Sustainable agriculture: Mobile weed killer for tree nurseries

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The LiDAR scanner (red arrow) installed in AMU-Bot continuously emits laser pulses as the vehicle moves, which the system uses to determine the position of the crop rows. Credit: Federal Office of Agriculture and Food/Fraunhofer

Fraunhofer researchers have collaborated with partners to develop a platform to remove weeds fully automatically. The mobile AMU-Bot robot system navigates using optical sensors and removes weeds mechanically without the need for chemicals. The researchers have also been working on a comprehensive, data-supported ecosystem for the resource-efficient and environmentally friendly automation of agricultural processes.

Weeds in tree nurseries, vegetable gardens and orchards are a grower's worst nightmare. Especially in the early stages of the crop's growth, weeds compete with crops for water, light and nutrients. Removing them by manual hoeing is labor-intensive and using herbicides is far from ideal as they pollute the environment. The Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart has joined forces with partners to develop a mobile, mechanical system that reliably removes weeds in a cost-effective and environmentally friendly manner. The autonomous caterpillar vehicle, AMU-Bot ("AMU" being short for "autonomous mechanical weed control" in German), drives between the rows of saplings in the tree nursery and removes any weeds using rotary harrows. The rotating blades are attached to a height-adjustable manipulator. At the end of the row of trees, the caterpillar vehicle turns around and autonomously starts on the next row.

Navigation with LiDAR scanners

The project team, headed by Kevin Bregler (Head of Field Robotics at the Robot and Assistive Systems department), together with partners Bosch and KommTek used optical sensors for the navigation system. The LiDAR (light detection and ranging) scanners installed in the robot system continuously emit laser pulses as the vehicle moves, which are then reflected by objects in the surrounding area. The distances to these objects can be calculated based on the time it takes for the reflected laser pulses to reach the sensor again. This produces a 3D point cloud of

the environment. The robot system uses this to find its way and determine the position of plants or trees.

The manipulator also moves in the gaps between the crop rows and removes any weeds here using the rotary harrows. Credit: Federal Office of Agriculture and Food/Fraunhofer

Kevin Bregler explains: "AMU-Bot is not yet able to classify all plants; however, it can recognize crops such as trees and shrubs in the rows of the tree nursery cultivations. Moreover, the distances between the individual crops are calculated. Using this information, the weeds can then be reliably removed. The robot uses these data to navigate along the rows while the manipulator removes any weeds."

Even weeds in the spaces between the plants or trees can be reliably killed off. To that end, the manipulator moves into the gaps between the crops. The weeds do not need to be collected and are left on the ground

to dry out. Thanks to its caterpillar drive, the self-driving weed killer moves along the ground with ease and is extremely stable. Even holes in the ground created when saplings are removed do not pose a problem for AMU-Bot. The AMU-Bot platform is economical, robust, easy to operate and highly efficient. Rotary harrows, for example, have long since proven successful in agriculture. They are often used to break up the soil prior to sowing crops. Fraunhofer expert Bregler says: "Removing weeds is a very relevant topic and one that is rather complex. There are various approaches that can be taken: grubbing, cutting, hoeing, flaming or treating the weeds with herbicides. However, herbicides are no longer popular, especially in ecological agriculture and for tree nurseries or orchards. Our method completely avoids the use of chemicals."

The autonomous caterpillar vehicle, AMU-Bot, drives between the rows in the tree nursery and removes any weeds. Credit: Federal Office of Agriculture and Food/Fraunhofer

Robust, reliable and cost-effective

The project managers made a conscious decision to develop a seemingly simple solution. "A system that classifies the different individual plants requires high-resolution cameras, AI-supported image recognition algorithms and plant profiles stored in a database. These systems are far more complex and expensive. Not only that, but they cannot readily switch to working in new contexts," explains Bregler. In comparison, the AMU-Bot platform relies on the sophisticated interplay of three fully developed modules: caterpillar vehicle, navigator system and manipulator. AMU-Bot is also the result of an efficient partnership. Bosch is responsible for the navigation and sensor system, while KommTek developed the caterpillar drive. Fraunhofer IPA engineered the height-adjustable manipulator, including rotary harrows, and was responsible for overall coordination.

The project was supported by the German Federal Ministry of Food and Agriculture (BMEL) and the German Federal Office of Agriculture and Food (BLE) was the project sponsor. The Fraunhofer experts are already planning the next step. Together with seven other Fraunhofer Institutes, IPA expert Kevin Bregler and the project team are working on a new, high-performance ecosystem called COGNAC (Cognitive Agriculture). Digital services and data, which also include interactions between biospheres and production, are networked to form this ecosystem. In addition, COGNAC integrates intelligent sensors and robotics. The aim is to create flexible and intelligent automation of sustainable agriculture—including weed control.

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