

# Monitoring of a Semi-automatic and an Automatic Greenhouse

Achouak TOUHAMI<sup>1</sup>, Amina BOUROUIS<sup>2</sup>, Khelifa BENAHMED<sup>2</sup>,  
Fateh BOUNAAMA<sup>3</sup>

<sup>1</sup>Department of Mathematics and Computer Science, Ali Kafi university center, Tindouf, Algeria

<sup>2</sup>Department of Mathematics and Computer Science, Tahri Mohamed university, Bechar, Algeria

<sup>3</sup>Department of Electrical Engineering, Tahri Mohamed university, Bechar, Algeria

E-mail: achouak.touhami@cuniv-tindouf.dz

**Abstract** - In a greenhouse, multiple parameters need to be monitored throughout the plant growth process. However, there are periods during which these parameters, such as temperature, humidity, solar radiation, soil pH, etc., inside the greenhouse become unfavorable for the plant. To solve this problem, we propose in this work two designs. The first design is for monitoring an automatic greenhouse using WSN, actuators and a microcontroller. And, the second design is for monitoring a semi-automatic greenhouse using WSN, actuators, a microcontroller and Internet. We, also, propose algorithms that are responsible for controlling air temperature and air humidity in the greenhouse.

**Keywords** – Actuators, Automatic greenhouse, Internet, Microcontroller, Semi-automatic greenhouse, WSN.

## I. INTRODUCTION

In today's markets, vegetables, fruits, flowers, and plants are no longer bound by their natural growing seasons and physiological cycles. They can only thrive under artificial conditions that are favorable and specific [1][2]. Greenhouses, which are enclosed structures designed for plant cultivation, serve the purpose of providing farmers with precise outcomes based on various environmental factors. Thanks to the rapid advancement of greenhouse control and monitoring technology, accurate and reliable information can now be obtained [3]. But, the critical question to be posed is how to monitor the internal microclimate of greenhouses? [4][5]

Sensors play a crucial role in the operation of monitoring and control systems. Maintaining an optimal microclimatic environment in a greenhouse is of utmost importance to safeguard crops from unfavorable conditions. In large-scale greenhouses, numerous sensors and actuators are employed to regulate the system [11]. Given the challenges and impracticality of manually monitoring and controlling such extensive systems, there has been a growing preference for automatic monitoring and control systems in greenhouses [6][10]. The intelligent greenhouse management system can not only reduce labor

costs but also improve agricultural products [12][13][14][15].

In this paper, we propose a design for monitoring an automatic and a semi-automatic greenhouse using wireless sensor networks, actuators and microcontroller. In addition, the system is composed of algorithms that are responsible for controlling air temperature and air humidity in the greenhouse.

The rest of the paper is structured as follows. The related work in this axis of research is presented in the second section. In the third section, we propose a design for monitoring an automatic and a semi-automatic greenhouse, we also propose the algorithms that control air temperature and air humidity in the greenhouse. The last section is dedicated to the conclusion of our work with some perspectives that we hope to realize in the future.

## II. RELATED WORKS

Divers works and research have been undertaken to monitor and control the internal climatic conditions of greenhouses.

The researchers in [7] have developed and deployed a system that enables real-time monitoring and control of various environmental parameters in a network of greenhouses. Each individual greenhouse functions as a node within

a wireless sensor network. A system based on a single-board microcontroller has been designed and implemented to effectively monitor and regulate multiple variables, ensuring optimal conditions within each greenhouse. To control the microclimate of each greenhouse, a rule-based fuzzy controller has been devised. This proposed system empowers farmers to oversee the internal environment of the greenhouses and remotely issue commands to activate or deactivate specific devices through wireless communication. Through a combination of simulated and real-world experiments, the system's performance and its capability for real-time remote monitoring and control have been successfully demonstrated.

The authors in [2] have introduced a novel mechanism for the automated control of greenhouse climate. Their approach utilizes advanced algorithms and employs cutting-edge technologies such as sensors, actuators, microcontrollers, and the Internet of Things (IoT) to streamline the tasks of farmers in southern Algeria and enhance agricultural productivity. To transmit data from the sensors to the actuators, they adopted the Constrained Application Protocol (CoAP). The authors showcased the outcomes of implementing their proposal in a greenhouse over a brief duration, highlighting the alterations in the greenhouse's environmental parameters. The parameters monitored include temperature, humidity, and pH.

