The H2020 Project PANTHEON: Precision Farming of Hazelnut Orchards

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I. Extended Abstract

Agriculture has commonly been pioneer in the use of new technologies to improve productivity. Modern hazelnut farming generally is carried out using regular layouts to allow the mechanization of many field operations, as it is the use of tractors and specialized agricultural machinery. However, there are still time consuming and labor-intense agronomic activities that could be clearly improved. Inspired by the real needs of the consortium member FERRERO, project PANTHEON focuses on the management of large hazelnut orchards, where, to the best of our knowledge, precision farming techniques have not been investigated yet.

The main drawback of current hazelnuts farming procedures is that, for plantations larger than 10 ha, performing a per-plant monitoring and responding to the needs of each single plant is very challenging. In current best practices, decisions are often made by assessing the status of a few representative plants and then extending the treatments to the entire sectors were these plants are located, which in the case of large plantations, may mean areas up to 50 ha.

The goal of project PANTHEON is to develop the agricultural equivalent of an industrial Supervisory Control And Data Acquisition (SCADA) system to be used for the precision farming of large orchards of hazelnut (Corylus avellana L.). By taking advantage of the technological advancements in the fields of control, robotics, remote sensing, and big-data management, our objective is to design an integrated system where a relatively limited number of heterogeneous unmanned robotic components (including terrestrial and aerial robots) move within the orchard to collect data and perform typical farming operations. Notably, project PANTHEON will focus only on those farming actives where these enabling technologies would represent a key factor to achieve a real improvement of current management and define realistic goals for the duration of the project. In particular, the following activities will be considered: i) irrigation, ii) pruning, iii) sucker detection and removal, iv) pest and disease detection and v) production estimation. Briefly, the proposed SCADA system is composed of the following main components: i) a Wireless Backbone Network; ii) a fleet of Unmanned Ground Robots (UGVs); one or more Aerial Robots (UAVs); iii) an IoT (Internet of Things) Network infrastructure; and iv) a Central Unit. In the foreseen SCADA system, unmanned aerial and ground robots will move within the orchard to collect data from the plants status and, in the case of the ground robots, perform some farming operations. Each unit will perform different measurement activities depending on their characteristics and requirements. The idea is to collect diverse data from the orchard, augment them when relevant/possible with the data coming from the ground sensors, and extract relevant features for the agronomic analysis. In particular, using the data coming collected by the robots and bt the IoT-based agro-meteoreological monitoring network, the central unit will elaborate synthetic indicators (e.g [1] and [2]) for each tree. Based on these synthetic indicators, the system will elaborate a synoptic report for the agronomist in charge of the orchard, putting in evidence possible situations that may deserve attention, providing suggestions of intervention and, if requested, providing a historical view of the status of the plant and of the treatments already performed. For some interventions, algorithms to perform automatic decisions are envisioned such as the control of the levels of irrigation, the automatic treatment of suckers and the marking of trees' branches for pruning. For what concerns irrigation, the objective is to detect plant stress induced by limited water [3] developing techniques able to use the information collected by the aerial vehicle [4], and fuse them with the measurements of the IoT network to perform an efficient feedback-based irrigation. For the Pest and Disease control the goal is to detect the presence (or the suspicion) of pest infestations and plant diseases using multispectral visible and near infrared (VNIR) and thermal data collected from the UAV and the ground robots [5], [6]. Tree Geometry Reconstruction will be carried out using data acquired from ground robot LiDAR sensor to reconstruct the geometry of the tree and extract synthetic indicators/parameters describing the structure of the tree and the presence of suckers. Finally, to estimate the total orchard yield an estimator (see e.g [7], [8]) will be developed, able to take into account that the expected losses that occur over time during the maturation stage using standard object detection algorithms combined with information provided by the remote sensing.

The foreseen architecture will be based on the Robot Operating System (ROS) [9] as the software layer to make all the components of the SCADA system interact, thanks to a mesh of antennas an two long-distance antennas distributed in the

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field. These two long-distance antennas will connect the field system with a central unit workstation where the main software [10] components run. This Linux-based workstation will be the main point of control of the SCADA architecture.

The underlying idea of project PANTHEON is to achieve the resolution of the single plant in terms of monitoring and intervention capabilities. This novel paradigm for orchard management will permit to drastically increase the detection of possible limiting factors for each individual plant, such as lack of nutrients, or pests and diseases affecting the plant health, and then to react accordingly and in a more focused way. Compared to the current state of the art in orchard farming, we believe that the proposed SCADA infrastructure represents a relevant step ahead. In fact, the capability of monitoring the phytosanitary state and the evolution of each single tree will be the enabling-technology to allow more focused interventions. This will result in a better average state of health of the orchard and in an increased effectiveness of Integrated Pest Managements. Thus, the proposed SCADA architecture proposed has the potential to increase the production of the orchard while, at the same time, being more cost-effective and environmentally-friendly.

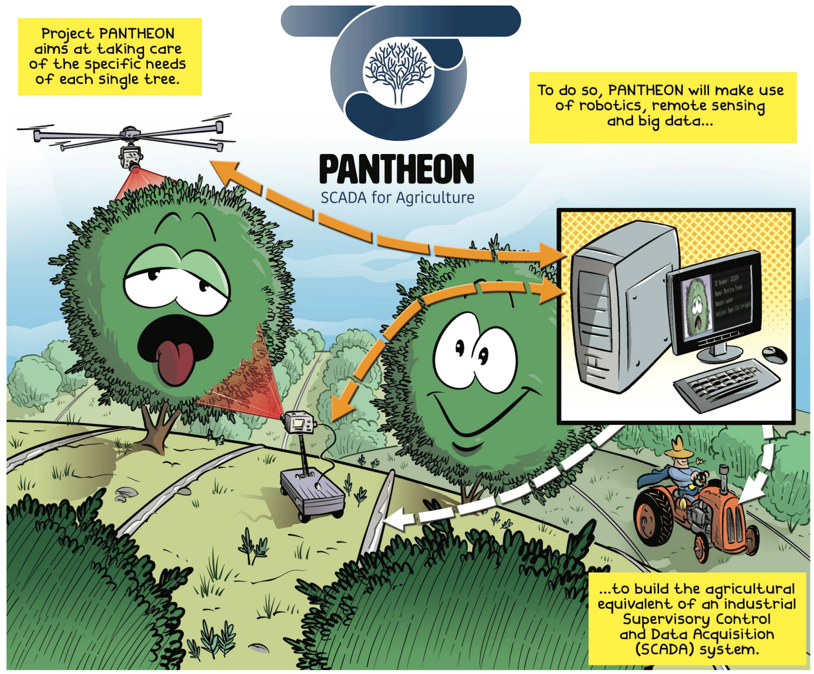

Fig. 1. Foreseen concept of the SCADA system for agriculture.

The main advantages of the proposed SCADA architecture can be summarized as follows: i) Increase in hazelnut productions; ii) Decrease in chemical inputs usage; iii) Environmentally-friendly water usage; and iv) Simplified orchard management. The outcome of the project will be validated through a final demo on a real-world (1:1 scale) hazelnut orchard.

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