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ANALYSIS OF ELECTRONIC SYSTEMS FOR CONTROL OF SMART GREENHOUSES

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Abstract: *Agriculture is an important part of our lives as human beings. A lot of research has been done in order to be able to develop a monitored and controlled greenhouse system/environment that will help to solve the main problems related to agriculture which is to allow the increase of crops grown all year round in the comfort of a small space like the house. Greenhouses help protect crops against many diseases, especially those that start in the soil and splash plants in the rain. Many farmers fail to reap good benefits from greenhouse crops because they cannot manage two critical factors, which determine plant growth as well as productivity. The temperature in the greenhouse should not fall below a certain degree. High humidity can cause crop transpiration, condensation of water vapor and evaporation of water from moist soil. To overcome such challenges, this greenhouse monitoring and control system comes to the rescue. This project demonstrates the design and implementation of various sensors for greenhouse environmental monitoring and control. The main idea of this paper is to research and compare existing technologies related to the control of parameters in a greenhouse.*

Keywords: *Greenhouse, Electronic Control System, Arduino, Raspberry, PLC.*

INTRODUCTION

According to the Cambridge Dictionary, the greenhouse is a building with a roof and sides made of glass, used for growing plants that need warmth and protection (Gaikwad, A., Ghatge, A., Kumar, H., & Mudliar, K., 2016). In later developments, other materials such as plastic, fiberglass and paranet were found, so the mention is replaced by a houseplant. In general, the figure of a greenhouse building consists of the frame as the strength support, the roof and the walls as the protectors, the interior of the greenhouse which is usually in the form of a support or supports of pots, and greenhouse equipment in the form of air conditioning units. The climate control devices are still manual, especially related to irrigating plants.

The use of automated microclimate control systems in greenhouses is promising. Greenhouse automation, implies the management and monitoring of climate parameters that can be adjusted. Automation of climate control promotes better growth and higher yields, as well as reduces manual labour costs. There is a need for a high degree of automation and mechanization of technological processes (Dwinugroho, T., Hapsari, Y., & Kurniawanti, 2020).

Using an automatic system for greenhouses makes it possible to greatly facilitate the work on your garden plot and increase the yield up to several times. By installing an automatic machine for a greenhouse with your own hands, it is possible to create favourable conditions for the development and growth of plants without human intervention. Autonomous irrigation systems will save time on watering, especially in summer cottages, when watering is needed even on weekdays.

The amount of water and fertilizer used is also significantly reduced. Automatic lighting and heating allow you to grow vegetables and herbs in greenhouses all year round. Automation systems will significantly simplify all technological operations in the greenhouse. Depending on the needs of farmers, all combinations of sensors are possible: humidity sensors, temperature sensors, light sensors, soil composition sensors (pH degree, chemical composition), irrigating water quality sensors, etc (Öztürk, E., Çelik, Y., & Kırcı, P., 2021, Yahaya, A., Abass, Y., & Adeshina A., 2019, Dwinugroho T. B., & Y T Hapsari and Kurniawanti, 2021).

As part of our review, we studied the deferent electronic controlled system used for controlling the smart greenhouses. There are my platforms but, in our work, will be limited to three platforms. We will compare Arduino, Raspberry and PLC and will choose the most suitable system.

The aim of this work is to provide an overview of existing design and control methods for transformation from traditional greenhouse to the modern greenhouse - key design factors including the greenhouse orientation, shape, covering materials, ventilation and lighting systems. Various techniques have been analysed to describe the overall energy-use performance of greenhouse systems. Control strategies are discussed to improve the energy efficiency of the greenhouse from aspects of sensors, communication technologies, and control algorithms. This review provides valuable insights and suggestions for the design of modern sustainable greenhouses.

SOLUTION WITH THE ARDUINO PLATFORM

Arduino is an open-source electronics platform based on easy-to-use hardware and software. An Arduino board can read input - light on a sensor, a finger on a button, or a Twitter message - and convert it into output - activating motors, turning on LEDs, posting content online. The board can be told what to do by sending a series of instructions to the microcontroller on the board. For this, can be used the Arduino programming language (Wiring-based) and the Processing-based Arduino software (IDE) (www.arduino.cc).

