European Commission
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The EU Framework Programme for Research and Innovation
WAGENINGEN
UNIVERSITY & RESEARCH

Robot performance
SWEEPER results

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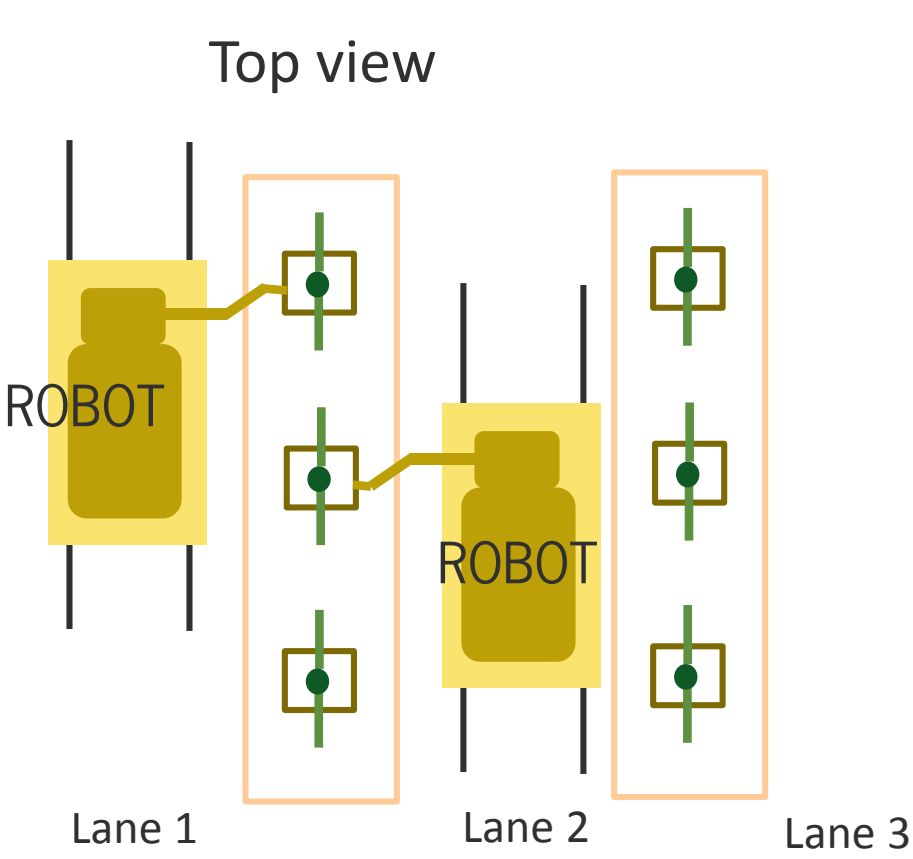
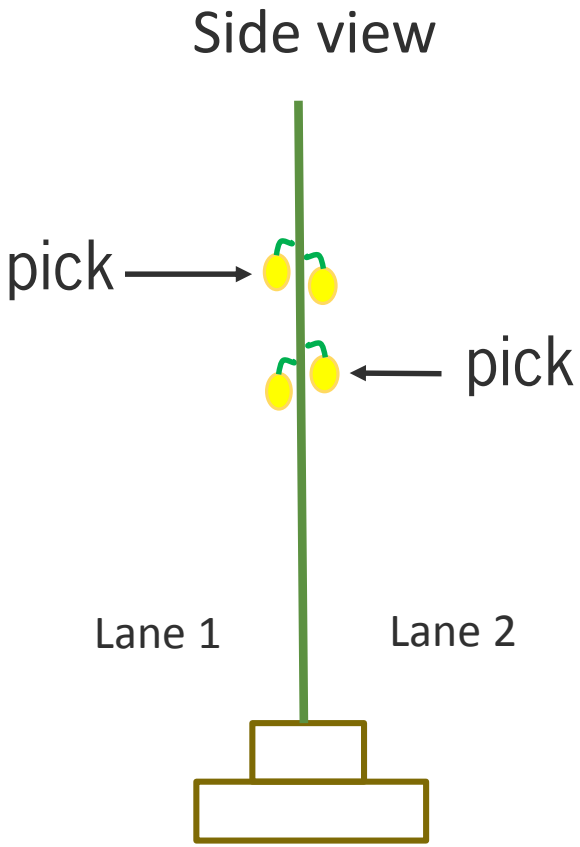
Sweeper

