Joint Lab
Künstliche Intelligenz & Data Science

Networks as a Sensor in Agriculture

Lennart Kaiser[1], Thomas Hänel[1,2], Sebastian Vogel[1,3], Volker Dworak[1,3], Nils Aschenbruck[1,2]
{lekaiser, haenel}@uos.de, {svogel, vdworak}@atb-potsdam.de, aschenbruck@uos.de
[1] Joint Lab Artificial Intelligence & Data Science · Osnabrück University · jl-ki-ds.uos.de
[2] Distributed Systems Group · Computer Science Institute · Osnabrück University · sys.cs.uos.de
[3] Diversified Crop Production Group · Leibniz Institute for Agricultural Engineering and Bioeconomy Potsdam (ATB) · atb-potsdam.de

Contact me!
Digital version

Motivation

- Sustainable Agriculture and reduced resource usage are very important, due to the increasing world population
- Optimal irrigation and fertilization only possible by measurements
- Manual measurements are resource-intensive in time and labour
- Automatic measurements are possible with Wireless Sensor Networks(WSNs)
  - corresponding sensors are required
  - usually smaller data resolution
  - high node density leads to expensive deployment

Key Concept

- Radio signals can not only be used for communication but to **gather information of the environment**
- Additional information can be retrieved ”for free”
- Passive measurements are possible by only using radio signals which are sent anyway
- Less invasive than manual measurements
- Reliable Long Term measurements are possible, by using fixed sensor nodes
- Existing solutions use one radio technology for soil moisture[1, 2] or for biomass[3]

Challenges

- Very noisy data, due to many small scale interferences, as well as environment parameters, like temperature and humidity ⇒ additional sensors are required
- Resistant sensor node design, e.g. regarding corrosion
- Gather reliable ground truth data
- Deployment opportunities are highly dependent on farm cycles, e.g. starting in spring, as well as weather conditions
- Other typical WSN Challenges also apply: Energy/Measurement frequency trade-off, Node placement, Data transfer

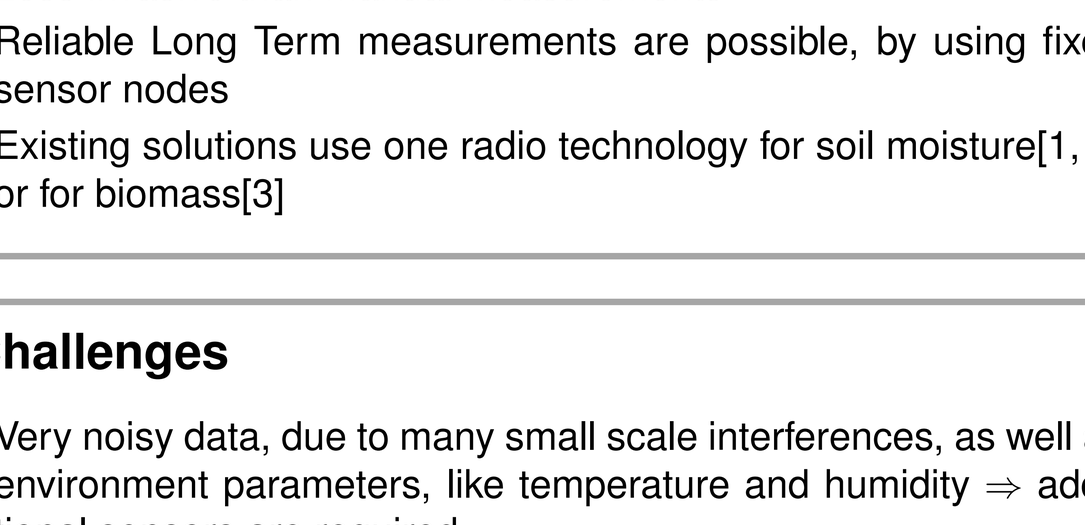

Fig. 1: Wi-Fi CSI RSSI and SMT50 plotted over time

This research was supported by the Lower Saxony Ministry of Science and Culture (MWK), funded through the zukunft.niedersachsen program of the Volkswagen Foundation.

