RADIO FREQUENCY PROPAGATION, CHARACTERIZATION AND MEASUREMENTS FOR ANTENNA SENSOR NETWORKS WITH APPLICATIONS IN SMART FARMING

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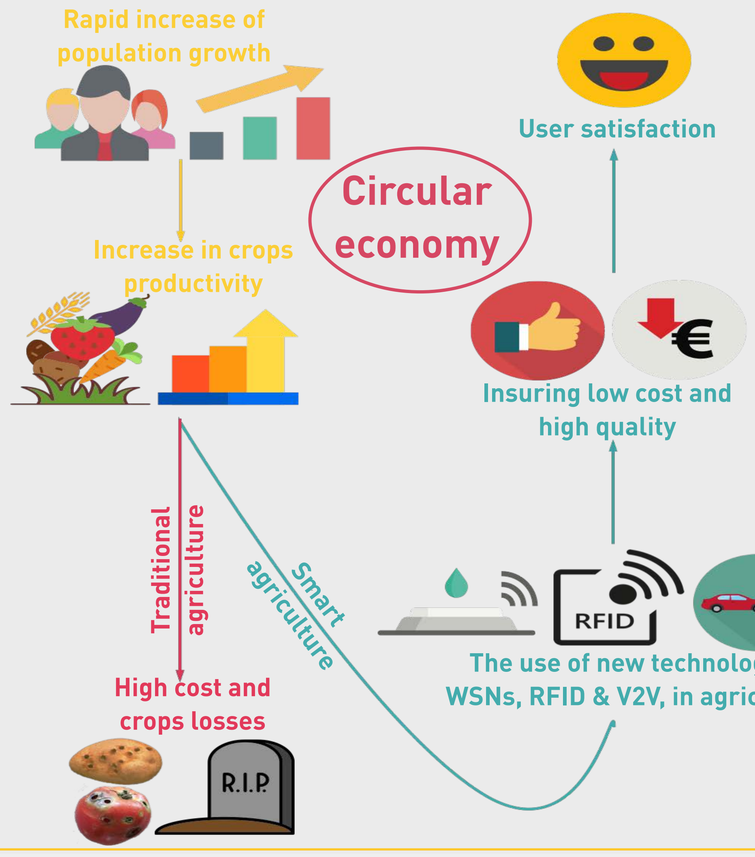
1 Motivation of the work



2 Thesis Objectives

The main objective of this research project is to design and develop an ideal smart farming system for crops monitoring from cultivation to transport and storage in warehouses using Internet of Things technologies, Wireless Sensor Networks, Vehicle to X communication and Radio Frequency Identification.

Throughout this research project, the following objectives are sought:

- **Conduct a state-of-art study on WSN, V2X and RFID technologies, such as radio frequency propagation and antennas, intended to applications in smart farming.**
- **Development of radio channel models for WSN and V2X communications improvement.**
- **Development of V2X protocol to improve long-distance and real time traceability of food transportation.**
- **Improvement of food detection using RFID tags to overcome the unreadability problems.**
- **Design, simulation and manufacture of antennas and circuits dedicated to WSNs for smart farming.**
- **Combining all developed applications in one responsive application for crops monitoring through all steps.**
- **Research results will be published in international journals and conferences.**
- **Technological transfer of the achieved results with detailed analysis, design, simulation, manufacturing and measurement will be implemented in many prototypes.**

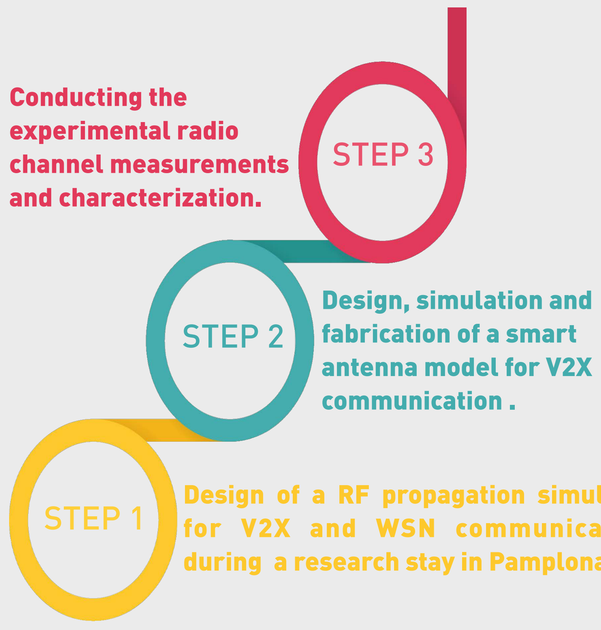
3 Research Plan

Design of novel elements of improvement for WSN technology:
-Design, simulation and fabrication of an intelligent antenna for WSN use.
- Development of a near-ground radio propagation channel model for WSN.
- Development of a complet WSN system dedicated to smart agriculture.

Design of novel elements of improvement for V2X communication:
- Design, simulation and fabrication of a smart antenna model for moving elements tracking and full duplex capacity analysis.
- Development of a radio propagation channel model for V2X communication.

Design of novel elements of improvement for RFID technology:
- Design, simulation and fabrication of an optimised antenna.
- Development of a radio propagation channel model for RFID communication.
- Development of a crop's tracking system.

4 Next year planning



6 Published/Under review publications

[1] Klaina, H.; Alejos, A.; Aghzout, O.; Falcone, F. Characterization of Near-Ground Radio Propagation Channel for Wireless Sensor Network with Application in Smart Agriculture. Proceedings 2018, 2, 110.

