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Data acquisition module for the operation of the Neural Network for crop rotation and soil analysis in a Greenhouse

Módulo de adquisición de datos para el funcionamiento de la Red Neuronal para la rotación de cultivos y análisis de suelo en un Invernadero

RAFAEL-PÉREZ, Eva†*, MORALES-HERNÁNDEZ, Maricela, NAVARRETE-INFANTE, Nestor Manuel and RIOS-MALDONADO, Vicenta

Tecnológico Nacional de México/ Instituto Tecnológico de Oaxaca, Departamento de Sistemas y Computación. Avenida Ing. Víctor Bravo Ahuja No. 125 Esquina Calzada Tecnológico, Oaxaca, Oax., México. C.P. 68030

ID 1st Author: *Eva, Rafael-Pérez* / **ORC ID:** 0000-0003-2793-1254, **CVU CONACYT ID:** 905268

ID 1st Co-author: *Maricela, Morales-Hernández* / **ORC ID:** 0000-0002-3521-2041, **CVU CONACYT ID:** 731036

ID 2nd Co-author: *Nestor Manuel, Navarrete-Infante* / **ORC ID:** 0000-0002-0170-5622, **CVU CONACYT ID**: 337188

ID 3rd Co-author: *Vicenta, Rios-Maldonado* / **ORC ID**: 0000-0002-1049-6631, **CVU CONACYT ID:** 90238

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Abstract

Currently, with the technological advances applied in various sectors, they have changed the way they operate in the control of their processes. In the agricultural sector, the automation of processes increases productivity and improves the quality of products. In the production crops using greenhouses, these protect the different plants from excess cold at certain times of the year, allowing control of temperature, humidity and other environmental factors that favor plant growth. This project describes the function of the data acquisition module, which aims to obtain or generate values of the variables of humidity, ambient temperature and soil pH, through electronic devices such as sensors and the arduino for the operation of the neural network for crop rotation and soil analysis. Through an interface, it is linked to the expert system that shows the values and results generated by the neural network on the ideal type of crop to plant. For the development of the project, the model in Prototypes was used

Data acquisition, Sensors, Soil analysis

Resumen

En la actualidad, con los avances tecnológicos aplicados en diversos sectores, han cambiado la forma en cómo operan en el control de sus procesos. En el sector agrícola, la automatización de los procesos aumenta la productividad y mejora la calidad de los productos. En la producción de cultivos bajo invernadero, estos protegen, las diferentes plantas del exceso de frío en ciertas épocas del año, permite el control de la temperatura, la humedad y otros factores ambientales que favorecen el crecimiento de las plantas. Este proyecto describe el funcionamiento del módulo de adquisición de datos, que tiene como objetivo obtener o generar información de los valores de las variables de humedad, temperatura del ambiente y pH del suelo, a través de dispositivos electrónicos como los sensores y el arduino para el funcionamiento de la red neuronal para la rotación de cultivos y análisis de suelo. Mediante una interfaz, se enlaza al sistema experto que muestra los valores y los resultados que genera la red neuronal sobre el tipo de cultivo idóneo a sembrar. Para el desarrollo del proyecto se utilizó el modelo en Prototipos.

Adquisición de datos, Sensores, Análisis de suelo

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* Author Correspondence (e-mail: evarafaelperez@gmail.com)
† Researcher contributing as first author.

Introduction

As part of the process of adaptation of society to technological changes, greenhouse agriculture has not been an exception to these changes, it has led to integrate with technology that allows improving and transforming the cultivation processes. This paper describes the operation of the data acquisition module, this module is part of the neural network project for crop rotation and soil analysis in a greenhouse based on the expert system, which was developed with the objective of supporting the farmer in making a decision on the optimal type of crop to plant in the greenhouse, to improve the production of greenhouse crops through an analysis of soil (pH) and environment (humidity and temperature). With the analysis, the ideal crop to be planted is determined, thus the risk of production loss is considerably reduced, resulting in increased production and improved product quality.

Therefore, this article describes the data acquisition module, the electronic devices used and the circuit design; the development methodology through the prototype model and the description of the stages of the first prototype. Subsequently, the functionality of the soil analysis and measurement interfaces, the results, acknowledgements, conclusions and bibliographical references are explained.

Data acquisition module

For the neural network for soil analysis in the crop rotation in a greenhouse to work properly, it is necessary that it is supported by a data acquisition module; the data obtained are used for the training phase of the neural network, in addition to predicting whether the soil and environmental data are favorable for the cultivation of plants of a specific family.