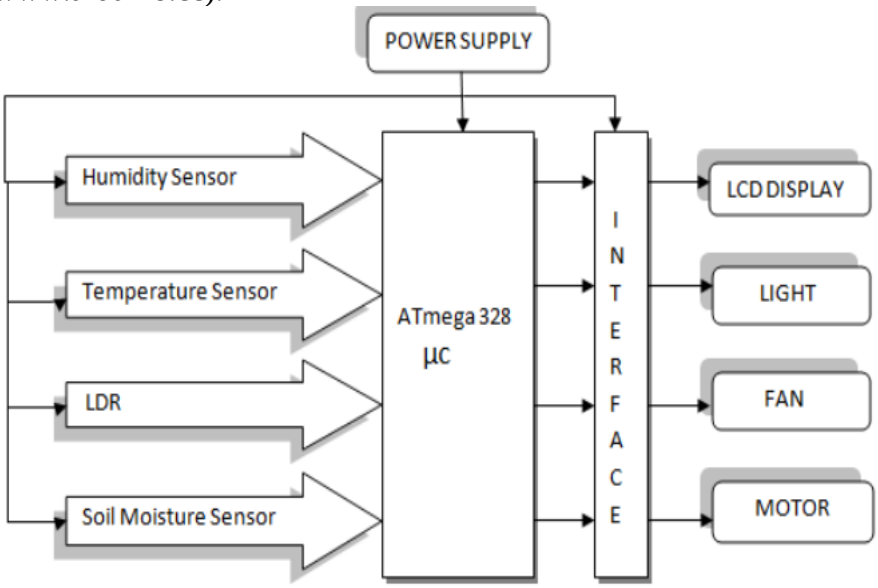


Fig. 1. Block Diagram of the Proposed System

In this study they used the Arduino ATMEGA, this system consists of various sensors, namely soil moisture, temperature, humidity and light sensors. These sensors sense various parameters and are then sent to the microcontroller. Here, Atmega328 MCU is used which controls the greenhouse. To implement greenhouse environment, soil moisture sensors, temperature sensors, LDR, humidity sensors are studied illustrated in Table 1.

After studying these, the program has been written on to the microcontroller for specific environment conditioning. The desired temperature and humidity are maintained by turning on heater/cooler. The moisture level within soil is also be controlled by turning the water valve on/off. Desired light intensity for that environment can also be controlled by emergency lights when necessary. Hence, the greenhouses' environment is controlled automatically. Fig.1 illustrates a block diagram of greenhouse automation system design with its hardware components involved and connections.

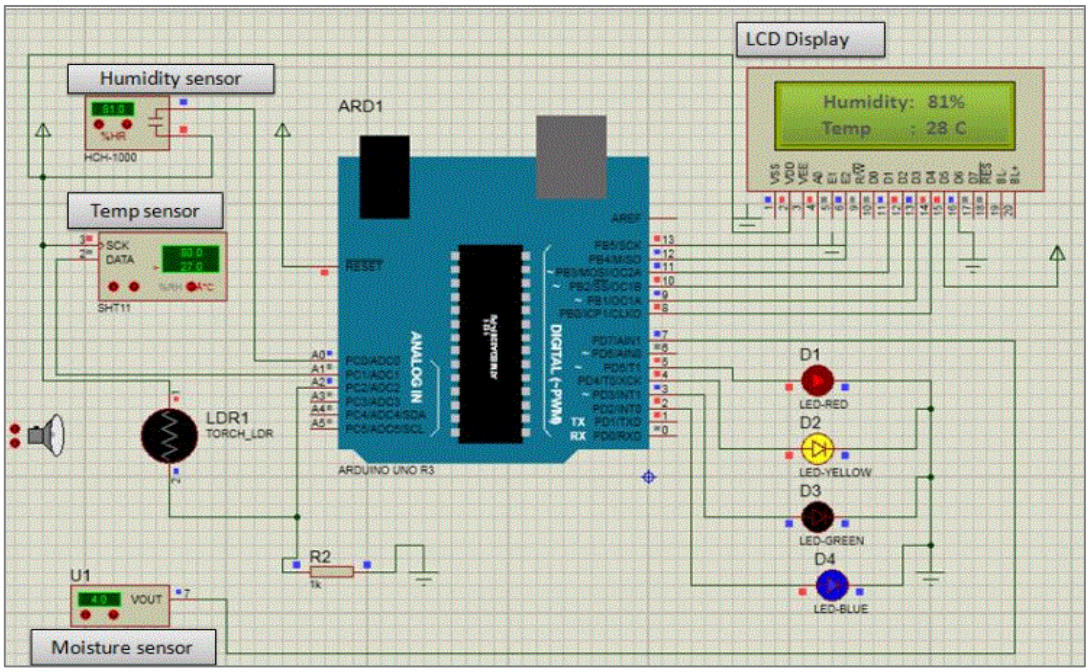
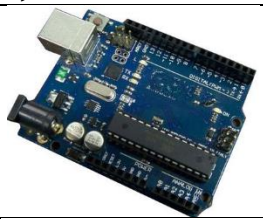
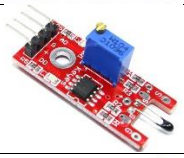
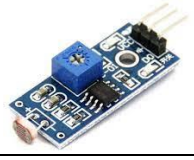
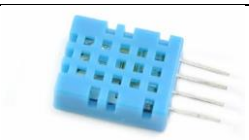