Growing system

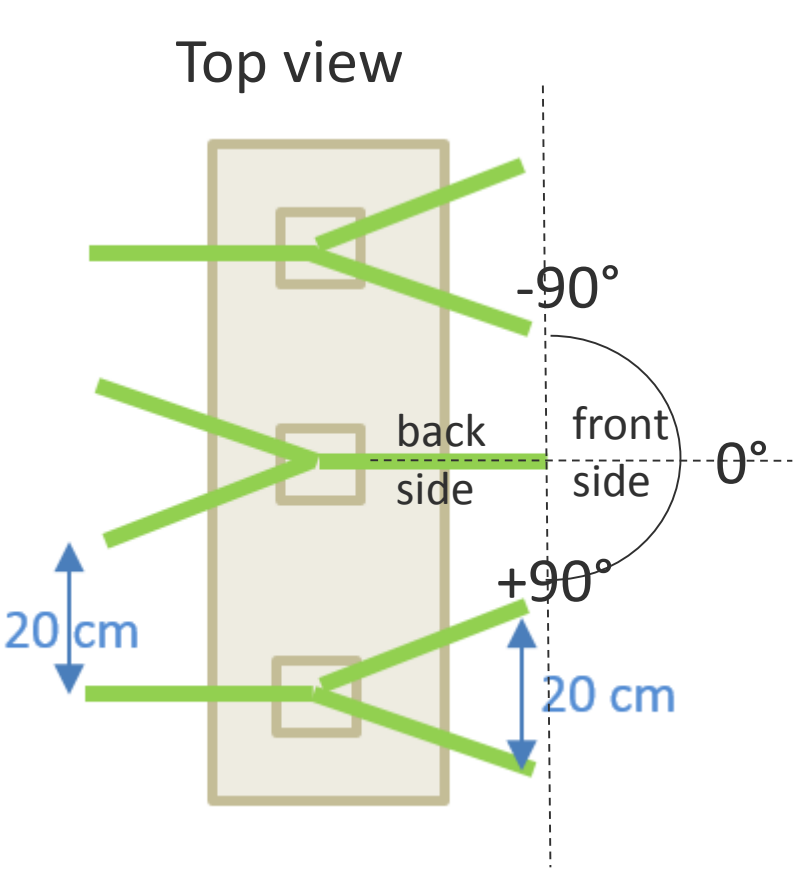
- SWEEPER robot was designed for a single row cropping system and pick from both sides of the plant

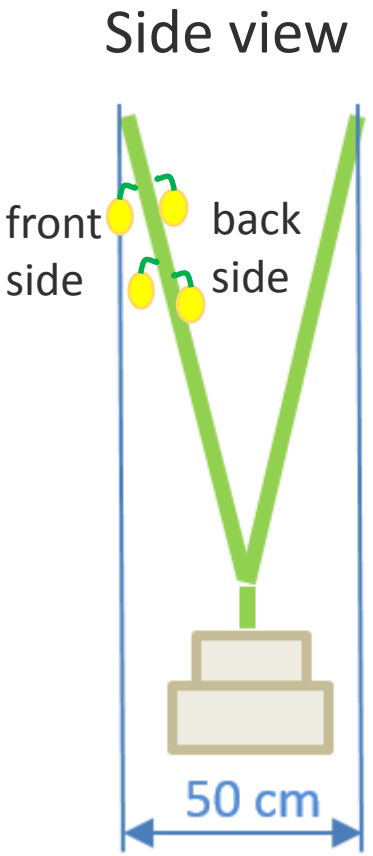




Growing system at “De Tuindershoek & PSKW”

