Horticulture Meets Automation in the Plant Factory -- Robotization in Plant production --

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The most desirable operation for automation

- Seedling production
- Plant management
- **Harvesting**
- Pre-Processing
- Grading and Packing

(Commercialized robot)

- Transplanting robot
- Grafting robot
- Cutting sticking robot
- Robotic sprayer

Pre-processing machines for fruits and vegetables
Fruit grading robot system
Seedling production

Transplanting robot (Visser, Netherland)

Grafting robot (BRAIN)
Plant factory and Greenhouse

Fully Automated Plant Factory
(Kyushu Electric Power Co., Ltd.)
The First Fruit Harvesting Robot was developed in 1982 by Kawamura et al., at Kyoto University.

The tomato harvesting robot consisted of:
- a 5 DOF manipulator
- a harvesting end-effector
- a stereovision (color camera)
- a travelling device (battery car).

Following the robot, robotic technologies were applied to cherry tomato, strawberry, cucumber, eggplant, cabbage, mushroom, orange, apple, grape, melon, watermelon, asparagus and etc.
Fruit harvesting robots in greenhouse

- Cherry Tomato (Osaka Pref. U)
- Cucumber (IMAG, Wageningen)
- Tomato (Okayama U)
- Lettuce (Shimane U)

Many robots were developed in 1980-1990s
Mushroom harvesting robot (Silsoe, UK)
Individual leaf harvesting is difficult.

Perilla Leaf Production on Table Top Culture
Difficulties on commercializing harvesting robot

1) Slow operation speed (1/3 or less)
2) Expensive cost (3 times or more)
3) Necessity of changing plant training system and cultivation method (Systematization of production)

→ Not commercialized yet so far

+ Information from robot’s sensors
  3D location of product, Harvesting time & date, Crop ID, Fruit Size, Color, Defects
Perilla Leaf Sorting Robot System

(Shibuya Seiki Co., Ltd.)
Managing operation

(Sera-Saien)

Grading and Packing System in Tomato Greenhouse
Fruit Grading Robot System with Traceability (Shibuya Seiki Co., Ltd.)
Constitution of robotic grading system
History of Agri-robot Researches

Agri-robot I (Since 1982, for ten years)
- Adoption of industrial robots
- Investigation of robot mechanisms based on plant properties

Agri-robot II (Since 1992, for ten years)
- Fusion between horticultural and engineering approaches
- Construction of fundamentals of relation “Human-Plant-Robot”

Agri-robot III (Since 2002)
- Precision Agriculture oriented robot
- Product information addition, accumulation, and utilization

Agri-robot IV (Since 2012)???
- Human health oriented robot
- Aged producer supporting robot
- Support of environmental conservation

By Kondo
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Desirable Horticultural Approaches from Engineers’ View Points for Automation of Harvesting Operation

1. Variety selection & breeding
   1) simultaneous maturing
   2) longer peduncle
   3) appropriate fruit size and number
   4) dwarf variety

peduncle

Biological potential

1.5 m
Desirable Horticultural Approaches from Engineers’ View Points for Automation of Harvesting Operation

2. Plant training system and cultivation method
   1) separate fruits from leaves and stems
   2) similar height (position) of fruits
   3) operation addition for helping robot (e.g. fruit thinning, leaf removing operations)

Physical potential
STTPS at Rutgers Univ.
Tomato Cluster Harvesting Robot

Kyoto U
MAFF
Inclined Trellis Training
Trellis Training System for Grapevine

Okayama U
A new model of strawberry harvesting robot on table top culture
3. Chemical control
(Gibberellin, growth retardant)
1) make peduncle longer
2) dwarfing
3) make easy-detach joint in peduncle
Conclusion

to develop harvesting robots for practical use

Challenging development of
1) cheaper and higher efficient robot (Engineering approaches)
2) adapting diverse plants’ properties (Engineering approaches)
3) in standardized plant conditions with variety selection, training systems, and chemical controls (Horticultural approaches)

Especially, morphological plant feature change such as separation of fruits from others, uniform shape, and easy handling size plants by Biological, Physical, and Chemical methods would be more discussed between horticulturists and engineers for automation in plant production.
Thank you

Discussions
Agricultural Robots
Mechanisms and Practice

Edited by Naoshi Kondo, Mitsuji Monta, and Noboru Noguchi

Kyoto Univ. Press, 2011

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Roles of Agricultural robots

To Substitute labor and workers
To Release from heavy, dangerous, or monotonous operations
To increase market value of product,
To produce uniform products
To make hygienic / aseptic production conditions
To give successors a hope for economic sustainability of small high value farm operations

+

Record of agricultural operations and accumulation of product information as precision agriculture oriented robots
An Evolved Grading Robot

Top cameras

Side camera

Bottom camera

Yonjiu, Korea