Digital solutions for on-farm crop quality assessment

Martina Galaverni (martina.galaverni@unipr.it)

Dept. Food and Drug, University of Parma, Parma, Italy

Tutor: Prof. Tommaso Ganino

This PhD thesis project is aimed at the use of innovative and digital technologies used in Agriculture 4.0, such as sensors and data analysis tools, to assess and enhance crop yield and crop quality on open fields.

Soluzioni digitali per la misura della qualità delle produzioni agrarie in pieno campo

Questo progetto di tesi di dottorato è volto all’utilizzo di tecnologie innovative e digitali utilizzate nell’Agricoltura 4.0, quali sensori e strumenti di analisi dati, per il monitoraggio e la valutazione della qualità delle produzioni agrarie in campo.

# **1. State-of-the-Art**

Recently, the increasingly extreme weather events due to climate change, such as drought and heavy precipitation and hot and cold waves, as well as environmental pollutions, soil degradation and scarcity of natural resources have negatively affected crop productivity (Araújo *et al.*, 2021). If we add to this that the world population is predicted to rise 31% by 2050, but arable land will be declined by approximately 50 million hectares (Abbasi *et al.*, 2022), strong technological innovation in agriculture becomes important in order to ensure food security. Agriculture 4.0 (or rather 5.0), which aims to sustain the raising food demand in a sustainable way, is the latest evolution of Precision Agriculture (or rather, precision predictions) with the technologies of Industry 4.0. Modern technologies, such as sensors, robotics, Internet of Things (IoT), cloud computing and data analytics are the agriculture 4.0 core technologies and are expected to enhance crop production by collecting, processing, managing, and sharing data (Araújo *et al.*, 2021). Thanks to the use of IoT devices, improvements at every stage of primary production are achieved, starting from the real-time, automatic monitoring of desired parameters in the field by different type of sensors and their further storage and processing. Next, based on the results of data analysis a control system is usually activated to modify the farming practices. Furthermore, by monitoring and storing environmental and crop conditions over time, data analysis tools, such as Artificial Intelligence (AI), Machine Learning (ML) and platforms like decision support system (DSS) can help the end-users in planning farm practises and type and number of farm inputs effectively (Abbasi *et al*., 2022; Araújo *et al.*, 2021; Raj *et al.*, 2021).

One of the main advantages of Agriculture 4.0 is, therefore, the reduction of the waste and water, as well as an efficient use of farm inputs, such as soil nutrient or pesticides. Nevertheless, by predicting production and its quality and by managing agricultural practices with AI, better and higher production should be ensured (Silveira *et al.*, 2021).

Based on the foregoing, irrigation is clearly a key agricultural practise in which IoT-devices are employed to efficiently manage scarce water resources and to achieve high quality production. New smart irrigation systems, by measuring specific parameters through sensors (weather and soil) and analysing the data collected, can automatically control actuators as required (Hamami and Nassereddine, 2020).

Fertilization is another agricultural practise that benefits from the application of IoT technologies since the exact amount and the type of minerals that are necessary in a specific location can be calculated and spread for an optimal plant development and an enhanced quality of its production. However, several other agricultural issues can be performed with IoT-devices, among which crop pest and disease control and phenotyping (Abbasi *et al.*, 2022; Araújo *et al.*, 2021).

Therefore, this PhD thesis will be focused on the application of IoT-devices (*e.g.*, wireless sensor networks) on field for the crop quality assessment. Different type of sensors for non-destructive analyses on crops and their production will be applied to assess their quality in response to environmental changes and different agricultural practises during the growing season. Furthermore, by monitoring and controlling the field conditions crop quality and yield will be enhanced in a sustainable way.

**2. PhD Thesis Objectives and Milestones**

Within the overall objective mentioned above this PhD thesis project can be subdivided into the following activities according to the Gantt diagram given in Table 1:

A1) **Experimental trial** on open field with real time monitoring of plant parameters of interest and control of agronomic practices with IoT-devices, crop quality assessment during the ripening stages and harvesting of crop production for its further analytical characterization.

A2) **Characterization of crop production** with analytical methods to verify parameters measured with different type of sensors.

A3) **Data processing** to identify changes in yield and quality of production in response to agronomic management and environmental conditionsand, to establish correlation between field and laboratory measured values.

A4) **Writing and Editing** of the PhD thesis, scientific papers and oral and/or poster communications.

***Table 1***Gantt diagram for this PhD thesis project.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Activity Months | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **21** | **22** | **23** | **24** |
| A1) | ***On-farm experimental trial*** |   |   |   |  |  |  |  |   |   |  |  |  |  |   |   |   |  |   |   |   |  |  |  |  |
| A2) | ***Characterization of crop production***  |   |  |   |   |   |   |  |   |   |   |   |   |  |   |  |  |  |  |   |   |   |   |   |  |
| A3) | ***Data processing*** |   |  |   |  |  |   |   |   |   |  |  |   |   |   |  |  |  |  |   |   |  |  |   |   |
| A4) | ***Thesis and Paper Preparation*** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |   |   |   |   |   |   |

# **3. Selected References**

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