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| RESEARCH ARTICLE

Monitoring of Water Level in Indoor Precision Vegetable Production Systems

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| ABSTRACT
Hydroponics is a growing plant method by adding nutrient-rich solutions. This method does not rely on soil usage; instead, the root system is based on an inert medium such as Rockwool, peat moss, perlite, clay pellets, or vermiculite. The basic interest behind hydroponics is to allow the plant's roots to grow while there is direct contact with the nutrient solution. Access to oxygen must be provided, indeed, as it is essential for proper growth. In this paper, we made the study-design approach of a "greenhouse", which was a digitally controlled environment device. In this approach, we will see how far we can control the growing process of a plant, together with monitoring the water level. For the experiments, a prototype of the electronic part is constructed. The testing of the "greenhouse" can be used for developing new applications, which will highlight the way we grow food and eliminate pesticide dangers.

| KEYWORDS
Water Level; Hydroponics; Indoor Precision Vegetable Production Systems; nutrient-rich solutions;

| ARTICLE INFORMATION
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1. Introduction
Every year, powerful businesses are built based on growing plants. Agriculture remains the prime business and the world's most important source of wealth. Growing with hydroponics has several advantages, the most important of which is a remarkable growth increase in the plants.

The setup of the hydroponics system might take a lot of time and should be done efficiently. Nonetheless, managing a hydroponics system should be done according to a strict schedule, depending on the needs of every plant.

Open agriculture is based on hydroponics and STEM (Science, technology, engineering, and mathematics) technology, which goes deeply into the biochemical machinery. To increase the quality of our grown food, we need to learn about what plants need in their different stages of growth. Plants need rich and different chemistry for self-defense and stress adaptation. Open agriculture is trying to induce a plant to synthesize these chemicals and molecules by adding some stresses to the plant's surroundings and measuring the changes in the different parameters.

2. Review of related literature
The development of an indoor precision vegetable production system is a new open agriculture initiative that will make a breakthrough in history, constructed from a Plexiglass greenhouse box and lightened by lamps sitting on the top. This production system is open-source even for growing the system itself. The main components are a few basil seedlings with small pots of Rockwool growing inside a transparent plexiglass box, then a single board computer controls and collects data on the box according to environmental variables such as humidity, co2, the light spectrum, and hydroponic nutrients through sensors. The motherboard is exposed completely with an intricate network of fans and processor chips.

Rows and seedlings sprout and grow faster inside a greenhouse box; a healthy green basil plant can grow inside the plexiglass box. Machine learning is used to continuously advance system growth conditions. Through the data correlations, the production system can pinpoint the environmental origins of a plant's labor outcome. For example, high humidity results in sweeter basil. Users can control the production system and share environmental recipes with farmers through an open agriculture web-based user interface.

Below is a schematic view of the elements constructing the production system:

