

How can robots help greenhouse growers today?

What is robotics in Ag? Takes many forms...

A recent success in Ag robotics:



Blue River Technologies sold to Deere for \$305M
Weeding and thinning lettuce

Today's Robots

Narrow robotic capabilities or structured environments

Industrial Robotics (82%)

- \$17.5B total worldwide market value
- strong adoption: 70% automotive & 26% electronics



ABB Power and productivity for a better world™



FANUC Robotics

Service Robotics: Professional (15%)

- \$3.2B total worldwide market value
- 45% defense & 30% field (Ag: milking robots), 14% medical



iRobot



LELY

innovators in agriculture

Service Robotics: Personal (3%)

- \$538M total worldwide market value
- 66% domestic & 34% entertainment



iRobot



LEGO



Robomow

Market numbers several years old

Automation and Mechanization in Horticulture

- Climate and Other Controls (water, energy, data, etc.)



- Food Processing Equipment: packaging, sorting, etc.



- Fixed Conveyance



Our focus at Harvest Automation is on robots that:

- ***Do physical work***
- ***Make complex decisions for sophisticated tasks***
- ***Work in 'mostly' unstructured environments***

Because that's where most Ag labor is

Key components in advanced robotics development

Structure and Human Collaboration

Structured



Unstructured



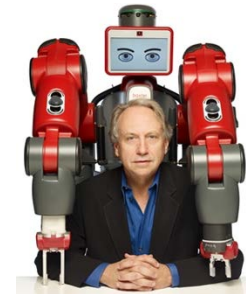
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KIVA Systems



AETHON



rethink
robotics.

Isolation



Collaboration

Low Ag labor



High Ag labor

Low robot cost



High robot cost

Robotics is the right solution for Ag labor, but there are challenges

Robots in unstructured environments w no price limit



video

DARPA Robotics Challenge



The biggest and most well-funded international robotics competition in years was a failure.

2015 Popular Science Magazine

The big challenges new robots face; part 1

The balance of cost and capability

- Expectations and Needs: fantastic machines with human-like skills



- Economics: component costs are trending down, but still VERY high

- Result:

what customers
want and need



expectation

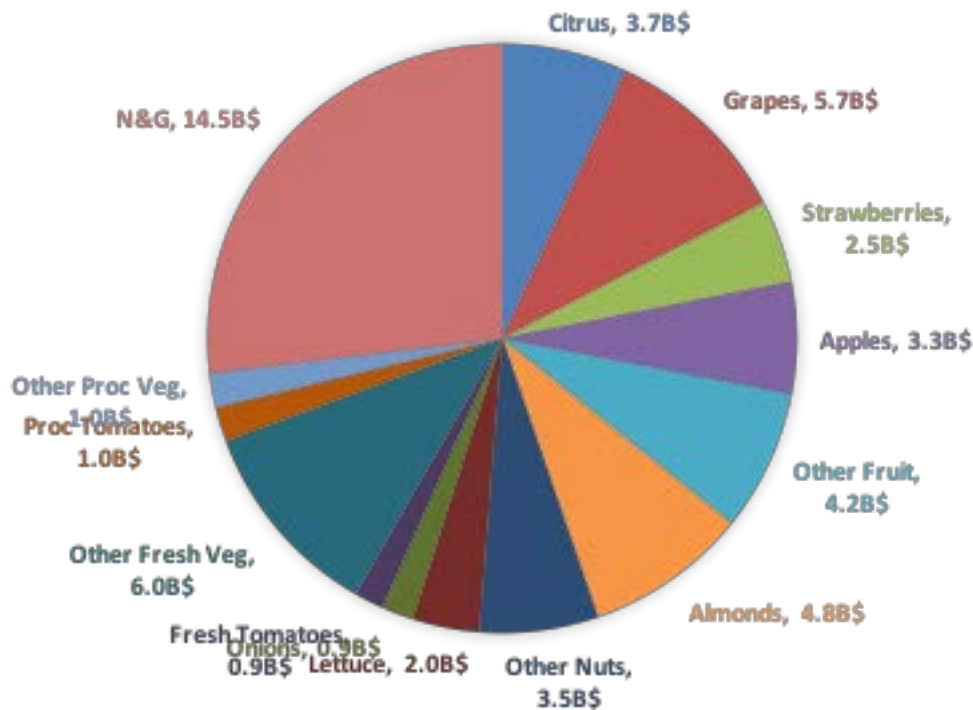


reality

what we can build for
a price customers
will pay

The big challenges new robots face; part 2

Development costs outpace market potential



US Specialty Crop Values
2012 - \$50B

- Robots must be very task specific to meet cost targets
 - Grape robot \neq Strawberry robot
- \$1M development cost must = \$10M projected annual sales
 - Investor \$ all in data, AI, IoT, etc.
- Outcome: funding beyond early research is hard to secure

What's here today and in development in Ag robotics?

