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Monitoring system of environmental variables for a strawberry crop using IoT tools

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Abstract

This research work is aimed at strengthening the resources that farmers have for crops management of pests and diseases in a digital way using internet of things through the development of a prototype. It can obtain important information of variables within a strawberry crop such as Relative Humidity, temperature and pH. These data are processed and received by means of protocols in real time. These devices allow managing the information of different variables through communication among sensors. This study presents the most critical characteristics of the strawberry by using the data collection of an IoT system. In this way the initial results can demonstrate that the system yields important information for the appropriate management of strawberry crop production.

Keywords: Internet of Things, strawberry, humidity, temperature, pH, conductivity

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1. Introduction

Science and technology have been getting significant advancements to improve the living conditions of beings that inhabit the earth. All interconnected and automated electronic circuits make a difference at this time and agriculture is no an exception. Information and communication technologies have allowed IoT to be integrated in various solutions of different fields [1]. By sending data over internet, solutions can be offered to mitigate the environmental crisis issue that is affecting crops in Colombia. Different technological systems have been applied in agriculture. These permit processes optimization and the possibility to set the conditions of humidity, temperature and pH of the soil. Also, it is possible to learn about the conditions of the plants to incorporate many treatments related to pests, diseases and better weather conditions that can help to improve production. The collection of information, monitoring and evaluation of a farming system is decisive for effective decision making [2-5]. Likewise, improvement or correction of production to reach the necessary global supply. Even, when inadequate management of water resources jeopardize this need. The goal of this study is the cultivation of strawberry as well as the characterization and implementation of a network architecture of sensors focused on the Internet of things. It is intended to improve productivity locally in strawberry crops and any other crop with this technological solution. Control of variables and parameters that affect the development of plants of a strawberry crop are seeked by employing technological tools applied to extensive crops [6-8]. Some characterizations and records that serve as indicators for decision making in the field are applied. Also by studying periodic production cycles, monitoring microclimates and monitoring variables within the crop. Hence, it will be possible to achieve a complete system with alarms, production indicators and logistic improvement. It is possible to adapt and review the feasibility to use crop control advances with sensors and computer-based systems. Also, we want to develop and implement a sensor network architecture that allows monitoring different climatic variables in order to analyze the situations of strawberry crops which are affected by climatic variations. Hence, its production can be improved against traditional techniques. To monitor strawberry crops, variables and parameters information are collected from the devices groups. The results shown are related to the percentage of soil moisture, ambient temperature and relative humidity, as well as the pH level of the soil. The permanent control of these values play a significant role in the quality of the strawberries grown in Colombia. Through the monitoring of variables and a precise analysis of the crop parameters, it is possible to allocate the resources available for different types of agriculture [8]. It may guarantee not only the control over them but also obtaining the quantities and qualities required. Interaction with the farmer is involved as well. The research on strawberry ranges from the study of the environmental conditions to the growth of strawberry [9-11], smart harvesting methods [12-14], remote monitoring, and automated control of irrigation system [15-17]. Furthermore, this section covers the description of the IoT and its application to greenhouse production. The benefits and challenges of IoT for greenhouse strawberry production is also presented. In this work, a theoretical framework, some data necessary for the understanding of the project such as the internet of things, the botanical characteristics of the strawberry, and some variables of collection in strawberry crops will be presented. Then, some conceptual aspects are considered as well as a project development methodology. Finally, conclusions or results of the present investigation are given.

2. Referring Activity

Strawberry is considered a prominent fruit for its flavor and excellent nutritional properties (for its high content of vitamins A and C). The demand for this fruit is high in Colombia and is used for the production of different agroindustrial products [18, 19]. This work shows the design of a sensor network and its implementation in a strawberry crop. A free hardware is used to show the application of the sensors, obtaining parameters information to study their behavior in a period of time and perform the analysis of the variables obtained. The Botanical characteristics of strawberry in Colombia are [18]:

- Common Name: Strawberry
- Family: Rosaceae
- Scientific name American species: Fragaria chiloensis, Fragaria virginiana.

