DESIGNING AND IMPLEMENTING AN EXPERIMENTAL MODEL OF AN INTELLIGENT SHELF THAT MONITORS ENVIRONMENTAL CONDITIONS FOR PLANT GROWTH

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Abstract: This project presents the stages of design, implementation and programming of an intelligent shelf that monitors the essential environmental conditions for plant growth. In the first stage the shelf was designed using specialized software for an easier visualization of all the details. In the second stage the shelf was built according to the 3D design specifications. In the third stage, electronic components that contribute to monitoring were acquired, tested, programmed, and mounted on the shelf. The final stage is the assembly and verification of the functionality of the shelf.

KEYWORDS: design, shelf, monitoring, plants

1. Introduction

Growing plants means developing them under optimal, constantly controlled environmental conditions to facilitate the growth process in order to yield better results in a shorter timeframe. This process involves monitoring essential environmental elements (for plants) such as light, temperature, humidity and soil moisture. The monitoring stage provides us with the necessary information to control these conditions in order to adjust them to optimal values for the existing plants.

2. Current stage

Currently, there are many technologies and tools available for monitoring environmental conditions in plant growth. These include moisture, temperature and light sensors that can ensure optimal plant growth. They are usually used in greenhouses that, in addition to monitoring the conditions, also control them according to needs. The aforementioned technologies are in a continuous improvement process and for more efficient monitoring, they may also include imaging technologies. These new monitoring processes involve scanning plants using video cameras to detect diseases that may occur in the early stages, or the presence of certain pests that can affect the healthy growth of plants.

3. Design and implementation of the experimental shelf model

3.1 Designing the experimental model

The first step in completing this project was designing a model for the shelf. The model is created in specialized software, incorporating knowledge acquired during undergraduate studies[1]. The shelf has two spaces specially allocated for two different plants. Each of these has dimensions of 140x125x250 mm. Being an experimental model, the space is smaller because small plants are used. Under these two plant spaces, a compartment was created as a storage location for the components, which completed the environmental measurement system. In this space, the following components are found: Arduino Uno board, breadboard, batteries and the sensor module for measuring soil moisture. A similar space to that under the plants is also found above them. This is done in order to accommodate the two LCDs of the circuit. Additionally, the space above the plants was created to serve as a hiding space for the wires that come from the light circle. The two specially created spaces for electronic components, the upper and lower ones, communicate with each other through a "drawer" located behind the plants, implicitly in the back of the shelf, which aims to allow wires in the upper part to reach the Arduino board and breadboard without being visible from the front of the shelf. The shelf and the three compartments can be seen in Fig. 1.