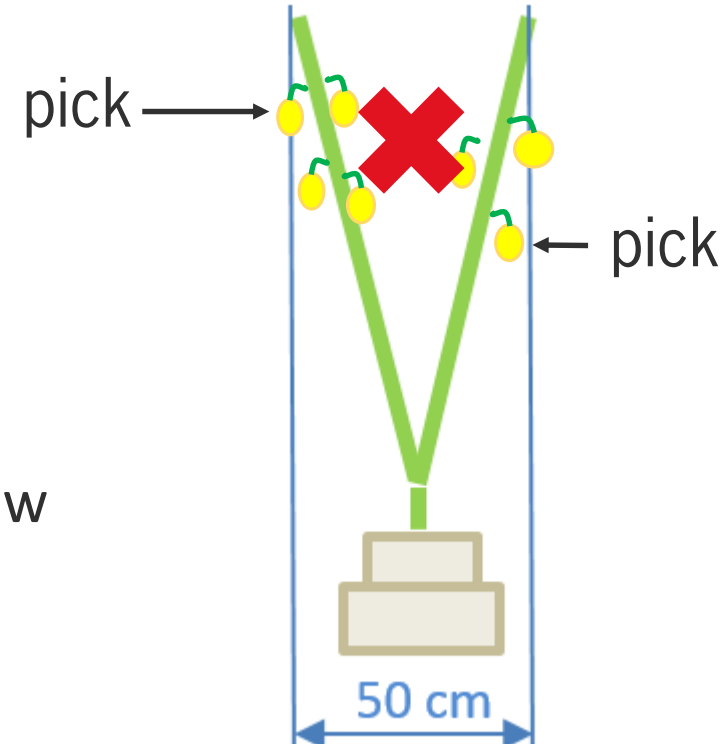
- V-system, double row, 3 stems per sweet-pepper plant





Growing system during experiments

- There was no single row system available for the performance experiments.
- However, we can also evaluate single row results by only taking into account the fruits growing on the front side of the stems.



Side view

Crop modifications

- Removal of fruit clusters
- Removal of leaves that largely occlude fruits

Results harvesting experiments

- **For single row growing system (when only fruits on front side of stem are evaluated) ***
  - **29% of ripe fruit were harvested in commercial crop.**
  - **61% of ripe fruit were harvested in modified crop.**

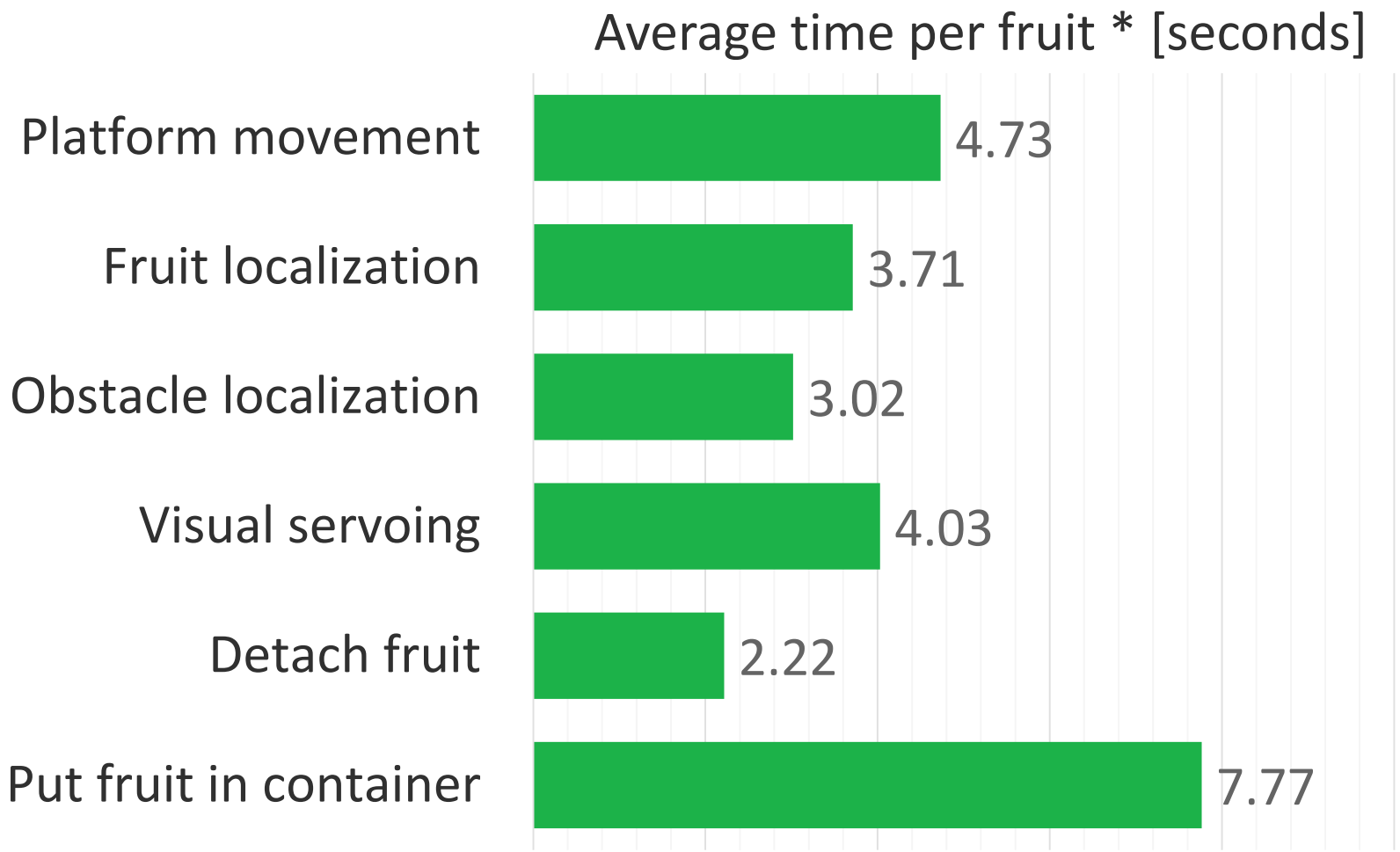
- For current double row growing system *
  - 18% of ripe fruit were harvested in commercial crop.
  - 49% of ripe fruit were harvested in modified crop.

