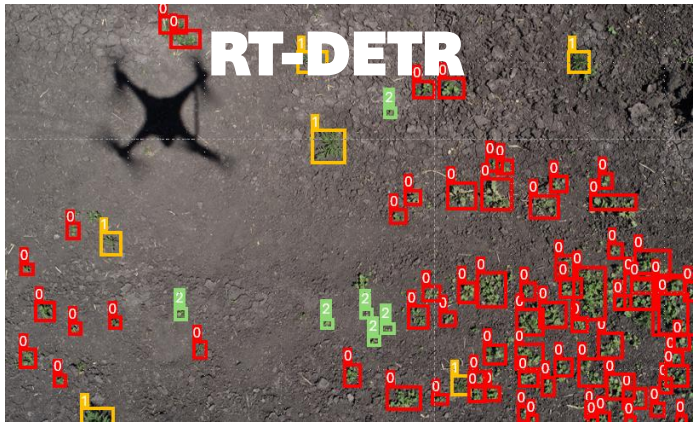
Inference Computation

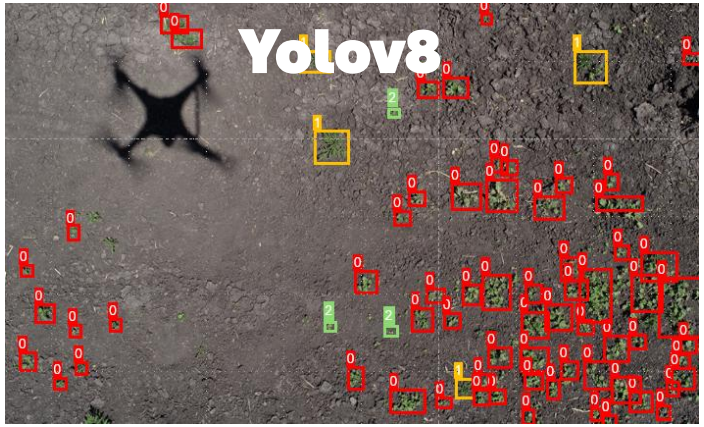
Performance Evaluation

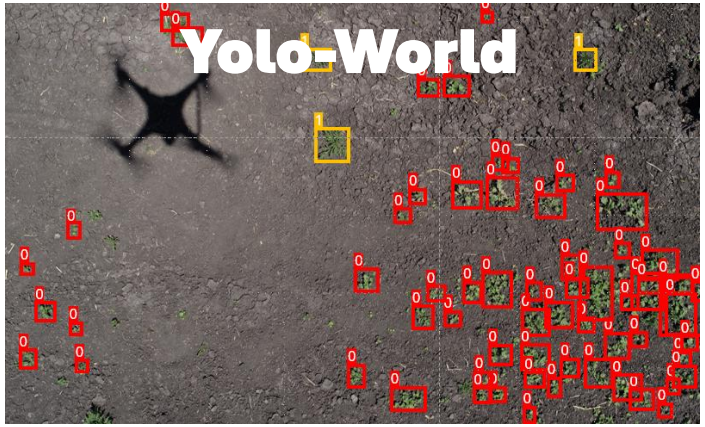
Optimal Model Selection

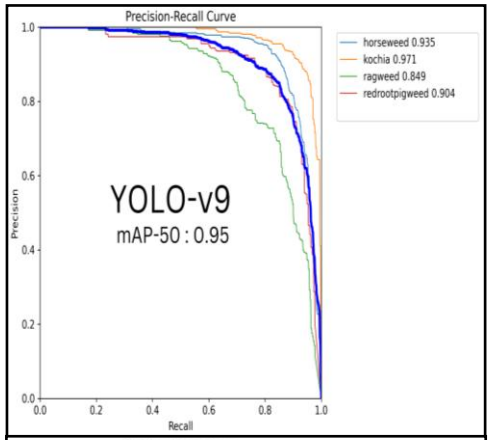
Results

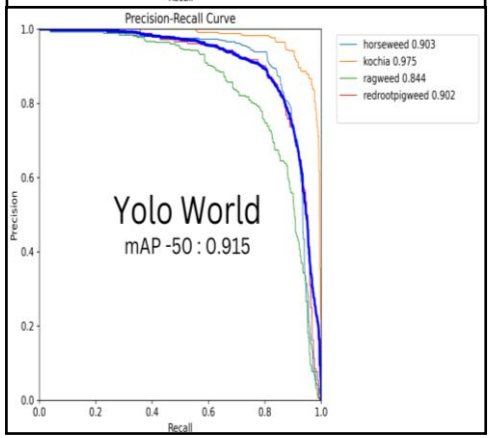

