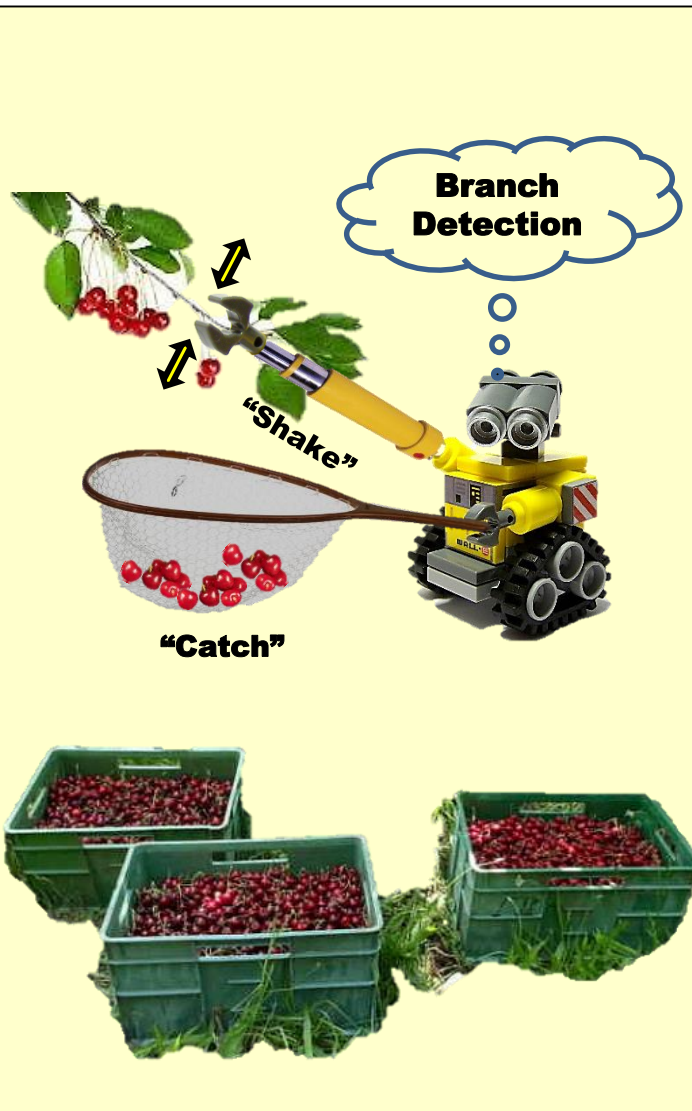# Giuseppe Pellizzi Prize 2016

26th Members' Meeting of the Club of Bologna

November 13, 2016

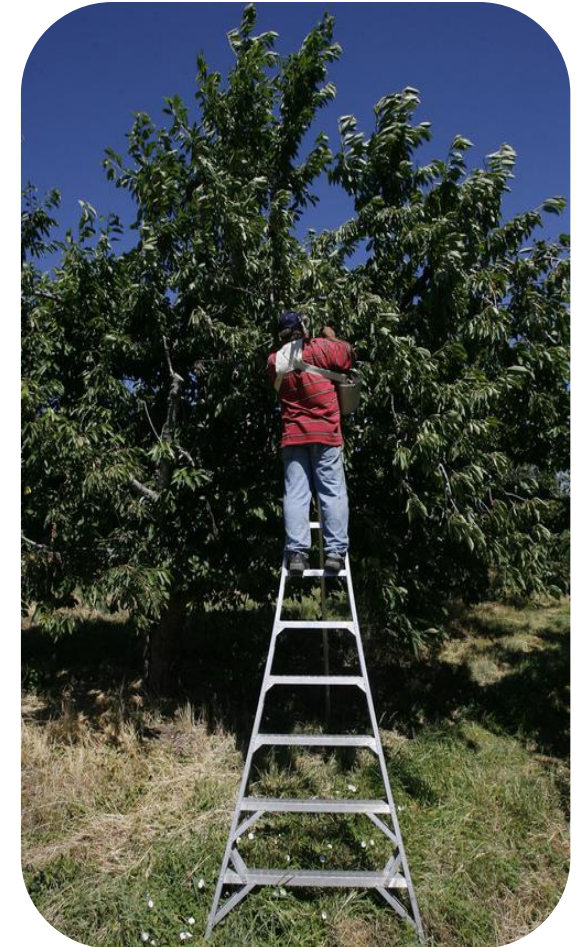## Detection of Cherry Tree Branches and Localization of Shaking Positions for Automated Sweet Cherry Harvesting