The results of the module are: The most optimal crop type to be planted, the optimal moisture values and the ranges in which they should be, the optimal temperature for the crop type to be planted and the corresponding family.

For data acquisition, it refers to the part in charge of acquiring data from sensors; it is a collection of software and hardware that allows measuring or controlling the physical characteristics of something in the real world such as voltage, temperature, sound level, among others.

Devices for the data acquisition module

The following devices were used in the design of the data acquisition module

1. Dht11 (temperature and humidity sensor).
2. Arduino Uno
3. Protoboard
4. Ph-4502C (pH sensor)
5. Electrode

Sensors

They are electronic devices with which we can interact with the environment, they provide us with information of certain variables that surround us, to be able to process them and thus generate orders or activate a process. The variables depend on the type of sensor and can be: temperature, light intensity, distance, acceleration, humidity, pressure, pH. They are used in different areas such as agriculture, mobile telephony, medicine, automotive or industrial automation processes (Serna R.A., Ros G.F.A. and Rico N.J. C. 2010).

For this project, the Dht11 digital sensor was used to monitor temperature and relative humidity. It integrates a capacitive humidity sensor and a thermistor to measure the surrounding air, and displays the data via a digital signal on the data pin. It is used in academic applications related to automatic temperature control, air conditioning, environmental monitoring in agriculture and more (Suarez, 2019), see Figure 1.

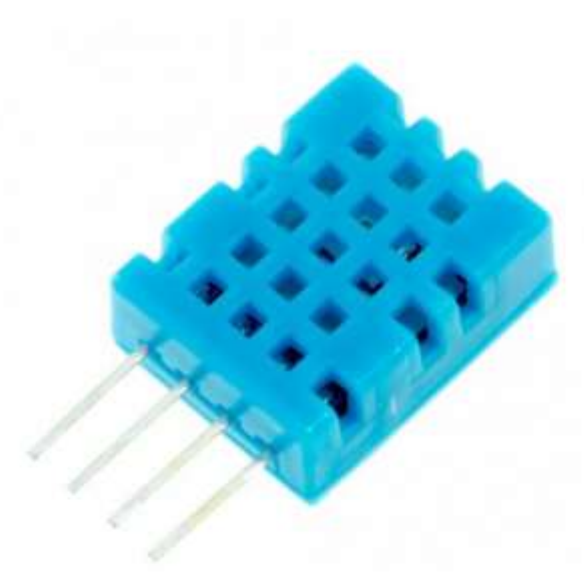

Figure 1 Dht11 sensor

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PH-4502C sensor

Device that allows to measure the PH with the help of a probe that takes the reading (E201 electrode) by means of the BCN connector. It is useful if you need to measure the PH.

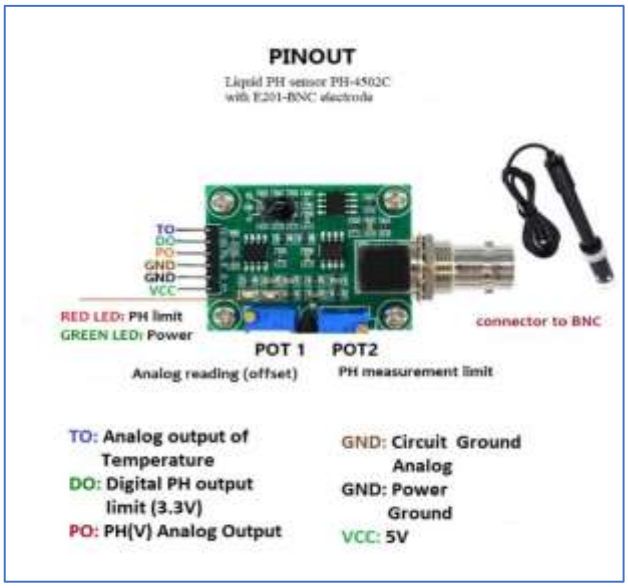

Figure 2 PH-4502C sensor

Arduino

It is considered a development platform based on a free hardware electronic board that incorporates a reprogrammable microcontroller and a series of female pins. These allow to establish connections between the microcontroller and the different sensors and actuators in a very simple way. One of the most important features of this platform is the possibility of building the boards at home since its components can be found in electronic component stores and using a Protoboard or an easy to produce low cost printed circuit board. For the programming of the Arduino we used the processing programming language.

