A New Challenge of Robot for Harvesting Strawberry Grown on Table Top Culture

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Strawberry harvesting robots

For Table top culture  For Annual hill culture
Problems in practical use from previous experimental results of strawberry harvesting robot

Similar operation speed with human (3-10 seconds per fruit)
Inferior accuracy (50% of attempts included immature fruits)

Reason of only labor substitution on harvesting does not strike producers for purchasing the robot!
Because grading and packing operation is much more laborious.
Roles of Agri-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

Precise operation record
Product Information accumulation
Use for safety food and farming guidance
Results Questionnaire to Producers

Do you need the harvesting robot?
- No need: 26.1%
- Necessary in future: 29.2%
- Want to get: 6.5%
- No reply: 2.1%

Do you require the robot 100% harvesting?
- Robot and human share: 69.4%
- Totally robot harvest: 16.8%
- No reply: 13.7%
Results Questionnaire to Producers

Expectation to robot’s success rate

Price of robot

- Number
- Expectation to robot’s success rate
- Price of robot

- Number
- Expectation to robot’s success rate
- Price of robot
Do you change plant training system for the robot?

- Use robot with change: 17.9%
- Use robot without change: 52.9%
- Not use if change: 23.7%
- No reply: 5.5%

Do you change plant variety for the robot?

- Use robot with change: 12.4%
- Use robot without change: 58.8%
- Not use if change: 17.2%
- Others: 6.2%
- No reply: 5.5%
**Change of product appearance**

**Do you change into fruit with peduncle for the robot?**

- Use robot with change: 31.3%
- Use robot without change: 32.3%
- Not use if change: 17.9%
- Already shipping fruit with peduncle: 10.3%
- Others: 3.8%
- No reply: 4.5%

**Do you change fruit packing for the robot?**

- Use robot with change: 39.2%
- Use robot without change: 33.0%
- Not use if change: 14.8%
- Others: 7.2%
- No reply: 5.8%
Do you need the grading robot (packing robot)?

- May use in future: 25.8%
- No need: 15.5%
- No reply: 4.5%
- Want to use: 13.7%
- Better to use: 40.5%

Expectation to grading robot

Price of the grading robot:

- < $10,000
- $10,000-20,000
- $20,000-30,000
- $30,000-40,000
- $40,000-50,000
- $50,000-60,000
- $60,000-70,000
- $70,000-80,000
- $80,000-90,000
- $90,000-100,000
- > $100,000
New concept of the harvesting robot

1. **Information accumulation** to contribute to traceability system and farming guidance
2. **Combination with grading and packing system** (Mobile grading robot)
3. **Multi-operation** (spraying, growth monitoring)
4. **Tailor-made-type robot** (company diagnoses producer’s production way and provides a fitted system)
Strawberry harvesting robot (1\textsuperscript{st} model)

\textbf{Robot constitution}
3 DOF manipulator
Sucking and cutting end-effector
Stereo vision by use of color CCD cameras
DL (Lighting devices) with PL filter
Rail type traveling device
Correspondence problem in fruit cluster

Un-Matched fruits
No.1, 3, 4
Exposure of fruit and peduncle
2nd model robot in plant factory
Problems and solutions for practical use from results of the new robot

Greenhouse specification is various (lack of uniform size, width, growing methods)
Standardization of surroundings
Construction of pilot greenhouse with robot

To add rail system for robot traveling to existed greenhouse is expensive rather than robot-self
Encouragement of laying rails when constructing greenhouse

Revolution of producers’ awareness and sense for the robotic and information agriculture
Never give up!
Never give up! Never give up! Never give up!

Enthusiasm

Strong WILL!

Solve the problem
Solve the problem
Solve the problem
Solve the problem
Advantages of development of strawberry harvesting robot

1. Small fruit growing range
2. Relative few obstacles (stems and leaves) around fruits
3. Easy fruit transportation due to small fruits.
4. Color CCD camera is usable to detect fruits because of red target fruit.
5. Changeable peduncle length