Suraj Amatya – surajonmail@gmail.com

Cherry Production

– Washington State largest producer (US)

– 264,000 tons per year (62% of total)

Cherry Harvesting

– Hand Picking

– Labor intensive

– Increasing costs

Mechanical Harvesting

Bulk Harvesting

– Mechanical branch shaking

– Efficient harvesting

– Potential for fully automated harvesters

Center for Precision Agriculture and Automated Systems, IAREC, Prosser, WA

Automation of sweet cherry harvesting

Objectives

- Detect cherry tree branches in full foliage canopies

- Identify cherry clusters in branches

- Locate shaking position for mechanical branch shaking

Branch Detection Challanges

Dormant Season   Vs   Harvest Season
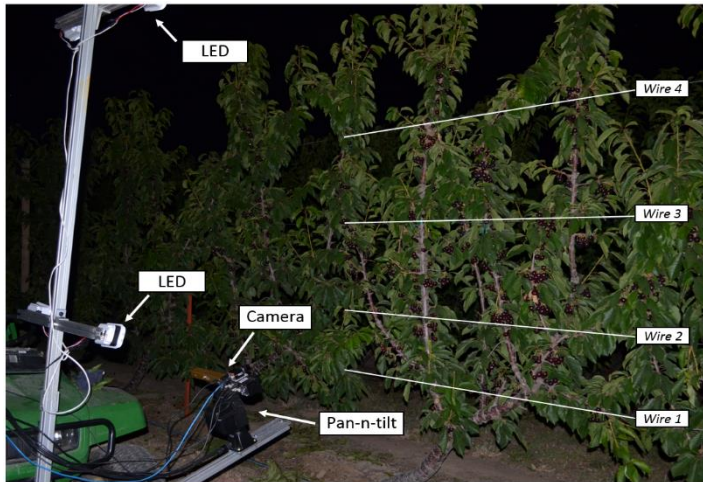
- No leaves

