



HORIZON 2020



WAGENINGEN
UNIVERSITY & RESEARCH

The EU Framework Programme for Research and Innovation

Robot performance SWEEPER results

Jos Balendonck/Jochen Hemming

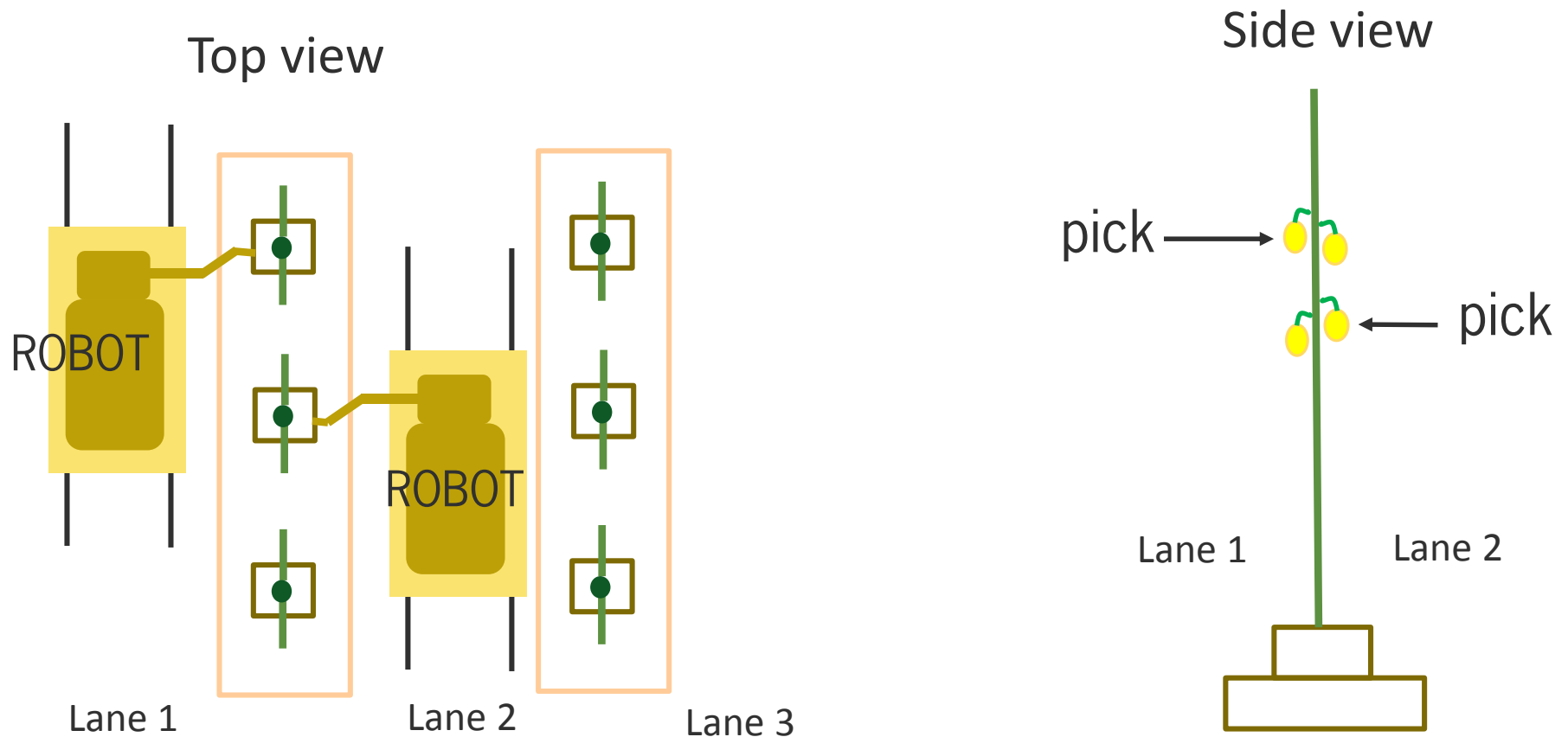
Wageningen University & Research, The Netherlands

Sweeper

A graphic element consisting of several curved lines in yellow, orange, and red, resembling a stylized 'S' or a brushstroke, positioned to the right of the word "Sweeper".

