

# PhD School on Agriculture, Environment and Bioenergy

[http://sites.unimi.it/dottorato\\_aab/](http://sites.unimi.it/dottorato_aab/)

(XXXV cycle, 2019-21)

## Project draft

### 1. Field of interest

AGR/09 Farm Machinery; AGR/12 Plant Pathology

### 2. Project title

Automation technologies for precision crop protection

### 3. Tutor: Roberto Oberti

Co-tutor: Marcello Iriti

### 4. Relevance of the topic and state of the art:

The objective of reducing pesticide use in agriculture is tackled through a variety of complementary approaches. Automation technologies can contribute to real implementation of intelligent, selective spraying capability by means of advanced equipment.

The fundamental rationale for this relies on the evidence that, despite in current practice pesticides are typically applied uniformly, several pests and diseases exhibit an uneven spatial distribution, with patch structures evolving around discrete foci especially during early stages of development. Highly automated equipment could enable the selective targeting of pesticide application only where and when it is needed, with the aim of controlling the initial foci and preventing the infection establishment and its epidemic spread to the whole field.

Automated crop protection from autonomous platforms, including UAV drones, is a blossoming field of research within the area of agricultural robotics, requiring the development of specific sensing techniques, of human-robot cooperation approaches, and of simplified and precise distribution actuators.

### 5. Layout of the project (draft)

#### 5.1. Materials & Methods:

The PhD project will consider two specific aspects of automated crop protection: multiscale sensing and simplified precision actuation.

Multiscale sensing is an approach aiming at combining a fast inspection of the canopy conducted at a moderate spatial resolution on a relatively wide area (e.g. with a UAV drone), complemented with more specific point-wise measurements, targeted on those regions exhibiting suspect patterns according the fast inspection. Wide area sensing will be based on imaging techniques (multispectral imaging), while point-wise specific measurements can combine more sensitive and specific techniques, as high-resolution spectroscopy, fluorescence or thermal sensing. The point-wise sensing probe will be directed on the suspect regions to be inspected by means of a light-weight and simplified actuator.

The goal of multiscale sensing will be to identify the potential targets of selective treatments, i.e. plants/leaves/fruits exhibiting specific disease symptoms and the neighbours regions where infection can already be established, even if at asymptomatic stages. The considered cases of study will include the detection of a fungal disease in an arable (e.g. cucumber) and a tree crop (e.g. grapevine) with experiments conducted in greenhouse and field conditions.

The identified targets have to be selectively treated with plant protection products; this is the objective of the precision actuation task. To this aim, light-weight, fast and simple (e.g. 2 degrees of freedom) actuators will be applied within an approach relying on simplified robotic technologies or on UAV drones. The goal will be the integration of a system able to quickly adapt to specific features of the plants and to focus spot-treatments only target regions within the canopy.

### **5.2. Schedule and major steps (3 years):**

Year 1. Setup of the point-wise measurement system and integration in the manipulator. Coordination and calibration of the multi-sensing approach in the lab.

Year 2. Testing of the multi-sensing system in greenhouse and simplified field conditions. Integration of a prototype for precision application of protection treatments.

Year 3. Testing of selective, precision treatments on the target areas detected by the multi-sensing system conducted in greenhouse and simplified field conditions.

## **6. Available funds (source and amount)**

80 k€ (AIRSPRAY-ISR/ITA2017-13928; CROPS-EU-NMP7-246252; FRYWEED – PSR\_AT18; Liberal funds)

## **7. Literature**

- Adamides G. (2018). Agricultural Robots in Targeted Spraying: A mini State-of-the-Art review. *Robot Autom Eng J.* 2: 555581.
- Tona E., Calcante A., Oberti R. (2018). The profitability of precision spraying on specialty crops: a technical–economic analysis of protection equipment at increasing technological levels. *Precision Agriculture* (Article in Press). DOI: 10.1007/s11119-017-9543-4
- Pantazi, X.E., Moshou, D., Oberti, R., West, J., Mouazen, A.M., Bochtis, D. (2017). Detection of biotic and abiotic stresses in crops by using hierarchical self organizing classifiers. *Precision Agriculture*, 18: 383
- Berenstein R, Edan Y. (2017). Human-robot collaborative site-specific spraying. *Journal of field robotic*, 34:1519
- Oberti R. and Shapiro A. (2016). Advances in robotic agriculture for crops. *Biosystems Engineering*, 146:1
- Xue X., Lan Y., Sun Z., Chang C., Hoffmann W.C. (2016). Develop an unmanned aerial vehicle based automatic aerial spraying system. *Computers and Electronics in Agriculture*, 128:58
- Oberti R., Marchi M., Tirelli P., Calcante A., Iriti M., Tona E., Hočevar M., Baur J., Pfaff J., Schütz C., Ulbrich H. (2016). Selective spraying of grapevines for disease control using a modular agricultural robot. *Biosystems Engineering* 146:203
- Malneršič A, Matevž D, Širok B, Oberti R, Hočevar M (2016) Closerange air-assisted precision spot-spraying for robotic applications: Aerodynamics and spray coverage analysis. *Biosystems Engineering* 146:216
- Oberti R., Marchi M., Tirelli P., Calcante A., Iriti M., Borghese A.N. (2014). Automatic detection of powdery mildew on grapevine leaves by image analysis: Optimal view-angle range to increase the sensitivity. *Computers and Electronics in Agriculture* 104:1
- Moshou, D., Gravalos, I., Kateris, D., Bravo, C., Oberti, R., West, J.S., Ramon, H. (2012). Multisensor fusion of remote sensing data for crop disease detection. In: *Geospatial Techniques for Managing Environmental Resources*, ISBN 9789400718586, pp. 201-219.
- Moshou D., Bravo C., Oberti R., West J.S., Ramon H., Vougioukas S., Bochtis D. (2011). Intelligent autonomous system for the detection and treatment of fungal diseases in arable crops. *Biosystems Engineering*, 108: 311