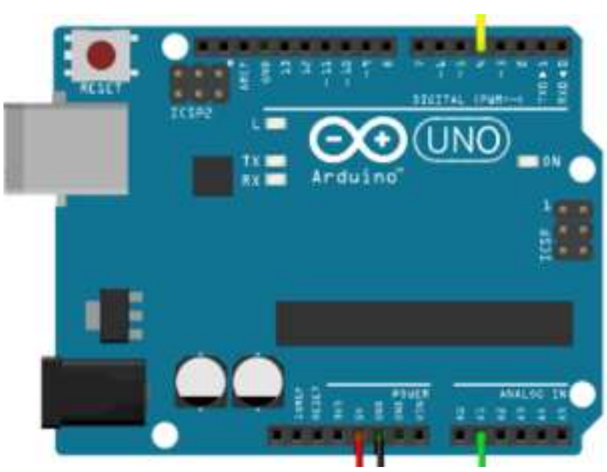

Figure 3 Arduino one

Protoboard

It is a test board that allows interconnecting electronic elements without the need to solder components. This facilitates the assembly of electronic circuits or systems. It is normally used to test electronic circuits. If the test is satisfactory, the circuit is designed on a copper plate and soldered to avoid the risk of disconnecting any component. If the test is not satisfactory, it is easy to change connections and replace components.

The Protoboard has three easily identifiable parts: the center channel, the tracks, and the buses. Center channel, as shown in Figure 4.

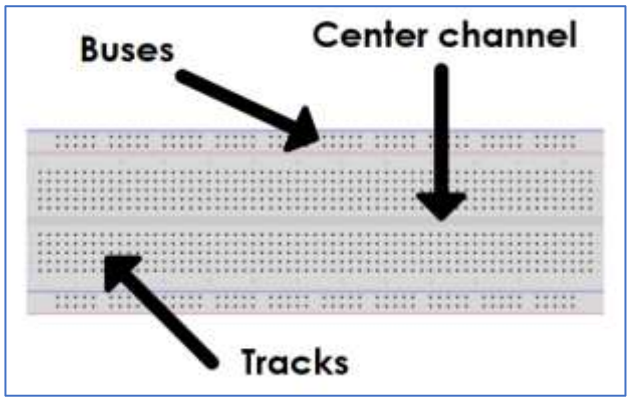

Figure 4 Parts of the Protoboard

Factors that influence crop growth

For Fernandez, (2014), mentions that it is necessary to know the conditions that favor or limit plant development, so that we provide plants with the optimal conditions for their growth and production.

The basic requirements for plant development regardless of the cultivation system are the following:

a. Humidity

The degree of humidity of the environment will condition to a great extent the transpiration of the plant and, therefore, the consumption of water. An adequate level of ambient humidity allows photosynthesis to take place in plants. It also allows plants not to evaporate and transpire as much water through their stomata, which in turn means that the plant loses less water and is not so dependent on irrigation.

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b. Temperature

This is a growth factor of the first magnitude, and consequently is one of the most important limiting factors in the practical development of crops, since it influences all the basic processes carried out by plants (germination, flowering).
Maintaining a balanced temperature in crops is essential to favor the correct development of the plant, as it influences its growth and productivity in the harvest. When cultivating, it is important to know what temperature conditions are necessary for each plant, as they vary depending on the species.

c) Soil

The soil is the top layer of the earth where the roots of the plants develop. This layer is a large reservoir of water and food from which the plants take the necessary quantities to grow and produce crops. Good soil is essential for a good harvest. The soil must have all the nutrients necessary for plant growth, and a structure that keeps the plants firm and upright. The soil structure must ensure sufficient air and water for the plant roots, but must prevent excess water by good drainage.

One of the main characteristics of soil is pH, which is a measure of the acidity or alkalinity of the soil, and affects the absorption of nutrients by plants.

The pH can vary from 0 to 14 and according to this scale, soils are classified as follows:

Type of soil	PH
Acid soil	Less than 6.5
Neutral soil	6.6 – 7.5
Basic soil	Greater than 7.5

Table 1 PH in soils

Development Methodology

For the operation of the two modules the Prototyping model was used, this model aims at the direct participation of the client in the construction of the required software, and serves as a mechanism to identify and define the software requirements, through an iterative process (Pressman, 2010, p. 37). Figure 5 shows the stages: communication, rapid plan, rapid modeling and design, prototype construction, deployment, delivery and feedback.