In [8], they detailed the design process of a smart sensor network developed as a component of a capstone design project. This network effectively integrates various aspects, including sensing, power and automation, as well as visualization and user interface, within the Automated Urban Greenhouse (AUG). By doing so, it enables automatic monitoring of crucial factors such as lighting, heating, watering, and ventilation. This innovative urban greenhouse, along with the integrated sensor network, is currently being installed at a local elementary school situated in downtown York, Pennsylvania. Its primary purpose is to serve as an educational tool, fostering awareness about the significance of fresh food.

They presented in [4] a wireless sensor network-based algorithm to monitor the microclimate within a greenhouse and utilized a linear equations model to optimize plant production and material cost. Additionally, they

proposed an innovative design for an intelligent greenhouse. To validate their algorithms, they conducted simulations using a benchmark dataset derived from experimental data collected at the INRA of Montfavet in France. Furthermore, they calculated statistical estimators including RMSE, TSSE, MAPE, EF, and  $R^2$ . The obtained results demonstrate promising outcomes, underscoring the effectiveness of their proposed system.

In [9] the study aimed to investigate the potential application of a Raspberry-Pi microprocessor-based smart greenhouse monitoring system. Two types of tomatoes, namely Roma and cherry tomato, were cultivated in both the smart greenhouse and conventional greenhouse systems to compare various agronomic and quality parameters. The automation system was utilized to regulate temperature and humidity based on the recommended tomato production techniques. The smart greenhouse monitoring system outperformed the conventional greenhouse by effectively maintaining the microclimate inside. It resulted in approximately 5-6 °C higher temperature and 20-30% higher humidity. The findings indicated a gradual improvement in agronomic parameters in the smart greenhouse, with a 10-15% difference observed in plant height, number of leaves, number of fruits, and fruit weight compared to the conventional greenhouse. Similarly, quality parameters were positively influenced, as the Roma variety exhibited a larger fruit size of 75 mm compared to 65 mm in conventional farming. The smart greenhouse also achieved an above-average tomato yield of 5.5 kg per plant in the Roma variety, showing a significant increase compared to the conventional greenhouse. These results suggest that the smart greenhouse monitoring system had a positive impact on tomato yield and demonstrate the potential of employing smart technologies for crop production and cultivation monitoring.

### III. OUR PROPOSED SYSTEM

#### A) *Proposed design*

As shown in the figure (Fig. 1), our design consists of two parts (greenhouse environment and remote environment), the Internet, and two systems (an automatic system and a semi-automatic system).

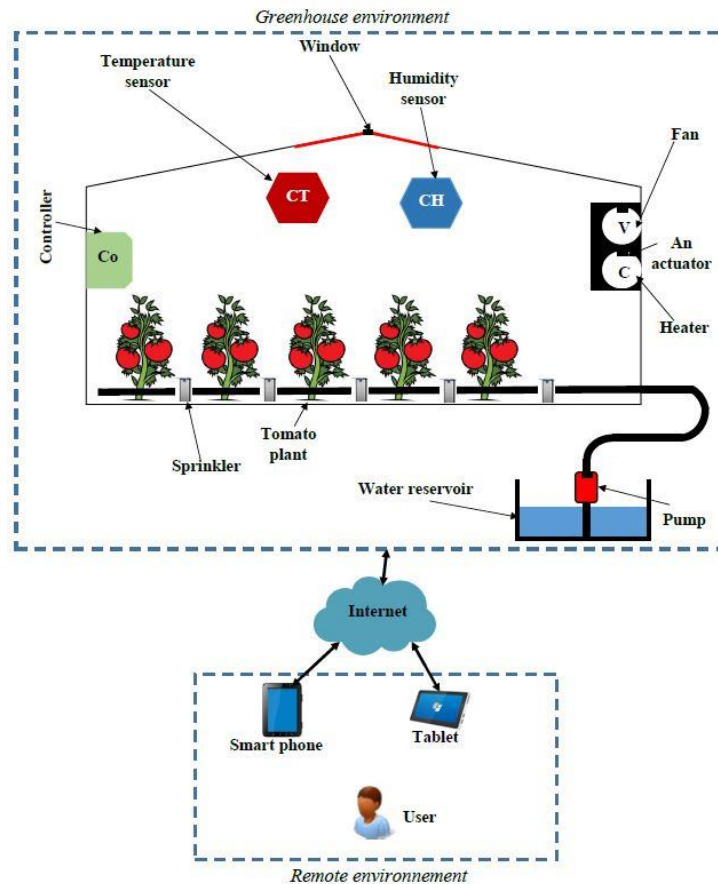


Fig. 1. Our proposed design.

