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DEVELOPMENT OF A SYSTEM FOR IRRIGATION AUTOMATION AND CONTROL

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Abstract: Agricultural production in Brazil is one of the main activities responsible for the values of the country's trade balance. Throughout history, the agriculture sector in Brazil has undergone several transformations. Currently, these transformations still occur, in addition to guaranteeing continuity to the transformations in technical development that occurred from the 20th century onwards, such as the mechanization of production and the modernization of activities. With this modernization, it is notable that some systems such as irrigation require even more automation and less human intervention, making the process more reliable and assertive. This way, we approach how an irrigation system can be developed for irrigation control, ensuring greater productivity. The results obtained complied with the proposal of the work, in which it was evident that the developed system was effective in its operation and control of soil moisture.
Keywords: Agribusiness, Irrigation, Automation, Control.

INTRODUCTION

Agribusiness is the result of the sum of all production chains from the beginning of production and distribution of inputs to the sale of food, fiber and energy. Being a set of activities that is closely linked to all sectors of the economy and society. In Brazil, agribusiness is responsible for almost 30% of GDP (CEPEA, 2021).

Brazilian agribusiness comprises economic activities related to inputs for agriculture, agricultural production, agro-industrialization of primary products, transportation and commercialization of primary and processed products (MAPA, 2011).

Irrigation is a process of great importance to maximize the potential of agricultural inputs in agribusiness. The various irrigation systems available on the market enable producers to use technologies that meet the conditions for plants to show their full genetic potential for production (EMBRAPA, 2010).

Guimarães (2011) states that among the systems of great importance, irrigation stands out, capable of providing an essential element for the plant.

Technology emerges as an ally for production systems, allowing greater agricultural production with fewer resources, without reducing product quality. Currently, technology can be observed in different agricultural segments, as a way to maximize productivity by automating processes.

Automation is necessary not only because of the possibility of reducing labor costs, but mainly because of operational needs (SUZUKI & HENANDEZ, 2009).

It is essential to use these technologies that enhance the production processes, making them more sustainable and simplifying the life of the producer. But the high cost of automation equipment in the agricultural sector is a hindrance for small and medium-sized farmers.

Given this factor, the objective of this article is to present relevant information about irrigation and to develop a prototype of an automated irrigation system that allows greater productivity and enables its control.

THEORETICAL REFERENCE

IRRIGATION

Water is the most important requirement for agriculture and the proper application of this resource becomes essential for plants. Its application in the soil allows the supply of moisture to the soil for germination and plant growth, dilutes soil salts, allows the application of fertilizers and prevents short-term droughts from damaging crops (ASAWA, 2008).

Irrigation in agriculture must not be

understood only as insurance against droughts and dry spells, but also as a technique that provides conditions for the genetic material to express its full productive potential in the field (HERNANDEZ, 2004).

According to Coelho (2011), the main objective of irrigation is to replenish the lack of water in the plants, contributing to the process of crop development, increasing productivity and harvest quality. Bjorneberg (2013), on the other hand, states that irrigation has as its main objective to meet the water demand of plants for their growth, which can be pumped from lakes and reservoirs or through natural channels.

Silva et al. (2007), points out that irrigation is a technology that needs significant investments and is associated with the handling of agricultural inputs, being fundamental the economic study of the components involved in the system.

The cost of irrigation can be predicted through an economic evaluation, in which all expenditures and expected annual returns on the agricultural project are stimulated. The result of this economic evaluation will allow observing whether or not the implementation of an irrigation system is interesting (SILVA, 2007).

AGRICULTURAL AUTOMATION

According to Veiga et al (2006), from a practical point of view, automation can be understood as an automatic system by which the mechanisms control their operation, eliminating, almost completely, human interference, which, regardless of the degree of automation, its final objective is common, that the intervention of the operator is the minimum possible, from the collection of the data until the final representation of the surveyed area.

Rodic (2009) emphasizes that automation can be understood as the use of control systems, whether numerical, programmable or other industrial control, together with various technologies, applications and mechanical machines. Automation and data collection systems can be seen in large engineering works, where the studies carried out verify the practicality and good results obtained with this technique, which is characterized as the most practical and economical solution to the use9 of robotic total stations in a complete automation system in obtaining measurements (LUTES, et al. 2001).