- Maximum branch visibility

- Fruit clusters

- Dense foliage

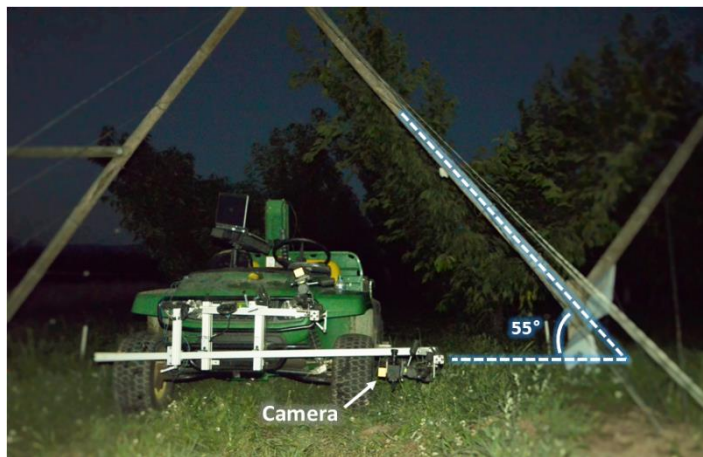- Low branch visibility

Gao et al., 2014

Karkee et al., 2014

Experiment Setup

Imaging setup for vertical trellis system

Imaging setup for Y-trellis system

Test Orchards

- Vertical trellis system
- Y–trellis system

Imaging sensors

- Bumblebee ® XB3 (Point Grey Research Inc., B.C., Canada) – RGB
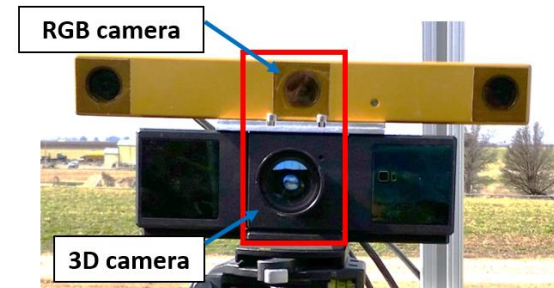- Cam Cube 3.0 (PMD Technologies) – 3D
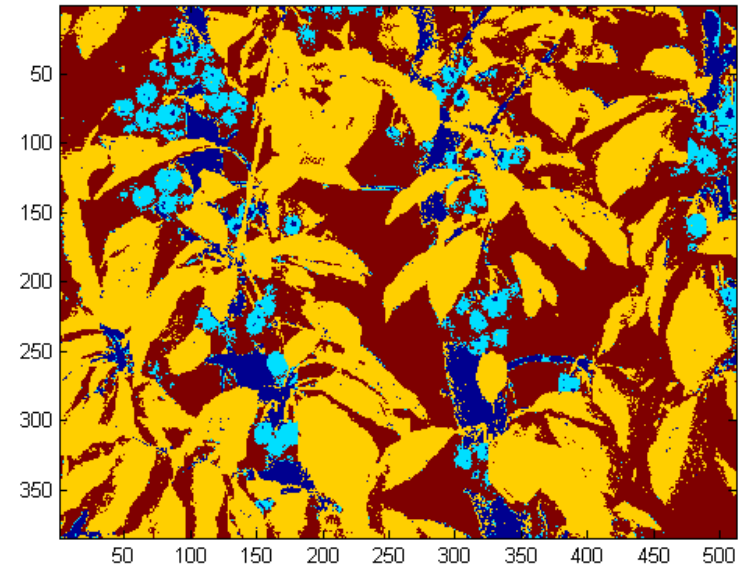
Night time imaging

Image Segmentation

- Image pixels classified into four groups
  - Branch, cherry, leaf and background
- Bayesian classification method used for image segmentation
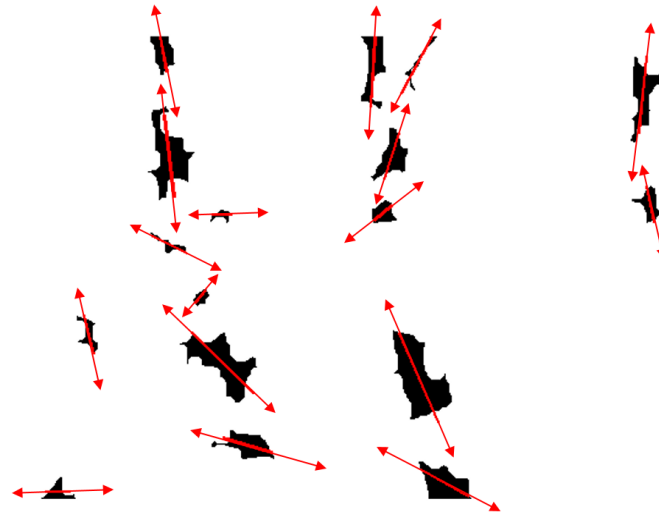

