AUTONOMUS MICROCLIMATE FOR REGULATING THE VITAL PARAMETERS OF PLANTS

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SUMMARY:
Considering the rapid advancement of automation technology, it is evident that a time will come when every aspect of our lives will operate autonomously. With this project my aim was to embark on a personal journey towards the implementation of ecological automation, specifically by creating a microclimate system that effectively regulates crucial factors for plants such as irrigation, ventilation and lighting. In the practical demonstration, sorghum plants were carefully selected as the primary specimens, although it is worth noting that alternative plant species can be seamlessly incorporated. By combining the principles of automation and ecology, I endeavor to pave the way for sustainable and efficient solutions in the realm of environmental management, setting a precedent for fture endeavors in this domain.
KEY WORDS: automation, healthy ecosystem, botany, Arduino Mega, plants

1. Introduction

An autonomous microclimate for regulating the vital parameters of a plant refers to a system that creates and maintains optimal growth conditions for plants, independent of external climatic conditions. This system is designed to control and regulate key factors that affect the health and development of plants, such as temperature, humidity, light, air and water circulation, CO_2 levels and nutrients.

Such an autonomous microclimate can be established within a greenhouse or a growth chamber, utilizing various technologies and equipment. For instance, an automated control system can monitor and adjust temperature and humidity using sensors and climate control devices. Artificial lighting can be employed to provide optimal light levels, while an automated irrigation system can deliver water in appropriate quantities and frequencies.

By maintaining an autonomous microclimate, plants can grow in a stable and controlled environment, leading to accelerated growth, improved crop quality and reduced risks associated with external climatic fluctuations such as drought or extreme temperatures. Nowadays, this approach is used in modern agriculture and scientific research to achieve more consistent and efficient results in plant production.

2. Current stage

For the purpose of illustrating the use of a microclimate, the plant chosen was sorghum, for which the parameters were adjusted to provide optimal growth conditions within the microclimate. The optimal growth conditions were taken into account regarding the requirements for light, air and water, using sensors and special devices illustrated in the table below.

Table 1. Electronic components used in the project

Category	*Name*	*Number*	*Voltage (V)*	*Location*	*Activation parameters*	*Actions activated*
IRRIGATION	Soil moisture sensor [1]	5	3.3-5	inside the microclimate	>34%	Water pump on
	Waterproof NTC sensor [2]	2	5	1.in the soil 2.in the water basin	<5ºC or >50ºC	Water pump off
	Water lever sensor [3]	2	3.3-5	1.inside the microclimate 2.in the water basin	1. >1% 2. <10%	Water pump off
	Water valve [4]	1	12	irrigation carcass	-	Water pump safety
	Water pump [5]	1	12	irrigation carcass	-	Irrigation
VENTILATION	DHT22 [6]	2	5	1.inner carcass 2.outer carcass	<30% or >68%	Ventilators on
	MQ135 [7]	2	2.5-5	1.inner carcass 2.outer carcass	>27%	Ventilators on
	PM sensor [8]	1	5	inner carcass	>0.28mg/m^3	Ventilators on
	BMP280 [9]	1	1.8-3.6	inner carcass	>25ºC	Ventilators on
	DC12V ventilator [10]	2	12	lateral walls	-	Ventilation
LIGHTING	TEMP6000 [11]	1	3.3-5	inner carcass	<200mV	LED band on
	LED band [12]	1	5	around the walls	-	lighting
OTHERS	Relay [13]	4	5	voltage control carcass	-	
	Voltage lowering mode [14]	3	2.5-25	voltage control carcass	-	1. output 3.3V 2.output 5V 3. output 12V
	LCD 20x4 [15]	1	5	LCD support	-	text messages
	Arduino MEGA [16]	1	5	Arduino carcass	-	-

3. Assembly process

The comprehensive assembly process encompassing all components was of a complex nature, spanning several days, to ensure that the ultimate outcome is characterized by aesthetic appeal, structural integrity and functional efficacy.

3.1. Central box

From three 50x100 Plexiglas sheets, six panels measuring 50x50 were derived. Among these panels, five were utilized in constructing a cubic enclosure, while the sixth panel constituted an endpiece that was securely connected through the implementation of two metallic hinges and endowed with a convenient handle. The structural integrity of the box's edges was ensured by reinforcing them with L2.5x2.5 plastic profiles, while a wooden plank was affixed at the base of the container to facilitate its transportation. Moreover, a 50x10 Plexiglas sheet was employed as the supporting element for the external casings of the microclimate. The comprehensive assemblage process involved the utilization of metallic brackets, M4 screws and nuts, and adhesive for plastic elements.

