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juliocmlautert@gmail.com

Development of a microclimatic monitoring station for precision agriculture with long distances wireless communication system.

Lautert JCM*, Santos RJ*, Drigo ES§, Del Monaco ADM§,

** Catholic University of São Paulo (PUC - SP), Brazil. §University of São Paulo - Dante Pazzanese Institute of Cardiology (IDPC - USP), Brazil.*

Abstract. In the scene of new technology for Smart Farming it is important to develop a low cost station that can be monitored remotely. This would make it easier for farmers to monitor different stations (within a radius of up to 15 km). In addition, the use of several wireless monitoring stations is considered advantageous because it generates a decrease in the amount of water used, avoiding waste due to the connection of the irrigation pivots without the real need. In addition, it also generates energy savings, saving resources in general. The main applications are in precision farming, for example, in control of irrigation pivots in large-scale crops, such as wheat and soybean plantations. This project developed a micro controlled system for radio frequency wireless communication (LoRa), since these plantations are generally not located in places with access to the electric and cellular networks. The main functions are to monitor temperature and humidity, soil and air, as well as to know the location (GPS) of each station, to feed microclimatic databases that allow the control of irrigation system and better planning of the use of pesticides.

Keywords. *Smart farming, wireless communication, GPS, LoRa, Dragino.*

Introduction. Prior to digital era, field monitoring was manually, it signify that a personal follow-up of agricultural production was required to have a good efficiency. But with the advancement of technologies, such as mobile networks (5G), IoT, geographic positioning, Big Data, sensors, Unmanned Aerial Vehicles such as Drones, robotics, etc, this feature is beginning to change, no longer being necessary the presence physicists, but rather remote, with a greater efficiency. This new scenario is called Smart Agriculture or Smart Farming. Where everything is connected, as well as information and data transmission over the internet, improving efficiency and business management. The term Smart Farming is related to use of applications of modern information and communication technologies in agriculture, leading to what may be called the Third Green Revolution [1, 2].
From the point of view of the farmer, a benefit should be provided in better decision-making or better operation, as well as more efficient management [3].

Smart Farming is not intended to replace specialists' farmers, but to help with decisions in real time through all information that is received, rich in detail. This occurs in a different way from the common agribusiness, where decision-making is made directly by human being, and when taken in an imprecise way, can compromise the whole result of a production. In this sense, Smart Farming is closely related to three interconnected technology fields: Management information systems, precision agriculture and automation (agricultural robotics) [4, 5, 6].

Among these technologies, the implantation of sensors to monitor local conditions of production and transmission of these data to the decision-making with greater precision are important points to be developed.

Amid the field information that are important for precision agriculture are soil and air humidity and temperature, which determine whether or not irrigation is necessary, and allow the programming of irrigation pivots, as well as planning the use of fertilizers and agricultural pesticides [6,7].

Within the concept of Smart Farming, in addition to obtaining more accurate data on soil and climate conditions in plantation, it is equally important to transmit this data in addition to registering them on interconnected platforms. A fact to be considered, in Brazil´s case, in this sense are the great distances between sensor stations in plantations and electric power sources, telephone network signals and satellites in regions far from urban centers, as is the case of most of the farms producing [8].

In Brazil, due to the large distances between plantations and urban centers, this issue should be considered in the choice of data transmission technology remotely, which should be without wireless. In view of the above, the present project has its importance in the development a microclimatic monitoring station for precision agriculture with long distances wireless communication system, that can be applied in the conditions of the large cultures, present in Brazil, considering distances of the order of kilometers between nodes and absence of mobile telephony network for data transmission.

Materials and methods. For the development of the prototypes presented in this project the steps described in the following items were performed:

Sensors and power module. Temperature and humidity sensors were used, which were divided into two sets: the first one corresponds to the sensors for positioning in the soil, and the second one for data acquisition of temperature and humidity of the air.

For outdoor use, the sensors must be water resistant, so the humidity sensor, DS18B20, which performs readings up to ± 0.5 ° C (between -10 ° C and + 85 ° C), and sends information to Arduino® platform using only one wire. Since each sensor has a physical address, it is possible to place several interconnected sensors on the same bus, using a single port of the micro controller, and read them individually. For better visualization of sensor data, the Arduino® allows the use of a 16x2 display (with a 10kΩ potentiometer for contrast adjustment) [9].

The humidity sensor consists of 2 parts: the Hygrometer, which has a probe for permanent ground contact and a small hardware with a comparator chip for reading and sending collected data. Depending on the humidity, the digital pin D0 will be in logical level 0 or 1, but for a greater precision in the measurement of the humidity one can use the analog pin A0 connected to the Arduino UNO. The sensor behaves detecting variation in soil moisture by reporting a high state for dry soil and a low state for wet soil.

The second set, Humidity and Temperature Sensor (DHT11), is an NTC thermistor and the Humidity sensor is of type HR202. The internal circuit reading the sensors and communicates with a microcontroller through a one-way serial signal, which makes the use very practical [10]. Having a small size, low electrical consumption and long transmission distance, it allows the DHT11 to be suitable for various types of application.

