

ROBOTIC SOLUTION TO DETECT ASYMPTOMATIC PLANTS INFECTED BY CANDIDATUS LIBERIBACTER SOLANACEARUM IN HORTICULTURAL CROPS USING MULTISPECTRAL COMPUTER VISION

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A field robot has been designed and built to automate the capture of images and the mapping of a horticultural field using different computer vision equipments. The robot moves by the impulse of two electric motors coupled to the front wheels and is operated by remote control. A telescopic system allows adapting the width of the robot to the needs of the field in a range between 100 and 200 cm because the geometry of the crop allows the wheels to circulate only by a few lines separated by a certain distance, which can vary from one crop to another. On the other hand, this system allows to reduce its size to be transported in a van. The robot equips three DSLR (Digital Single Lens Reflex) cameras (EOS 600D, Canon Inc, Japan), two of them modified to capture images in near infrared (NIR) from 700 to 1000 nm, and blue NDVI (normalized difference vegetation index), a thermal camera (A320, FLIR Systems, USA) and a multispectral camera (CMS-V, Silios Technologies, France) capable of capturing eight monochromatic images in 558, 589, 623, 656, 699, 732, 769 and 801 nm.

The cameras have been placed facing the ground (the plants) at a distance of approximately one meter from the plants. To avoid the influence of sunlight, the scene is protected from outside light by a canvas. In addition, four halogen spotlights illuminated the scene to provide artificial light. A GPS has been used to geolocate the images and to be able to reference each plant in the images with its physical location in the field. The cameras and the GPS are connected to an industrial computer. An application running on the industrial computer captures the signal from an inductive sensor coupled on a robot wheel and triggers the cameras to synchronise the image acquisition with the robot's advance.

Surveys were carried out in two experimental carrot plots located in Villena (Spain) with the aim of detecting asymptomatic plants infected with '*Candidatus Liberibacter solanacearum*', a vascular bacterium that causes vegetative disorders in *Apiaceae* and *Solanaceae* plants. The plot 1 was inspected monthly at different vegetative status while the plot 2 was inspected only once before harvesting, with the robot carrying the proximal sensing equipment. Several

maps of the field have been created using spectral indices at a resolution of 0.5 mm/pixel using the images captured by the DSLR cameras, and 2.5 mm/pixel using the images captured by the other cameras.

During the last survey of the field, 100 plants were marked to be later identified in the images. These plants were collected separately and taken to the laboratory to undergo a spectral analysis with a hyperspectral camera and a molecular analysis using specific real-time PCR, to determine the presence or absence of infection in the leaves and compare them to the maps created by the robot.