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Research Article

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IoT based system for humidity monitoring applied to smart agriculture

Amadou Mbagnick Gning*, Donatien Gueswende Kabore*, Cheikh Cissé*, Cheikh SARR*

*University of Thies, UFR Sciences and Technologies, Cité Malick Sy, BP 967, Thies, Senegal

Abstract With the growth of the Internet of Things (IoT), LPWAN technology becomes more and more popular. LPWAN networks are well designed for large-scale IoT deployment due to low power consumption and long-range wireless communications especially in urban and metropolitan areas. A large number of devices typically communicate directly to a gateway node which forwards packets to a remote server for specific treatments. Internet of things (IoT) is now widely used in smart agriculture scheme. Sensors gather information about environment such as humidity, temperature for example and send it to a collection point through a LoRa network. Humidity is one of the most commonly measured physical quantities and is of great importance in smart agriculture. Thus, in this paper, we present a new connected system for monitoring humidity of the ground. LoRa is used as LPWAN technology to create a local network and send information through servers.

Keywords Internet of Things sensors, temperature, humidity, LoRa, machine learning

1. Introduction

Agriculture is considered as the main source of food, employment and economic development around the world. Internet of Things (IoT) is widely used for collecting devices and sending data information. IoT is used in a lot of domain like for example smart agriculture, smart cities, environment, security, health, home automation. There are several challenges facing agriculture such as climate change, poor agricultural extension services, poor irrigation [1-4]. Nevertheless, combination of traditional methods with technologies as IoT can lead to agricultural improvements. The main objective is increasing quality and quantity of production while reducing operating costs. Use of technology help farmers find solutions for different challenges and make maximum use of the available limited resources. Therefore we aim in this study to deploy a new LoRa architecture which can monitor soil humidity. LoRa seems to be the best candidate protocol for agriculture technology solution because the physical and data link performance have been largely evaluated and provide good performance [5-7]. The remainder of the paper is organized as follows. Section II presents Related Works about IoT and smart agriculture. Section III provides a brief overview of LoRa technology while Section IV describes our LoRa-based new architecture for soil humidity management. Section V gives the performance evaluation of our solution and finally, Section VI concludes our work.

2. Related works

Nikesh Gondchawar et al., [1] proposed work on IoT based smart agriculture. The aim of the paper is making agriculture smart using automation and IoT technologies. Smart GPS based remote controlled robot will perform the operations like weeding, spraying, moisture sensing etc. It includes smart irrigation with smart control and intelligent decision making based on accurate real time field data and smart warehouse management. It monitors temperature maintenance, humidity maintenance and theft detection in the warehouse. All the operations will be controlled by smart device and it will be performed by interfacing sensors, ZigBee modules, camera and actuators with microcontroller and raspberry pi. All the sensors and microcontrollers are successfully interfaced with three Nodes using raspberry pi and wireless communication. This paper gives information about field activities, irrigation problems, and storage problems using remote controlled robot for smart irrigation system and smart warehouse management system respectively.

Tanmay Baranwal et al., [2] this project concentrates security and protection of agricultural products from attacks of rodents or insects in the fields or grain stores. Security systems are used to provide real time notification after sensing the problem. Sensors and electronic devices are integrated using Python scripts. Algorithm is designed based on collecting information to provide accuracy in notifying user and activation of repeller. Testing is done in an area of 10 sq. m. and the device is placed at the corner. The PIR sensor identifies heat it starts URD sensor and webcam. Based on attempted test cases 84.8% success is achieved. It will be helpful to extend the security system to prevent rodents in grain stores.

In [3], Web of Things case study for agriculture was put forward, which focuses on an experimental smart farm that uses a range of environmental sensors and livestock-monitoring technologies. A system that specifies the alert was tested in a farming area and the results were analyzed. The linked cube was used which allows longer-term analysis and data sharing to a larger scale.