3.2. Auxiliary casings

To enhance the aesthetic appeal, six casings were printed for each set of components: an irrigation casing including the valve and pump, an exterior sensor casing (for DHT22 and MQ135), en electric voltage control casing, an Arduino MEGA board casing, an interior sensor casting and a casing for the LCD module with a mounted LCD stand positioned above it. The casings were designed using Fusion software and printed using a Creality Ender-3 3D printer.

Fig.1. Side view of the microclimate, illustrating the shape and assembly of the casings and the box itself

3.3. Electrical connections

Commencing from the "brain" casing, which houses the Arduino Mega board, meticulous attention was given to establishing the intricate electrical connections that corresponded to each individual component. Prior to the voltage reaching its intended destination, a prudent measure was taken by routing it through a voltage step-down module. This precautionary step served the purpose of safeguarding the delicate electronic components from the perils of excessive voltage, thereby mitigating the risk of irreversible damage. By diligently implementing this crucial intermediary, the potential hazards of both excessively high and low voltages were effectively neutralized. Once these intricate electrical connections were impeccably established, the subsequent stages of coding and comprehensive testing ensued. This meticulous approach was paramount in ensuring a seamless integration between hardware and software components, ultimately culminating in a robust and reliable result.

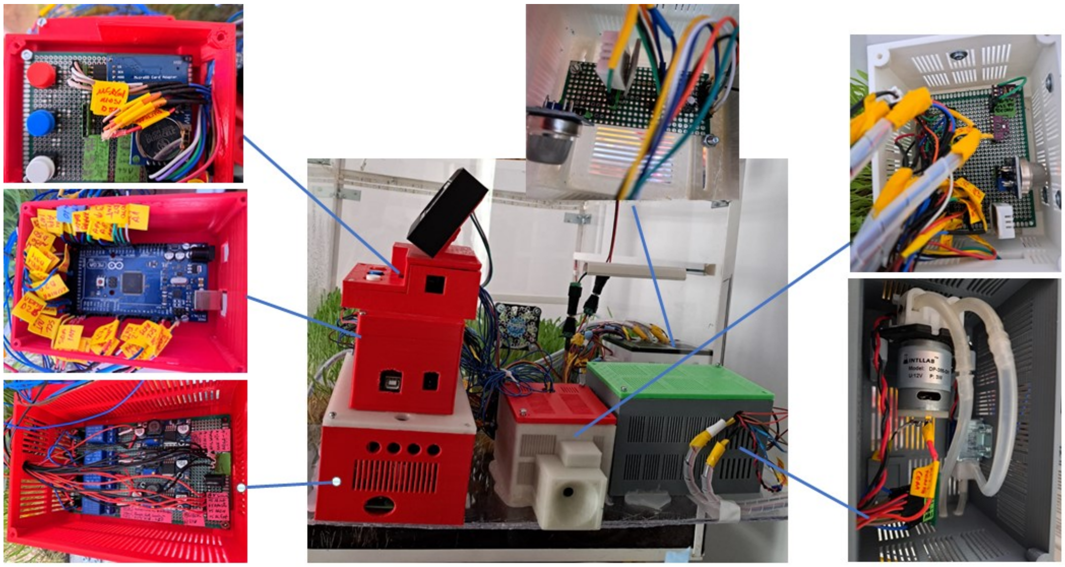

Fig.2. The electrical connections, delineated for each individual casing, were clearly delineated and organized, highlighting the orderly arrangement of each individual component.

4. Coding and results

The process of coding and testing the microclimate involved a systematic approach to programming and verifying the functionality of the created software. It began with the development of the code, where the desired behavior and operations are defined using the Arduino programming language in the Arduino IDE App. This entails writing functions, loops, conditional statements, and utilizing libraries as needed. After writing the code, it was uploaded to the Arduino board, where it is executed.

During the testing phase, various scenarios and inputs are simulated or provided to observe the behavior of the code and ensure its correctness. This includes checking sensor readings, verifying output signals, and testing the integration of different components.

Debugging techniques are employed to identify and fix any errors or unexpected behavior in the code. Through iterative testing and refining, the code is optimized and fine-tuned to meet the desired functionality, reliability, and efficiency. Rigorous testing is essential to ensure that the microclimate operates as intended, providing the desired results in a consistent and dependable manner.

The test results obtained could be observed both on the LCD screen attached to the microclimate system and in the Serial Monitor of the Arduino IDE application. Similarly, any errors or issues that arose during testing were identified and resolved using the same method. Upon final verification, a series of example text messages displayed in the Serial Monitor were extracted and compiled in the table below.