Lucena et al. (2007) attest that with the evolution of technology in recent years, automation is reaching new levels, emerging new techniques for implementing functionalities, thus improving industrial production, thus providing the cheaper production of devices on a large scale.

Agricultural automation is a system where the operational processes of agricultural, livestock and/or forestry production are monitored, controlled and executed by means of machines and/or mechanical, electronic or computational devices, to expand the capacity of human work (EMBRAPA, 2015).

Automation is fundamental in agricultural processes, providing a better quality of life for workers in production chains, system productivity, improved use of time and inputs, as well as reducing production losses and increasing product quality. Agribusiness is being integrated into broad management, in parallel and linked links. The reduction of the rural population and the need for a qualified contingent have been increasingly highlighted by farmers. Many sectors, mainly tropical crops and varieties, do not have solutions for importing. Increasing the income from work in the field, reducing suffering and increasing the quality of life in agricultural activities is strategic.

Automation in the irrigation process must no longer be a luxury, especially when it streamlines the activity, makes the process more reliable and assertive, in addition to reducing human intervention in the segment. With this, it is possible to use automation in our daily lives, such as irrigation, in small projects that allow greater productivity and avoid manual work.

MATERIALS AND METHODS

Bibliographic analyzes were carried out in books and reputable internet sites, as well as an experimental research, with the performance of tests to verify the electronic components used in the prototype of the automated irrigation system.

For the development of the prototype, the device used for the application was the Arduino. Arduino is a platform that enables the development of electronic projects. In other words, it is an electronic prototyping platform. The Arduino consists of hardware and software, thus making it possible to carry out various technological projects. The main component of the board is the microcontroller, which is a much smaller type of processor than the conventional one. The microcontroller executes the programs and evaluates the quality of the inputs and outputs, that is, the channels through which communication between the external and digital world is possible. The Arduino is an open-source board9. Therefore, all intellectual property is shared between users. Users then share code solutions for platform enhancements (MAKIYAMA, 2022).

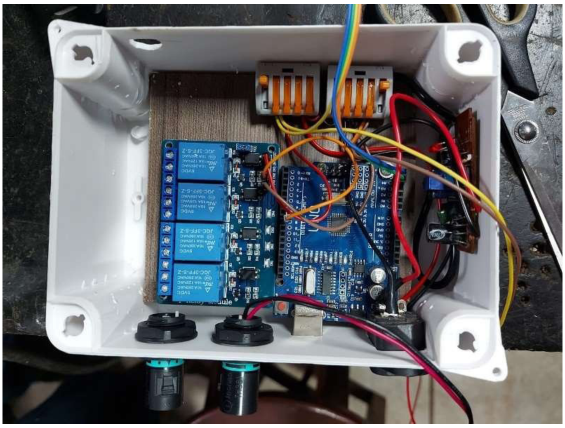

Figure 1. Junction box and system assembly

Source: Authors, 2023.

The entire circuit was arranged internally over an electrical passage box (figure 1) with an internal seal, responsible for the passage of electrical wires and cables. Two waterproof electrical connectors against dust, water, vapors and pressure were also used to facilitate the passage of cables, one to connect to the humidity sensor and the other to connect to the mini water pump.

To build the system, some sensors were needed, such as the HD-38 humidity sensor, and other sensors that make the project more complete, such as the HD-38 humidity sensor, and other sensors that make the project more complete, such as the Photosensitive P7 luminosity sensor, the DHT-11 humidity and temperature sensor, in addition to relay modules, an LCD display and a mini water pump for irrigation.

HD-38 HUMIDITY SENSOR

It is an electronic device specially developed to assist designers who need a high-quality sensor, capable of presenting more reliable and accurate data. Another distinguishing feature that draws attention to this model is that it is produced with better quality materials, ensuring superior durability compared to more common models. The Arduino HD-38 Soil Moisture Sensor probe features 85mm long metal terminals, which can be easily inserted into the earth, in addition, it features a 1-meter long connector cable.

