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Digital control of plant development through sensors and microcontrollers in Kosova

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ABSTRACT

The plant monitoring system aims to develop an automated solution for optimizing plant growth. Using the Arduino Uno ATMEGA328P microcontroller module and various sensors, this system regulates environmental conditions to promote optimal plant development. It requires adequate software to operate effectively, enabling the microcontroller to monitor and regulate climatic conditions. The primary goal of this paper is to present a comprehensive system that continuously measures parameters such as light intensity, air humidity, and soil moisture in real time within a vegetable greenhouse or a plastic-covered plant environment. This scientific paper provides an in-depth description of the hardware components used, their electronic connections, and the implementation of program code written in C++. Based on the measured physical parameters, the plant monitoring system performs specific actions, such as watering the plants and regulating the ambient temperature. In conclusion, this system effectively supports healthy plant growth and enhances the quality and yield of plant products. The paper serves as a practical example for improving plant cultivation in the agricultural sector in the Republic of Kosova.

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1. INTRODUCTION

Digital control systems are increasingly vital for project managers and their teams, helping them track progress, identify obstacles, and make informed decisions [1]. In this paper, we utilize hardware devices to achieve this goal, with the Arduino Uno ATMEGA328P module serving as the primary programmable hardware. The Arduino Uno stands out among other microcontrollers due to its open-access nature and ease of programming, especially when compared to PLCs (programmable logic controllers). The system incorporates various hardware elements, such as sensors, an LCD screen for visualizing processes, and additional components for connectivity [2], [3]. Existing solutions often require a unified communication infrastructure for hardware devices, facilitating necessary communication and control. The main objective of this paper is to develop a digital and intelligent system that enables real-time monitoring of plant development. Utilizing the Arduino Uno module, this system aims to provide managers and stakeholders with valuable insights into plant growth progress [4]-[7]. It features an intuitive interface for visualizing key measurements, generating reports, and promoting efficient communication among team members involved in plant monitoring in the Republic of Kosova.

By connecting sensors for temperature, air humidity, and soil moisture to the Arduino Uno module, the intelligent digital system processes data and provides accurate information to plant managers. This information is displayed visually on a 20×4 LCD screen and, during critical moments, is communicated through a buzzer alert. In response, plant managers can take appropriate measures, such as activating fans to reduce high temperatures or opening windows in the plastic greenhouse for natural cooling. When soil moisture is low, the system prompts irrigation through water pumps. Researchers can further expand this system by enhancing its automation capabilities [8], [9]. For instance, fans and water pumps can be integrated directly into the Arduino Uno's output pins using 5 [VDC] coil relays, enabling the connection to a 220 [VAC] power supply for controlling fans and water pumps.

This scientific paper demonstrates the use of the Arduino Uno module, along with various sensors and intelligent software code, to facilitate decision-making based on real-time measurements. The aim is to inspire young researchers by showcasing the potential of digital control systems. Although the construction of such systems can be complex, it mainly depends on the financial resources of agricultural producers operating plastic greenhouses [10], [11]. This study presents a system tailored to the financial capabilities of the Republic of Kosovo, the youngest country in the world, which emerged from conflict two decades ago. Given the availability of a young workforce, due to the high unemployment rate, they often perform tasks that might otherwise be managed by more sophisticated automated systems. The plant monitoring system, as implemented in this research, has proven highly effective in supporting the development of annual plants in plastic greenhouses across the Republic of Kosovo.

2. RESEARCH METHOD

The research method used in this paper is based on field experiments. The following sensors and electronic devices were the primary components utilized:

i). Environmental sensors: the system employs various sensors to measure key environmental parameters, such as temperature, ambient humidity, light intensity, and soil moisture. These sensors provide accurate data, allowing users to gain insights into the plant's environmental conditions [12]-[15].

ii). Data visualization: the system features on-screen visualization capabilities, enabling users to analyze trends and patterns in the plant's environment. This functionality helps in understanding how different factors impact plant development over time.

iii). Real-time alerts and notifications: the system is equipped with an alert mechanism that notifies users of critical conditions, such as excessively high or low temperatures, improper humidity levels, or dry soil. These real-time alerts allow for immediate action to be taken, helping to address issues promptly and prevent potential damage to plant development according to the climatic conditions in the Republic of Kosova.

iv). Hardware configuration: the Arduino Uno ATMEGA328P is an ideal electronic module for getting acquainted with electronics and device coding, as illustrated in Figure 1. This versatile microcontroller is equipped with the ATmega328P processor, which processes data received from the system's sensors, and provides memory for storing sensor data connected to the system [16].