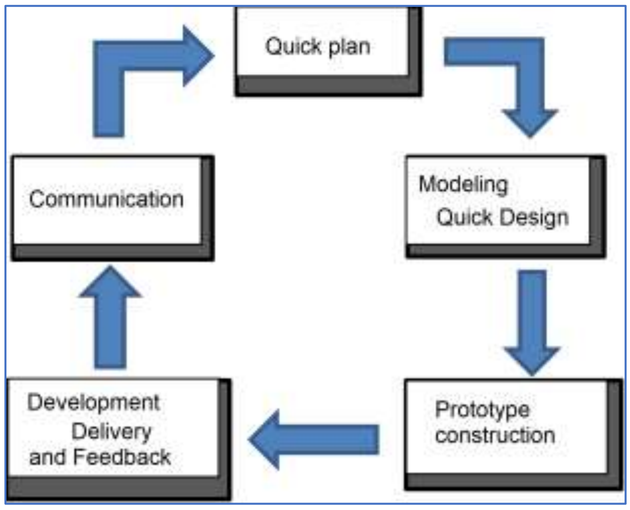

Figure 5 Adapted Prototype Model
Source (Pressman, 2010, p. 37)

First Prototype: The data collection module is created, the results of which will be used in the training phase of the neural network, in addition to predicting whether the soil and environmental data are favorable for harvesting plants of a specific family. In this work, emphasis will be placed on the data acquisition module.

Development of the stages

– Communication stage, in this first stage it is required to obtain the data of the environment and soil, in a fast and efficient way, for this pH, humidity and temperature sensors will be used.
– The Rapid Plan stage. In this stage, the use case technique was used to model the requirements of the data acquisition module. Figure 6 shows a use case for obtaining data from the Dht11 temperature and humidity sensor and the pH-4502C sensor.

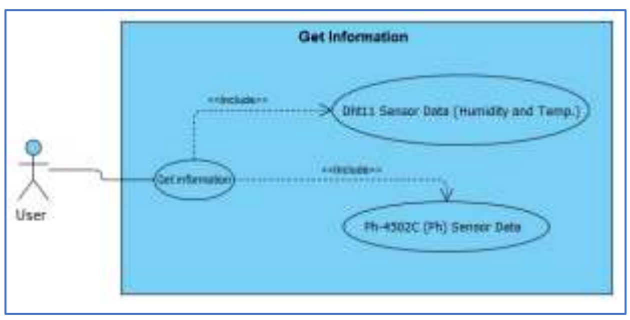

Figure 6 Sensor data collection use case

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Figure 7 shows its use case table.

No.	2
Use case:	Sensor data dht11 (Humidity and Temperature)
Actor:	User
Description:	The Arduino program displays the values obtained by the sensor on the screen.
Validation	The sensor must be connected.

Figure 7 Temperature and humidity sensor use case

– In the Rapid Design Modeling stage, the sequence diagrams and the circuit diagram design were designed. See figure 8.

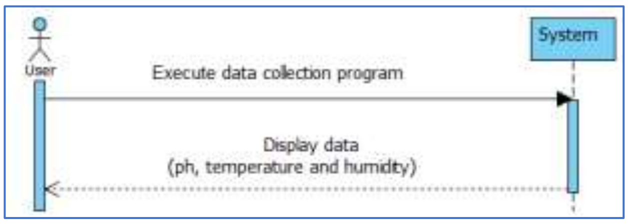

Figure 8 Sequence diagram: Data acquisition

Circuit diagram

Figure 9 shows the design of the circuit diagram to obtain data through the Dht11 sensor to obtain the values of temperature and humidity of the environment, in addition to the Ph-4502C sensor for pH values.

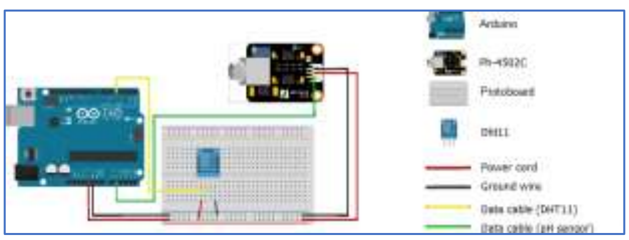

Figure 9 Circuit diagram

– Prototype construction stage, the circuit is built, as shown in Figure 10.