Fig. 2. Schematic diagram of the project

Table 1 presents the list of used materials.

Table 1. Used materials

Materials	**Picture, view**
Arduino UNO based on Atmega328	
Soil moisture sensor	
Temperature sensor	
LDR light sensor	

Humidity sensor	

From this study and analyses, can be concluded that the Arduino is a cheap way to create an automatic controlled system. Its advantage and disadvantage are summarized in Table 2 (Gaikwad, A., Ghatge, A., Kumar, H., & Mudliar, K., (2016), www.arduino.cc).

Table 1. Advantages and disadvantages of the Arduino platform

Advantage of Arduino	**Disadvantage of Arduino**
Very easy to get started.	It is not very powerful when compared with Raspberry Pi
It can be used for real-time applications for both hardware, software and IDE is open source.	You need to program using either Arduino or C/C++
Not much programming knowledge needed to do basic stuff.	Connecting to the internet is slightly difficult, but not impossible.
It is very easy to extend and has tons of user-contributed shields and libraries. Shields are available to do attractive much anything.	Parsing of Arduino with YQL and JSON is possible.

SOLUTION WITH A PROGRAMMABLE LOGIC CONTROLLER (PLC)

The climate control units are still manual, especially when it comes to watering plants. The role of the PLC as an automation tool here is related to the watering of plants, as the greenhouse is designed to protect the plants and protect them from the climate, especially to reduce the intensity of sunlight and rain, which means that the plants are watered manually, and the watering of these plants Water frequency depends on the type of plant being planted or the later level in the plant's soil.

Automatic watering in the greenhouse can be carried out simultaneously using PLC based on a clock and a sensor. The parameters to be considered for automating watering of a greenhouse system using PLC in this study are clock parameters for watering (based on clock) and soil moisture (sensor-based).

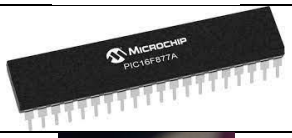
The timer (H) can be set according to the time required for watering and the number of watering frequencies per day. In the analysed study, the timer (H) is set to water once a day. Sensor-based irrigation can also be done using programmable logic control (PLC).

The sensor reads the drought which will trigger a switch on the controller to do the watering. Sensor irrigation is based on soil moisture, constant monitoring in this type of irrigation cannot be done directly, the only indication is obtained by observing the difference in water reduction in the water tank between clock-based irrigation and combined sensor clock-based irrigation.

Further research needs to be done regarding this combined sensor and clock-based sprinkler notification system and many points from this research to achieve a tight fully automated system.

In this study they using a PIC16F877A microcontroller as the main processing unit that accepts input from a temperature sensor (LM 35), a light intensity sensor LDR (Light Dependent Resistor) and a humidity sensor has already been built (Dwinugroho, T., Hapsari, Y., & Kurniawanti, 2020) as illustrated in Table 3.