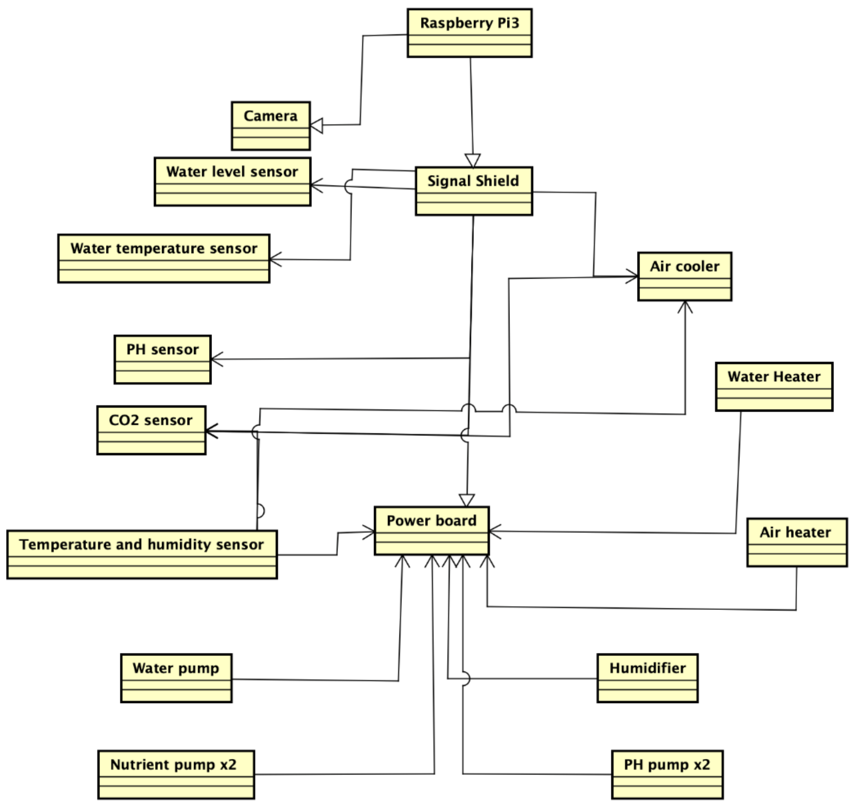

Figure 1 Shematic view of the electronic circuit

3. Methods

The following section outlines the steps we applied to design the growing system. The design includes two main steps. The first one is the design of the enclosure, and the second is the design of the electronic assembly. Most of the existing commercial devices are very limited in the range of possibilities for the user. Most of them are rather closed systems which allow a very low range of capabilities

3.1 Computer-Aided Design

In the computer-aided design process, a central aspect is the choice of software. For this purpose, we decided to use Catia V5 software.

The growing chamber consists of a box with 4 faces of plexiglass plates; the back plate is covered. The top and bottom plates are supplied by thin wood plates. The aim of the wood plate on the top side is to hold the 4 bulbs, while the bottom plate is to hold the reservoir, all together with the remaining components. In the beginning, the parts were designed independently using the part design section. The parts were assembled together using the assembly design section. We have used multiple types of constraints to connect the parts together. For connecting the light bulbs to the wood plate, we have used coincidence constraint and the same for the bolts. As for the other parts, we have simply used contact surface constraint by defining the multiple surfaces where contact takes place. For positioning some parts to others, we have used the offset constraint by defining the distance at which one part is located from another

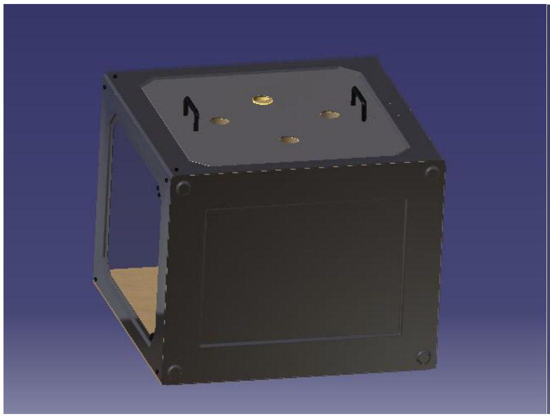

Figure 2 Front view of the personal food computer *Figure 3 Back view of the personal food computer*

The electronic design of the personal food computer consists of five elementary elements:

- Raspberry Pi 3B
- 1 Pack Computer Fan
- 4 Channel Relay
- 1 Breadboard
- 4 lighting LEDs