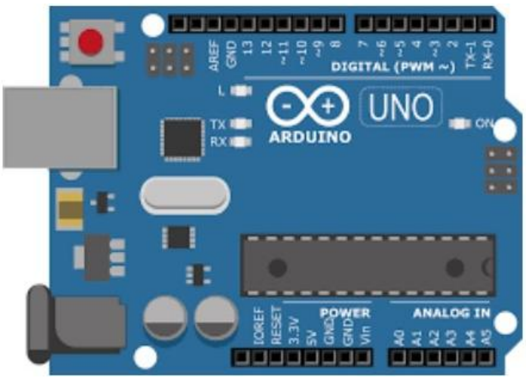

Figure 1. Arduino Uno ATMEGA328P module [17]

v). Sensors used: the plant monitoring system utilizes three key sensors to measure essential environmental parameters:

– Ambient temperature and humidity sensor (DHT11): this sensor monitors the air temperature and humidity levels around the plants.

- Soil moisture sensor (FC-28): as shown in Figure 2, the FC-28 sensor measures the soil's moisture content, providing valuable data for irrigation management.
- Light dependent resistor (LDR) sensor: the LDR sensor detects light intensity, helping to assess the lighting conditions around the plants.

These sensors play a crucial role in delivering accurate, real-time data to ensure optimal care and development of the plants.

Figure 2. DHT11 temperature and humidity sensor [18]

The DHT11 sensor measures the relative humidity of the environment, which refers to the amount of water vapor present in the air compared to the maximum amount it can hold (saturation point) at a given temperature. When the air reaches this saturation point, water vapor condenses and forms dew on surfaces [19]. The saturation point changes with air temperature: colder air can hold less water vapor before becoming saturated, while warmer air can hold more. The formula for calculating relative humidity is:

$$RH = \left(\frac{\rho_w}{\rho_s}\right) \times 100\% \quad (1)$$

ρ_w - water vapor density
ρ_s - density of water vapor at saturation

The DHT11 sensor detects water vapor by measuring the electrical resistance between two electrodes. Its moisture-sensing component consists of a substrate that absorbs moisture, with electrodes applied to its surface. As water vapor is absorbed by the substrate, ions are released, which increases the conductivity between the electrodes. The change in resistance between the two electrodes is directly proportional to the relative humidity: higher relative humidity decreases the resistance, while lower relative humidity increases it. Additionally, the DHT11 measures temperature using a surface-mounted temperature sensor (thermistor) built into the unit [20].

The FC-28 soil moisture sensor, shown in Figure 3, is a soil hydrometric transducer designed to measure the moisture content in the surrounding soil. The module operates using two probes that pass an electrical current through the soil and then measure the resistance to determine the moisture level. When the soil is moist, it conducts electricity more easily, resulting in lower resistance; conversely, dry soil conducts electricity poorly, leading to higher resistance. The FC-28 sensor also offers enhanced protection features, such as electrostatic discharge (ESD) protection and undervoltage protection functions [21]-[23].

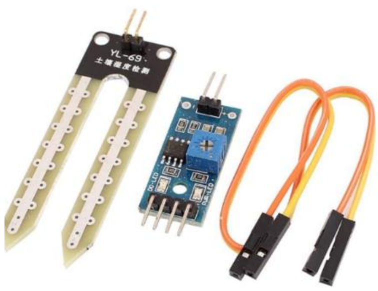

Figure 3. FC-28 soil moisture sensor [24]

The LDR, shown in Figure 4, is a type of photoresistor that operates on the principle of photoconductivity [25], [26]. This means its resistance varies based on the intensity of the light it receives. As light intensity increases, the LDR's resistance decreases. Commonly used as a light sensor, it is applied in devices such as light meters, automatic lighting systems for street lighting, parks, and public squares, as well as in other applications where sensitivity to light is required. The LDR is also often referred to as a light sensor [27]-[29].