In [4], a real-time monitoring of GPS-tracking was suggested for multifunctional vehicle path control and data acquisition based on Zig-Bee multi-hop mesh network. It summarizes portion that is related to path planning for a multifunctional vehicle. The vehicle tracking system uses the global positioning system (GPS) and ZigBee wireless network based on to make the system communication.

In [5], a wireless sensor network and cloud IoT based Decision Support System which notifies the farmer when Late Blight may first attack potatoes by sending an SMS. In this study a sensor network monitor and report information to the cloud server about temperature and humidity then SIMCAST model assess the risk of Late Blight appearance.

From the above literary survey, we see that technologies have been widely used for agricultural task automation. We propose a novel approach using a smart sensing system that keeps track of the external environmental factors and does communication using LoRa technology for transmission. Machine Learning techniques are also used for prediction of data analysis.

3. Brief overview of LoRa technology

This section provides an overview of both physical (LoRa) and medium access control MAC (LoRaWAN) layer protocol. The basic architecture of a LoRaWAN network consists of nodes equipped with sensors that communicate with servers through gateways (Fig. 1). The main purpose of these sensors is to collect a set of parameters of the immediate environment, such as temperature, atmospheric pressure and light intensity and to route them to treatment points. LoRa is a physical layer radio modulation based on Chirp Spread Spectrum (CSS) [4]. It allows long range communication up to several kilometers while using low power consumption. The advertised communication range of LoRa is more than 15 km for suburban environments. Free unlicensed ISM bands are used and particularly the 868 MHz frequency in Senegal. LoRa provides several physical parameters that can be customized. These parameters include Spreading Factor (SF), Bandwith (BW) and Coding Rate (CR) that affect the quality of the transmission. LoRaWAN is a MAC layer organized in a star of star topology composed of three elements: end-devices represented by sensor nodes, gateways and network server (Fig. 1).

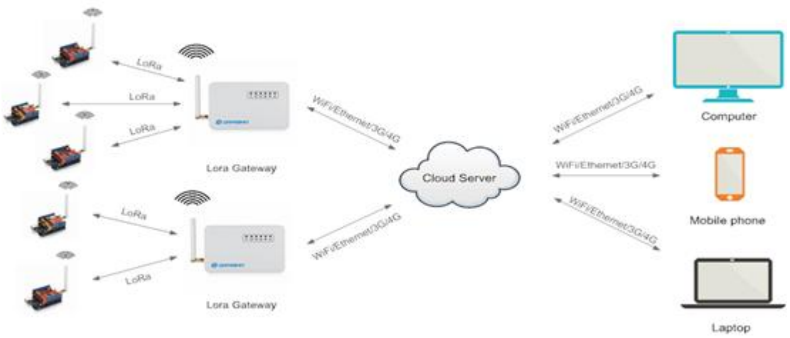

Figure 1: LoRa architecture

The LoRaWAN specification defines three device types:

1. Class A is the basic LoRaWAN and must be implemented by all end-devices. It allows bidirectional communication and use pure ALOHA access for the uplink.
2. Class B is conceived to guarantee uplink and downlink separation. Nodes are synchronized using a beacon transmitted by the gateway. Thus, they can receive information from Internet without sending requests.
3. Class C, the node has a continuously opened receive windows that are closed only while transmitting. Compared to A and B classes, C class consumes much energy to operate but it offers the lowest latency and is well designed for bidirectional communication.

4. Proposed system

This section describes the detailed implementation of system deployment. The main idea of our system is to automate the activities of farming by using the principles of communication and electronics devices. We accomplish our goal by using sensors, actuators and wireless transmission system. As we can see, the central element of the client device is an *Arduino* board. The architecture of the deployed system is presented in Figure 2 and can be divided in three parts:

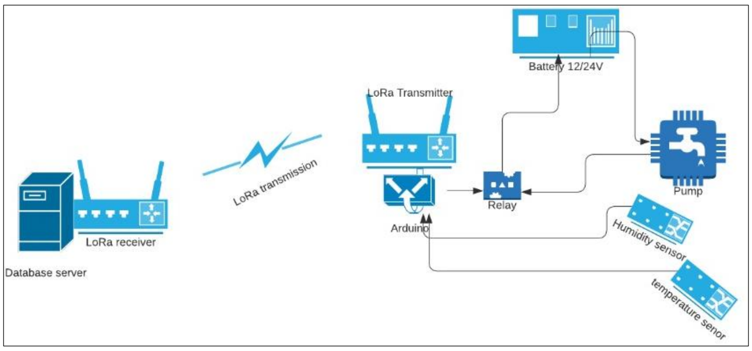

Figure 2: The architecture of the implemented system

- The first part is the data acquisition (DAQ) process. Current humidity and temperature sensors are connected to the *Arduino UNO* Card. Thanks to the Arduino board, the humidity and the temperature generated by the sensors are collected at regular time interval.
- The second part is about activating automatic watering of the system. A relay controlled by the *Arduino* board is connected between the battery and the water pump. The *Arduino* board, via the relay, blocks the power supply to the water pump if the humidity level is below a threshold value which is fixed to 50% of humidity.
- The last part is the transmission process. The LoRa transmitter sends information about humidity and temperature to LoRa receiver at the frequency of *868 Mhz*. The parameters of the LoRa transmitter are presented on Table 1. A software tool written in Python retrieves the collected data from the serial port and stores them inside a Database server hosted by the computer.

Table 1: Parameters of LoRa transmission

Parameters	Values
Frequency	868 Mhz
Power transmission	14 dBm
Spreading Factor	SF 7
Bandwidth	125Khz
Coding Rate	4/5

For comparison, we use two types of plants: one with a root ball (Figure 3a) and another one without a root ball (Figure 3b). A pump could be also activated to maintain the humidity beyond a predefined threshold.

(a) plant without root ball (b) plant with root ball

Figure 3: Plant with and without root ball

5. Performance Evaluation

In this section we compare results obtained in three cases: when the plant is without root ball, with root ball and when the pump is activated. We focus on humidity which is defined as a measure of the water vapor present in the ground. Two common parameters in associated with humidity measurement are absolute humidity and relative humidity. In our case we measure relative humidity which varies from 0% (totally dry) to 100% (totally wet). The relative humidity is related to ambient temperature. We also discuss two different supervised machine learning algorithms for humidity prediction: linear regression and polynomial regression.

Fig. 4 (a) presents the results of humidity in percentage. We can notice that when the plan is with root ball, it consumes much more water (the humidity decreases from 60% to 5%). At the same time, when the plan has no root ball, the humidity decreases more slowly (about 75% to 60%). Therefore we can conclude that when a plan is with root ball, it needs much more water to grow.

