Collaborative Research: NRI: Balance Pruning of Dormant Grapevines with Autonomous Robots

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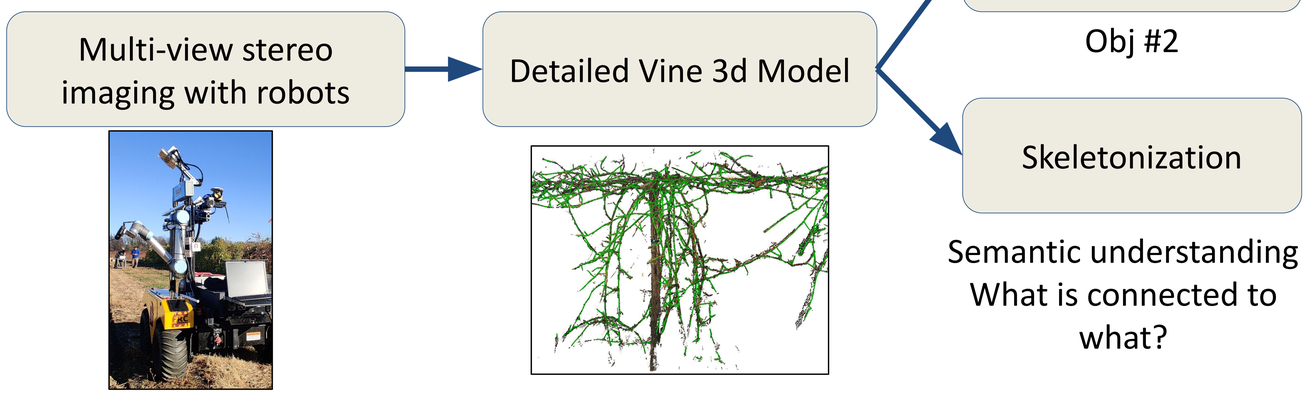
Background Dormant season grapevine pruning involves removal of excess one-year-old canes during the winter season. It is an important yet labor-intensive task that is highly dependant on skilled seasonal workers. From robotics perspective, pruning for vine poses multiple interesting challenges that require research advances in the fields of perception, control, robotic manipulation, and artificial intelligence (AI), in general. Dormant vines contain dense criss-crossing branches that fill a 3D volume while also leaving many small unoccupied spaces resulting in highly occluded complex geometry is which is difficult to model. Deciding where to make a pruning cut requires intelligence to understand the canopy at multiple levels, including its geometry, its topology and its semantic meaning and the ability to automatically generate this level of understanding does not currently exist.

Objectives

1. Active perception for vine modeling: This involves reasoning about occlusions and choosing optimal viewpoints that fill gaps. (CMU)
2. Robust vine vigor measurement: Pruning weight estimation using regression model. (CMU)
3. Learning from demonstrations: Investigating AI-based methods to learn pruning rules from human demonstration. (CMU)
4. Further design and develop grapevine training system for robotic applications. (Cornell)

Methods

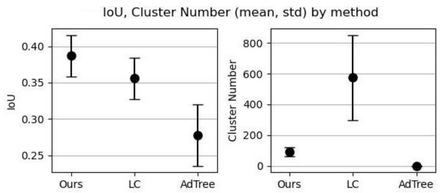
- Baseline approaches (Obj 1 &2)

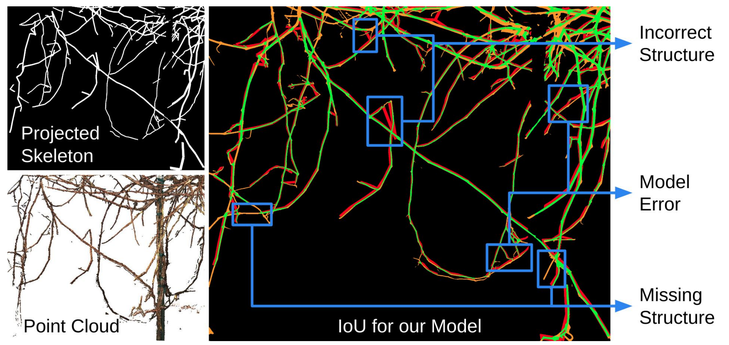


- Baseline approach (Obj 3) Data collection on human demonstration by capturing 3D model of the canopy with before and after vine pruning.

Results We calculate pruning weight using linear regression based on (cane voxels, cordon voxels, pole distance, skeleton length, and # cane pixels). We more accurately predict pruning weight on these dense vines than previous methods.

	R^2		**RMSE** (kg)	
Method	Avg.	Std. Dev.	Avg.	Std. Dev.
Ours	0.51	0.10	0.33	0.03
Cane pixel count [10]	0.33	0.10	0.39	0.04
Cane surface area [11]	0.38	0.10	0.38	0.04





Scientific Impact

- Dataset: We are providing a high-resolution stereo Dataset with ground truth for 144 Winter Grapevines from a commercial vineyard at CLEREL: labs.ri.cmu.edu/aiira/resources/

- We achieve higher reconstruction scores than Laplacian Contraction (LC) and Adtree. Connectivity is higher than the LC.

Broader Impact

- Summer internship for undergraduates, professional training for graduates.
- Leadership opportunities to staff both and CMU and Cornell.

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