Using these sensors, the plant development monitoring system can continuously monitor light intensity, ambient humidity levels, and soil moisture content. The data obtained from these sensors enables the system to make informed decisions regarding watering, lighting, and environmental adjustments to ensure optimal plant growth and development [31].

Figure 4. LDR sensor [30]

2.1. Other electronic components

In addition to the aforementioned sensors, the plant monitoring system includes two essential components: an LCD screen (20x4), as shown in Figure 5, and an audible alarm siren. These components provide visual and audible feedback to the user, enhancing system functionality and enabling real-time responses [6].

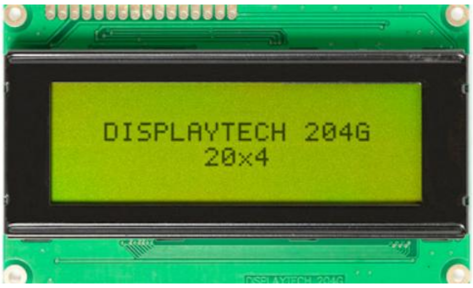

Figure 5. LCD screen (20x4) [32]

Description: the LCD screen used in the system is a 20x4 electronic model, consisting of 20 columns and 4 lines. This configuration allows it to display alphanumeric characters and symbols, providing relevant messages based on the monitoring situation of the system. Function: the LCD screen serves as an output interface, delivering real-time information about the plant environment and the system's status. It ensures a clear and easily readable display of messages, facilitating convenient monitoring and interaction with the system [33]. Implementation: the LCD screen is connected to the Arduino Uno via the appropriate digital input/output pins. The system communicates with the screen using the LiquidCrystal library, which enables control over the displayed content, such as printing sensor information, system messages, and prompts.

Sound alarm: The sound alarm horn-siren used in the plant monitoring system is a small electronic audio transducer that generates sound signals or tones when activated. Figure 6 illustrates the sound alarm. Function: the siren serves as an audio indicator, providing audible feedback to alert users about specific events or conditions. It enhances the system's ability to notify users of critical situations, such as low humidity levels or system malfunctions, even when they are not actively monitoring the visual display. Implementation: the siren is connected to a digital output pin on the Arduino Uno. By controlling the voltage levels applied to this pin, the system can trigger the buzzer to produce different tones or sequences in response to specific events or conditions [34].

Figure 6. Sound alarm horn! [35]

When combined with the sensors and the Arduino Uno ATMEGA328P module, these components create a comprehensive digital plant development control system that offers timely feedback to users, facilitating effective care and management of plant development [36]. The electrical diagram showing the connections of the electronic components and sensors is provided in Figure 7. Additionally, Table 1 offers a simple and organized overview of the main components used in the digital plant development control system, including their descriptions and functions. This table allows readers to quickly grasp the essential components of the system [37], [38].

Table 1. Components used in the digital control system of plant development

Name	Components	Functions
U1	Arduino Uno R3	Control unit for system, processing, and I/O
U2	Temperature and humidity sensor - DHT11	Monitors ambient humidity levels for optimal plant growth
R1	Photoresistor	Monitors light intensity for plant photosynthesis.
SEN1	Soil moisture sensor FC-28	Monitors soil moisture levels of soil for proper irrigation
U3	LCD 20 x 4	Displays real-time data and system information.
R2	1 kΩ Resistor	Limits or regulates the flow of electric current in an electronic circuit to protect other devices
R3	5 kΩ Resistor	Limits or regulates the flow of electric current in an electronic circuit to protect other devices.
PIEZO1	Sound alarm horn	Provides audio alerts and voice notifications.
R4	100 Ω Resistor	Limits or regulates the flow of electric current in an electronic circuit to protect other devices.