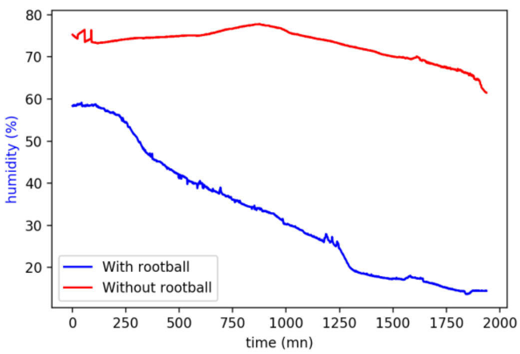

Figure 4 (a): Humidity with and without root ball

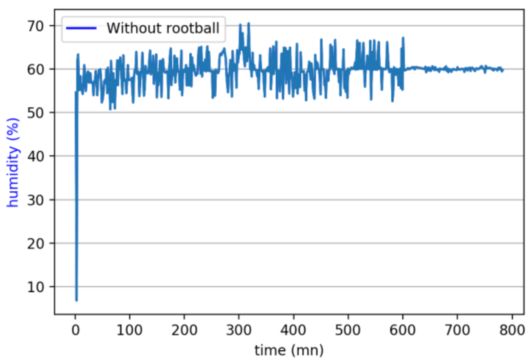

Figure 4 (a): Humidity when pump is activated

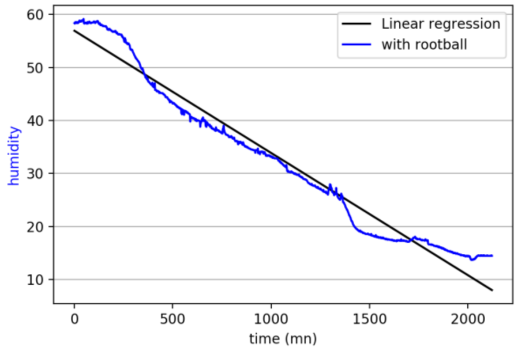

Figure 5(a) : Linear regression with root ball
Precision = 96.69 %

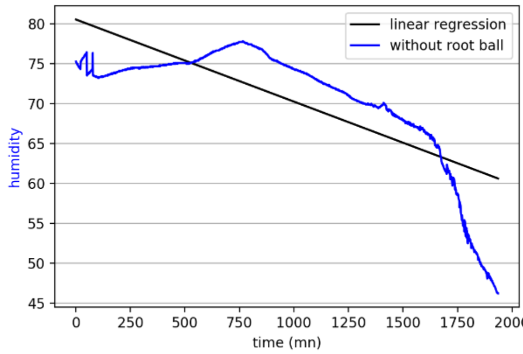

Figure 5(b) : Linear regression without root ball
Precision = 59.20 %

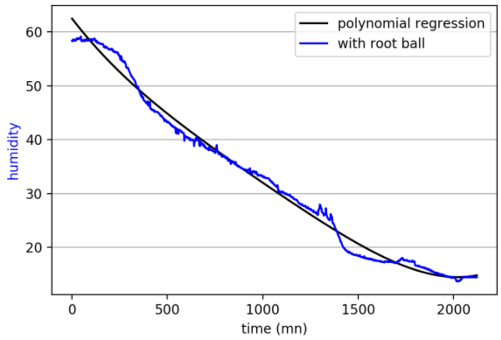

Figure 6(a) : Polynomial regression with root ball
Precision = 99.10 %

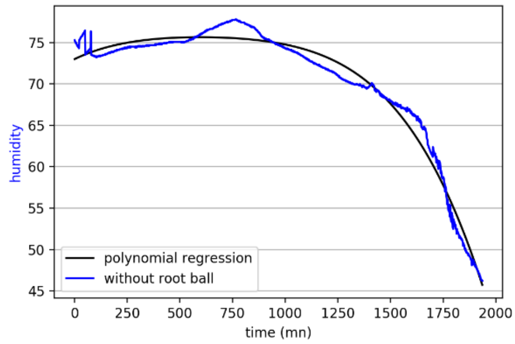

Figure 6(b) : Polynomial regression without root ball
Precision = 97.36 %

In parallel, we use Machine Learning techniques to provide a reliable solution for estimation and prediction of relative humidity of our system. Results for linear regression are presented on figure 5(a) and (5b), while results for polynomial regression are presented on figure 6(a) and 6(b). Based on these figures, polynomial regression gives more accurate estimation of relative humidity percentage near to 99% (Fig 6(a)) and 97% (Fig 6(b)) respectively when the plan is with and without root ball. However, linear regression is not efficient when the plant is without root ball (Fig 5(b)) with a precision of only 59.2%. This value increase to 96.9% when linear regression is done with root ball.

6. Conclusion and future works

In IoT-based smart agriculture, we propose a new system for monitoring, with the help of sensors, relative humidity of the ground and automating the irrigation system. LoRa protocol is used to send data to a database and machine learning techniques provide estimation for the percentage of humidity. IoT-based smart farming is highly efficient when compared with the conventional approach. As future works, we plan to implement other sensors like for example wind speed and light sensor to see how these parameters will in influence relative humidity of the ground.

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