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XXXVII Cycle

Long-Range Low-Power Electronic System for Precision Agriculture

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Research context and motivation

- **WAPPFRUIT** regional project develops cutting-edge technologies for water management in fruit growing.
- This work follows one of the United Nations' global goals, 6.4 SDG (Sustainable Development Goal) – More efficient water use.
- The main goals are the **definition of the water requirements** and the **realization of a complete automation of a micro-irrigation system** in orchards.

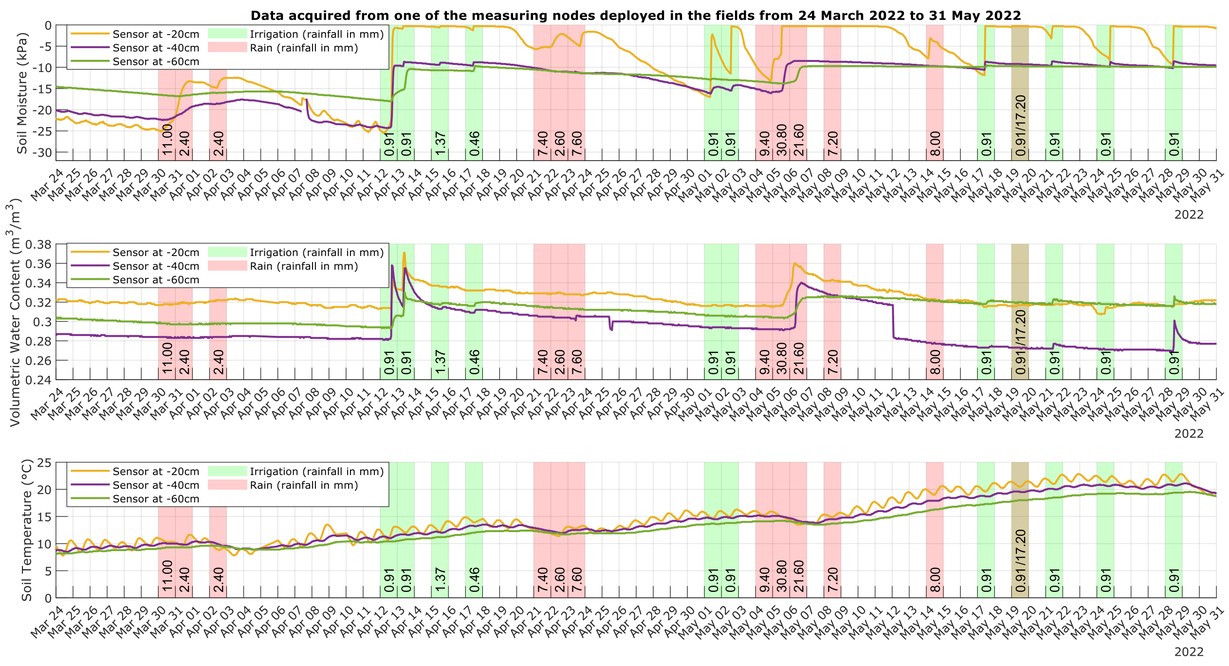
WAPPFRUIT

Addressed research questions/problems

- Definition of optimal conditions where a plant could maximize its yield. **Plant**, **soil**, and **environment** are the main elements to define the correct requirements.
- Definition of useful **fruits parameters** to evaluate quantitatively and qualitatively their organoleptic features.
- Comparison between **smart irrigation** based on soil sensors with respect to **manual and timed drip irrigations** based on the knowledge of the farmers.
- Methods to **reduce carbon footprint** in agriculture: reduction of water usage means less energy spent to supply water pumps.

Novel contributions

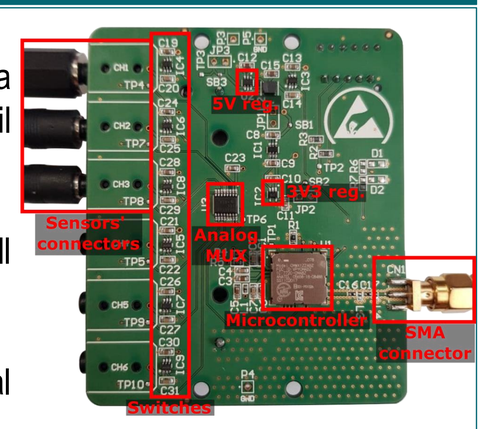
- A complete characterization of trunks and fruits (**dendrometers** and **fruitmeters)** is performed, correlated to the soil variables (**soil temperature**, **soil water potential**, and **volumetric water content**).
- Data are sampled at various depths (-20, -40, and -60 cm) to characterize **root layers**.
- **Design of a cloud-based irrigation algorithm** working on specific plant varieties and fields involved in the WAPPFRUIT project.

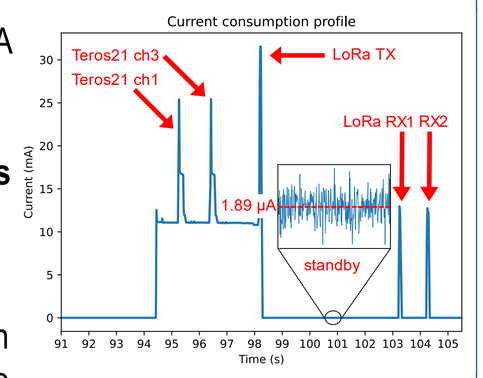


Adopted methodologies

Measuring Node

- Low-power IoT node designed to supply and read data from digital industrial soil sensors (soil temperature, soil water potential, and volumetric water content).
- Radiofrequency protocol: **LoRa (Long Range)**.
- Custom hardware designed to reduce costs in small production, sizes, and static current contribution.
- Custom firmware based on STM middleware.
- Able to sense up to six soil sensors in DDI serial protocol.
- Supplied with a **single battery 3.6 V LiSOCl2** in AA package (nominal capacity 2600 mAh).
- Very low standby current draw: **1.89 µA**.
- Long lifetime: theoretical lifespan greater than **11 years** with 1-hour sampling time.