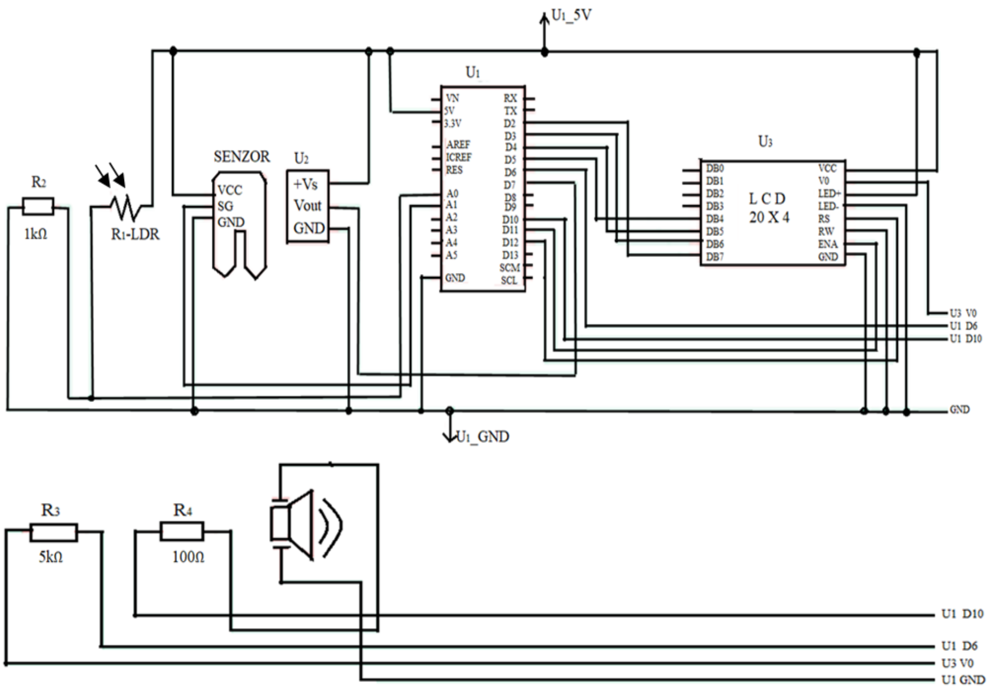

Figure 7. Component connection diagram

2.2. Software description

The Arduino UNO software was developed with the Arduino IDE 2.2.1 and consists of three source files written in the C/C++ programming language in the IDE environment.

```
• definition of libraries
#include <LiquidCrystal.h>
#include <dht11.h>
#define DHT11PIN 7
• definition of constants
const int ldr = A0;
const int buzzer = 10;
const int moistureSensor = A1;
const int rs = 12, en = 11, d4 = 5, d5 = 4, d6 = 3, d7 = 2;
• definition of variables
int ldrValue;
int monthsValue;
float moisturePercentage;
float humidity;
float temp;
dht11 DHT11;
```

Of course, the next logical step involves the program instructions within the infinite loop [39]. The operational algorithm of the intelligent system for monitoring plant development is illustrated in Figure 8. This figure outlines the sequence of processes that the system follows to continuously monitor and manage plant development effectively.