Original Image
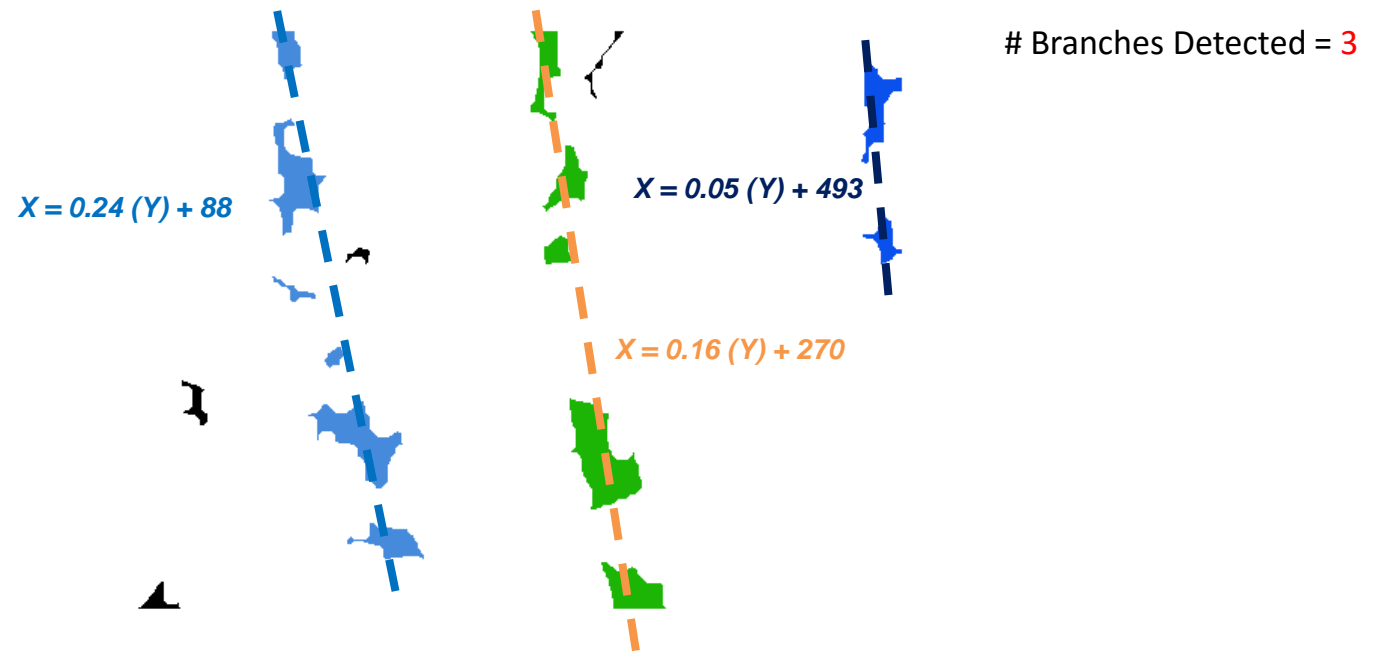

Segmented Image

Branch Detection Algorithm

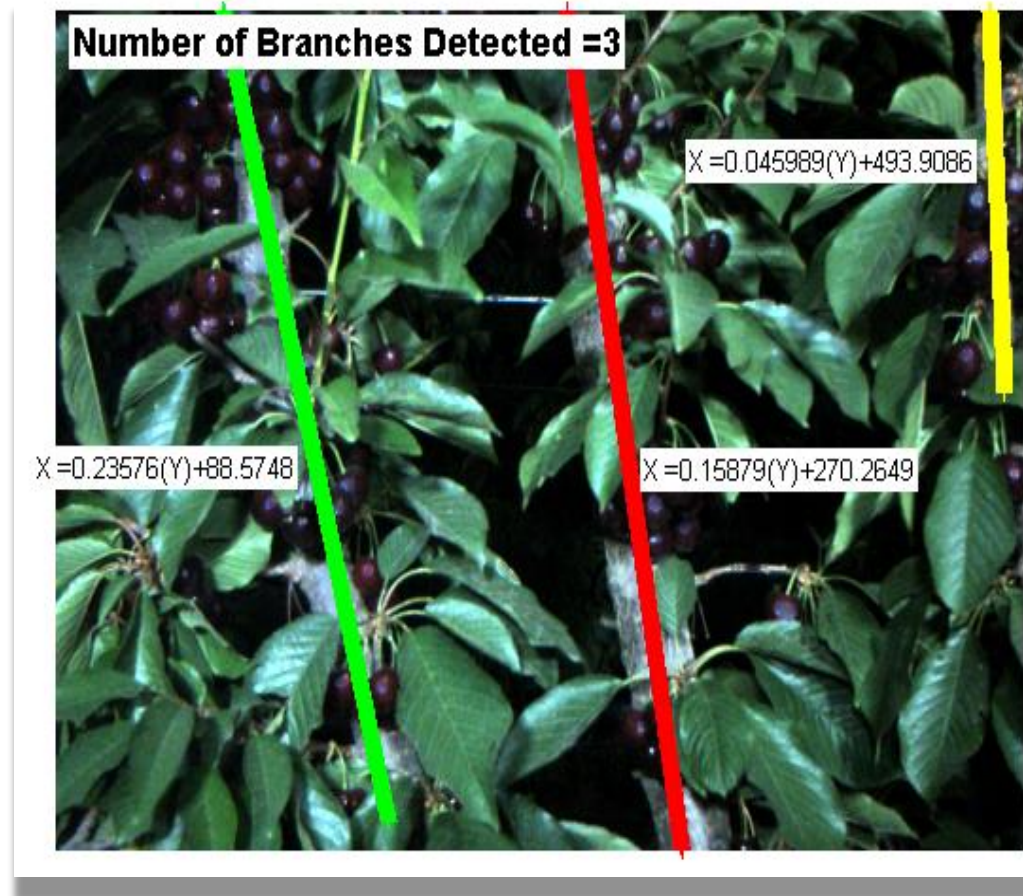Geometric properties of branch segments
– Orientation, Major Axis, Minor Axis