❖ *Parts*

- **Greenhouse environment**

This part includes: sensors (temperature sensor and humidity sensor), a controller, and four actuators for: the window, the fan, the heater, and the water pump located at the water reservoir to irrigate the tomato plant through the sprinklers.

- **Remote environment**

This part includes the user, or more precisely, the farmer. They have smart devices (either a smartphone or a tablet...)

- **Internet**

It connects the greenhouse environment part with the remote environment part.

❖ *Systems*

- **Automatic system**

An automatic system is a system that operates without user intervention. It consists of only one part, which is the greenhouse environment. Its operation is as follows.

The sensors placed in the greenhouse continuously measure the values of air temperature and relative humidity, then transmit these values to the controller.

The controller contains an intelligent program to automatically analyze the data and act based on the obtained results, by selectively activating the actuators according to the needs (Fig. 2 and 3):

- If the temperature recorded at time  $t > a$  given threshold temperature, the controller commands the fan actuator to operate automatically.

- If the temperature recorded at time  $t <$  a given threshold temperature, the controller commands the heater actuator to operate automatically.

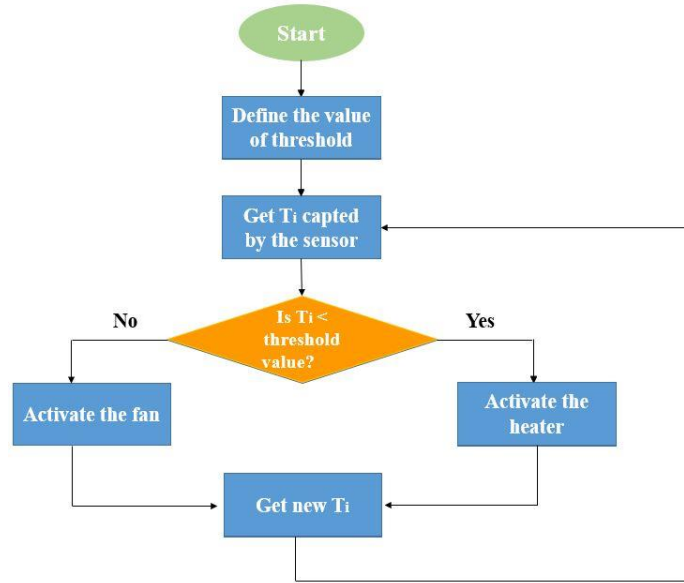


Fig. 2. Flowchart for monitoring of air temperature

- If the humidity recorded at time  $t >$  a given threshold humidity, the controller commands the window actuator to open automatically.
- If the humidity recorded at time  $t <$  a given threshold humidity, the controller commands the water pump actuator to distribute water automatically.

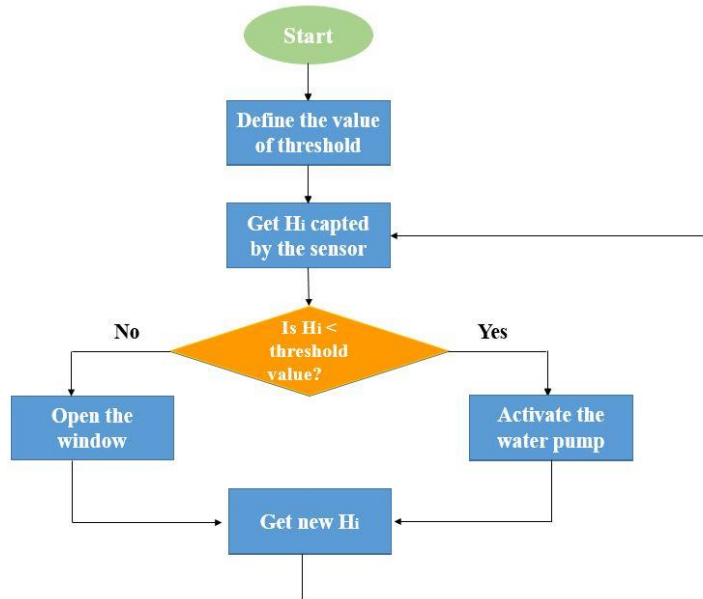


Fig. 3. Flowchart for monitoring of air humidity

- **Semi-automatic system**

A semi-automatic system is a system that operates with user intervention. It includes both the greenhouse environment and the remote environment with the Internet (Fig. 4). In

addition to the existing equipment in both environments, there is also an intelligent 6LoWPAN gateway. The communication network used is Low and Lossy Networks (LLN), using the RPL routing protocol for LLN. Its operation is as follows.