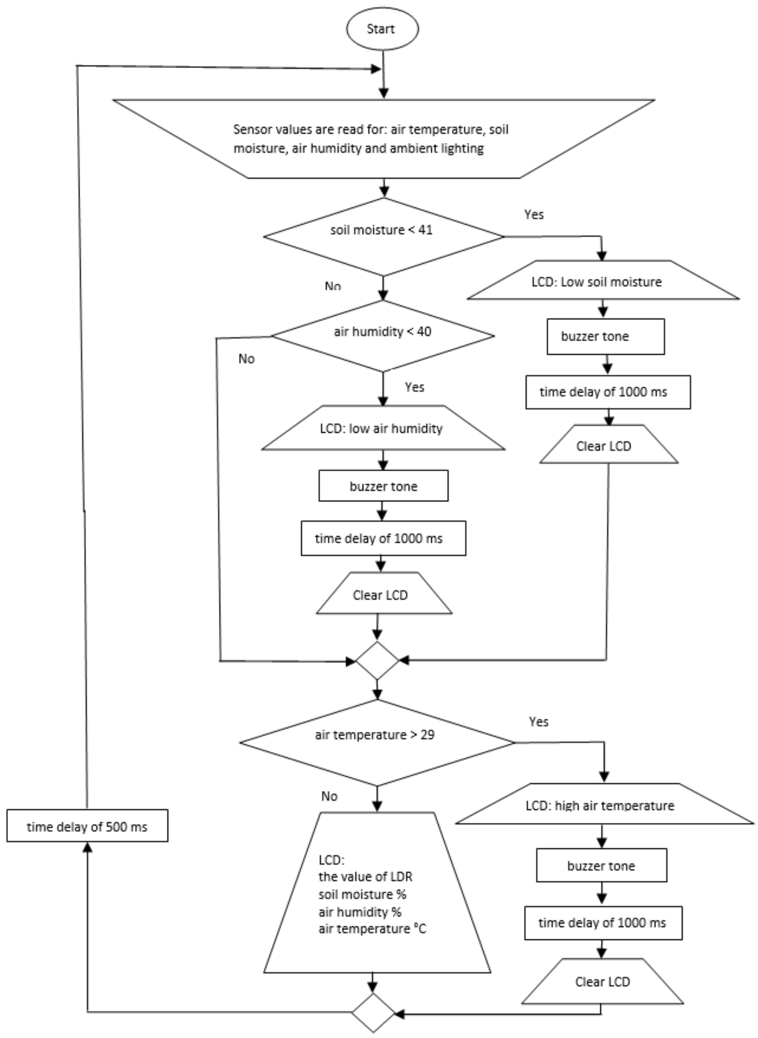

Figure 8. Algorithm of the operation of the digital system for monitoring the development of plants

The software code implementation provides a detailed explanation of the code responsible for operating the digital plant development control system. This code is based on an Arduino Uno ATMEGA328P sketch that controls the various electronic components and processes the data received from the sensors within an infinite loop. This approach ensures continuous monitoring and management of the environmental conditions essential for optimal plant growth.

```
#include <LiquidCrystal.h>
#include <dht11.h>
#define DHT11PIN 7
const int ldr = A0;
const int buzzer = 10;
const int moistureSensor = A1;
const int rs = 12, en = 11, d4 = 5, d5 = 4, d6 = 3, d7 = 2;
int ldrValue;
int moisValue;
float moisturePercentage;
float humidity;
float temp;
dht11 DHT11;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);
void setup() {
  pinMode(buzzer, OUTPUT);
  pinMode(ldr, INPUT);
  pinMode(moistureSensor, INPUT);
  lcd.begin(20, 4);
  analogWrite(6,10);
}
void loop() {
  int chk = DHT11.read(DHT11PIN);
  ldrValue = analogRead(ldr);
  moisValue = analogRead(moistureSensor);
  humidity = (float)DHT11.humidity;
  temp = (float)DHT11.temperature;
  moisturePercentage = (100 - ((moisValue/1023.00) * 100));
  if (moisturePercentage < 41)
  {
    lcd.setCursor(0, 0);
    lcd.print("Soil moisture ");
    lcd.setCursor(0, 1);
    lcd.print("it is low ");
    lcd.setCursor(0, 2);
    lcd.print(moisturePercentage);
    lcd.print("%");
    tone(buzzer, 220);
    delay(1000);
    lcd.clear();
  }
  else if (humidity < 40)
  {
    lcd.setCursor(0, 0);
    lcd.print("Air humidity ");
    lcd.setCursor(0, 1);
    lcd.print("it is low ");
    lcd.setCursor(0, 2);
    lcd.print(humidity);
    lcd.print("%");
    tone(buzzer, 240);
    delay(1000);
    lcd.clear();
  }
  else if (temp > 29)
  {
    lcd.setCursor(0, 0);
    lcd.print("The temperature is ");
    lcd.setCursor(0, 1);
    lcd.print("lhigh");
    lcd.setCursor(0, 2);
    lcd.print(temp);
    lcd.print("C");
    tone(buzzer, 250);
    delay(1000);
    lcd.clear();
  }
```

```
  else
  {
    noTone(buzzer);
    lcd.setCursor(0, 0);
    lcd.print("LDR: ");
    lcd.print(ldrValue);
    lcd.setCursor(0, 1);
    lcd.print("Moisture:");
    lcd.print(moisturePercentage);
    lcd.print("%");
    lcd.setCursor(0, 2);
    lcd.print("Humidity:");
    lcd.print(humidity);
    lcd.print("%");
    lcd.setCursor(0, 3);
    lcd.print("Temp:");
    lcd.print(temp);
    lcd.print("C");
    delay(500);
    lcd.clear();
  }
}
```