PHOTOSENSITIVE SENSOR P7

P7 Photosensitive Luminosity Sensor Module is a board developed for application in conjunction with prototyping platforms, including Arduino, ARM, AVR, PIC, Raspberry PI. The Photosensitive Luminosity Sensor Module is composed of an LDR photocell sensor (Light Dependent Resistor), responsible for the resistance variation according to the intensity of the light incident on it. In practice, as the light increases the resistance decreases.

HUMIDITY AND TEMPERATURE SENSOR DHT-11

The DHT11 Module is a Temperature Sensor and at the same time a Humidity Sensor. As its name suggests, it is used to measure temperature on scales from 0 to 50° degrees Celsius and air humidity in ranges from 20 to 90%. Especially, it has been used in the development of electronic and robotic projects through microcontroller boards, including Arduino, ARM, AVR, PIC, etc. The DHT11 Humidity and Temperature Sensor actually detects humidity and temperature, sending this information to the microcontroller board, which must be programmed to perform some action when a certain temperature or humidity is reached.

RELAY MODULE

The 5V 4 Channel Relay module is a drive module that allows integration with a large number of microcontroller systems, including: Arduino, AVR, PIC, ARM, Raspberry PI, etc. Through this drive board (5V relay module) it is possible to control up to 4 alternating current devices, up to 10 A, such as, for example, lamps, electronic gates, fans, etc.

16X2 LCD DISPLAY

The 16x2 LCD Display is a small screen with a blue background used in the development of robotic and home automation projects, it is compatible with many microcontroller systems, including Arduino, PIC, Atmel, etc. Among the main features of the 16x2 LCD Display Screen is its modern and compact design with 4 fixing holes, very useful for presenting and viewing information along with projects.

MINI WATER PUMP

The 12V RS385 Mini Water Pump was created especially for the development of prototyping projects, including home automation (domotics) and robotic prototypes based on microcontroller platforms, including Arduino and Raspberry Pi. With an engine of adequate size, it is capable of boosting between 1500ml and 2000ml per minute, being highlighted for its efficiency and precision when running in conjunction with Arduino, for example. It is generally applied in the development of fire trucks or robots, hydraulic robots, automatic sprinklers in the case of home automation, etc.

In the development of the prototype of the automated irrigation system, the first step consists of mounting the humidity sensor to the Arduino control board. Jumpers were needed to connect the component to the board and a notebook to configure and power the Arduino.

Soon after, coding tests were performed compiling the code to run the Arduino board, thus concluding the first part of the project. The code was developed based on programming knowledge in C++, as well as examples of similar projects found on the internet. The level of difficulty encountered in uniting all the sensors and their respective operating codes was average, since it required knowledge when communicating with the board, in addition to building the system itself.

In the second stage of assembly, the P7 light sensor was inserted on the Arduino board.

Then, the humidity and temperature sensor was added for complementary ambient information.

For the activation of the water pump to occur through the Arduino, a relay module was necessary for the activation of the pump to be executed.

The LCD Display was integrated into the project so that it was possible to visualize the information received by the sensors and inform the user of the reading.

In order to carry out the irrigation, a mini water pump was used, which is activated by the relay module, which in turn is activated by the Arduino.

RESULTS AND DISCUSSION

As it is very difficult to manually monitor large areas of planting, the soil moisture identification system enabled agility in irrigating the dry area and, above all, monitored the environmental conditions that make up the cultivation set (luminosity, temperature, ambient humidity). Thus, when implementing the automatic irrigation system, it allows you to have more time to dedicate to other areas of your business.

The automatic irrigation system works by identifying soil moisture through specific sensors, which identify the low percentage of soil moisture (must be entered according to the purpose and type of crop) which then, when checking a dry soil condition, pumps water in the amount that the soil stays in the irrigated or wet condition that can be adjusted. The percentage defined in the code during programming of the Arduino board, of the HD-38 soil moisture sensor in this project was 45%. Therefore, human or rainfall interference is not necessary to make the soil moist. The application becomes interesting, for example, for the producer who travels, who does not have availability to water the crop or where the planting region is too extensive. All control was monitored and performed through an Arduino board that integrates all sensors and unites the information in a single environment.