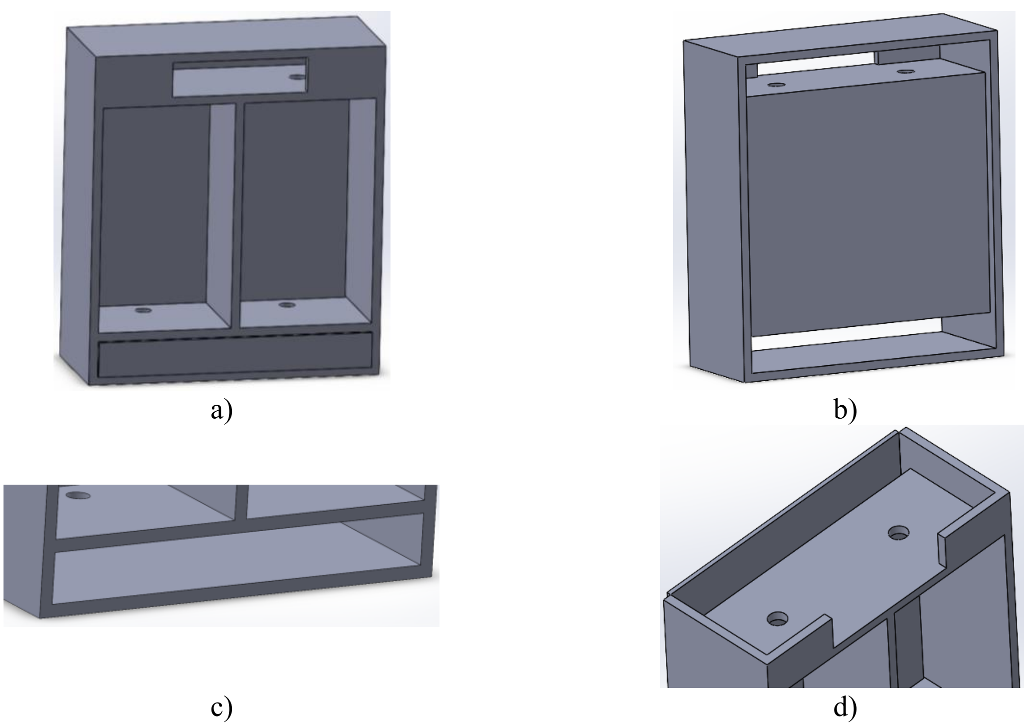


Fig. 1 a) Modeled shelf, b) Space behind the shelf, c) Bottom space, d) Top space

3.2 The experimental model

After the design stage of the experimental raft model was completed, a physically feasible solution was sought based on the dimensions used in the design.

a)

b)

Fig. 2 a) Actual shelf, b) Back part

Considering the pieces needed for constructing the shelf, shown in Table 1, the choice was made to create the components from plywood. The result of this operation can be seen in Fig. 2. Table 1 shows the dimensions of the component plates of the shelf and the number of pieces required.

Table 1. Component parts of the shelf

Nr. crt.	Pieces	Quantity (number of pieces)	Nr. crt.	Pieces	Quantity (number of pieces)
1	300x170mm plate	3	5	80x40mm plate	2
2	330x170mm plate	1	6	300x 285mm plate	1
3	370x170mm plate	2	7	335x370mm plate	1
4	240x120mm plate	1	8	335x70 mm plate	1

4. Sensors used on the shelf

To create the circuit that monitors environmental conditions, the components presented in Table 2 are used.

Table 2. The electronic components

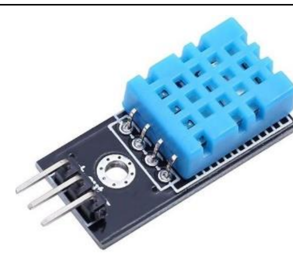
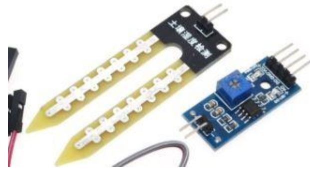
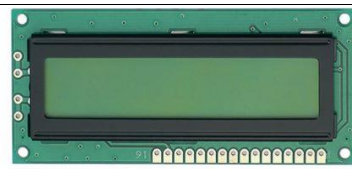
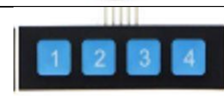
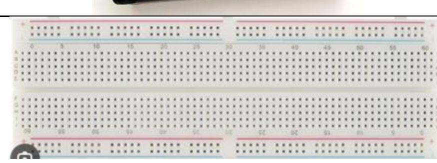
Nr. crt.	Component	Representation	Quantity (number of pieces)
1	Humidity and temperature sensor		1

Table 2. The electronic components (continuation)

Nr. crt.	Component	Representation	Quantity (number of pieces)
2	Soil humidity sensor		2
3	LCD		2
4	Neopixel 16 RGB		2
5	Keypad 1x4		2
6	Arduino Uno		1
7	Batteries		2
8	Breadboard		1

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To assemble the electronic components, in the first stage, the connection diagram presented in Fig. 3 was created.