Branch orientations

Branch Detection Algorithm

Branches Detected = 3

$X = 0.24 (Y) + 88$

$X = 0.05 (Y) + 493$

$X = 0.16 (Y) + 270$

Branch Detection Algorithm

Number of Branches Detected = 3

$X = 0.045989(Y) + 493.9086$

$X = 0.23576(Y) + 88.5748$

$X = 0.15879(Y) + 270.2649$
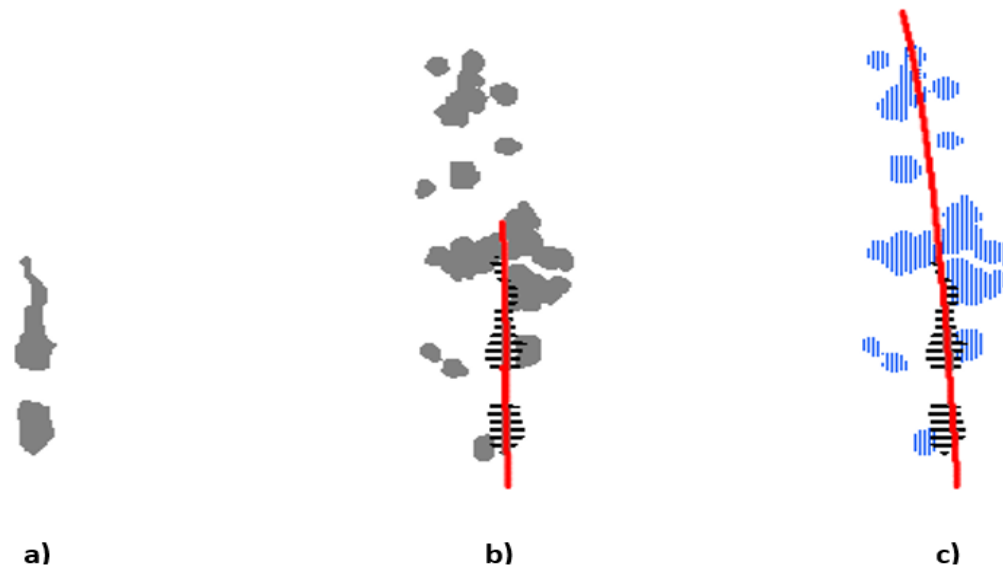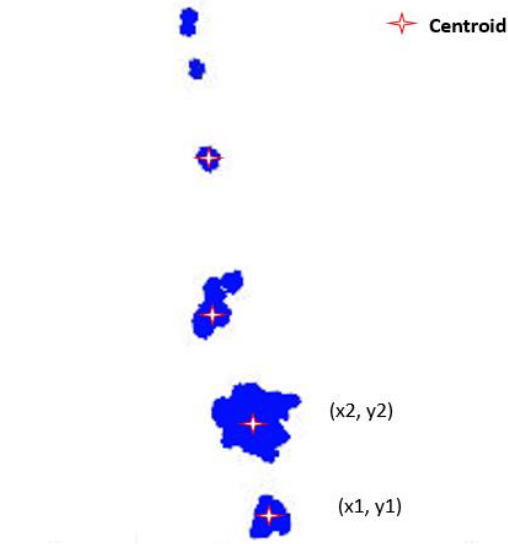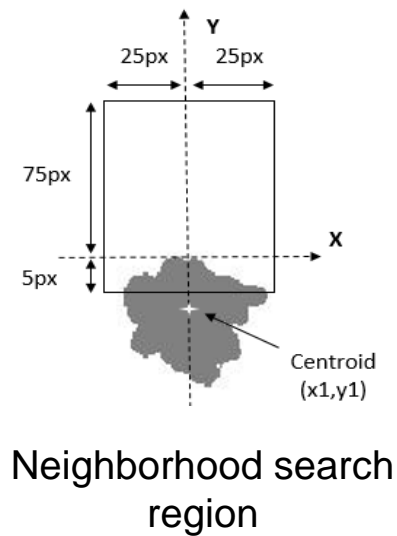
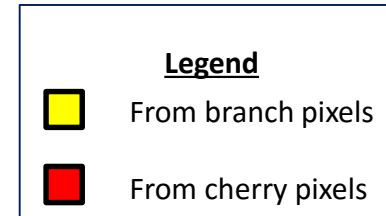# Branch Detection Algorithm