The temperature and humidity sensors measure the corresponding values, which are required to be transmitted to the root nodes of the Directed Acyclic Graph (DAG) subgroups (coordinator nodes). Each sensor transmits the measured values to the coordinator node, which computes the average of the received values and forwards them to the intelligent gateway via a Zigbee mesh network.

The data is then sent over the Internet to a web application located on the farmer's smartphone and tablet.

The farmer can check the air temperature and humidity values using a smartphone and tablet application directly connected to the intelligent gateway using HTTP or CoAP protocols. They can decide to either open the window or activate the water pump, or start the fan or heater by sending a response to the gateway. The gateway acts as an intermediary, forwarding this response to the coordinator node to enable or disable the actuators as needed.

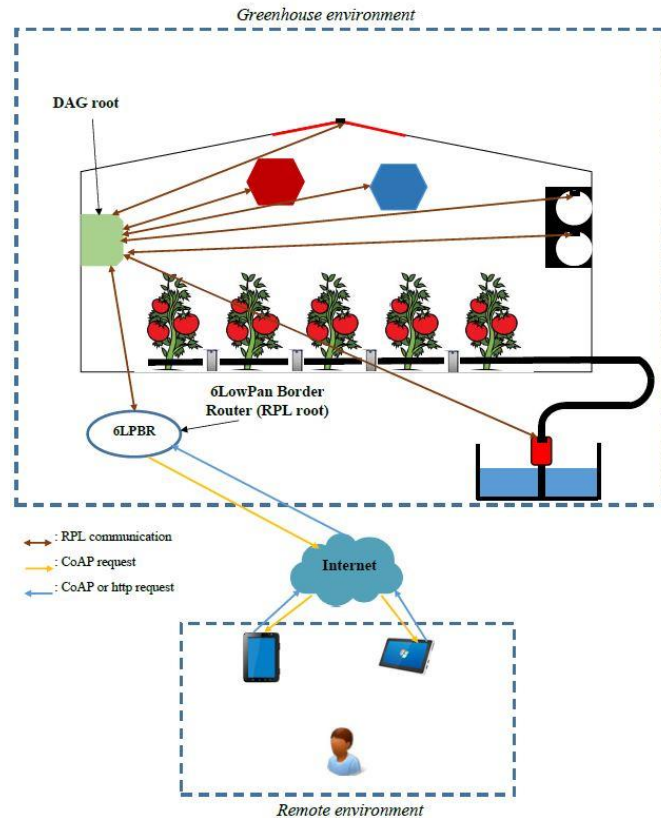


Fig. 4. Network architecture.

### B) Advantages

Among the advantages of our design, we have:

- ✓ The system is easy to deploy and use.
- ✓ The system simplifies tasks for farmers.
- ✓ The system provides improved productivity through the management and control, whether automatic or semi-automatic, of the greenhouse microclimate.

## IV. CONCLUSION

In this paper, we have proposed a design for monitoring an automatic and a semi-automatic

greenhouse using wireless sensor networks, actuators and microcontroller. Also, we proposed algorithms that are responsible for controlling air temperature and air humidity in the greenhouse. We treated, in this system, two parts. The first part is monitoring an automatic greenhouse. The second part is monitoring a semi-automatic greenhouse.

As a perspective, we plan to realize our algorithms in real time, to validate our algorithms with real data and to include other climate parameters. Also, for the issue of equipment energy consumption, we will address this

problem in our future work by integrating solar panels or other renewable energy tools.