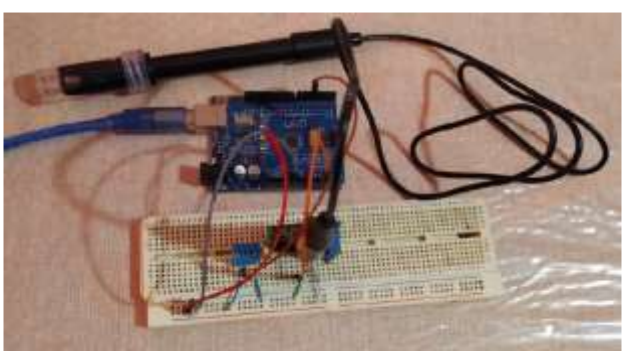

Figure 10 Circuit construction

– Deployment, delivery and feedback stage. In order to perform the soil analysis tests and check correctly, it is necessary to follow the steps below:

1. Make a solution with two portions of water and one portion of soil in a container.

2. Shake the solution and let it stand for at least 15 minutes.

3. Clean the electrode nozzle with a dry and soft cloth to remove any existing solution as it may contaminate the sample.

4. After the 15 minutes of waiting, insert the electrode nozzle into the solution.

5. Run the data acquisition program.

The final design of the data acquisition module is shown below.

Figure 11 Final design of the data acquisition module

Results

The results obtained from the Data Acquisition module are shown below, describing the functionality of the Soil Analysis and Measurements options. To start, the user must log into the system with the user name and password. See Figure 12.

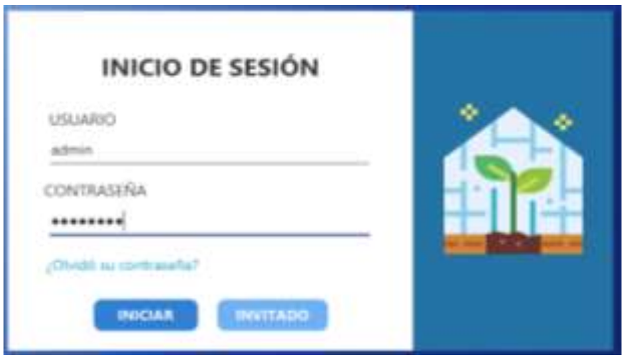

Figure 12 System access screen

A. Soil Analysis Interface

Select from the main menu the soil analysis option, as shown in Figure 13.

Figure 13 Main menu of the expert system

1. When clicking on the soil analysis option, the system first validates that there is a connection to the data acquisition device. If there is no connection, it sends a message as shown in the following message.

Figure 14 Connection problems

2. Once the connection has been validated, click on the Take measurements button.

Figure 15 Soil analysis module

3. It shows the following message, that measurements are being taken from the data acquisition module in real time, as shown in Figure 16.

Figure 16 Temperature, humidity and pH measurement taking message

Results

Figure 17 shows the values obtained from the data acquisition module:

– PH: This text field shows the PH of the soil obtained by the data acquisition device.

– Humidity: This field shows the humidity of the environment obtained by the data acquisition device.

– Temperature: This field displays the temperature of the environment obtained by the data acquisition device.

Figure 17 Values obtained

When the data is obtained, the type of previous family that was sown must be selected, in this case the Solanaceae family is chosen, when clicking on the CALCULATE button, the neural network begins to perform the analysis and shows as a result the most optimal type of crop to be sown.

B. Measurements *Interface*

When clicking on the Measurements option, the system sends a message that the current measurements of temperature and humidity of the environment are being taken from the data acquisition module, see figure 18.

Figure 18 Measurements module

The measurements show in real time the temperature and humidity values, see Figure 19.

Figure 19 Current temperature and humidity measurements

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We are grateful for the collaboration and dedication of the authors of the article who participated with responsibility in the research until the results presented were obtained; the objective of this research is to be able to disseminate the findings to the academic community and the general public about the work being carried out at the Institution.

Conclusions

The evolution of technologies allows the automation of processes and communication between different electronic devices for data acquisition. Samples from the real world to generate data that can be manipulated by a computer.

The development of the data acquisition module in this project was indispensable since it allows to generate and obtain real time values of temperature and humidity variables and soil PH for the execution of neural network for crop rotation and soil analysis in a Greenhouse, since it provides alternatives on the type of crop to plant through crop rotation, an alternative technique for the types of plants that are grown in the same place with the intention of not developing diseases that affect a specific family of crops and prevent the soil from being exhausted.

Finally, the communication capacity of intelligent devices with electronic circuits opens a range of possibilities for future work, as they can be applied in home automation, data control, industrial security and others, which help in improving the social problems facing society today.

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