Yolov9

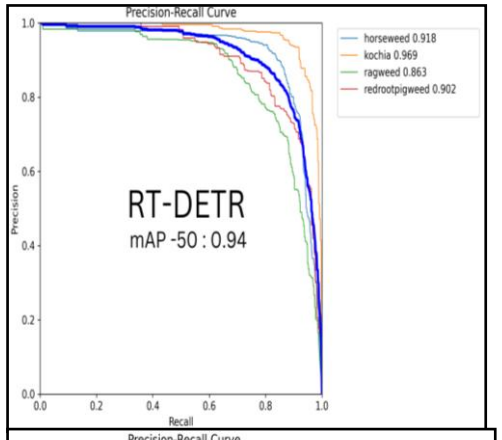

RT-DETR

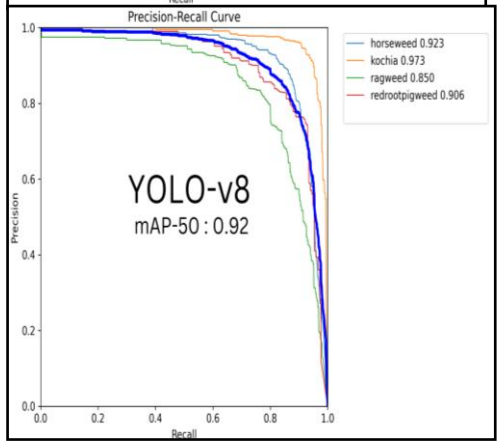

Yolov8


Yolo-World


Precision-Recall Curve
horseweed 0.935
kochia 0.971
ragweed 0.849
redrootpigweed 0.904
YOLO-v9
mAP-50 : 0.95
Precision
Recall