When the sensor identifies the humidity below the entered value, it sends an analog signal to the board, which after conversion, will send an activation signal to a relay, which will turn on the irrigation pump. The pump will irrigate the planting area until the same humidity sensor identifies that the humidity is above 45%. At the end of operation, the system goes into a loop, keeping the system always in operation. The entire process was visually monitored on a 16x2 LCD screen, whose information is constantly updated. The ambient temperature and humidity sensors together with the luminosity sensor are devices that can help in the growth of a crop in a controlled environment such as greenhouses.

In this project, these devices were used to emphasize the actual planting conditions, in addition to real-time information about what happens during the process, thus making it possible to avoid wasting water, correct planting irrigation and regular monitoring.

The culture used to analyze the functioning of the system was chives. Because it is a crop highly sensitive to water deficit, requiring good availability of water in the soil and frequent irrigation (EMBRAPA, 2007). The developed system proved to be effective in controlling the irrigation periods established for the chive crop, optimizing the use of water, without leaks or losses. It also presented a great performance in relation to the irrigation time. The sensor used for humidity monitoring worked precisely and accurately.

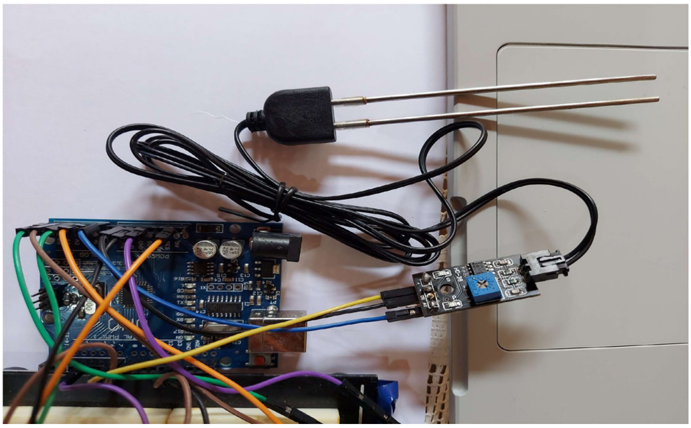

Figure 2. HD-38 Humidity Sensor connected to Arduino board via jumpers

Source: Authors, 2023.

```
// Código de Funcionamento para Sistema de Monitoramento e Irrigação com Arduino
#include "DHT.h"
#include <Wire.h> //INCLUSÃO DE BIBLIOTECA
#include <LiquidCrystal_I2C.h> //INCLUSÃO DE BIBLIOTECA

LiquidCrystal_I2C lcd(0x27,2,1,0,4,5,6,7,3, POSITIVE); //ENDEREÇO DO I2C E DEMAIS INFORMAÇÕES

#define pino5VL 4
#define DHTPIN A1 // pino que estamos conectado
#define DHTTYPE DHT11 // DHT 11
#define pinoAnalog A0 // Define o pino A0 como "pinoAnalog"
#define pinoRele 8 // Define o pino 8 como "pinoRele"
#define pino5V 7 // Define o pino 7 como "pino5V"

int LED = 13; // Pino no qual o LED está conectado
int LDR = A2; // Pino no qual o LDR está conectado
int entrada; // Variável que terá o valor do LDR
int ValAnalogIn; // Introduz o valor analógico ao código
DHT dht(DHTPIN, DHTTYPE);
```

Figure 3. Function code header

Source: Authors, 2023.

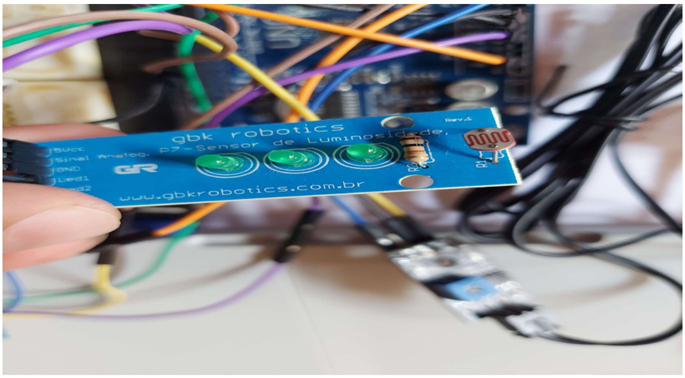

Figure 4. P7 Photosensitive Sensor

Source: Authors, 2023.

