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Robotic harvesting of vegetable fruit

Introduction

Since labour costs are high and still increasing, automated harvesting of fruits as cucumber, paprika and tomato will be important in the near future. Supported by the Dutch Ministry of Agriculture, Food and Fishery a project to develop a system for robot harvesting of cucumbers in greenhouses started in 1996.

The robot harvester is mounted on an autonomous vehicle that serves as a mobile platform. The robot can move through the greenhouse using the heating pipes (figure 1).

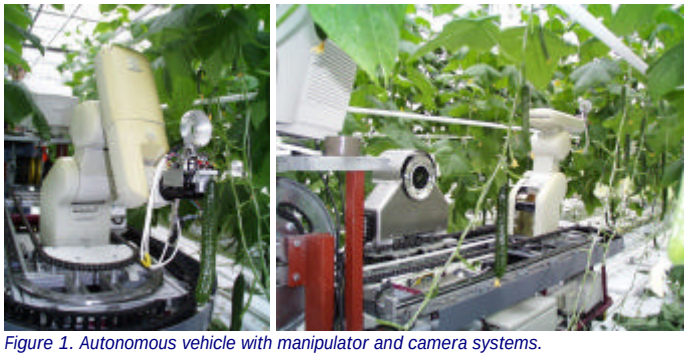

Figure 1. Autonomous vehicle with manipulator and camera systems.

The vision systems

The harvest robot carries two camera systems. One system is mounted on the vehicle on a rail, the other camera is mounted on top of the end-effector. 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 of the cucumber with the gripper.

Detection of fruit

The camera system on the vehicle uses two synchronized CCD-cameras mounted onto one wide-angle optical system. The detection of the fruits is achieved by using different filters on each of the two cameras. Whereas in the 970 nm band the cucumber fruits show approximately the same reflectance as the leaves, the reflectance of the fruits is significantly higher in the 850 nm band. By combining the images of both cameras it is possible to detect the cucumber fruits in the green environment (figure 2). Greenhouse experiments showed that more than 95% of the cucumbers can be detected using this method.

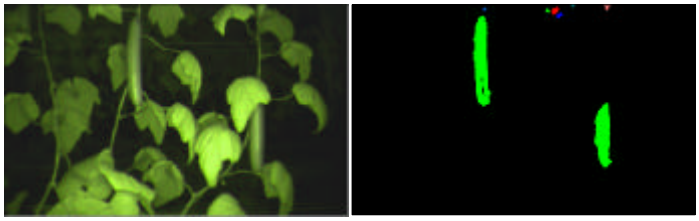

Figure 2. Original Image of plant stand (left) and resulting image with 2 cucumbers detected (right).

3D-localization

Both the camera on the vehicle and the camera on the end-effector are able to move on a rail. By taking two images from a slightly different perspective it is possible to perform a 3D-scene reconstruction using triangulation techniques. Figure 3 shows a pair of stereo images of the top of the cucumber fruit using the camera mounted on top of the end-effector. After matching similar points in the stereo images a 3D map can be built and used for the harvesting task.

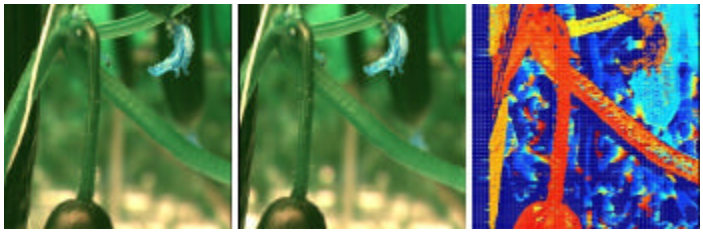

Figure 3. A pair of stereo images of the top of a cucumber fruit and solved points in 3D-space (red: close to the camera, blue: further away from the camera).

GreenVision
P.O. Box 17, NL-6700 AA Wageningen, The Netherlands
Telephone: +31 317 478558 Fax: +31 317 475347
E-mail: GreenVision@wur.nl
Internet: greenvision.wur.nl