By no means an exhaustive review, especially regarding projects in development

Advanced automation in structured hort settings



video



video



Harvest Automation ~ HV-100 Plant Handling Robot



video

HV-100 in Action ~ Greenhouse Customers



<https://www.youtube.com/user/harvestai>

HV-100 in Action ~ Greenhouses



video

HV-100 in Action ~ Nursery Customers



HV-100 in Action ~ Nurseries



video

Naio Technologies ~ Oz Weeding Robot



Vineyard and vegetable weeding robots in development

Priva Kompano Deleafing Robot



Commercial status unknown

Vineland Research and Innovation Center

Multiple project ongoing



Augean Robotics 'Burro' ~ in Development

- Bulk carrier – 300 to 450 lbs
- Can follow a person and retrace a learned path
- Development plans uncertain



This application could represent a great balance between capability and cost

Field Robotics ~ in Development



BoniRob

planting, weeding, etc.



Rowbot

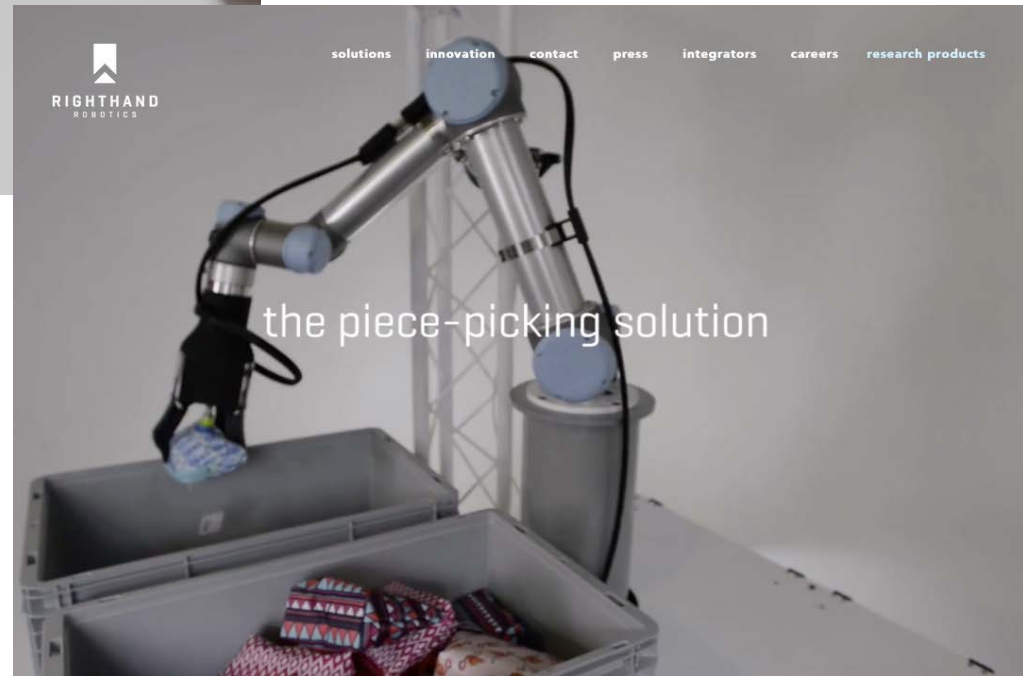
in-season nitrogen
management

Agrobot

pick strawberries



Smart Graspers ~ in Development



HAI Ongoing New Application Development

- **Poultry:** tasks relating to animal health and house maintenance
- **Dairy:** controls system for automated hay bail collection
- **Grapes:** harvest collection
- **Cannabis:** handling potted plants
- **Select Vegetables:** growing crops in containers instead of ground
 - Reduces inputs
 - Instant organic
 - Grow anywhere / local
- **Ornamental Horticulture:**
 - Automated fertilizing
 - Moving trays of potted plants

Conclusions

- Current suppliers of 'classic' automation provide a wide variety of solutions for greenhouse growers
- Robots with advanced skills to tackle the vast majority of Ag labor 'in the wild' remain very challenging

Thank you

*Charles Grinnell
Founder and CEO
Harvest Automation, Inc.
charlieg@harvestai.com*