NRI: INT: COLLAB: Tree Fruit Harvesting with Arrays of Vision-Guided Linear Robot Arms

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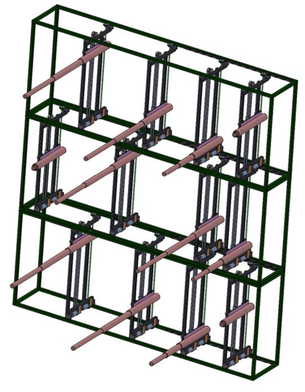
1. Introduction

Fruit harvesting is the most labor-intensive task in fresh fruit production.

Existing robots are effective only when tree canopies offer high fruit visibility and reachability.

2. Project goals

Design a multi-armed robot exhibiting high *picking efficiency* and *speed*, for a wide range of trees, and perform economic analysis of robotic fruit harvesting.



3. Technical Challenge

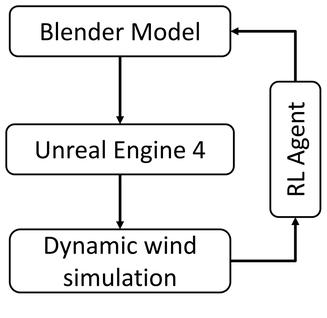
Increase the visibility and detection of fruits in the presence of severe occlusions.

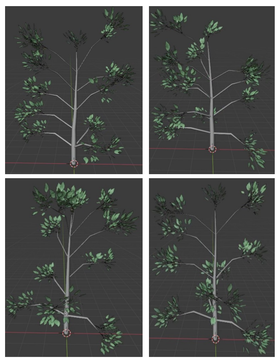
Approach

Utilize air-induced foliage agitation trained via deep learning to increase visibility.

Detect fruits from multi-view, multi-frame images with active light stereo cameras.

Intelligent canopy agitation





Miniature Active Light Stereo Camera

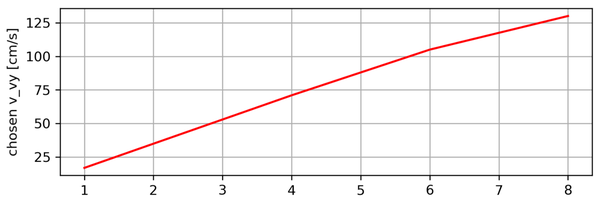
4. Technical Challenge

Maximize fruit harvesting speed under uncertainty in fruit perception.

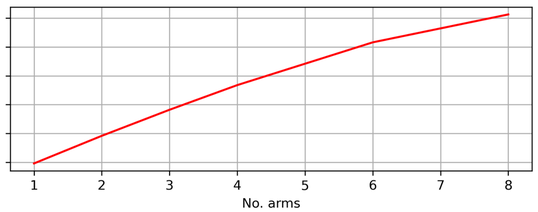
Approach

A Mixed Integer Programming model minimizes the *makespan* by computing the optimal vehicle velocity and arm-to-fruit assignments while picking at least 95% of fruits.

Tested on 1-D uniformly spaced fruit distribution.



Selected vehicle speed vs. number of arms.



Fruit Picking Throughput vs. number of arms.

5. Broader Impact - Societal

- Increased competitiveness and sustainability.
- Increased production of low-cost, high-quality fruits:
  - More, higher-paid operator jobs.
  - Improved nutrition for consumers & low-income families.

6. Broader Impact - Educational

- Project activities feed into UCD and CMU courses.
- Engagement of K-12 students:
  - UCD – Ag-robot presentations to North Davis Elementary.
  - CMU - Girls of Steel Robotics Initiative.

7. Scientific Impact

- Illumination invariant perception in the outdoors
- Intelligent learning-based canopy agitation.
- Near-linear harvest speed increase as more arms are deployed.

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