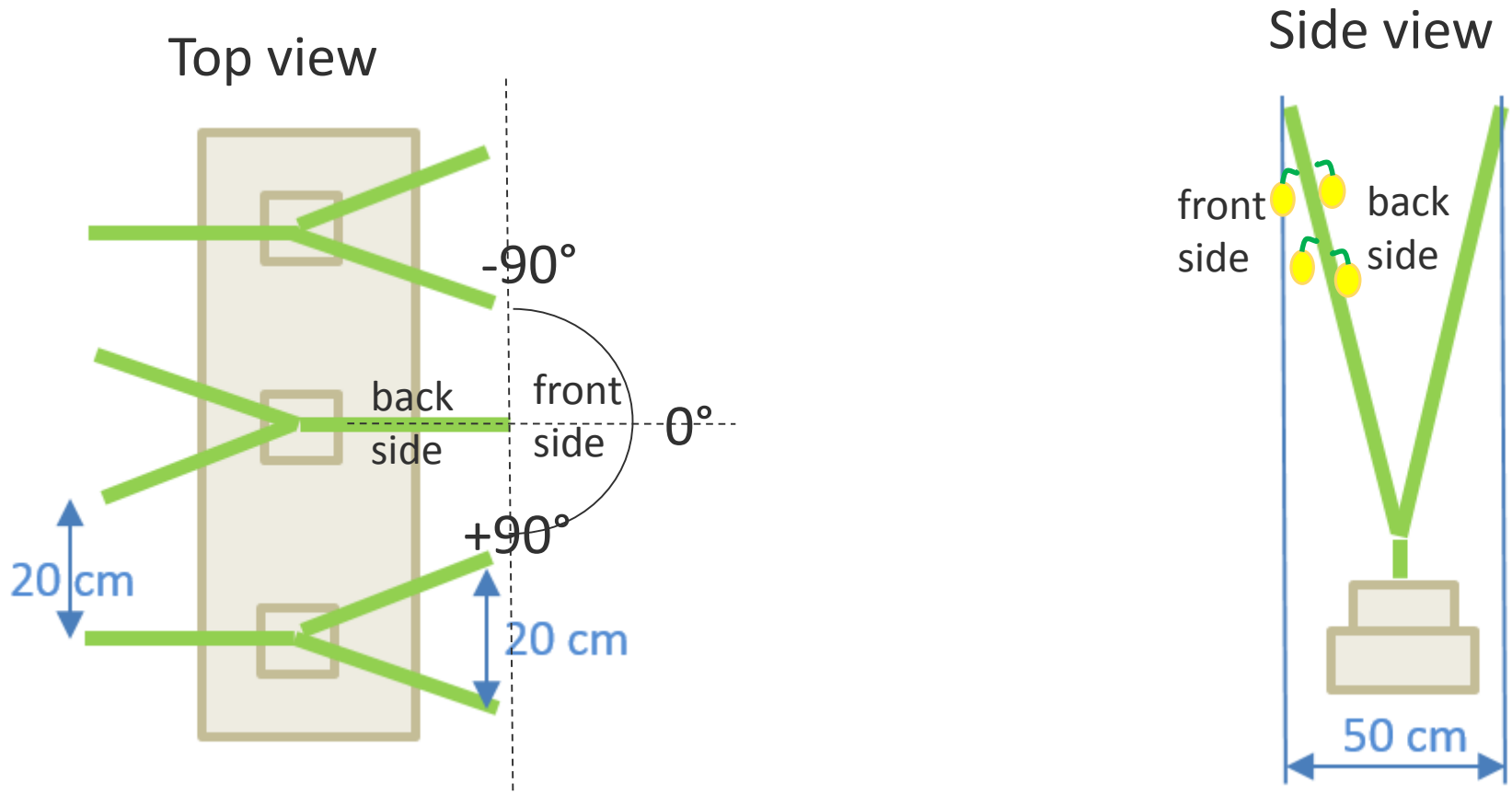
Growing system

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



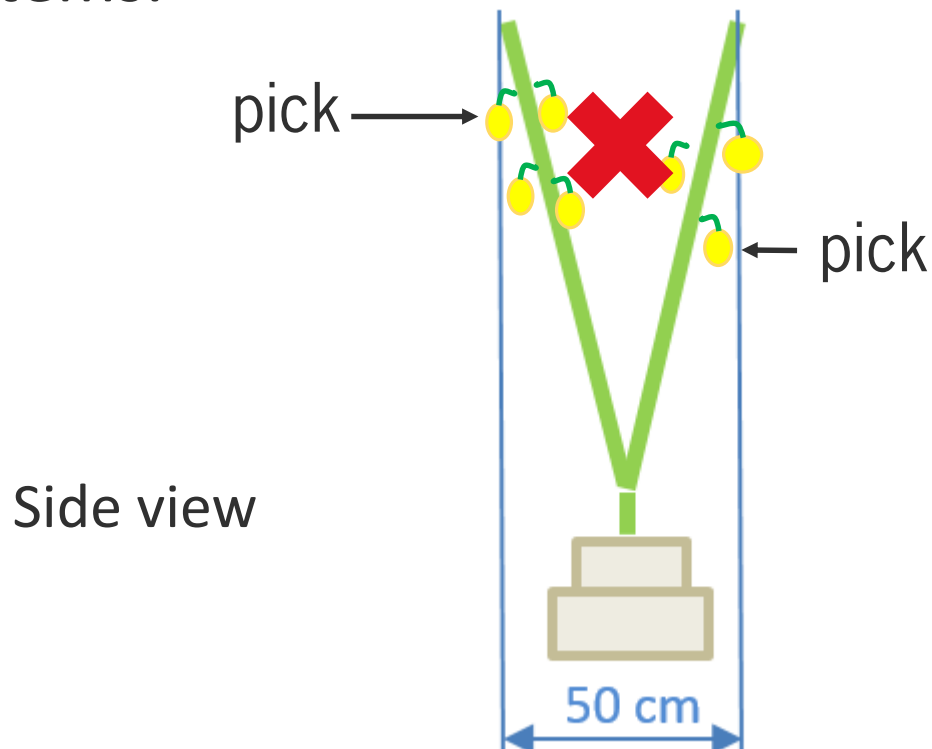
Growing system at “De Tuindershoek & PSKW”

- 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.