The provided code begins by including the necessary libraries for the project, such as the LiquidCrystal library for controlling the LCD display and the DHT11 library for reading data from the DHT11 ambient temperature and humidity sensor. It also defines the pins used for various components, including the LDR (Light Dependent Resistor), buzzer, and humidity sensor, along with the pins for the LCD display.

In the setup() function, the code initializes the required pins and components. It sets the pinMode for the buzzer as an output, the LDR pin as an input, and the humidity sensor pin as an input. The LCD screen is initialized with the specified number of columns and rows. Additionally, an analog output pin is set to a specific value [11]-[13]. The loop() function contains the main functionality of the system. It begins by reading data from the DHT11 sensor, the LDR, and the soil moisture sensor. The ambient humidity, temperature, and soil moisture percentage are then processed based on the sensor data.

The code checks various conditions to determine the state of the digital electronics and displays the relevant information on the LCD screen [40]. If the moisture percentage falls below a predefined threshold, indicating low soil moisture, a warning message is shown along with the moisture percentage. The horn is activated briefly to provide an audible alert. Similarly, if the humidity drops below a certain level or the temperature exceeds a specified limit, appropriate warning messages are displayed, and the alarm is activated. If none of the warning conditions are met, the code displays normal sensor readings on the LCD, including the LDR value, humidity percentage, humidity level, and temperature. The display is updated every 500 milliseconds. This code effectively demonstrates the integration of various components and the utilization of sensor data to provide real-time information about plant conditions. It controls the LCD screen and activates the buzzer for real-time notifications.

3. RESULTS AND DISCUSSION

3.1. Operation instructions

The implementation of the plant development monitoring system using the Arduino Uno involves the successful integration of various electronic components, including sensors, actuators, and supporting devices. This section provides an overview of the hardware configuration, including electrical connections and setups necessary for optimal system operation. The hardware configuration of the plant development monitoring system includes the following main components: Arduino Uno ATMEGA328P microcontroller module. The Arduino Uno serves as the central control unit for the digital plant development control system. It offers the processing capability, along with digital and analog input/output pins and communication interfaces, required to connect and control the various electronic components effectively. This microcontroller plays a crucial role in processing sensor data and managing the overall functionality of the system, ensuring that all components work together seamlessly.

3.1.1. Sensors

– Light dependent resistor (LDR): is connected to an analog input pin on the Arduino Uno module to measure light intensity. The name "light dependent resistor" accurately reflects its function as a sensor that changes resistance in response to varying light levels. In the automated lighting system, the LDR