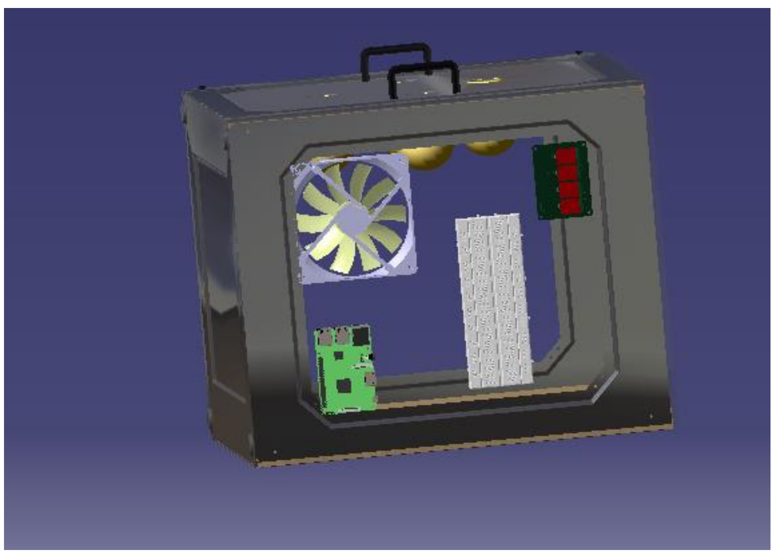

Figure 4: fan placed inside the growing chamber

Like the enclosure design, the brain design parts were done independently in the part design section. In the main assembly, we connected the brain parts to the left plexiglass plate using the appropriate constraints. We could not connect the jumper wires to the design because this procedure needs a certain affinity that CAD software does not provide. For this purpose, we have used a different method to show the logical way of connecting the components. However, we could mount the brain components in their exact position as it is supposed to be in a real prototype using the offset constraint by defining the distance at which every component is located with respect to the other.

3.2 Circuit design

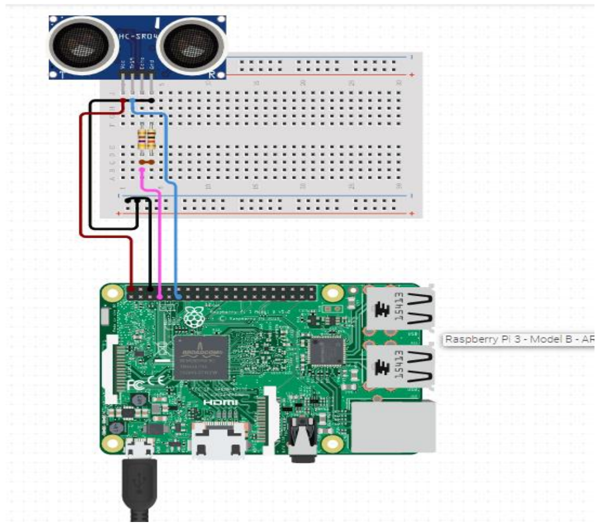

Figure 5 Circuit Diagram of the brain assembly

Through the breadboard, we connect the sensor to the raspberry PI. The sensor has four pins. We connect the ground GND pin of raspberry PI and the sensor. We connect the SCK pin of the sensor to the third pin of the raspberry PI. This connection serves as an input of data. We connect the VIN pin to the 3V3 in raspberry PI. This connection serves as a low power energy and a maximum available current of about 50 mA. The last connection is between the SDI pin of the sensor and the second pin of the raspberry PI. This is for the data sent from the processor to the sensor.

