Agricultural Robotics:
Opportunities, Challenges and Perspectives

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Agriculture in State of Washington
Many types of crops

- More specialty crops than grains
- Varies from herbs to trees
- Many big farms but small industry

Crop specific operations

- Wide variations in operations
- Interfering differently with crops
- Many are highly labor dependency

Varying levels of mechanization

- Fully mechanized with precision
- Mechanical assist operations
- Still rely on manual labor now
WSU Center for Precision & Automated Agricultural Systems

Mechanization & Automation For Specialty Crop Production

Productivity

Quality

Sustainability

Profitability
Growing opportunity for Ag. robotics due to:

- Increasingly pressure on labor shortage in agriculture.
- Continuously losing experienced workforce for skill-dependent tasks.
- Most field operations are highly repetitive.
- Many field operations are highly seasonal with a small time window.
Challenges for Agricultural Robotics

Operating in natural environment and handling biological materials often cause:

- Inconsistency and/or unpredictable changes in environment (grounds, lights, weathers)
- Interactions with randomly grow deformable plants
- Damage sensitive to interactions and/or impacts
- Multiple operations of complicated actions
- Objects are sometimes hard to distinguish
- Used by inadequately educated workforce
- Specific and small market
Examples of Agricultural Robotics

A few research projects on developing robotic solutions for Ag productions:

- High-trellis twining robot
- Apple picking robot
- Fruit shaking harvest robot
- Bin managing robot
- Vegetable weeding robot
- Asparagus harvest robot
- Smart spraying robot
- UAS bird deterrence robot
Example 1: High Trellis Twining Robot

**Major Challenges**

- Requires for special string and knot for PNW windy environment
- Tie on “infinitive” long cable, none similar mechanism usable
- Very large number of knots (>10,000/ha) done in a short time window
- Operating at a high elevation on unprepared ground surface with wind
Our Solution

Mimicking human hand to make a clove hitch knot tying
Example 2: Robotic Harvest of Apples

Major Challenges

- Randomly oriented, variable size, and unevenly distributed
- Blocked by leaves, branches/limbs causing poor visibility & accessibility
- Operating on unstructured environment with all kinds of disturbances
- Fruit quality VERY sensitive to **excessive** force
Three Steps in Typical Apple Harvest

“See” it:
- Detect it - find mature fruits
- Locate it - guide to reach them

“Pick” it:
- Grasp it - gently & securely hold fruits
- Remove it - detach them from the tree

“place” it:
- Release it - discharge picked fruit
- Deliver it - place them in container (bin)
Challenge 2 - Difficult to See All
Challenge 2 - Picking-Induced Bruising

Different grasping and picking pattern requires different amount of force being applied on an apple, and such force could cause substantial bruising if excess a threshold value (varies for different varieties).
Challenge 3 - Long Cycle Time

Operator-assistant mechanisms are available to be modified for supporting faster robotic picking
Shaking-Catching: A New Concept

- Shaking energy - location, frequency, amplitude, tree structure
- Shaking pattern - direction and distribution of detached apples
Robotic apple harvest is a system, the **Cannikin Law** works here!

Currently managed by a human operator, and required to be able to autonomously support a picking robot to bring empty bin to the site and remove the filled bin from the harvesting zone.
Our Solution - Make Trees Robot-friendly

- Complex system (4D)
  need high degree of skill
  Wide range of size quality

- Simpler (3D)
  Improved quality
  Apply existing technology

- Simplest (2D)
  Ability to be market specific
  New & existing technologies

More Suitable for Robotic Harvesting
Example 3: Robotic Target Application

~33%

~10%

<3%
Example 4: Robotic Asparagus Harvest

- A concept-proof machine fabricated and tested in field
- Core Technology: whole spear selective robotic harvesting.
- Operations: detect spear(s); engage cutter wheel(s); capture/cut spear(s); & deliver and release harvested spear
Major Challenge to Improve Efficiency

- Low harvest efficiency attributed to low accessibility, which is caused by:
  - random growing pattern
  - non-uniform maturity.

A. Single spear
B. Occlusion
C. Adjacent (different size)
D. Adjacent (similar size)
Capable technology been developed, prototype fabricated and validated, but the industry is almost gone!

Robotics R&D for special crop production - need do it now!
One More Challenge to Ag Robots
Robotics could be the solution!

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