efficiently adjusts the brightness based on ambient light conditions, ensuring optimal illumination for plant growth.
- Ambient humidity sensor: the ambient humidity sensor is connected to either a digital or analog input pin on the Arduino Uno module, depending on the specific model of the sensor being used. This connection allows the Arduino to accurately read humidity levels in the environment, contributing to effective monitoring and control of plant conditions.
- Soil moisture sensor: the soil moisture sensor is connected to an analog input pin on the Arduino Uno module to measure the soil's moisture levels [41]. This connection enables the Arduino to accurately assess soil hydration, which is crucial for effective irrigation management in the plant development monitoring system.
- Audible alarm horn: connects to a digital output pin on the Arduino Uno to provide audible alerts and notifications LCD display (20x4): the LCD display is connected to the Arduino Uno using digital I/O pins and interfaces through the LiquidCrystal library. This setup ensures the proper operation of the digital plant development monitoring and control system.
- The LDR is connected to an analog input pin on the Arduino Uno module. A voltage divider circuit or another suitable electrical circuit is used to convert the variable resistance of the LDR into an analog voltage, allowing the Arduino to accurately measure light intensity.
- The ambient humidity sensor is connected to a digital or analog input pin on the Arduino Uno, following the manufacturer's specifications and pin configurations.
- The soil moisture sensor is connected to an analog input pin on the Arduino Uno. The output voltage of the sensor is measured and calibrated to correspond to the soil moisture level.

3.1.2. Connection to siren-horn

The siren or horn is connected to a digital output pin on the Arduino Uno. The appropriate voltage level is applied to the pin to activate the buzzer and produce audible tones or sequences [17]. The siren-horn functions as a signaling device similar to an electric bell, but without a hammer or gong; it produces a buzzing sound through the vibration of an armature. In the plant monitoring system, it is used to alert users about low soil moisture, high temperatures, or excessive ambient humidity.
- LCD screen configuration: the LCD display is connected to the Arduino Uno using digital input/output pins. Specific pin connections for data and control signals are established according to the requirements of the display module, ensuring effective communication between the Arduino and the LCD.
- The LiquidCrystal library is utilized to configure the display and control its content. This involves initializing the library, setting the appropriate parameters such as the number of columns and rows (20x4), and defining custom characters when needed. This setup enables effective management of the information displayed on the LCD.

After completing the hardware connections and configurations, the Arduino Uno module is programmed using the Arduino IDE software, specifically in the C++ programming language within the Arduino Uno ATMEGA328P environment. The programming code encompasses reading data from sensors, controlling actuators, and displaying information on the LCD screen based on specific conditions and thresholds. The results chapter highlights the successful implementation and performance of the plant development monitoring and control system using the Arduino Uno [42], [43]. Based on the results and analysis, the following main conclusions can be drawn:
- Accurate sensor readings: the sensors, including the LDR, ambient humidity sensor, and soil moisture sensor, provide consistently accurate and reliable readings. This accuracy is essential for monitoring environmental parameters critical to plant health, growth, and development.
- Real-time data monitoring: the plant monitoring system facilitates real-time data monitoring, allowing users to access up-to-date information on light intensity, ambient humidity levels, and soil moisture content. This capability enables timely decision-making and proactive adjustments, ensuring optimal care for plant development.
- Alarms and notifications: the alarm system for plant monitoring plays a crucial role in notifying users of critical conditions, such as low humidity levels, excessive light intensity, or deviations from desired parameters. Real-time alerts and notifications empower users to take immediate action, preventing potential damage to the plants.

The results obtained from the plant monitoring system underscore its effectiveness in providing accurate data, automated control, and timely alerts. By leveraging information technology to optimize plant care, the system offers significant advantages over traditional manual monitoring methods, ultimately enhancing plant health, resource efficiency, and productivity.

3.2. Validation and characterization

The discussion chapter explores the benefits, limitations, and potential future improvements of the plant monitoring system using the Arduino Uno ATMEGA 328P microcontroller. This chapter analyzes the system's strengths and weaknesses, providing suggestions for further enhancements. The integration of hardware and software enables intelligent monitoring of plant development, assisting plant managers in making informed decisions based on alerts from the system. For instance, the soil moisture sensor informs managers when and how much to water the plants, helping to prevent trauma to the plants. Similar guidance is provided for managing temperature fluctuations, ambient humidity, and light levels, ensuring optimal growing conditions.