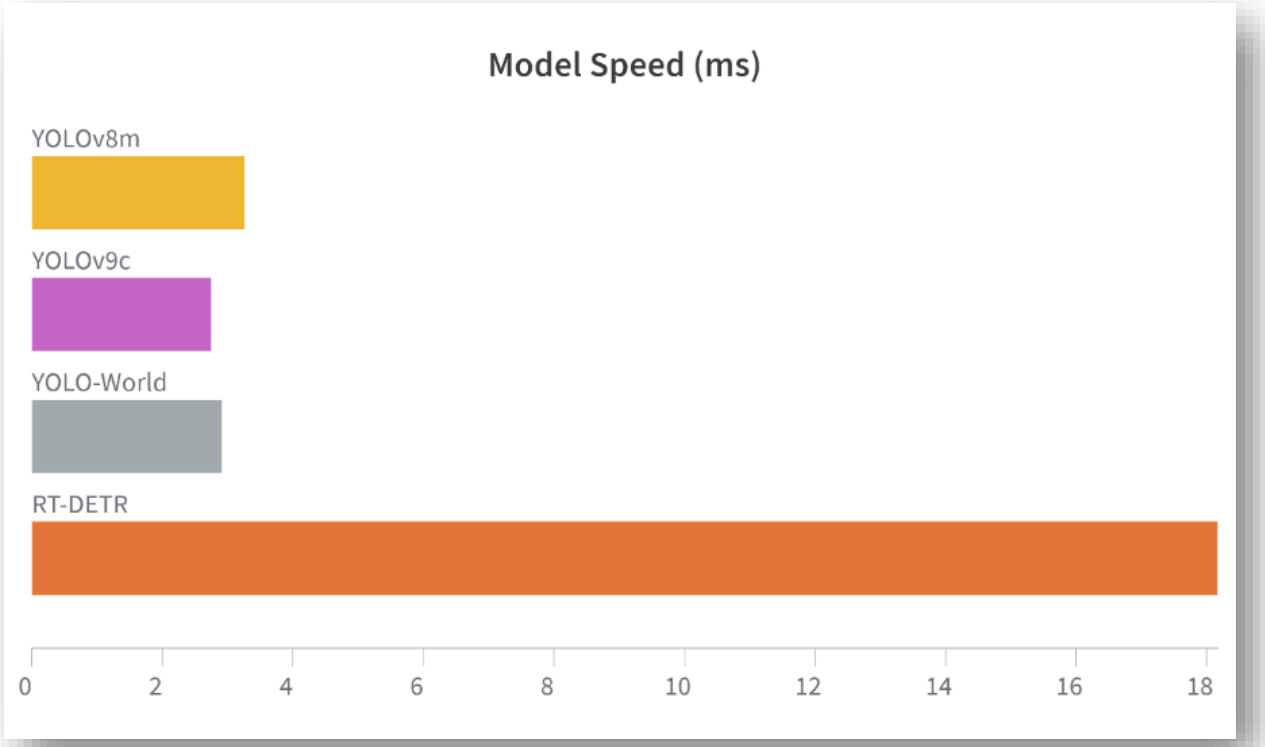

Precision-Recall Curve
horseweed 0.903
kochia 0.975
ragweed 0.844
redrootpigweed 0.902
Yolo World
mAP -50 : 0.915
Precision
Recall


Precision-Recall Curve
horseweed 0.918
kochia 0.969
ragweed 0.863
redrootpigweed 0.902
RT-DETR
mAP -50 : 0.94
Precision
Recall