3.3 Prototype and testing Design considerations

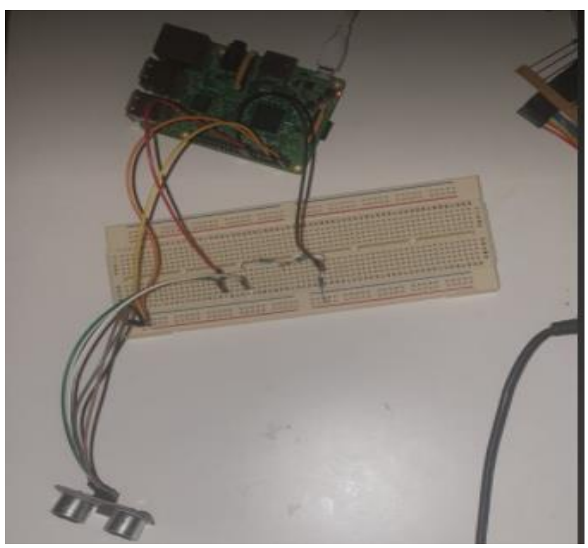

Figure 6 Electronic circuit2`

The electronic circuit consists of a circuit board. A Raspberry Pi microcomputer hosts the software that allows us to control the system from a computer, while an Arduino microcontroller links to the temperature and humidity sensor that collects data about the environment and communicates it to us. As for testing the ultrasonic sensor, its features are not defined on PyPI. Therefore, we could not install the driver locally from PyPI. So, the solution is to write a script which python based in order to get the sensor installed on the Raspberry PI.

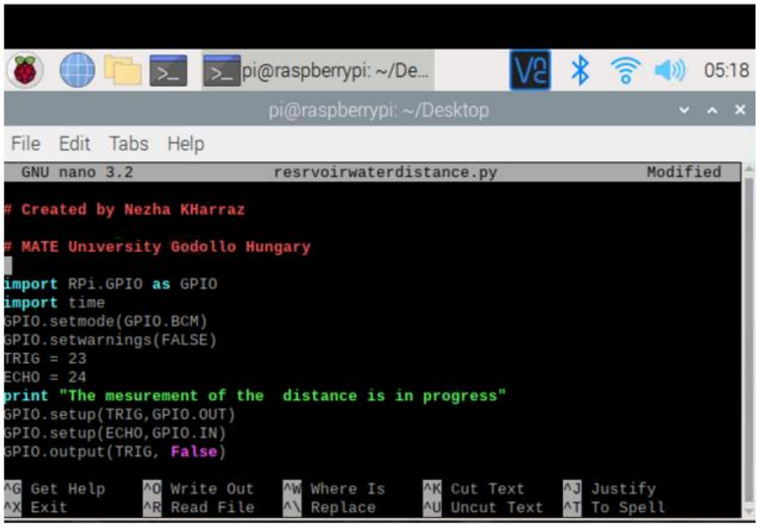

Figure 7 Script for ultrasonic sensor

In the picture, a section of the script is written. We started the script by importing the GIPOs used in the script. Then we defined the inputs from the sensor, which are the two pins we previously connected, the TRIG and ECHO pins. We started the command in the terminal by defining the location of the script; then, we named the script in order to be able to start writing the script. The first command is <cd Desktop/>; the script was saved in Desktop, we named it smartwaterreservoirdistance, and we gave.py at the end for the python extension; the command <nano> is used whenever we want to name a file.

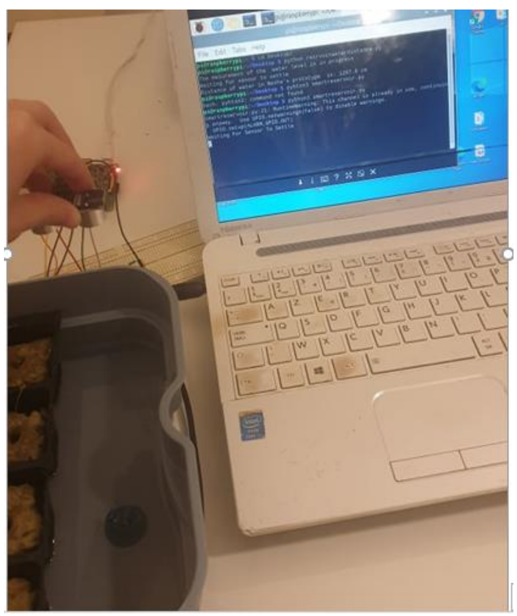

Figure 8 water reservoir distance

Growing chambers differ a lot in size, resolution, and shape. The used lighting method is needed to be a more flexible solution. Therefore, the idea arose to develop a code for controlling light and the rest of the variables. With respect to the claim of a friendlier user device, the raspberry PI microcontroller gives access to a friendly user interface.