To feed the prototype developed in the present project, a lithium alkaline battery with nominal voltage of 9 V, when fully charged, and capacity of 565 mAh was used.

Measuring station. It is an open source platform, both hardware and software, that has an 8-bit micro controller and uses an adapter for USB-Serial conversion. It has an Atmega328 processor (Uno), with several pins where we can manipulate the inputs and outputs of information, recording schedules on the Arduino® board, looking like a minicomputer.

For Arduino® configuration there is a "program" that can be downloaded from manufacturer's own website, from where all the programming that is executed on each Arduino is loaded. With the use of a Serial-USB cable it is possible to manipulate the Arduino® and begin its configuration. When the program is loaded, it is stored in Arduino®, which uses both C and C ++ languages, and also has several function libraries that are used to create special functions [11].

The first tests were performed with the connection of temperature and humidity sensors on the Arduino Uno, separately. Subsequently, the sensors were connected simultaneously by capturing the soil temperature and humidity information displayed in the same log of generated information.

For latest version of the prototype was used DHT 11, which has temperature sensor and air humidity. And finally, the DHT 11 was installed along with the soil moisture sensor, completing the weather station, with soil and air temperature and humidity information.

For the protection of electronic system against weather conditions (rain and dust), the PVC light box was used, which has internal dimensions of 154 x 110 x 70 mm, which has an IP-55 degree of protection according to the IEC60670-1 Regulatory Norm - boxes and boxes for electrical accessories.

Transmission of data. In the first tests, for reading, recording and interpretation of the data, an Arduino® programming was implemented that shows the information collected by the sensors on the screen of the computer via USB cable in real time. Having this information collected and available in the Arduino data log, it was possible to import the data into Excel and generate charts to illustrate the reading of data and also maintain a history of the information.

For wireless data transmission, a specific programming was adapted and the Arduino-coupled Shield LoRa was used to allow the connection to the gateway (Dragino LG01-P) via a radio frequency (RF) signal of 915Mhz. With this connection, the Dragino LG01-P, which is

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connected to internet, transmits this data to an external server available on the free ThingSpeak platform.

To test the operation of the prototype, the distance test was carried out, in which the set of sensors connected to LoRa Shield and Arduino was removed from the gateway until the signal loss limit.

Storage and interpretation of data obtained. The platform available in ThingSpeak has been configured to plot temperature and humidity graphs collected by each sensor, and it is possible to add new graphics as needed.

With data on this server it is possible to download the information for the registration and formation of a history for a future analysis of the obtained data.

Results and discussion.

Sensors and power module. Temperature and humidity sensors were implemented at the measuring station and it was possible to obtain the data with both the sensors and the humidity-temperature set. The assembly of the sensors can be seen in Fig. 1 (A and B).

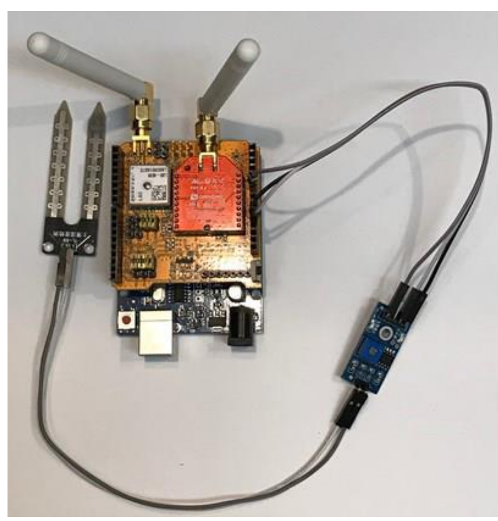

(A)

(B)

Figure 1. A- Photograph of sensors installed in a plant vessel for data collection. B- Photograph of the sensors for data collection.

Development of the measuring station. The measuring station was developed with sensor array and Shield LoRa coupled to the Arduino UNO, according to Fig. 2 (A and B), for the two sets: sensors for soil and air.

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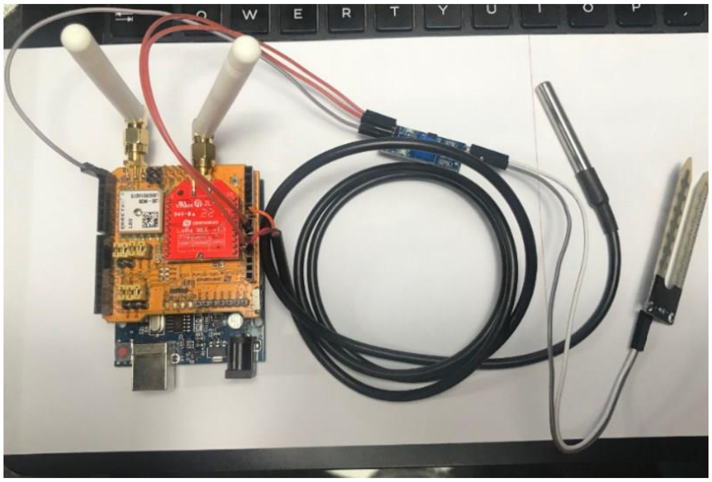 (A)  (B)

Figure 2. A- Photograph of soil temperature and humidity sensors installed in the Arduino; B- Final assembly in the insulation box.