- Its stem is constituted by a short conical shaped axis called a crown where leaf scales are observed.
- Its leaves appear in rosette and are inserted into the crown.
- Its total cycle is 150 days (5 months).

The Diseases that most attack Strawberry [18] are:

- Dusty Cenicilla or Mildiú.
- This fungus (Sphaerotheca macularis) has been reported in all strawberries produced in all regions. Losses can be total when the fungus attacks flowers and fruits.
- The infection of this pathogen to the foliage affects the leaves, reducing the photosynthetic activity, since mycelium and conidia (spores) cover the foliage.
- Symptom. The whitish spots that develop on the underside of the leaves are mainly characteristic. The leaves are rolled from the edges upwards, showing the growth of the white mycelium.

Table 1. Ideal Climate Conditions for Strawberry Cultivation in Colombia [20]

Variable	Magnitudes
Altitude	1300-3000 meters above sea level
Ideal temperature	Daytime: 18-25 ° C - Night: 8-13 ° C
Brightness	3,000 hours of sun / year
Relative Humidity	60 to 75%
Precipitation	Minimum (1000 to 2000 mm / year)
Hail	Causes severe mechanical damage. Facilitates the entry of Pathogens

For the development of the monitoring system, a farm in a nearby town was chosen where there is a large concentration of strawberry growers. This place meets the necessary climatic conditions, see Table1.

3. Methodology

The architecture system is open to inserting new sensors, the Raspberry-Pi card is responsible for performing a sensor scan and learning from the sensors involved within the network according to the request of the data. It is then processed and notified that a new sensor was added through communication through Free Software and sensors connected to the board. The entire project is built around the microcontroller and the server. The sensors communicate the values received to the Raspberry-Pi 3 card, where they are stored in the database. The server is located in the microcontroller. The different web pages stored on the server read the information from the database creating graphs that the user can consult. Finally, the microcontroller sends alert messages to users.

Platform

For the development of this research, different IoT platform options were reviewed to determine the most convenient for integration with network infrastructure and benefits such as graphic visualization and presentation of data to the end user. So, the Wyliodrin platform supports the connection of several embedded third-party systems for IoT. In addition to the easy-to-use block programming structure for sending data, it is very didactic for mobile device implementation because it is practical and allow to see the variables on the PC, android, IOS and on any other device. Wyliodrin is a service that allows programming and control of embedded devices directly from a browser. The user can write, store and execute their programs. We can modify and view the parameters of the board in real time, no matter where the board is located. Overall, programming embedded devices requires the installation of specific software. A computer, a browser and an Internet connection are required. It is even possible to use a public computer as it is not necessary to install anything on it. The Components diagram of the IoT network is shown in Fig. 1.

