The main objective of the EU-funded CROPS project (www.crops-robots.eu) is to develop a highly configurable, modular and clever platform comprising a modular manipulator and “intelligent tools” (sensors, algorithms, sprayers, grippers) that can easily be installed onto the carrier and that is capable of adapting to new tasks and conditions. Both the scientific know-how and a number of technological demonstrators are being developed for the agro management of high value crops like greenhouse vegetables, orchard fruits, and grapes for premium wines. The CROPS robotic platform will be capable of intelligent spraying (targeted spraying only on foliage and selected targets) and selective harvesting of fruit (i.e., it will detect the fruit, determine its ripeness, move towards the fruit and grasp it and softly detach it). Another objective of CROPS is to develop techniques for reliable detection and classification of obstacles and other objects to enable successful autonomous navigation and operation of the platform in plantations and forests. The rationale for this aspect of the project is that agricultural and forestry applications share many common research areas, primarily regarding sensing and learning capabilities.

CROPS project has received funding from the European Union’s 7th Framework Programme

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CROPS “Clever Robots for Crops”

CROPS

Intelligent sensing and manipulation for sustainable production and harvesting of high value crops

www.crops-robots.eu

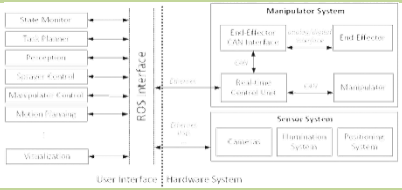
CROPS project has received funding from the European Union’s 7th Framework Programme for research, technological development and demonstration under grant agreement no 246252

Clever Robots for Crops

CROPS high tech robots are developed for site-specific spraying and selective harvesting of high-value crops such as greenhouse vegetables, fruits in orchards and grapes for premium wines. A CROPS robot is able to detect the fruit, sense its ripeness, then move to grasp and gently detach only the ripe fruit. With intelligent crop protection the canopy sprayer can detect contours of trees in an orchard and only spray on the plant, or to selectively and precisely target the pesticide only on detected diseases foci in grapevines. Attention is paid to reliable detection and classification of objects and obstacles for safe autonomous navigation in plantations and forests.

Hardware and Software architecture

CROPS robots use ROS (Robotic Operating System) as middleware. The supervisory control system and the high-level software architecture have been developed and tested within a framework of high modularity and configurability of hard- and software.

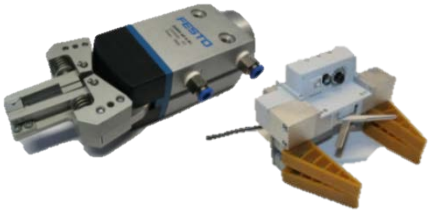


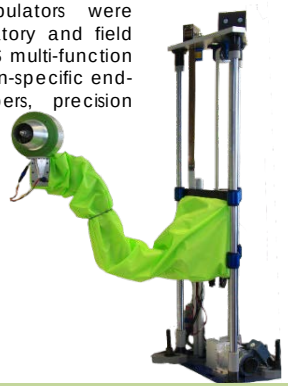
Sensing

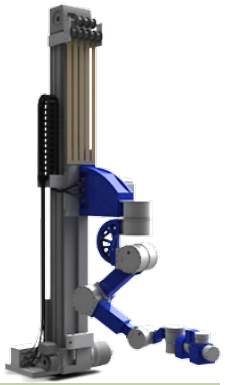
The design and implementation of the sensory systems for CROPS includes multispectral imaging for detection, classification and localisation of products to be harvested and of crops diseases to be sprayed; imaging and fluorescence sensing for fruit ripeness evaluation; LIDAR for canopy sensing and thermal infrared for human detection in forestry.

Manipulators and end-effectors

Different generations of agricultural manipulators were designed, manufactured and tested in laboratory and field experiments. Based on these tests a final CROPS multi-function manipulator was implemented. Several operation-specific end-effector prototypes were developed: grippers, precision sprayer effector, canopy sprayer.

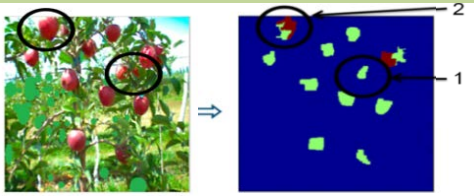






Intelligent sensor fusion and learning algorithms

Adaptive sensor fusion algorithm was implemented and tested for apples and sweet pepper. A fuzzy grasp affordance manifold based on learning from human demonstration was developed. A learning framework was demonstrated to learn features for classification of forestry objects.



Sweet pepper harvesting

A number of modules for hardware (sensors, grippers) and software (e.g. algorithms for sweet-pepper fruit localization) were built and tested for sweet pepper harvesting in greenhouse production. The CROPS manipulator, a carrier platform, a gripper and a sensing system were integrated into a complete system and successfully tested and demonstrated to growers in a laboratory setting and in a commercial greenhouse.

Apples and grapes harvesting

Based on discussions with grapes and apples growers, to maximize visibility and reachability of the fruits, the 'fruit-wall' growing system was adopted. CROPS manipulator, grippers, sensors and software architecture have been tested. All the modules have been integrated into a mobile platform system, which was successfully tested during fruit harvest in laboratory and in orchard conditions.

Precision spraying

A canopy optimised sprayer was designed as a trailed sprayer with a three hydraulic driven arms and tested in orchard experiments to optimally spray the canopy according to tree shape and foliage volume with significant reduction of pesticide use. Selective, close precision spraying was focused on targeting pesticides on disease foci detected by means of optical sensing. CROPS manipulator equipped with waterproof case, disease sensors and precision spraying end-effector were integrated in an intelligent precision spraying robot for viticulture. The robot was successfully tested in a greenhouse environment and the attained a pesticide reduction above 80% compared to current homogenous crop treatment technique

Forestry

For forestry applications a sensory system for detection and classification of trees and obstacles has been defined and evaluated in field test. A ground bearing capacity sensor for propulsion of forest machines has been specified together with a human detection system for safe navigation in forests environment and operations in plantations and tree harvesting