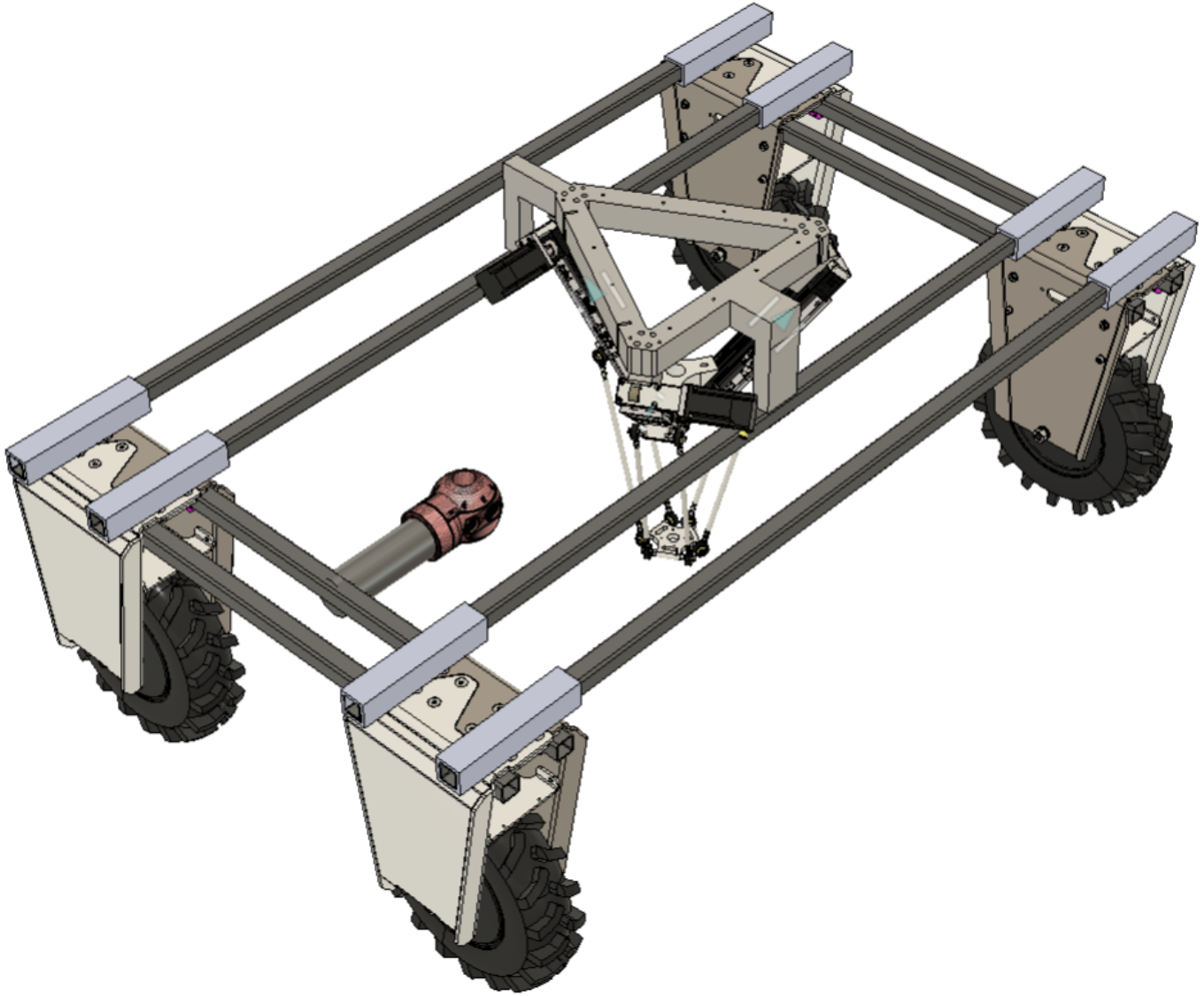

Precision-Recall Curve
horseweed 0.923
kochia 0.973
ragweed 0.850
redrootpigweed 0.906
YOLO-v8
mAP-50 : 0.92
Precision
Recall