Crop modifications

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



Commercial crop



Modified crop



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.
 - 55% of ripe fruit were harvested in modified crop.

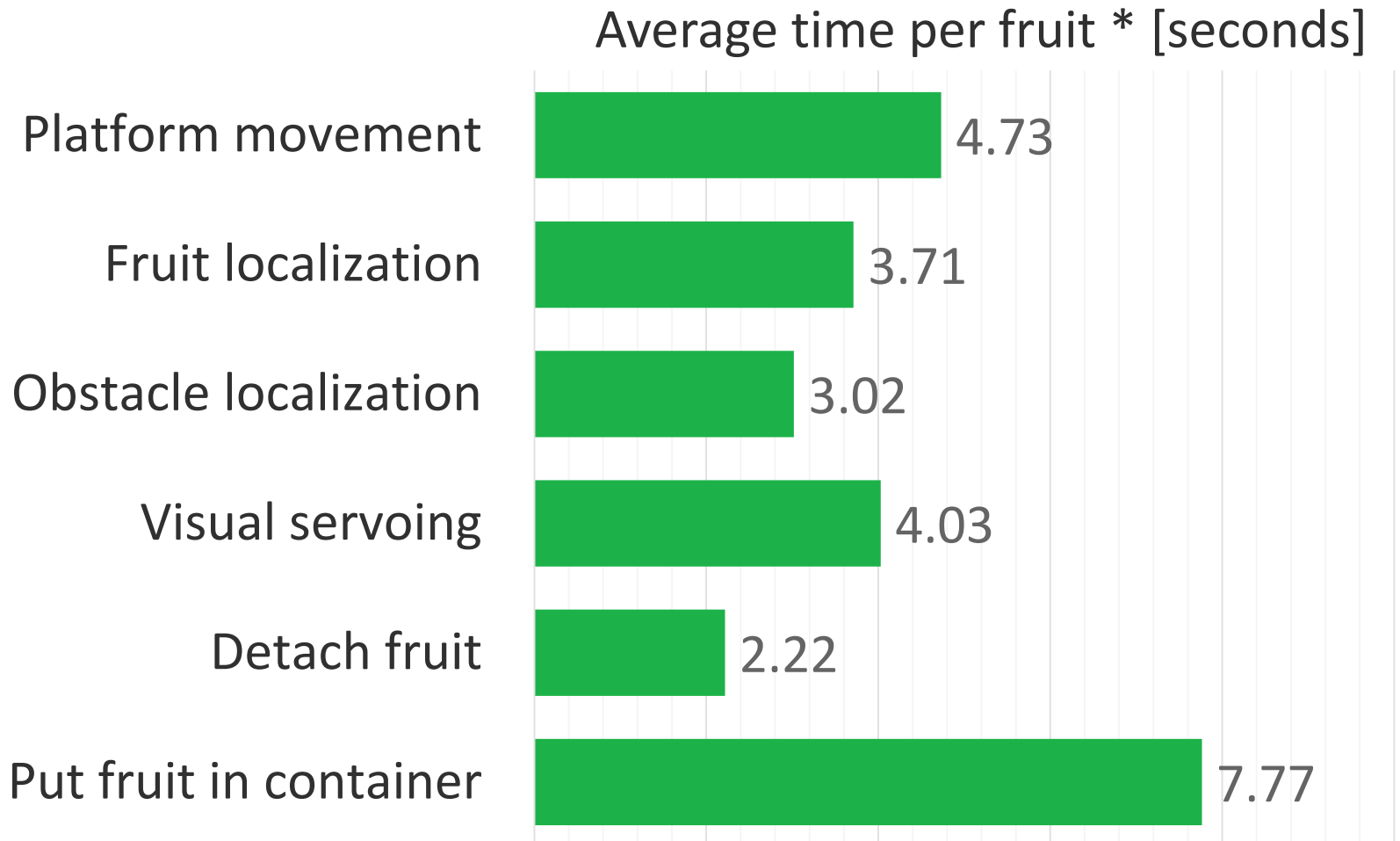
- **For current double row growing system ***
 - 18% of ripe fruit were harvested in commercial crop.
 - 49% of ripe fruit were harvested in modified crop.

* 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 !
 - 55% 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



www.sweeper-robot.eu



UMEÅ UNIVERSITY



de tuindershoek



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No **644313**.

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 safe 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