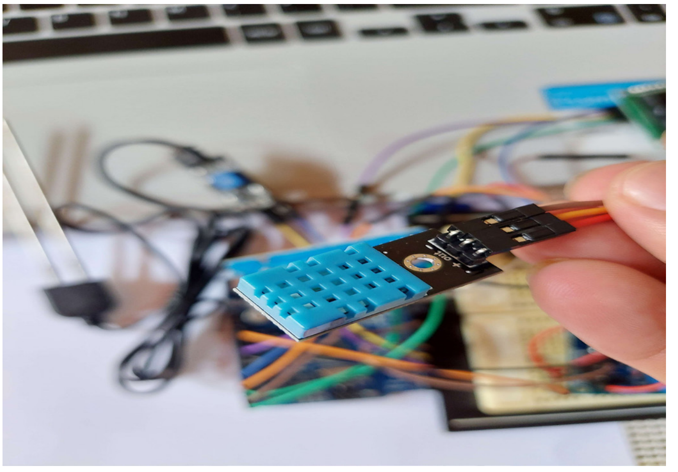

Figure 5. Humidity and temperature sensor DHT-11

Source: Authors, 2023.

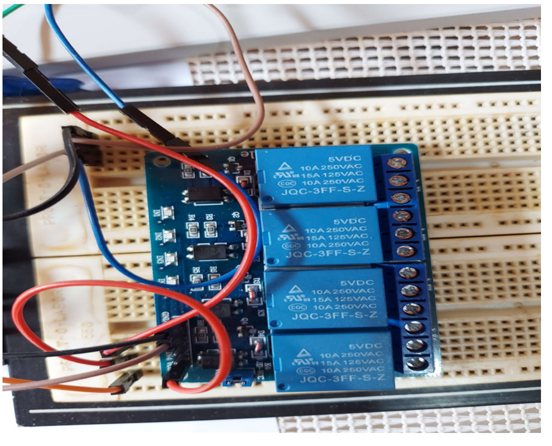

Figure 6.5V 4 channel relay module

Source: Authors, 2023.

Figure 7. 16x2 LCD display

Source: Authors, 2023.

Figure 8. Irrigation system prototype checking soil moisture

Source: Authors, 2023.

```
  {
    Serial.print("Umidade no ambiente: ");
    Serial.print(h);
    Serial.print("%");
    Serial.print(" Temperatura no ambiente: ");
    Serial.print(t);
    Serial.println(" *C");
  }
ValAnalogIn = analogRead(pinoAnalog); // Relaciona o valor analógico com o recebido do sensor
int Porcento = map(ValAnalogIn, 1023, 0, 0, 100); // Relaciona o valor analógico à porcentagem

Serial.print(Porcento);
Serial.print("% umd no solo  ");
lcd.setCursor(0,0);
lcd.print(Porcento); // Imprime o valor em Porcento no monitor Serial
lcd.print("% umd no solo  "); // Imprime o símbolo junto ao valor encontrado

if (Porcento <= 45) { // Se a porcentagem for menor ou igual à
lcd.setCursor(0,1);
lcd.print("Irrigando...    "); // Imprime a frase no monitor serial
digitalWrite(pinoRele, LOW); // Altera o estado do pinoRele para nível Alto
}
```

Figure 9. Part of the code showing how the system works

Source: Authors, 2023.

Figure 10.HD-38 humidity sensor in use

Source: Authors, 2023.

Figure 11: Irrigation system in operation

Source: Authors, 2023.

FINAL CONSIDERATIONS

This work proposed the development of a prototype of an automated irrigation system for small producers, using easily found components and enabling soil irrigation control. As the system is automated, it simplifies processes and saves labor, which can ensure greater productivity.

The results obtained were satisfactory, showing that the developed system was effective in its activation and operation, with soil moisture control. It was possible to calibrate the sensors, define the type of management suitable for the crop used and develop the automation system, based on the integration of all components. Finally, the results obtained complied with the proposal and the idealized objective for this work and the prototype operated according to the defined schedule.

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