## V. REFERENCES

- [1] Achouak Touhami, Khelifa Benahmed and Fateh Bounaama, Monitoring of Greenhouse Based on Internet of Things and Wireless Sensor Network, *Proceedings of the 8th International Conference on Sciences of Electronics, Technologies of Information and Telecommunications (SETIT'18)*, Hamamet, Vol.2, 2020, 1–9.
  - [2] Touhami Achouak, Benahmed Khelifa, Laura García, Lorena Parra, Jaime Lloret, Bounaama Fateh, Sensor Network Proposal for Greenhouse Automation placed at the South of Algeria, *Network Protocols and Algorithms*, 10(4), 2018, 53-69.
  - [3] Achouak Touhami, Sana Touhami, Nawal Touhami, Khelifa Benahmed, and Fateh Bounaama, Design of Smart Irrigation System in the Greenhouse Using WSN and Renewable Energies, *Advanced Computational Techniques for Renewable Energy Systems*, 2023, 1–6.
  - [4] Achouak Touhami, Khelifa Benahmed, Lorena Parra, Fateh Bounaama, Jaime Lloret, An intelligent monitoring of greenhouse using wireless sensor networks, *Smart Structures and Systems*, 26(1), 2020, 117-134.
  - [5] Redmond R. Shamshiri, Ibrahim A. Hameed, Kelly R. Thorp, Siva K. Balasundram, Sanaz Shafian, Mohammad Fatemieh, Muhammad Sultan, Benjamin Mahns and Saba Samiei, Greenhouse Automation Using Wireless Sensors and IoT Instruments Integrated with Artificial Intelligence, *Chapter*.
  - [6] Pinar Kirci, Erdinc Ozturk and Yavuz Celik, A Novel Approach for Monitoring of Smart Greenhouse and Flowerpot Parameters and Detection of Plant Growth with Sensors, *Agriculture*, 12, 2022.
  - [7] Kasim M. Al-Aubidy, Mohammad M. Ali, Ahmad M. Derbas & Abdallah W. Al-Mutairi, Real-Time Monitoring and Intelligent Control for Greenhouses Based on Wireless Sensor Network, 2014.
  - [8] Kala Meah, Jason Forsyth, James Moscola, A Smart Sensor Network for an Automated Urban Greenhouse, *International Conference on Robotics, Electrical and Signal Processing Techniques*, 2019.
  - [9] Bilal Ahmad, Raees Ahmed, Sohaib Masroor, Basharat Mahmood, Syed Zia Ul Hasan, Muhammad Jamil, Muhammad Tariq-Khan, Muhammad Tahir Younas, Arshad Wahab, Bilal Haydar, Muzaffar Subhani, Muhammad Ammar Khan, Sohail Tariq, Evaluation of Smart Greenhouse Monitoring System using Raspberry-Pi Microprocessor for Tomato Production, *J. Appl. Res Plant Sci.*, 4(1), 2023, 452-458.
  - [10] Beveren, P.J.M. Van, Bontsema, J., Van Straten, G., et Van Henten, E. J., Optimal utilization of a boiler, combined heat and power installation, and heat buffers in horticultural greenhouses, *Computers and Electronics in Agriculture*, 162, 1035-1048, 2019, <https://doi.org/10.1016/j.compag.2019.05.040>.
  - [11] El Afou Youssef, *Contribution au contrôle des paramètres climatiques sous serre*, Doctoral thesis, Moulay Ismail university, Morocco, and Lille 1 university, France, 2014.
  - [12] Shi Yan -fang, Shi Jian-guo and Xue Yu-qian, Design and application of distributed intelligent greenhouse computerized system, *Proceedings of the Seventh International Conference on Measuring Technology and Mechatronics Automation*, 331-334. DOI: 10.1109/ICMTMA.2015.85, 2015.
  - [13] Yan Liu et Chunhua Bi, The design of greenhouse monitoring system based on zigbee WSNs, *Proceedings of the IEEE International Conference on Computational Science and Engineering (CSE) and IEEE International Conference on Embedded and Ubiquitous Computing (EUC)*, 430-433. DOI: 10.1109/CSE-EUC.2017.268, 2017.
  - [14] Gholamreza Asadollahfardi, Nima Heidarzadeh, Atabak Mosalli and Ali Sekhavati, Optimization of water quality monitoring stations using genetic algorithm, a case study, Sefid-Rud River, Iran, *Advances in Environmental Research*, 7(2), 87-107, 2018, <https://doi.org/10.12989/aer.2018.7.2.087>.
- Jin Xu, Fang Dai, Yuhui Xu, Changhui Yao et Chendan Li, Wireless power supply technology for uniform magnetic field of intelligent greenhouse sensors, *Computers and Electronics in Agriculture*, 156, 203-208, 2019, <https://doi.org/10.116/j.compag.2018.11.014>.