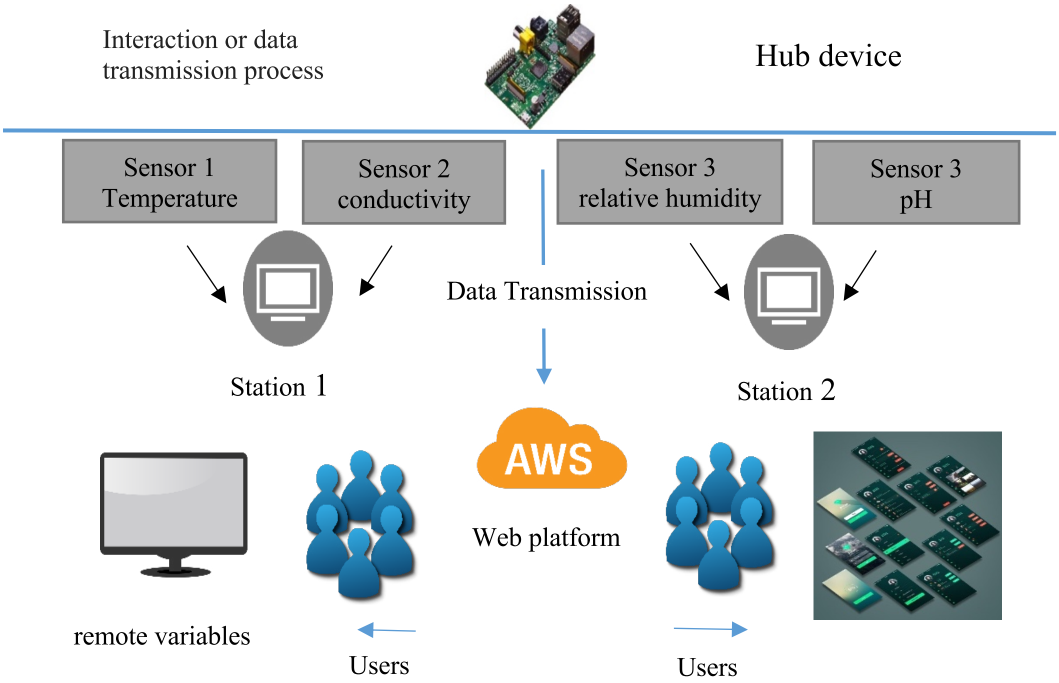

Fig. 1. Components diagram of the IoT network sensor solution.

Embedded data collection system for strawberry crops

Data is sent using both a sensor network and a Raspberry PI-3 card configured as a weather station. It captures data within strawberry crops in which an embedded system is in charge of sending the microclimate variables collected from the sensors, the frames packaging and routing of information from all sensors to the internet network. For packaging, the data frame must be assembled following the TCP / IP communication protocol. This device is responsible for taking local orders and responding to requests on the server. For the development of the specific hardware prototype for frames sending, the transmission technology via GPRS of a cellular network is used. It is because there is no broadband technological infrastructure of the internet in the crops region. Additionally for this architecture configuration, nodes devices are used, which fulfil a hierarchical topology called master devices. Their fundamental function is the coordination of two different networks from the internet cloud (servers) and its distributed internal network. Communication protocols are different due to the amount of data flow.

The cloud server must exceed the capacity of data collection. A scale collection is necessary according to the amount of crops. Thus, the nodes can coordinate the sensors and that a sensor can be integrated according to the needs of the crop wirelessly. The data topology to the cloud is also hierarchical. The server is the unit of processing of multiple sources of information. The frames are stored in databases that provide the system sufficient decision information to be processed and sent to a control actuator center. Nodes are special processing devices that collect dynamic information based on the number of sensors. For the distributed architecture created, each sensor has its internal processing and communicates wirelessly to the coordinating node. These hardware platforms are employed in wireless sensor networks (WSN). WSN use media designed to measure environmental and / or agronomic variables. Telemetry is also considered to be an important resource for measurement of different physical variables at a distance. The advantage of this topology is the flexibility of the nodes and sensors that are able to reorganize depending on the necessity in any agricultural space. It is feasible to highlight the flexibility of the control that is directly adapted to the genetics of its dendrite and the knowledge of its actuators. The system sensors are able to measure many variables and are self-regulated by their coordinator (node n). These sensors work on the 434 MHz frequency and process the digital frames of the different variables captured by the IoT (Internet of Things) sensors. The architecture of the system also gets measurements of microclimates by means of the implementation of meteorological stations within the crop and in local measurement centers. These stations also have nodes connected to the server. The communication frames to the server are similar to that of the crops. For implementation purposes, the nth nodes were coded.

