WHEN FIELDS AND MACHINES COEXIST IN CYBERNETIC GRACE*

ROBOTS BECOME PART OF THE CYCLE OF PLANT LIFE

For most of human history, people have worked directly with the soil and their plant crops. With the advent of modern precision agriculture and mechanical, electrical, and computational engineering, humans have taught machines to perform, the most tedious, strenuous, and meticulous of tasks. In the next decade, we will see robots become more tightly integrated into natural growing cycles, helping both plants and humans to increase performance and versatility in the fields.

FARMING

UNDERSTANDING HUMANS: Agricultural Judgment

In order for robots to care for living fields through complete seasonal cycles, the machines will need to learn human capabilities—to continuously evaluate field and crop conditions in order to perform the right actions at the right times. The same goes for robotic fields with embedded, automated functions, like digitally controlled watering. Developers worldwide are teaching robots to make subtle agricultural judgments that only humans could make in the past.

Source: http://spectrum.ieee.org/automaton/robotics/robotics-software/vision_robotics_down_on_the_fa

Orange-picking device

Robots from Vision Robotics pick only ripe oranges. One scans and maps each fruit, while a second follows and picks identified fruit.

Source: http://precisionpays.com/2009/08/precision-agriculture-robot-style/

Herbicide application

Small robots can distinguish between good and bad plants to direct a detergent spray; on weeds with such high precision that they avoid touching the crop itself.
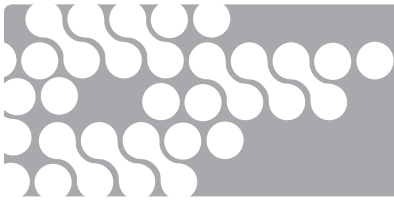

Source: http://www.roboticharvesting.com/products.html

Strawberry harvester

A self-propelled, self-navigating harvester from Robotic Harvesting is capable of picking only ripe strawberries.

THE FUTURE OF HUMAN-MACHINE INTERACTION

AUGMENTING HUMANS: Helpers in the Field

Robots are becoming performance amplifiers, giving on-the-ground agricultural workers more power, precision, and versatility in optimizing crop yields. Humans have long used machines like tractors to increase food production field by field. Now intelligent robots are extending human capabilities to ultimately increase food production meter by meter, plant by plant.

Source: http://www.jorymon.com/robotic/agriculture-robot-by-shigeki-toyama/

Robotic suit

The Tokyo University of Agriculture and Technology developed a robotic suit to help with tough agricultural work like pulling radishes because about 40 percent of agricultural workers in Japan are age 65 or over.

Source: http://blogs.warwick.ac.uk/jaffers/entry/research/

Robotic lawnmower

Warwick Automation Research group is creating an autonomous robot platform that can be adapted to perform specific tasks like keeping a golf course cut and helping farmers with pasture management.

AUTOMATING TASKS: Fields as Factories

Humans are already using location-aware, autonomous robots for the most tedious, strenuous tasks in the fields, like plowing large fields into perfect rows. As onboard computational and networked intelligence increases, people are beginning to use robotic machines for tasks requiring instant judgment and meticulous dexterity. In the future, networks of sensors and robotic devices promise to bring farms ever closer to managing themselves.

Autonomous tractor

A field robotic prototype of an autonomous tractor from John Deere shows that removing the constraints of onboard human operators can lead to revolutionary designs of current systems.

Source: http://www.deere.com/en_US/careers/midcareer_jobs/field_robotics.html

Gardener robot

An autonomous gardener robot being developed at MIT's Computer Science and Artificial Intelligence Laboratories is equipped with a dexterous arm, a "hand," and a watering mechanism. It will be able to distinguish and pick ripe produce, water, or pollinate plants.

Source: http://www.gizmag.com/robotics-sustainable-precision-agriculture/11326/

FORECAST

By 2020 to 2025 we will begin to see the first generation of nearly fully automated smart fields, tended by highly intelligent mobile robotic machines. The fields and their robot tenders will be cooperatively capable of precise, contextual sensing and interaction with living crops and soils. The robots on top of the fields, embedded field robotics, and crop plants will move through the seasonal cycles in linked symbiosis, assisted by machine intelligence that processes real-time data from onboard and embedded sensors, and from external data streams and the Internet.

(1) Increasing versatility

Although agricultural task requirements are quite variable across growing cycles, agricultural robot manufacturers will build a variety of devices to work both independently and in tandem to perform an expanding range of farming tasks—from preparing and maintaining soils to planting and maintaining crops and harvesting.

(2) Smart fields

Fields will become smart with active robotic infrastructures of embedded sensor networks, processors, and actuators. Dynamic, automated fields will process stored data such as hyperspectral crop health imagery (special aerial images where sensor data is shown in colors to indicate variations in crop health or soil conditions) and real-time sensor data

about soil and plant conditions. Embedded actuators (for example, in special irrigation systems) will initially be used to treat precise zones forwatering, soil nutrition, and pest control, and later will perform more complex tasks (for example, physically adjusting individual fruits on a tree to optimize solar exposure).

(3) Symbiotic interaction between intelligent robots and smart fields

Over time, technologies for wireless communication, sensing, and computation will be combined in agriculture for large multiplicative effect. Mobile robots and embedded sensor/actuator networks will work together symbiotically to automate a wide scope of tasks in fields of row crops, pastures, and orchards.

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Robots will relieve humans of the most tedious, strenuous, and difficult jobs in growing food and will ultimately be able to make complex real-time decisions resulting in higher yields of healthier crops. Ultimately, machines may be able to make more precise and better judgments than humans. Finely tuned agricultural robotics will eventually allow humans to manage crop cycles more sustainably by continuous automated application of the best scientific farming practices. The net result of these developments is that fewer humans will be required for stoop labor. Initially large-scale industrial farmers will benefit most, but later as manufacturing economies of scale increase, even individual farmers will be able to afford sophisticated robotic assistance in optimizing the crop production in their fields.

RESOURCES

- UniBots.com is an agricultural robotics portal and a good place to start learning about development of agricultural robots around the world. **http://www.unibots.com**

- Another good starting place to learn about agricultural robotics is Wikipedia. **http://en.wikipedia.org/wiki/Agricultural_robot**

- "Agriculture, Natural Resource Management, and the Environment" on the Artificial Intelligence Topics site is an extensive survey of agricultural robotics research and development projects. **http://www.aaai.org/aitopics/pmwiki/pmwiki.php/AITopics/Agriculture**

- The Precison Pays site offers news and information about precision agriculture from around the globe. **http://precisionpays.com/**

- Agriculture.com is another source of news from around the world covering all aspects of farm management and technologies. **http://www.agriculture.com**