For easier manipulation and testing, we took the reservoir out and manually measured the distance between the reservoir and the water level; then, we ran the script and got the same result.

4. Results and discussions

For water level monitoring, we choose to use an independent source from the MVP software. This method involves measuring the water level of the water reservoir using Raspberry Pi and the ultrasonic distance sensor HC-SR04. Raspberry Pi is programmed to take the water level readings every minute and send the data to a remote custom Web Application hosted that recognizes the PI address of the Raspberry PI. The Web Application provides us with a real-time update on the water reservoir level. As shown before, the ultrasonic sensor is placed on top of the reservoir. The sensor is connected to Raspberry Pi, which measures the water level in the reservoir every minute. The water level reading is sent to a remote database. The Web Application running in the remote host uses the sent data to keep the water level updated in the thin bar line graph.

Below is a section of the python code that we wrote on the Raspberry Pi. As we explained before, in order to run this code and enable the WEB application to access the sensor, it is highly needed that the Raspberry Pi recognizes the sensor, and its features must be installed into the Raspberry PI. This step was fulfilled in the first part.

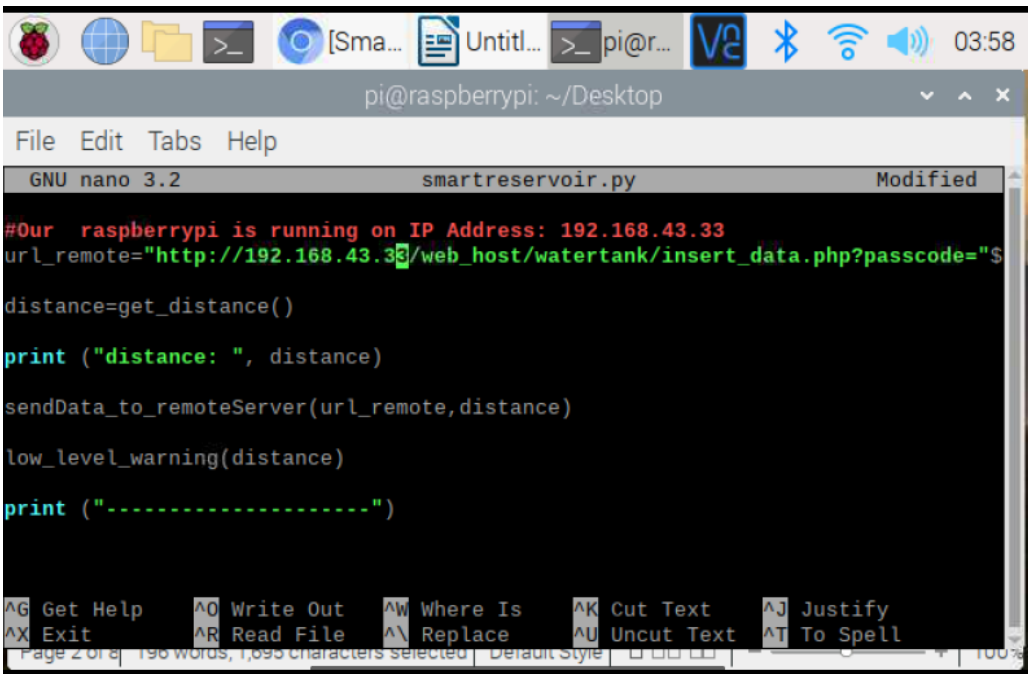

Figure 9 Smart reservoir python code

After writing the python code, we save it into the Raspberry PI, and after, we run the command <python3 smartreservoir.py>. We needed to make sure that the code would run with the third version of python; therefore, we wrote at the beginning of the command python 3 then we followed by the name of the file and the extension.