* Pleased note that these numbers have been corrected in October 2018 after finalizing the data analysis.
In the earlier version of this document it was stated:

- For single row growing system (when only fruits on front side of stem are evaluated)
  30% of ripe fruit were harvested in commercial crop.
  62% of ripe fruit were harvested in modified crop.
  For commercial/current growing system
  20% of ripe fruit were harvested in commercial crop.
  49% of ripe fruit were harvested in modified crop.

Robot speed

- Average time to harvest 1 fruit: **24** seconds (18 to 25s)



* for one harvest attempt

Robot speed

- For safety reasons the robot was not operated at full speed during experiments.
- Laboratory experiments showed that it is possible to harvest one fruit in less than 15 seconds*.

* Excluding platform movement

Lessons learned in the 3.75 years project

- We made a big step !
  - 61% Success rate* and 4 times faster than CROPS
  - Market introductions requires higher performance

- We know of the major bottlenecks and further steps:
  - **Technology:** improving detection, reaching, cutting, catching, post-harvest logistics.
  - **Cropping system:** Single-row. Adopted growing system will increase success rate (e.g. fruit and leave pruning)
  - **Sweet pepper variety:** less clusters, better visibility (breeding)

- Pleased note that these numbers have been corrected in October 2018 after finalizing the data analysis.
  In the earlier version of this document it was stated: 62% Success rate

Direct (re)useable technologies and tools

- ROS-Software
  - Control of the robotic arm (path-planning)
  - Robot simulation tools
- 3D Vision detection system
- Obstacle detection (deep-learning)
- Fruit cutting mechanism (patent pending)
- Crop management practices for robotic harvesting
- Economic evaluation tool
- Integration in greenhouse logistic systems
- Use for other crops and applications

Future research topics

- Further technical improvements
  - cycle time, harvest success rate, fruit damage
- Deep-learning
  - Increase detection (also green peppers)
  - To support navigation in unstructured environments
- Human-robot collaboration
  - Robot-assisted human work, safety issues
- Combine robotics with plant breeding expertise
- Crop monitoring (added value)
  - Early detection of diseases/pests and crop quality/yield

Thanks

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VOOR DE GROENTETEELT

bogaerts
greenhouse logistics

de tuindershoek

www.sweeper-robot.eu

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Sweeper

Live demonstration

- Challenge to do so for a large audience.
- In the crop there is no space and a bad visibility.
- Because of safety issues – not close to robot
- We will show operating robot also live on screens.

Guidelines for going into the greenhouse

- Machine Safety Guidelines
  - A robot can make sudden and quick movements and it has an end-effector for cutting
  - Keep save distance from a working robot
  - Only trained people may operate the robot
- Stay on the concrete path (NOT INTO CROP ROWS)
- No food/drinks !
- Follow up instructions of personnel

Program

Info market in the main hall and live demonstrations

16:15 Group 1 live demo

(invited press only)

16:45 Group 2 live demo

17:00 Group 3 live demo

Info market

17:15 Discussion in the main hall

17:30 Food and drinks

18:00 Closure

European Commission