Case Study: Soil Moisture Design

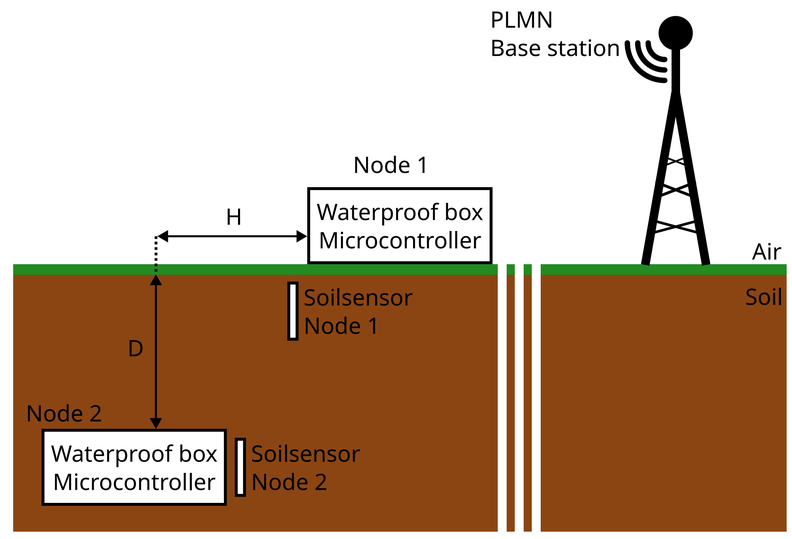

Fig. 2: Conceptual sketch of a deployment structure

- ESP32 TTGO T-Beam is used as the platform
- Combination of multiple radio technologies: Wi-Fi 2.4 GHz, BLE, LoRa, LTE
- SMT50 Sensor is used for ground truth data

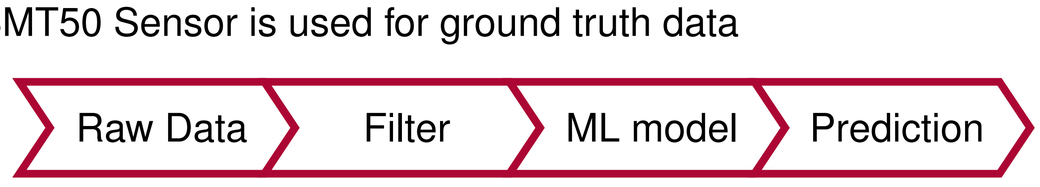

Fig. 3: Simplified Data Flowchart

Case Study: Soil Moisture Deployment

Fig. 4: Overview of the deployment site in November 2023

Fig. 5: Example Deployment at the ATB in Marquardt

- Problems with heavy rain led to complications
- First results are promising

First results & Future Work

- Multichannel usage improves the quality of the results
- Filtering of the raw data is needed to reduce the noise
- Larger and longer deployments in the future

References

[1] Daniel Kiv et al. “smol: Sensing Soil Moisture using LoRa”. In: *Proceedings of the 1st ACM Workshop on No Power and Low Power Internet-of-Things*. 2022, pp. 21–27. DOI: 10.1145/3477085.3478991.
[2] Steven M Hernandez, Deniz Erdag, and Eyuphan Bulut. “Towards dense and scalable soil sensing through low-cost WiFi sensing networks”. In: *2021 IEEE 46th Conference on Local Computer Networks (LCN)*. IEEE. 2021, pp. 549–556. DOI: 10.1109/LCN52139.2021.9525003.
[3] Jan Bauer and Nils Aschenbruck. “Towards a low-cost rssi-based crop monitoring”. In: *ACM Transactions on Internet of Things* 1.4 (2020), pp. 1–26. DOI: 10.1145/3393667.