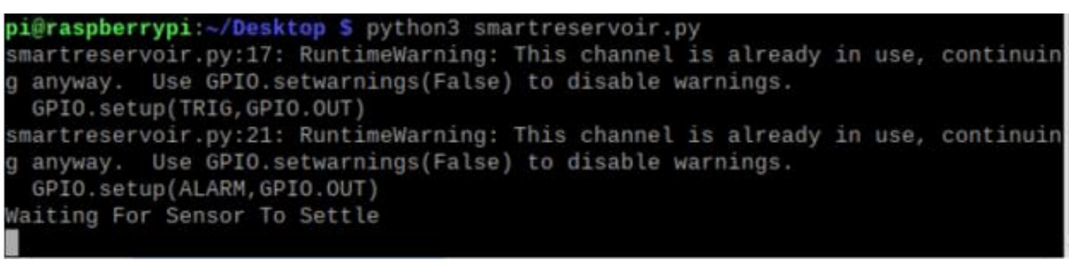

Figure 10 Running the command of the smart reservoir

After running the command, we type in the web browser the command:

< http://192.168.43.33/web_host/watertank/insert_data.php?passcode= >, the latter shows the water reservoir level with the date. It is highly important to type the IP address of the Raspberry PI we are working with in order to get our data

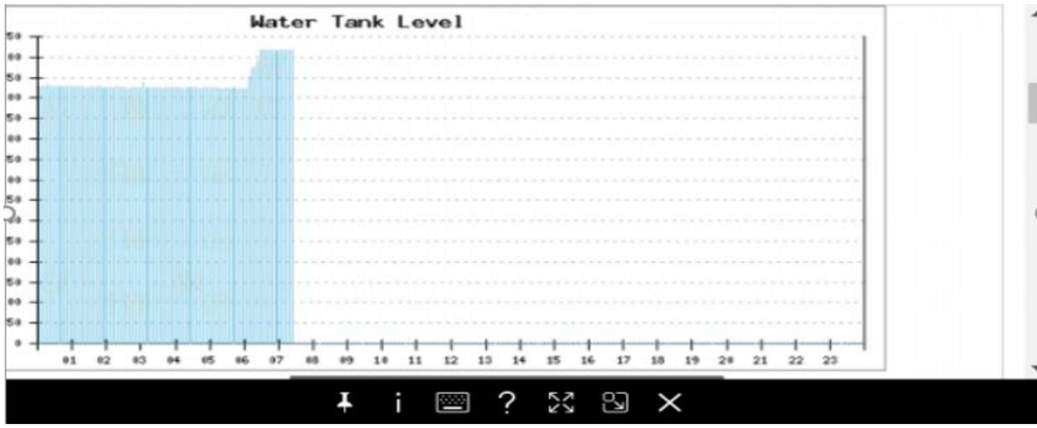

Figure 11 Water level dashboard

The horizontal axis showed the daily hours until the hour when we performed the measurement, and the vertical axis showed the level of water in mm.

The personal food computer is the future of agriculture inside every house. The machine is plugged into a network, so all the environmental information runs into a database, where other users can see how much water the plant is getting and use that data to improve the way they grow their crops.

The new device is a way to program how we grow what we eat. It's a digital interface that controls a physical object. What's interesting is that at the end of the growing cycle, we get a digital recipe. If we want to grow the same crop again, we will get the same thing every time.

5. Conclusion

The hydroponic system is the new plant cultivation method implemented in modern agriculture. Its development allows growing plants independently of the weather. From one side, the real-time monitoring of water level in a hydroponic system through the ultrasonic distance sensor HC-SR04 enabled us to make the reservoir a smart one. On another side, the MVP software was a good addition to our project since it is a Raspberry PI based one, and its interface is very user friendly; it is a straightforward result data basis. This can open the door to its usage by normal farmers; however, the limitation remains in the size of the indoor system. We cannot yet grow plants in the same quantity as we can on a usual farm, and thus we cannot monitor the water level for bigger reservoirs. Our future research will be focused on the application of our findings in real farms.

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