4. Results

A wireless hierarchical system was developed. The sensors are used in 8-bit low consumption microcontroller. Transmitters in reception consume 50 mA and in low consumption 30uA as given in technical specifications of the manufacturer. The different data frames must vary at the connection level with the server due to bandwidth consumption. It is not the same to collect data from 100 sensors to collect crop data with 4 sensors. Due to this fact, a data packet detection algorithm is determined for later sending. Within this routine, a cyclic redundancy code is implemented for receipt confirmation and confirmation with the server is implemented within the TCP protocol. The images of the final prototype are shown in Fig. 2.

Fig. 2. IoT sensors central connection in strawberry crop.

The system was put into operation for a full day on September 26, 2019 and Data was sent to the server. In Fig. 3 the graph of temperature behaviour was obtained to verify the proper functioning of communication with the server. The maximum temperature recorded was 28 ºC, which indicates that the strawberry crop does not have an optimal condition. This issue can determine important damages in fruit damage. Fruits with specific deformities can be established by studying these data analyses. Fig. 3 displays this type of deformities.

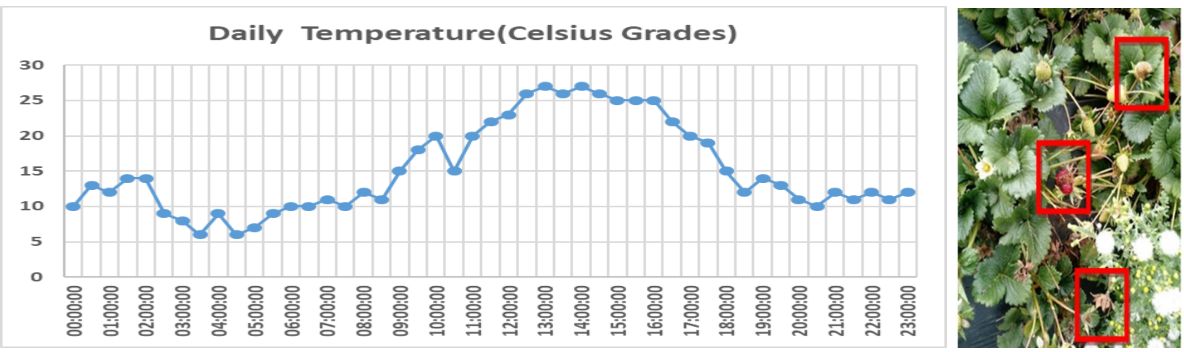

Fig. 3 Average data provided every 30 minutes in a time window of 1 day in strawberry crops and Fruits damage of strawberry cultivation.

5. Conclusions

Strawberry crops require monitoring of environmental variables. Although there are many climate conditions, it was concluded that relative humidity, rainfall, pH and temperature, are the most important for the development of sensory entities. These 4 variables have been characterized and facilitate the development of a system based on IoT (Internet of things) as well as the implementation of environmental variables. For data analysis, monitoring in relatively long time windows should be carried out as well as electronic devices that allow controlling the relationship between water consumption and the water requirements of the crop. These are fundamental factors of study for crop characterization. It is important to create the necessary hardware to take samples of different crops in order to ensure reliable, economical, and friendly measurements and that let to study the influence of climate change against agricultural production. All this, through characterization and correlation of sources of information by taking significant constant data. To reach more accurate results, longer time windows must be taken and historical information created. These will be indicated in later stages with the implementation of data analysis in big data and the construction of more devices to collect data from different crops. Likewise, through the correlation of data, artificial intelligence algorithms will be performed for determination and anticipation of frosts, climatic variations, affectation of crops and coloring characteristics of fruits according to the area. The implemented system has a cost of 3000 US dollars. Because of the implementation of a network-based system of Internet sensors of IoT things, the study of weather changes and the factors that can affect strawberry cultivation can be achieved. The IoT is a technological tool that appeared in this century to completely change the socio-economic scenarios. It opened a wide range of possibilities to the evolution of man with the new information technologies. Any object can be monitored, automated and controlled to better manage all resources and thus obtain and manage information and large volumes of all kinds of data.

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