WAGENINGEN UR
For quality of life

An autonomous harvesting machine for cucumbers

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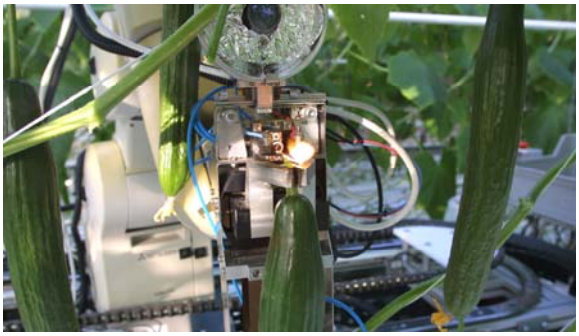
Objective

Reduction of labour cost by means of automating the harvest of cucumbers in greenhouses

In the greenhouse

Both cucumber fruit and cucumber plants are green. Cucumbers do not ripen at the same time.

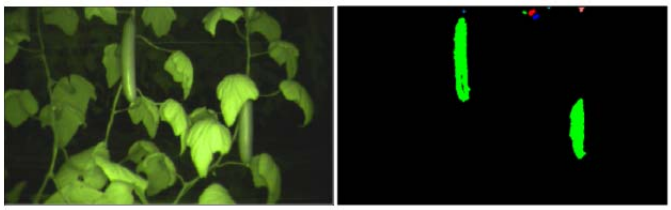


Bron: APA/Frans Ypma

How does it work?

The harvest robot carries two camera systems. The camera mounted on the vehicle is used for the detection of the fruits, determination of the ripeness and quality of the fruits and a low-resolution 3D-localization of the fruits for coarse robot motion planning. The camera mounted on top of the end-effector is used for high-resolution stereo imaging in the neighbourhood of the cucumber during the approach.

During the harvest the robot mimics the hand_eye co_ordination of a human being.



Original Image of plant stand (left) and resulting image with 2 cucumbers detected (right).

Results

During greenhouse experiments 95% of the ripe cucumbers were detected and 75% cucumbers were harvested.

Financing

The development of the harvesting robot was subsidised by the Dutch ministry of LNV.

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Introduction

Wageningen UR has developed an autonomous harvest machine for cucumbers. Today, labour is the largest cost factor of a modern greenhouse holding. Therefore, the reduction of the amount of human labour has become a key issue.
The harvest machine has been developed for a high wire cultivation system. This cultivation system results in a canopy with an open structure. And thus, compared to the traditional cultivation system, it is easier to detect, locate and approach the fruit.

The prototype

The machine consists of an autonomous vehicle, a manipulator, an end-effector, the camera based vision system and miscellaneous electronic and pneumatic hardware. The vehicle uses the heating pipes mounted on the ground as a rail for guidance and support. The vision system is used to detect cucumbers, to assess their ripeness and to determine their position in the 3D space.

Eye-hand co-ordination

In a Dutch cucumber production facility, the robot operates in a very tight working environment. Therefore the robot should be able to speedily and precisely position the end-effector without hitting the crop, the greenhouse construction or parts of the robot itself (such as the vehicle and vision system). Therefore a good eye-hand co-ordination is required. Flexibility of the eye-hand co-ordination is needed since in the greenhouse time after time the robot is confronted with different harvest scenes. Using information about the harvest scene collected by the vision system, the robot motion control system calculates a collision-free motion strategy for the manipulator.
The manipulator carries an end-effector, a device that is used to grip and cut the fruit. A thermal technique from medicine was adopted for cutting the stalks of the fruit. The high temperature at the cutting surface insures that viruses are killed. Also the cutting surface is closed. This prevents undesired leakage from the fruit which results in a longer shelf-life of the fruit.

Vision technology

Detection of the green cucumbers in the green environment was a crucial step for automation of the cucumber harvest. For detection of the fruit a technique is used that exploits the differences in spectral properties of the leaves and the fruits. Leaves show approximately the same reflection properties at 850 nm en 970 nm. The cucumbers however show a significantly higher reflection at 850 nm than at 970 nm. These differences allow for a discrimination between leaves and fruit. With this technique 95% of the cucumbers were successfully detected in the greenhouse.
Cucumbers, as many other fruit, do not ripen at the same time and, consequently, every cucumber has to be evaluated for ripeness (classified) prior to harvesting. Cucumbers contain 95% water. Therefore the fruit weight can be determined using an estimate of the volume of the fruit. The camera vision system estimates the volume of the fruit using a geometric model. The calculated fruit weight showed a 97% correlation with the actual fruit weight.
Finally, for positioning of the end-effector at the fruit, the 3D co-ordinates of the cucumber fruit have to be known. To determine the 3D position of the fruit a stereo-vision technique is employed. Two images are taken from different positions. From the shift of the objects in these images the 3D position of the fruit can be reconstructed. This technique resembles human vision.

Greenhouse experiments

In autumn 2001 the robot was tested in a greenhouse. With success 75% of the ripe cucumbers were harvested. On average the machine required 65 s to harvest a single cucumber. Future research focuses on improving the success rate and reduction of the cycle time by means of faster hard- and software.