[2] Klaina, H.; Alejos, A.; Aghzout, O.; Falcone, F. Narrowband characterization of near-ground radio channel for wireless sensors networks at ISM bands. Submitted to Sensors Journal.

[3] H. Klaina, A. V. Alejos and O. Aghzout. Characterization of Impairments in the detection of RFID Tags for Smart Agriculture Applications. Submitted to WINCOM'18 conference in Morocco.

5 Results & Discussions

Measurements show that a significant change in path loss occurs when lowering the height of the antennas near to the ground after a break distance, changing the field (soil, short grass and tall grass field) and the radio frequency (868MHz, 2.4GHz and 5.8GHz).

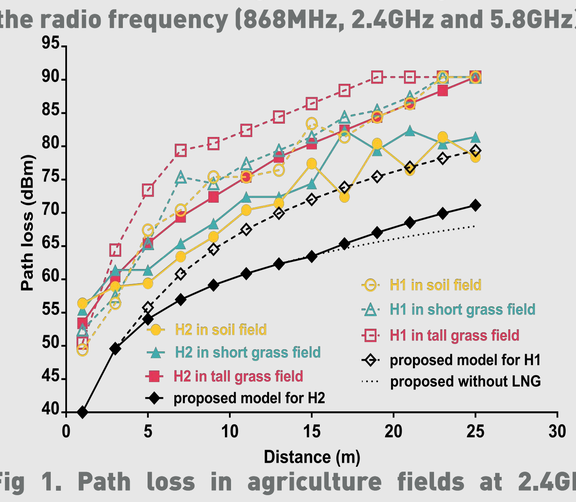


Fig 1. Path loss in agriculture fields at 2.4GHz for H1=20cm & H2=40cm.

Published in [1]
4th International Electronic Conference on Sensors and Applications (ECSA-4) BEST PAPER PRIZE.

The near ground scenario is more restrictive than an OLoS link, and would require the use of more robust modulations or error correction codes to equal the performance of LoS based networks.

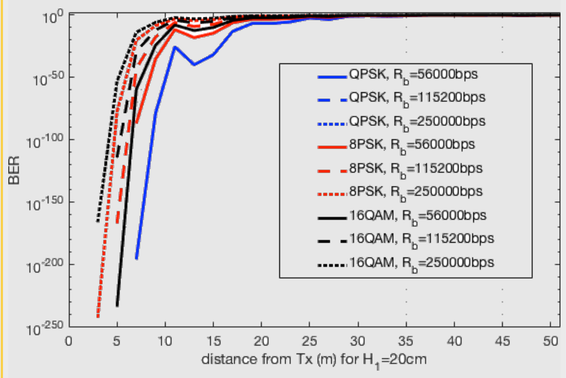


Fig 2. BER for H1=20cm and B=100MHz.

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the good choice of tag's type and positioning, and taking into account the crop's dielectric constant allows high detection performances of the whole system. A lower crop's dielectric constant allows a stronger received signal strength.

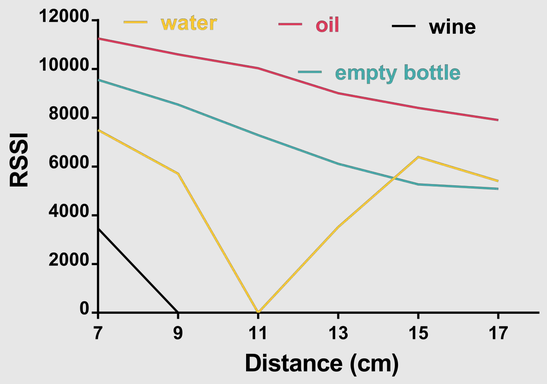

Fig 3. RSSI values using ALN G tag attached to a plastic bottle at 7cm from the bottom.

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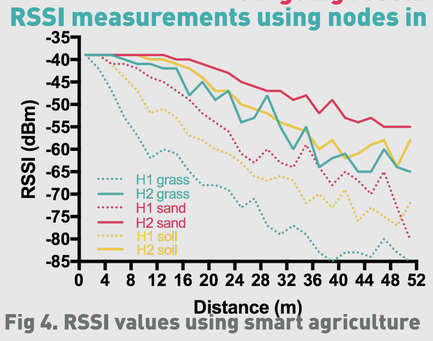
On-going research

RSSI measurements using nodes in various fields.



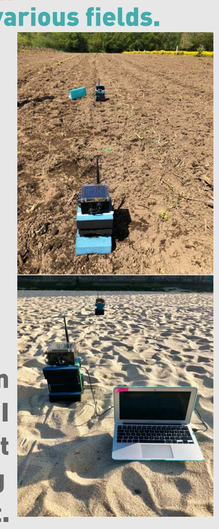


Fig 4. RSSI values using smart agriculture nodes in soil, sand and grass fields.

Using smart agriculture nodes in sand, soil and grass fields, RSSI measurements results show that unlike grass and soil, sand is offering a better RF propagation environment.

Near ground wideband and narrowband channel models

Using both omni/directional antennas (868MHz, 2.4GHz and 5.8GHz), S21 is measured. The in frequency domain is converted via the inverse FFT to domain time, so the channel impulse response can be analyzed.

Dual band FP Cavity antenna

Design, simulation and fabrication of Dual Band FP Cavity antenna (2.4-5.8GHz) with high gain and directivity, and narrow beamwidth for WSN use in farms during a research stay in Paris.