Fig. a) Segmented branch; b) Detected branch and segmented cherry region; c) Improved branch trajectory by integrating cherry regions

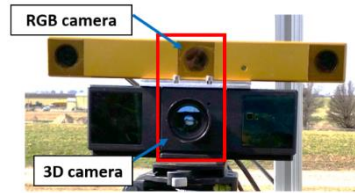# Cherry Based Branch Detection

Neighborhood search region

Segmented cherry clusters

Branch Detection Example

3D Branch Reconstruction

Original Image
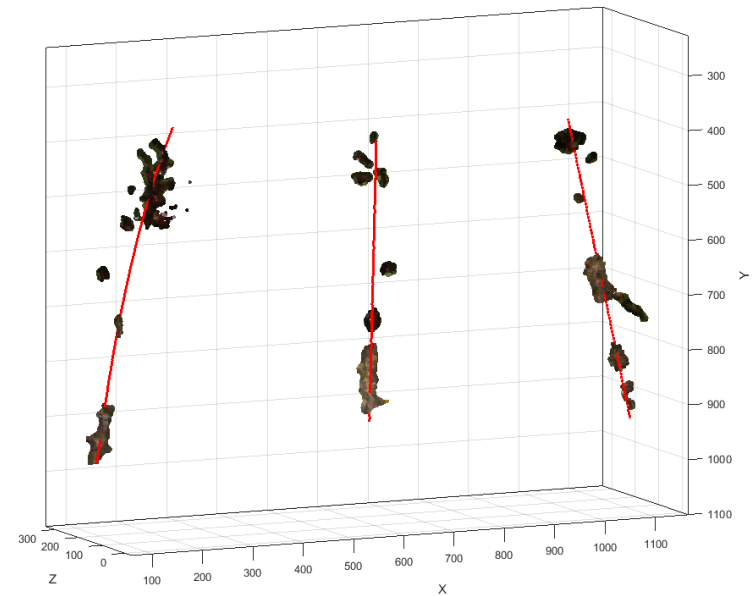
3D Reconstructed Branches

Results: Detection Accuracy

		Actual	Detected	False Detection	True Detection	Undetected
Vertical	No. of Branches	453	477	73	404	49
	Percentage (%)	100.0%	105.3%	16.1%	**89.2%**	10.8%
Y-trellis	No. of Branches	453	481	56	425	28
	Percentage (%)	100.0%	106.2%	12.4%	**93.8%**	6.2%

Harvesting Test

Table: Result of manual cherry harvesting on detected branches

	Harvested	Not Harvested	
		Within FOV	Beyond FOV
Weight (lb)	306.7	12.0	9.4
Percentage	93.5%	3.7%	2.9%

FOV = Field Of View

- 93.5% of cherries were successfully harvested

- 3.7% cherries within camera's view was not harvested

  – Because of occlusion by foliage or ineffective energy transfer

- 2.9% cherries were below camera's view

  – Cherries on horizontal limb

Conclusions

- Branch detection within full canopies is essential for developing robotic harvesters
- Branches with full foliage can be detected using morphological features
- In addition, Integration of detected cherries can improved detection accuracy
- Overall 91% branches were detected
- 93% cherries were harvested by shaking branches detected by this method
- Fully automated harvesters can be guided using machine vision

Thank You