Table 3. List of materials used in the PLC system

Materials	Picture
PLC	
Microcontroller PIC16F877A	
Temperature sensor LM 35	
LDR light sensor	
Humidity sensor for PLC	

The use of PLC as an automation tool has been widely applied in industry and research. Its advantage and disadvantage for the investigated purpose are summarized in Table 4 (Dwinugroho, T., Hapsari, Y., & Kurniawanti, 2020, Alphonsus E. R., & Abdullah M. O., 2016).

Table 4. Advantage and disadvantage of the PLC platform

Advantages	**Disadvantages**
Many inputs and outputs, excellent for controlling and monitoring many processes	Do not use the full capabilities of the microprocessor
Designed for industrial environments, robust and reliable	Ladder logic programming style is cumbersome and prone to mistakes
Reprogrammable	Only good for yes/no decisions
Modular	Do not handle continuous inputs and outputs, not good for "direct control"
Ideally suited to supervisory control	Inflexible (compared to microprocessors)
Easy to set up, good for FMS environment	

SOLUTION WITH THE RASPBERRY PLATFORM

Raspberry Pi is defined as a minicomputer with the size of a credit card that is interoperable with any input and output hardware device like a monitor, a television, a mouse, or a keyboard – effectively converting the set-up into a full-fledged PC at a low cost (Ganesan, K., Walele, U., Hambire, N., Choughule, P., & Oommen, D., 2018).

The greenhouse makes use of four different types of sensors to help regulate plant cycles and give the user useful information to further aid the growing process. The four sensors are DS18B20 Temperature, DHT11 Humidity, YL69Hence and illustrated in Fig. 3, it is straightforward to utilize one chip to control numerous DS18B20s dispersed over a huge range.

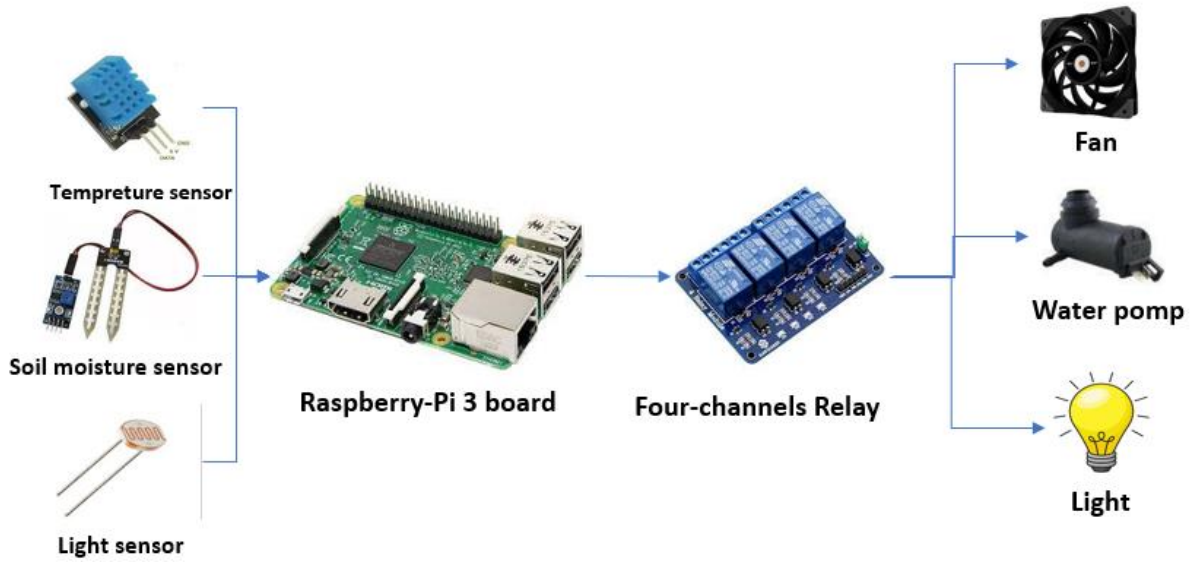


Fig. 3. Structure of a project with Raspberry Pi platform

Although the Raspberry Pi is more Practical for wireless communication and be programmed with any language, its advantage and disadvantage are summarized in Table 5 (www.spiceworks.com, Ganesan, K., Walele, U., Hambire, N., Choughule, P., & Oommen, D., 2018, www.quora.com).