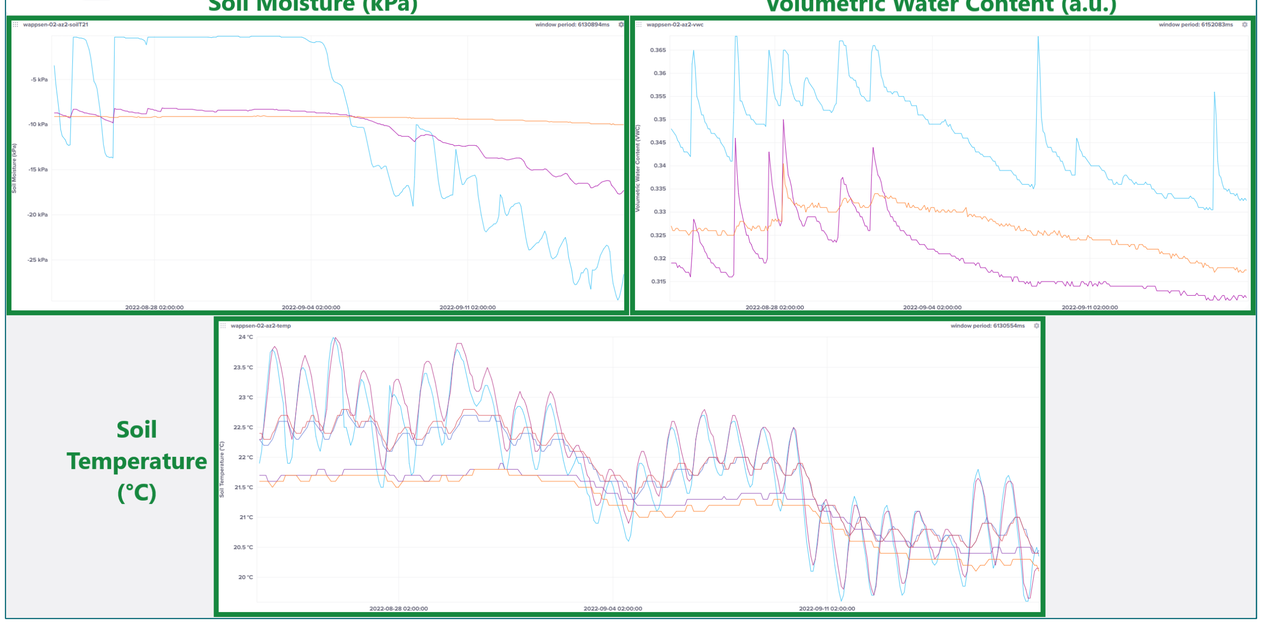


Actuation Node

- Low-power IoT shield in charge of driving an electrovalve connected to the drippers in the experimental rows.
- Radiofrequency protocol: **LoRa (Long Range)**.
- **Two power sources**: regulated to 3.3 V from 3.6 V LiSOCl2 AA battery and 9 V alkaline 1604 battery.

Cloud architecture

- LoRaWAN network server: The Things Network.
- Server agents: Node-RED and Telegraf.
- Visualization platform: InfluxDB.
- Storage platforms: InfluxDB and private server.



Future work

- **Improved measuring and actuation motes versions**: lower power consumption in both runtime and standby, increasing range, and design of a battery monitoring stage.
- **Updated software architecture** towards a draft commercial product.
- **Fault tolerance**: testing software and hardware architectures against broken or missing IoT nodes and out-of-service soil sensors.
- **Irrigation algorithm**: testing effectiveness of an automated smart micro-irrigation system.
- Evaluation of **fruit figures of merit**: yield, qualitative parameters (Brix, water hardness, etc.) compared to the actual methodology.
- **Energy and water savings** with respect to the non-automated crop by the farmer.

Submitted and published works

- Barezzi, M., Garlando, U., Martina, M., and Demarchi, D., "*On the impact of the stem electrical impedance in neural network algorithms for plant monitoring applications*", 2022 IEEE International Workshop on Metrology for Agriculture and Forestry (MetroAgriFor), Perugia, 2022
- Barezzi, M., Garlando, U., Pettiti, F., Nari, L., Gisolo, D., Canone, D., and Demarchi, D., "*Long-Range Low-Power Soil Water Content Monitoring System for Precision Agriculture*", 2022 IEEE 13th Latin America Symposium on Circuits and System (LASCAS), Santiago de Chile, 2022, pp. 1-4
- Garlando, U., Calvo, S., Barezzi, M., Sanginario, A., Ros, P. M., and Demarchi, D., "*Ask the plants directly: Understanding plant needs using electrical impedance measurements*", Computers and Electronics in Agriculture, vol. 193, no. 106707, 2022, pp. 1-13

List of attended classes

- 01QTEIU – Data mining concepts and algorithms (03/02/2022, 4 CFU)
- 01DUCRV – Principles of digital image processing and technologies (22/07/2022, 5 CFU)
- 02SFURV – Programmazione scientifica avanzata in matlab (21/04/2022, 6 CFU)
- 01QEZRV – Sviluppo e gestione di sistemi di acquisizione dati (05/09/2022, 5 CFU)
- 01DNHRV – System level low power techniques for IoT (15/07/2022, 4 CFU)

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