3.2.1. Benefits of the system

The plant monitoring system offers several key benefits, including:

i) Efficient resource management: the system optimizes resource use by providing real-time data on environmental parameters such as light intensity, air humidity, and soil moisture levels. This allows for precise control of water consumption, energy use, and overall resource efficiency.
ii) Improved plant care: by continuously monitoring and adjusting plant conditions, the system ensures optimal growth and health. It eliminates guesswork, providing accurate information that aids effective decision-making regarding watering, lighting, and other factors crucial to plant well-being.
iii) Early detection of problems: the system's alarm mechanism promptly notifies users of critical conditions, such as low humidity levels or excessive light intensity. This enables timely intervention and preventive measures, helping to mitigate potential plant damage or stress.

3.2.2. Limitations and challenges

While the plant monitoring system offers significant benefits, it also presents some limitations and challenges that must be considered:

i) Reliance on sensor accuracy: the accuracy of sensor readings is crucial for informed decision-making. However, variations in sensor performance and calibration issues can affect the reliability of the collected data. Regular maintenance and calibration of the sensors are essential to ensure accurate readings.
ii) System complexity: implementing the system may require a certain level of technical expertise and familiarity with electronics and programming. Users with limited technical knowledge might encounter challenges in configuring and troubleshooting the system.
iii) Environmental variability: environmental factors, such as weather conditions and seasonal changes, can introduce additional complexities in plant care. The system's effectiveness may vary under different environmental conditions, necessitating adaptations and periodic adjustments.

3.2.3. Potential for future improvements

To further enhance the plant monitoring system, several potential areas of improvement can be explored:

i) Automated irrigation: integrating an automated irrigation system based on soil moisture readings can provide more precise and efficient control. This feature would eliminate the need for manual intervention, ensuring that plants receive the right amount of water at the optimal times.
ii) Plant-specific recommendations: incorporating a plant database or machine learning algorithms could enable the system to offer personalized recommendations and care instructions based on the specific species being monitored. This would enhance the system's adaptability to different plant needs.
iii) Remote monitoring and control: adding remote monitoring and control capabilities would allow users to access the system and receive real-time updates from anywhere. This feature would facilitate remote management, making it convenient for users to care for their plants even when they are away.
iv) Data visualization and analysis: enhancing the system's data visualization and analysis capabilities would provide users with deeper insights into plant growth patterns, trends, and correlations. Visualizing data through charts, graphs, or interactive interfaces would support better decision-making and long-term planning.
v) Integration with smart home systems: integrating the plant monitoring system with existing smart home systems or platforms would increase its compatibility and interoperability, allowing users to seamlessly control and monitor their plants alongside other smart devices.

4. CONCLUSION

In conclusion, the digital plant development monitoring and control system successfully develops an automated solution using the Arduino Uno microcontroller and various sensors to monitor and adjust environmental conditions for optimal plant growth. The system continuously measures parameters such as light intensity, ambient humidity, and soil moisture content, providing real-time data that supports informed decision-making in plant care. The implications of this plant monitoring system are significant in the realm of automation and plant care. It offers several benefits, including efficient resource management, improved plant health, and enhanced productivity by precisely monitoring and adjusting environmental conditions.

Moreover, the system's capability for continuous monitoring allows for proactive plant care. Plant owners can make data-driven decisions regarding watering, lighting, and other critical factors, promoting healthier development, reducing the risk of disease or pests, and maximizing overall yield and quality. Beyond individual plant care, the data collected from multiple systems can be analyzed to reveal insights into plant behavior, growth patterns, and environmental trends. This knowledge can contribute to scientific research, agricultural advancements, and the formulation of more effective plant care strategies. Overall, the plant monitoring system represents a valuable tool for plant owners, researchers, and the agricultural industry. Its benefits extend to resource efficiency, improved plant health, and the potential for broader scientific and agricultural advancements. As technology continues to evolve, further improvements and innovations in plant monitoring and automation are anticipated, opening up new opportunities for efficient and sustainable plant care.

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AUTHOR CONTRIBUTIONS STATEMENT

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Kujtim R. Mustafa	✓	✓	✓			✓		✓	✓	✓	✓	✓		
Refik Ramadani		✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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