Table 5. Advantage and disadvantage of the Raspberry Pi platform

Advantage of Raspberry Pi	**Disadvantage of Raspberry Pi**
You can install a fully-fledged Operating System (eg Raspbian which is Linux-based or Windows IOT Core which is Windows based OS) and use it as a day to day computer	There is not any fuse protection on the Rpi, so if the pins are connected incorrectly, the board can be damaged
The presence of GPIO (General Purpose Input Output pins) is what distinguishes a RPi from traditional computers. You can connect these pins to sensors and external components and interact with them programmatically using a language such as Python. This allows you to build and prototype Internet of Things devices that can sense the real world	It is not as fast in terms of CPU processing speed nor does it have as much memory as traditional PC or laptops.
RPi has WiFi and Bluetooth built in which allows wireless communication.	There is no built-in analog to digital conversion on the GPIO pins like there is in Arduino. So, an external ADC chip is required to work with analog signals.

CONCLUSION

After comparing, examining and studying the feasibility of three different approaches to automate the smart greenhouse, it can be concluded that PLC is used mostly for industrial purposes and requires advanced knowledge. Unlike RASPBERRY, whose characteristics are similar to ARDUINO, but there is a difficulty in terms of programming and high physical cost compared to the previous one.

Therefore, it can be concluded that ARDUINO is the most appropriate for prototype and small projects that do not require a big number of sensors. Based on the above research and analysis can be said that the Arduino is the better electronic control system device when it comes to building small scale smart green houses, that requires low knowledge in programming languages.

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REFERENCES

Alphonsus E. R., & Abdullah M. O., (2016), *A review on the applications of programmable logic controllers (PLCs),* Renewable and Sustainable Energy Reviews, Volume 60, Pages 1185-1205, ISSN 1364-0321

Arduino, https://www.arduino.cc/

Dwinugroho T. B., & Y T Hapsari and Kurniawanti, (2021), *Greenhouse automation: smart watering system for plants in greenhouse using programmable logic control (PLC),* Journal of Physics: Conference Series, 1823 (2021) 012014, doi:10.1088/1742-6596/1823/1/012014

Dwinugroho, T., Hapsari, Y., & Kurniawanti, (2020), *Greenhouse automation: smart watering system for plants in greenhouse using programmable logic control (PLC),* Journal of Physics: Conference Series, Volume 1823, Second UPY International Conference on Applied Science and Education (2nd UPINCASE) 3-4 November 2020, Yogyakarta, Indonesia.

Gaikwad, A., Ghatge, A., Kumar, H., & Mudliar, K., (2016), *Monitoring of Smart Greenhouse*, International Research Journal of Engineering and Technology (IRJET), India, Volume: 03 Issue: 11/ Nov -2016, e-ISSN: 2395 -0056, p-ISSN: 2395-0072

Ganesan, K., Walele, U., Hambire, N., Choughule, P., & Oommen, D., (2018), *Raspberry-Pi Based Automated Greenhouse,* International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395-0056, p-ISSN: 2395-0072.

Öztürk, E., Çelik, Y., & Kırcı, P. (2021), *Akıllı Tarımda Sensör Uygulaması,* Avrupa Bilim ve Teknoloji Dergisi, (28), 1279-1282

What is Raspberry-pi (n.d.), https://www.spiceworks.com/tech/networking/articles/what-is-raspberry-pi/

What are the advantages and disadvantages of Raspberry Pi (n.d.), https://www.quora.com/What-are-the-advantages-and-disadvantages-of-Raspberry-pi

Yahaya, A., Abass, Y., & Adeshina A., (2019), *Greenhouse Monitoring and Control System with an Arduino System,* 15th International Conference on Electronics, Computer and Computation (ICECCO), pp. 1-6