Conclusion

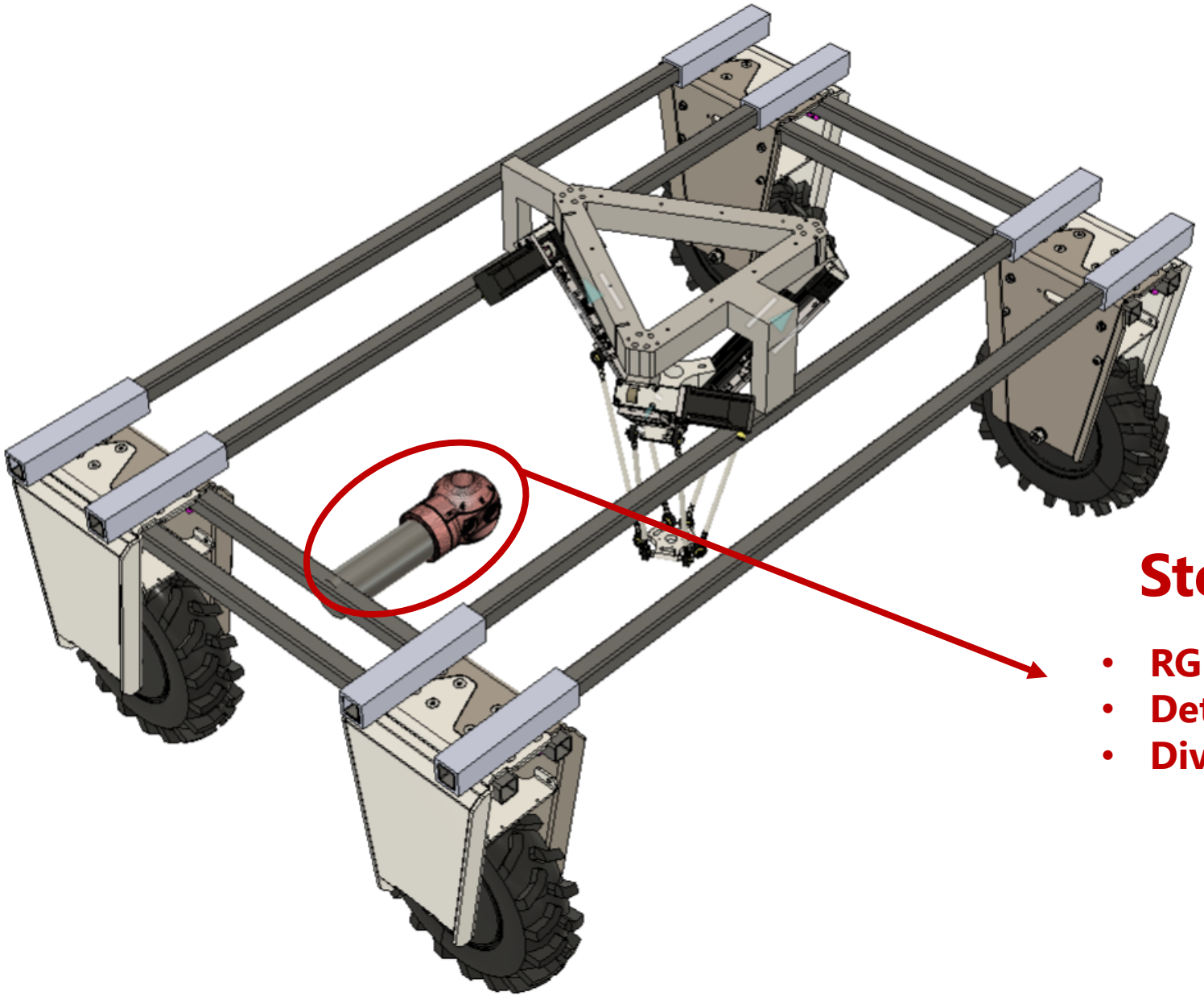
- **YOLOv9 had the fastest inference speed at 2.9ms, while RT-DETR, with similar results, was the slowest.**
- **YOLOv9 outperformed YOLOv8 with a 2.15% improvement**
- **Real-time capabilities**
- **Suitable for robotic system integration**