The final assembly of prototypes was carried out with an adaptation in the PVC Light box to pass the wires of the sensors, which are positioned externally. In this way, new tests will be necessary to comply with the Brazilian standard NBR IEC60670-1 and IP-55 degree of protection.

Transmission of data. The transmission of data collected from sensors was performed successfully, for the preliminary assembly with connection of Arduino® in the computer, by cable, the results visualized on the screen are presented in Fig. 3.

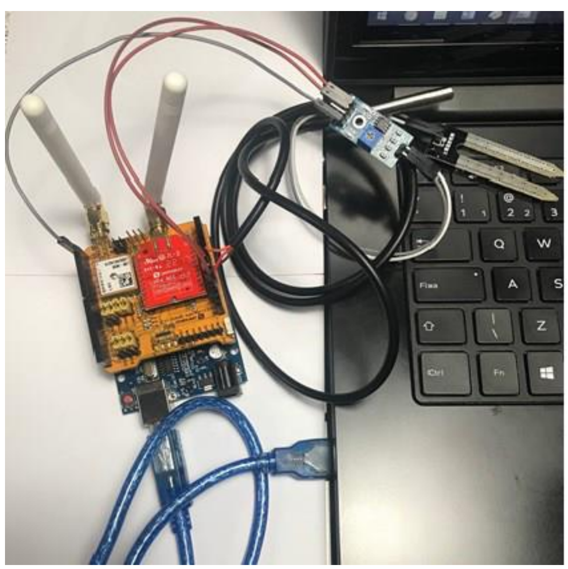

Figure 3. Photograph of the soil temperature and humidity sensors installed on the Arduino connected to the computer via USB cable.

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For the RF transmission to the Dragino gateway, and via WiFi to the central in Cloud, the results are sent directly to computer via WiFi by the Dragino gateway, feeding the graphics of ThinkSpeak platform, as shown in Fig.4 (A and B).

(A)

(B)

Figure 4. A- Photograph of temperature and humidity sensors connected to Arduino and the Shield LoRa and Dragino gateway. B- Results obtained from sensors transmitting via RF to the gateway, and feeding the graphics displayed on computer, where data of humidity and temperature are observed.

The DHT11 sensor (temperature and air humidity) data was obtained at a distance of approximately 528.9 meters, as indicated in Fig. 5.

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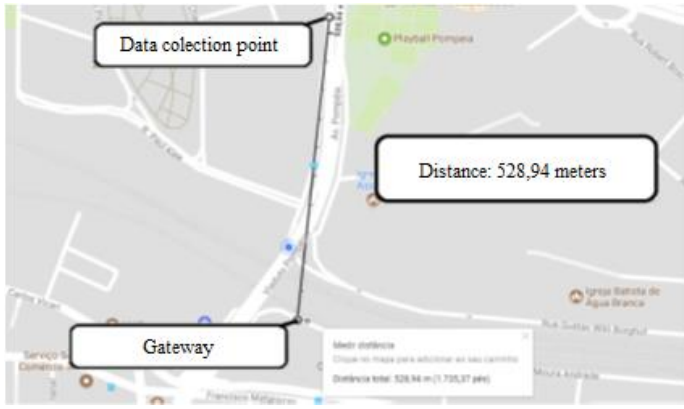

Figure 5. Approximate measurement of the distance from the data collection using the Google Maps tool.

Loss of connection occurs from a distance greater than 550 meters (approximately). This is due to the fact of the excess noise coming from the high concentration of RF antennas and electronic equipment in the urban region, besides a high number of buildings and constructions that can affect the efficiency of the signal.

Storage and interpretation of data obtained. The humidity and temperature data are obtained every 15 seconds, according to the programming developed. This range can be modified according to the need, for each application.

The data can be sent to an Excel® spreadsheet and fed to meteorological databases with microclimatic conditions of each station, allowing the implementation of an automated irrigation pivot control system, for example.

The total cost for the elaboration of the prototype was approximately BR R$ 900.00, containing two measuring stations with data transmission modules, processor, temperature and humidity sensors, power module, including also the transmission / reception module of data center and insulation system and protection against bad weather.

For the improvement of the developed project the GPS module was implemented in the programming developed so that in addition to temperature and humidity data, location data obtained by the GPS sensor of Shield LoRa itself.

Conclusion. It was possible to develop a long-range remote monitoring system that can be implemented to control irrigation pivots in precision agriculture.
A platform for data acquisition for temperature and humidity, air and soil monitoring was developed with a long-range data transmission network by Radio Frequency.
Data storage and visualization was performed, allowing the interpretation and registration in meteorological platforms and databases.

In this way, it can be considered that the project can be implemented in the future at a competitive cost in relation to the services available in the national market.

Future implementations. As future works are the implementation of the GPS system in the measuring stations to send all the data simultaneously by RF and tests in conditions of operation closer to those applied in precision agriculture, with less interference that hamper the signal reach. In addition to the possibility of implementing other types of sensors, such as rainfall and wind speed, for example.

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