Success Story

The sweet pepper robot SWEEPER detects and picks ripe crops using MVTec HALCON

The Wageningen University & Research (WUR) in the Netherlands developed a greenhouse harvesting robot, which is able to pick ripe crops. The shape- and color-based detection algorithm for this task, which was implemented using MVTec HALCON.

The organization

Wageningen University & Research is a university plus a contract research organization for innovation in life science and agri-food. The contract research organization is mainly working with industry, governmental authorities and other knowledge institutes. It currently counts about 11.000 BSc/MSc students and almost 2.000 PhD students. About 5.000 full time equivalent employees are employed at WUR. Students and employees originate from over 100 countries. The WUR Agro Food Robotics initiative is a joint program by several research groups of WUR. About 30-50 people are working in this field within the different science groups of Wageningen. The program tries to bring new knowledge to practice by carrying out feasibility studies, functional designs, prototype development, testing, validation and by supporting new product implementations. Furthermore, the members of the program give expert advice and support management and government decisions on when and how to use or not use robotics.

The challenges

Greenhouses are used throughout the world as a powerful instrument to produce crops. It is an intensive production method with high investment and operational costs. In the past decades this type of production has been confronted with the increasing size of production facilities, increasing labor demands and increasing product quality demands by the consumers. Additionally, there are nowadays intensified hygiene, food safety and traceability demands. Many operations are still done manually, for example the harvesting. However, the availability of a skilled workforce that accepts repetitive

tasks in the harsh greenhouse climate conditions is decreasing rapidly. The resulting increase in labor costs puts major pressure on the sector, asking for alternative solutions. Robotics and sensing technologies have the potential to contribute to these demands. By moving towards a robotic production system, crop production is expected to be significantly more efficient and more sustainable.

The solution

From 2010 to 2014, the European research project "Clever Robots for Crops" (CROPS) was carried out, in which the first steps were taken to robotize the picking of sweet peppers. This project has been followed up by the "Sweet Pepper Robot", called SWEEPER project. The developed prototype comprises the following modules: a tool to cut and catch the pepper, a combined color and 3D camera, an industrial six degrees of freedom robot arm, computers and electronics, all assembled on a battery powered platform that moves the robot autonomously through the greenhouse. The harvesting tool is mounted at the end of the robot arm and consists of a mechanical roller, a knife and a catcher. Once the camera system has found a ripe pepper, the robotic arm positions the tool on top of the fruit stem. The arm then moves the tool a few centimeters down with a vibrating knife and cuts off the pepper fruit near the main plant stem. The camera system for detecting ripe peppers is mounted directly on the harvesting head. Eye-in-Hand, is the name of this principle. As a result, a higher harvesting speed can be achieved with the robot than with previous models, where the sensor unit and robot arm were still separate from each other. LED flash lights are arranged around the camera. This allows the system to work independently of daylight. The image analysis algorithms have been trained to

source: www.sweeper-robot.eu

detect obstacles such as leaves and plant stems. The training process was accelerated using simulated artificial pepper plant models and deep learning network algorithms.

Object detection with MVTec HALCON

A central function in the SWEEPER robot is detection of ripe crops to be harvested. For successful operation, the 3D location of each crop must be determined with high accuracy. The chosen solution is based on an RGB-D camera that simultaneously reports color and depth information. The camera (Fotonic F80) employs a time-of-flight (ToF) technology for depth measurements, and uses a single sensor for measuring both RGB and depth, thus allowing fully registered channels. Using this camera and a custom built LED-based flash-light illumination system, RGB images of the plant are acquired from both overview distance and close range. In order to facilitate high frame-rate operation, a straight forward shape- and color-based detection algorithm was implemented using HALCON. The algorithm scans each acquired image for regions matching the target color thresholds. Detected regions are refined by removing detections exceeding predefined minimum/maximum sizes. To further remove misdetections additional shape parameters are calculated. Finally, depth information from the camera is used to compute the volume of the detected regions. This information is then used to further prune false detections, avoid non-harvestable crop clusters, and define harvest priorities. The exact 3D location of the point of mass is calculated using the depth information extracted from the detected region and a standard procedure of pixel-to-world transformation of the region. Given the subsets of regions that are classified as peppers to be harvested, a methodology for harvesting sequencing was defined. The robot arm then approaches the target by visual-servo control that keeps the target in the middle of the images until it is reached.

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Advantages of MVTec HALCON

The speed and robustness of HALCON convinced the developers of the SWEEPER robot. The HDevEngine implementation allows easy development and debugging with HDevelop. HALCON can be used on multiple platforms, in this example Linux/Ubuntu. This allowed the developers to link it to the Robot Operating System (ROS).

The results and prospects

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In the summer of 2018 experiments in a commercial Dutch greenhouse were carried out to evaluate the performance of the robot. The robot was successful in harvesting 61% of all ripe crops. The average time to harvest one crop was 24 seconds. The SWEEPER robot had significantly increased performance and was four times faster than the CROPS prototype. The developers expect that harvest success will increase to 75 to 80 percent due to further technical development.

Get more information here www.sweeper-robot.eu and www.mvtec.com