Future Work



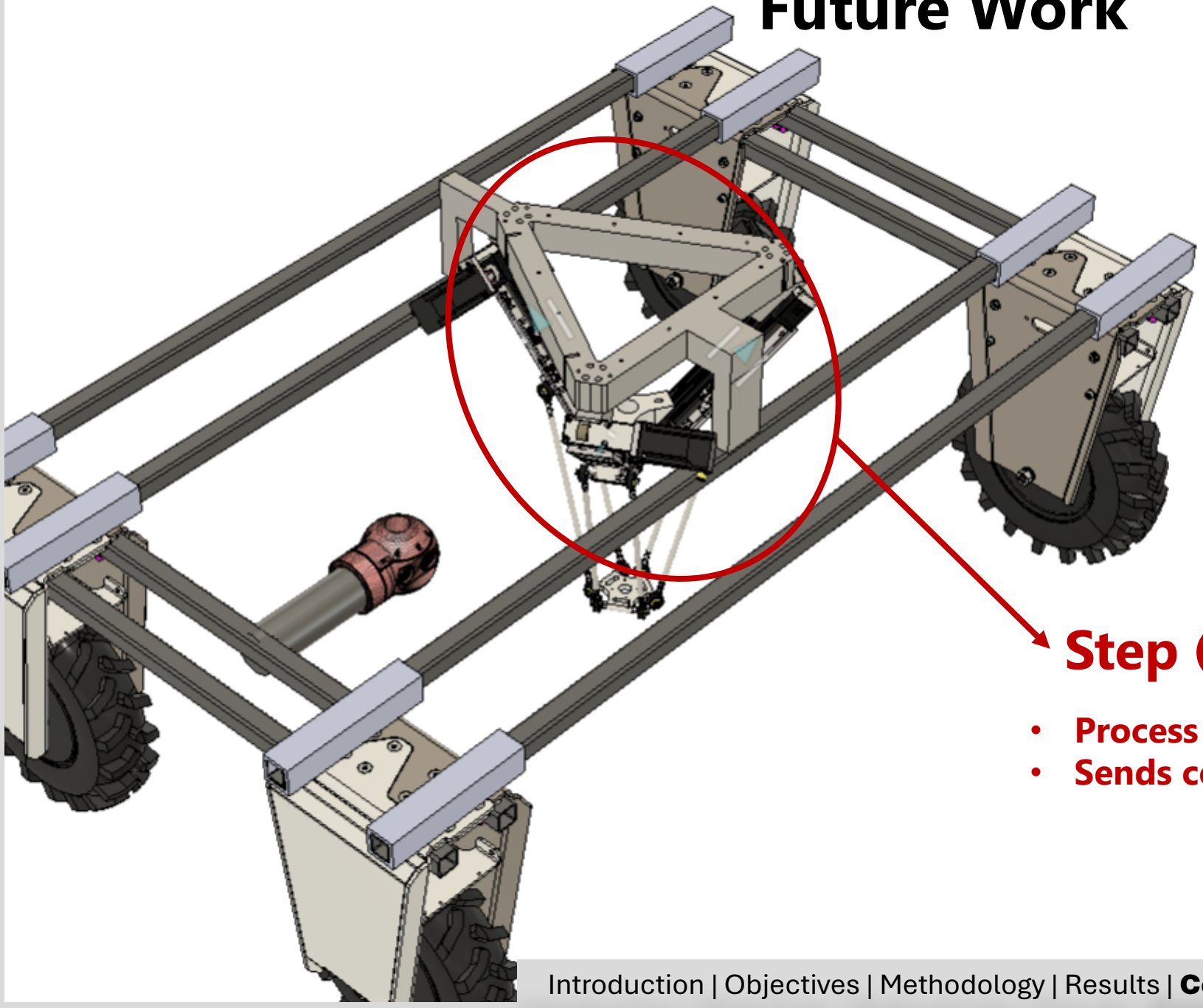
Future Work



Step 1

- RGB Camera and other sensors
- Detect multiple weed species
- Diverse field conditions