Table2. Examples of messages on Serial Monitor, the same as the text messages on the LCD

<table>
<tr><th>Observations</th><th>Text message</th></tr>
<tr><td>Reading the external sensors</td><td>DHT22 - EXTERIOR - Umiditate aer : 61.20 % | DHT22 Temperatura aer: 23.90 *C |
PM, Particule fine aer: 0.00 mg/m3 | | PM - Aer Curat !!! | Ventilatoare OFF
PM 2 - EXTERIOR, Particule fine aer: 0.00 mg/m3 |
NTC 1 | Temperatura Sol (in adancime): 22.44 *C | NTC 2 | Temperatura Apa Bazin: 20.33 *C |
Nivel Inundatie Sol : 6 % | Nivel Apa Bazin: 0 % | | NIVEL APA OK | Pompa - Vana OK | Bazin Apa GOL | Alimentare OPRITA!</td></tr>
<tr><td>Increased air humidity is observed inside so the fans are activated until the humidity level drops below 68%</td><td>DHT22 Umiditate aer: 75.80 % | DHT22 Temperatura aer: 23.90 *C | | Umiditate excesiva! | Ventilatoare ON
DHT22 Umiditate aer: 76.20 % | DHT22 Temperatura aer: 23.90 *C | | Umiditate excesiva! | Ventilatoare ON
DHT22 Umiditate aer: 76.20 % | DHT22 Temperatura aer: 23.90 *C | | Umiditate excesiva! | Ventilatoare ON
DHT22 Umiditate aer: 76.10 % | DHT22 Temperatura aer: 23.90 *C | | Umiditate excesiva! | Ventilatoare ON
DHT22 Umiditate aer: 76.00 % | DHT22 Temperatura aer: 23.90 *C | | Umiditate excesiva! | Ventilatoare ON
DHT22 Umiditate aer: 75.80 % | DHT22 Temperatura aer: 23.90 *C | | Umiditate excesiva! | Ventilatoare ON
DHT22 Umiditate aer: 75.60 % | DHT22 Temperatura aer: 23.90 *C | | Umiditate excesiva! | Ventilatoare ON
DHT22 Umiditate aer: 75.60 % | DHT22 Temperatura aer: 23.90 *C | | Umiditate excesiva! | Ventilatoare ON
DHT22 Umiditate aer: 75.20 % | DHT22 Temperatura aer: 23.90 *C | | Umiditate excesiva! | Ventilatoare ON
DHT22 Umiditate aer: 74.70 % | DHT22 Temperatura aer: 23.90 *C | | Umiditate excesiva! | Ventilatoare ON
DHT22 Umiditate aer: 74.20 % | DHT22 Temperatura aer: 23.90 *C | | Umiditate excesiva! | Ventilatoare ON
DHT22 Umiditate aer: 73.90 % | DHT22 Temperatura aer: 24.00 *C | | Umiditate excesiva! | Ventilatoare ON
DHT22 Umiditate aer: 73.60 % | DHT22 Temperatura aer: 23.90 *C | | Umiditate excesiva! | Ventilatoare ON
DHT22 Umiditate aer: 73.50 % | DHT22 Temperatura aer: 24.00 *C | | Umiditate excesiva! | Ventilatoare ON
Umiditate aer: 68.20 % | DHT22 Temperatura aer: 24.40 *C | | Umiditate excesiva! | Ventilatoare ON
/ 2009 -> DHT22 Umiditate aer: 67.90 % | DHT22 Temperatura aer: 24.40 *C | | Umiditate normala! | Ventilatoare OFF</td></tr>
<tr><td>Output from the light intensity sensor</td><td>Senzor foto Modul : Bine luminat ! : Banda LED OFF 263 Volti</td></tr>
<tr><td>Reading the soil moisture sensors</td><td>Umiditate Sol Zona A: S1: 39.49% ; S2: 30.21% ; S3: 53.57% ; S4: 51.91% ; Pompa OFF Umiditate Sol Zona A Buna. Pompa 1 este Oprita</td></tr>
<tr><td>Closing the loop and returning to reading the external sensors</td><td>MQ135 Calitate aer: 11% | | Aer curat! | Ventilatoare OFF
MQ135 Calitate aer - EXTERIOR: 6% |</td></tr>
</table>

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6. Conclusions

In conclusion, it is evident that automation technology continues to advance rapidly, with the potential to revolutionize various aspects of our lives. Also, the integration of automation and ecology, as demonstrated through the microclimate project, showcases the potential for sustainable and efficient solutions in environmental management.

Based on the obtained results, we could envision a potential future version of the microclimate system that incorporates an interactive means of communication with the human operator, such as a simple keyboard, allowing for an easy monitoring and control. Additionally, the addition of a functionality of data storage could be implemented by creating a database that captures both sensor readings and their continuously interpreted actions. This would enable the human operator responsible for the microclimate system's operation to access this database in the event of an error occurrence, facilitating error identification and troubleshooting.

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