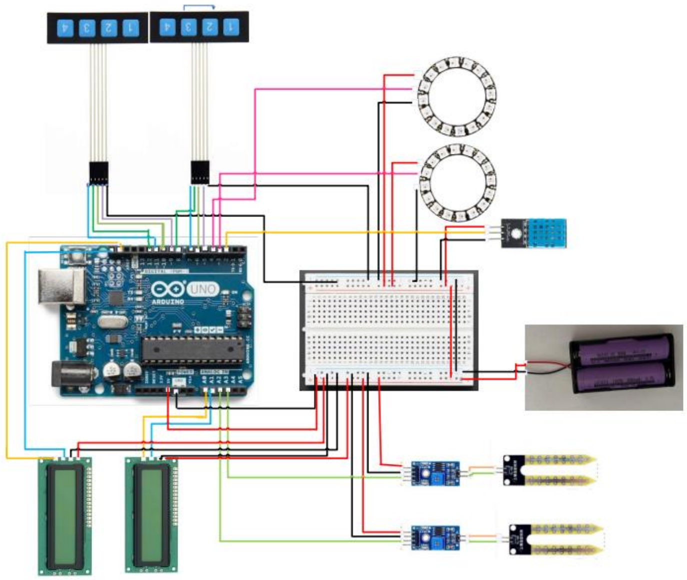

Fig. 3 Connection diagram

The figure bellows shows the assembled shelf containing the components presented in Table 2.

Fig. 4 The assembled shelf

In this project the development of plants influenced by the type of light they receive is monitored. Red light helps plant growth in height, while blue light helps plant growth in width. For this important element in plant development, a Neopixel 16 RGB [6] is used, which represents a luminous ring that can change color. The changes in light are made with a 1x4 keypad [9]. Therefore, when button 1 is pressed, the Neopixel will have red light, when button 2 is pressed it will have blue light, when button 3 is pressed it will have white light, and when button 4 is pressed the light generated by the ring will turn off. These four options allow for modification and monitoring of the optimal variant for the plants that are placed on the shelf.

In addition to monitoring light, other extremely important conditions for the proper development of plants are the temperature and humidity of the environment, as well as the moisture of the soil. To monitor the temperature and humidity of the environment, the DHT11 [8] sensor is used. It is positioned approximately in the center of the shelf (Fig. 4), in order to be as close as possible to the plants. The data collected by this sensor is displayed on an LCD for easy viewing by users.

Perhaps the most important factor that influences plant growth is soil moisture. It must be carefully monitored in order to be controlled, resulting in healthy plant growth. In this sense, the experimental model of this shelf has two soil moisture sensors [5], one for each plant. They are used to collect data from the pot. The values for both plants are also displayed on an LCD [3], [7].

5. Conclusions

In conclusion, this experimental model of an intelligent shelf created for monitoring environmental conditions in plant growth is a more accessible experimental model of a system that can be used at the greenhouse level. The conditions it monitors are essential for plant growth, contributing directly to both growth duration and the health of the plant. In addition, like any system, it can be improved in several ways. One of the possible improvements would be the existence of an automatic irrigation system, so that plants would no longer need the constant presence of a human. Another improvement that could be made to this project would be the control of environmental temperature through the existence of a fan. Although there could be enhancements to this model, it is still a useful shelf model that controls plant growth conditions for a higher possible efficiency of their development.

6. Bibliography

[1] Filip, V., Marin, C., Grunoiu, L., Negrea, A., 2008, *Proiectarea, modelarea, simularea sistemelor mecanice, utilizând SolidWorks, CosmosMotion si CosmosWorks*, Valahia University Press, Târgoviște

[2] ARDUINO IDE, Professional software, available at: https://www.arduino.cc/en/software, accessed on: 20.03.2023

[3]https://www.youtube.com/watch?v=-eqirn-2yKA&ab_channel=Clgproject,Accessed 02.05.2023

[4] https://www.farnell.com/datasheets/1682209.pdf, Accessed on 27.04.2023

[5]https://www.optimusdigital.ro/ro/senzori-senzori-de-umiditate/73-senzor-de-umiditate-a-solului.html, Accessed on 15.03.2023

[6] https://pdf1.alldatasheet.com/datasheet-pdf/view/553088/ETC2/WS2812.html, Accessed on 15.03.2023

[7] http://eprints.polsri.ac.id/4642/9/18_DATASHEET%20LCD.pdf, Accessed on 15.03.2023

[8] https://pdf1.alldatasheet.com/datasheet-pdf/view/1440068/ETC/DHT11.html, Accessed on 15.03.2023

[9] https://thinkrobotics.com/products/1x4-key-matrix-membrane-keypad, accessed on 15.03.2023

[10] https://datasheetspdf.com/pdf/1408721/TENERGY/18650/1, accessed on 15.03.2023

[11] https://cdn.sparkfun.com/datasheets/Prototyping/breadboard.pdf, accessed on 15.03.2023