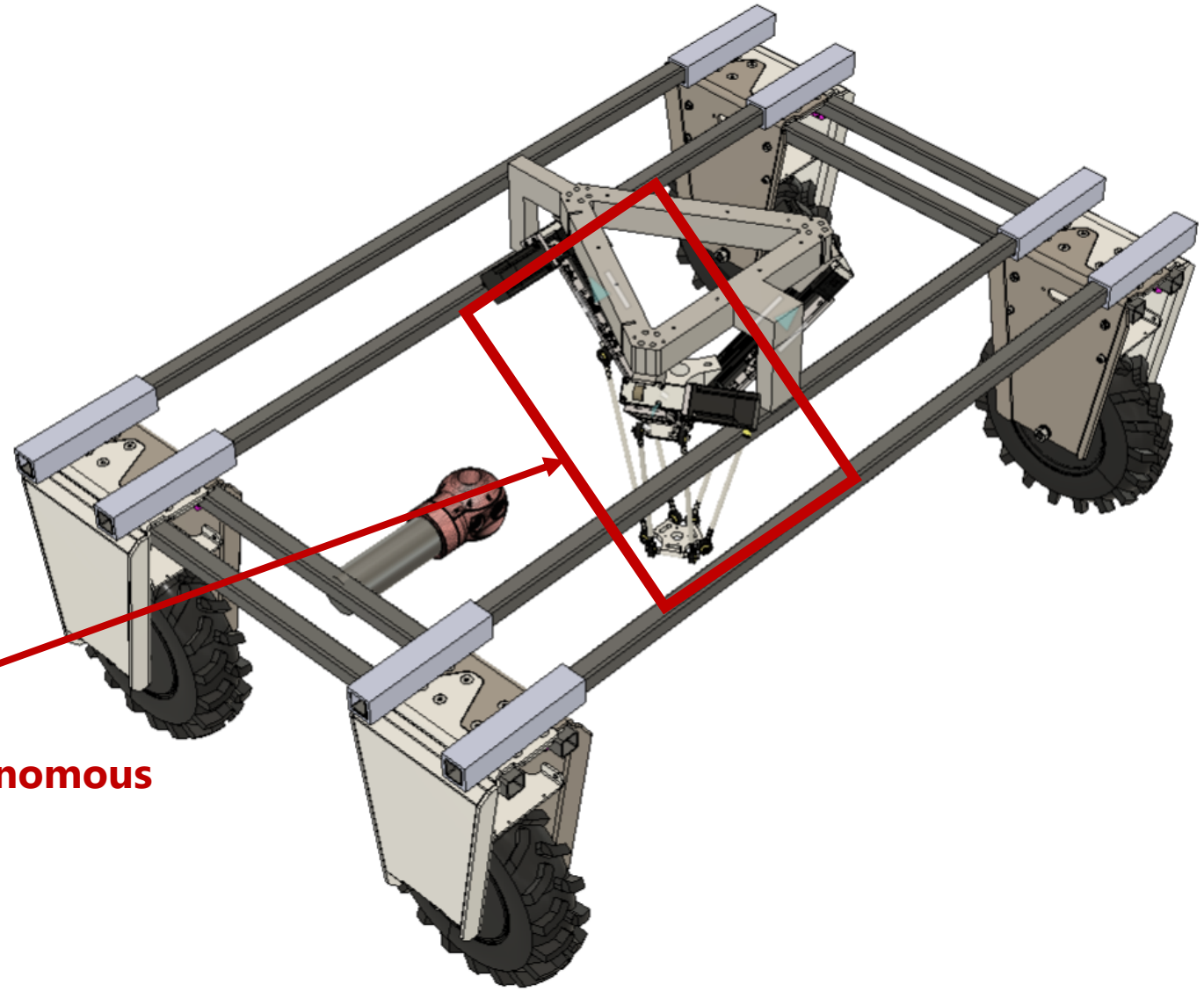
Future Work



Step 2

- Process input data
- Sends control signal

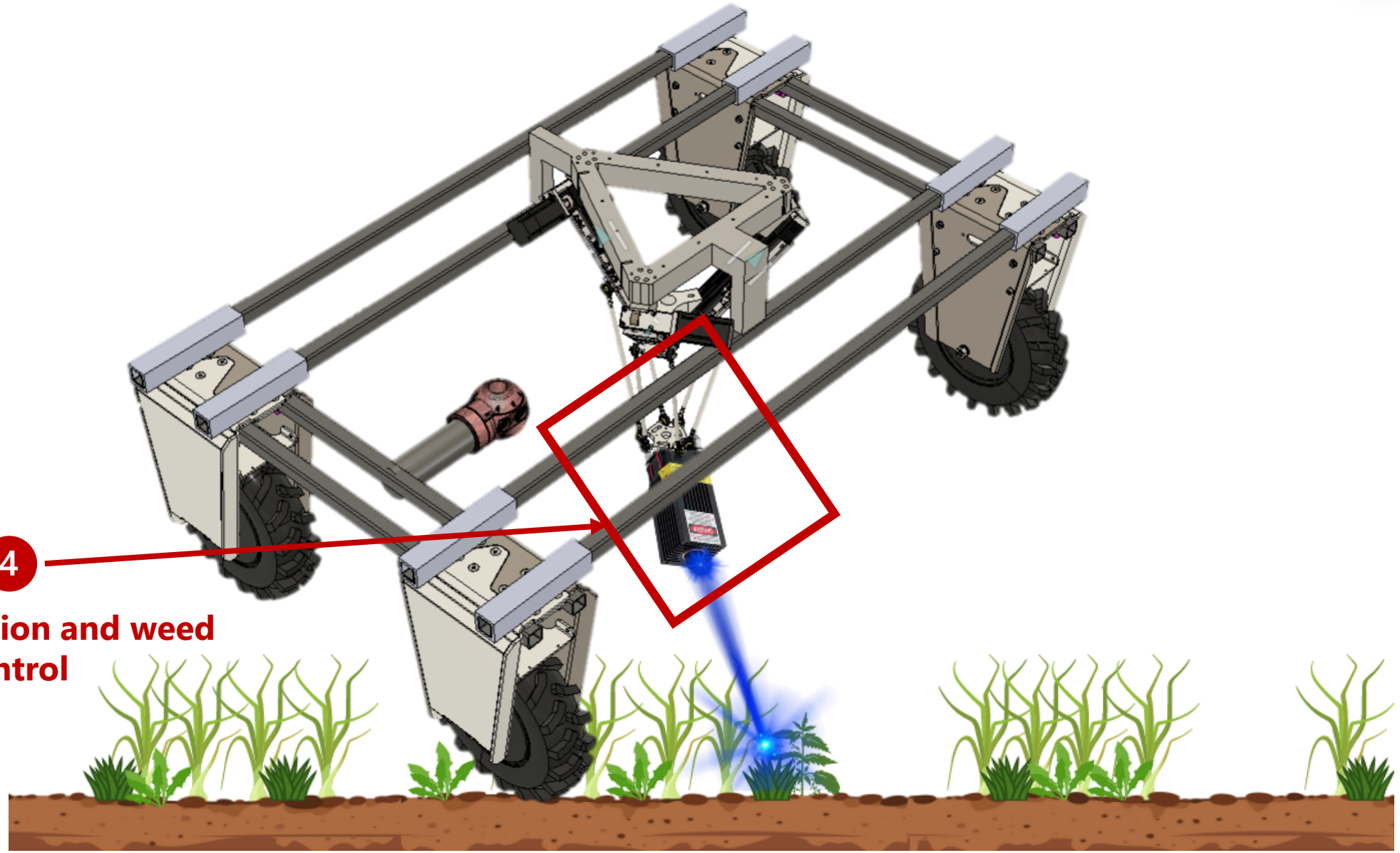
Future Direction



3

Execute robot's autonomous movements

Future Direction



Acknowledgments

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GS24-316

Thank you!

Any Questions?

References

[1]https://www.fs.usda.gov/detail/r8/landmanagement/resourcemanagement/?cid=fseprd972844#:~:text=Studies%20show%20that%20economic%20losses,by%20non%2Dnative%20invasive%20species

[2] https://wssa.net/2016/05/wssa-calculates-billions-in-potential-economic-losses-from-uncontrolled-weeds/

[3] https://crops.extension.iastate.edu/encyclopedia/managing-weeds-protect-crop-yields

[4] Rai, N., Mahecha, M. V., Christensen, A., Quanbeck, J., Zhang, Y., Howatt, K., . . . Sun, X. (2023). Multi-format open-source weed image dataset for real-time weed identification in precision agriculture. Data in Brief, 51, 109691. doi:https://doi.org/10.1016/j.dib.2023.109691

[5] Sudars, K., Jasko, J., Namatevs, I., Ozola, L., & Badaukis, N. (2020). Dataset of annotated food crops and weed images for robotic computer vision control. Data in Brief, 31, 105833. doi:https://doi.org/10.1016/j.dib.2020.105833