

Greenhouse Monitoring Robot

M. Vijayalakshmi^{1*}, A. Sri Chandraja Reddy², CH. Sreeja³, K. Chandana Lakshmi⁴, P. Sirisha⁵

Abstract

In the realm of agriculture, where sustainable food production is paramount, the Greenhouse Monitoring Robot emerges as a game-changing project. Greenhouse farming, with its year-round cultivation and resource efficiency, relies on precise environmental control, notably temperature and humidity. This paper focuses on the successful implementation of an autonomous Line-Following Robot equipped with sensors like the DHT11 to ensure an ideal greenhouse environment. This innovative solution has enabled the accurate recording of temperature and humidity values, facilitating comprehensive greenhouse monitoring and management for optimal crop growth and resource utilization.

Keywords: Green house, Humidity monitoring, Temperature monitoring, Autonomous moment, Line follower robot, Dynamic system.

INTRODUCTION

In the world of agriculture, where the demand for sustainable and efficient food production is ever-increasing, technological innovations are driving fundamental shifts in farming practices. Controlled-environment agriculture, particularly greenhouse farming, has emerged as a cornerstone of modern agriculture. It offers the promise of year-round cultivation, reduced water usage, and minimized pesticide dependency. However, to unlock the full potential of greenhouse farming, the precise control of environmental parameters is paramount. Among these parameters, temperature and humidity reign supreme, as they directly govern plant growth, health, and overall yield.

In the pursuit of a more sustainable and productive future for agriculture, the Greenhouse Monitoring Robot takes center stage. This pioneering robot is not merely a marvel of automation; it is a transformative force poised to reshape the way we nurture crops within controlled environments. Beyond its capability to traverse the greenhouse with agility, this robot's defining feature lies in its ability to actively monitor two critical environmental variables—temperature and humidity. These variables are the lifeblood of greenhouse cultivation, and their meticulous regulation is a non-negotiable factor in ensuring healthy, thriving crops.

*Author for Correspondence

Dr. M. Vijayalakshmi
E-mail: mvijayalakshmi.gnits@gmail.com

¹Associate Professor, ECE Department, G. Narayanamma Institute of Technology and Science, Hyderabad, Telangana, India

^{2,5}Student, ECE Department, G. Narayanamma Institute of Technology and Science, Hyderabad, Telangana, India

Received Date: August 26, 2023

Accepted Date: October 03, 2023

Published Date: December 27, 2023

Citation: M. Vijayalakshmi, A. Sri Chandraja Reddy, CH. Sreeja, K. Chandana Lakshmi, P. Sirisha. Greenhouse Monitoring Robot. International Journal of Robotics and Automation in Mechanics. 2023; 1(1): 11–16p.

The allure of greenhouse agriculture lies in its ability to extend growing seasons, mitigate the impact of adverse weather conditions, and provide a haven for plants to flourish. Yet, the delicate balance of temperature and humidity is often disrupted by factors such as external weather fluctuations, equipment malfunctions, or even human error. These disruptions can have catastrophic consequences for crop health and productivity. Therefore, the role of a vigilant, data-driven guardian within the greenhouse becomes essential—a role that the Greenhouse Monitoring Robot is uniquely poised to fulfill.

In this paper, we introduce an autonomous Line-Following Robot, ingeniously equipped with sensors for real-time monitoring of temperature and humidity within the greenhouse. This robotic marvel combines the advantages of automation with precision data collection, ensuring that the greenhouse environment remains conducive to plant growth year-round. While the robot's ability to autonomously follow predefined paths grants it mobility, it also empowers it to systematically cover large greenhouse areas, collecting vital data points from multiple locations.

LITERATURE SURVEY

The paper [1] by T. Ahonen, R. Virrankoski, and M. Elmusrati, the use of wireless sensor networks (WSNs) in modern greenhouses to monitor local climate parameters is explored. Traditional cabling for measurement points is deemed expensive and inflexible. The authors developed a wireless sensor node for greenhouse monitoring, integrating a sensor platform with three commercial sensors capable of measuring four climate variables. They conducted experiments in a greenhouse, demonstrating the network's reliability in detecting microclimate layers and local variations caused by factors like direct sunshine near the greenhouse walls. This research represents an initial step in greenhouse monitoring and control, focusing on the feasibility and reliability of the developed sensor network.

The [2] “Greenhouse Monitoring and Automation Using Arduino: a Review on Precision Farming and Internet of Things (IoT)” explores IoT applications in precision farming and greenhouse management using Arduino-based systems. It discusses sensors for monitoring environmental factors, wireless connectivity options, and the versatility of Arduino UNO in data acquisition and control. The concept of precision farming, driven by data analytics, is introduced for optimizing crop yields. The paper emphasizes the potential of IoT in agriculture while acknowledging the associated challenges.

The [3] Algorithm for Line Follower Robots to Follow Critical Paths with Minimum Number of Sensors presents an algorithm for line follower robots to navigate complex paths with minimal sensors, including straight lines, curves, 90-degree turns, T-junctions, and + junctions. By strategically positioning just four sensors, the robot can detect and follow lines efficiently. The algorithm incorporates feedback mechanisms for handling critical junctions and has been successfully tested on a sample path. This approach reduces complexity and cost, though further work is needed to enhance high-speed performance.

The [4] “A line follower robot from design to implementation: Technical issues and problems” discusses the development of TABAR, a line follower robot designed for competitions where it must autonomously follow predefined paths, often marked by visible lines on the floor or invisible magnetic fields. TABAR relies on infrared sensors to detect these lines and transmit data to its processor, which then determines the appropriate commands for the robot to follow the path. The paper highlights the design, implementation, and testing of TABAR, addressing both technical and mechanical challenges encountered during its development.

The [5] “A novel design of line following robot with multifarious function ability” introduces a Line following robot designed to follow a black line on a white surface. The robot features two modes: line following and obstacle detection, capable of identifying obstacles in multiple directions. Its design incorporates Arduino programming, electrical circuit integration, and basic mechanical engineering principles. Equipped with three sonars and two infrared sensors connected to a motor driver IC, the robot operates on a 6-volt rechargeable lithium battery. It can transport up to 600 grams of components while efficiently following its designated path and detecting obstacles, with an estimated cost of 4500 BDT (Bangladeshi Taka) or around 64.136 USD.

These three papers contribute to the field of line follower robots. The paper [3] introduces an algorithm for efficient navigation with minimal sensors, reducing complexity and cost, although speed improvements are needed. The paper [4] documents the development of TABAR, highlighting practical challenges in building a competition-ready robot. The paper [5] presents a versatile robot

capable of line following and obstacle detection, emphasizing integration and cost-effectiveness. Together, these papers address sensor optimization, practical implementation, and multifunctionality in the field of line follower robots.

The [6] “Temperature and humidity wireless sensing and monitoring systems applied in greenhouse” presents a wireless system for greenhouse temperature and humidity control. Using a star topology network structure, it offers adjustable sensing distances and timely alarms for abnormal conditions. The system ensures low power usage, simple network setup, and easy maintenance, making it suitable for efficient greenhouse environmental management.

The [7] “System Design of Greenhouse Temperature and Humidity Monitoring and Alarming” addresses the need for efficient greenhouse environmental monitoring, particularly focusing on temperature and humidity, in agricultural production. It introduces an online monitoring system based on wireless communication technology. The system employs DHT11 sensors for temperature and humidity monitoring and utilizes ZigBee wireless communication to enable real-time data transmission and monitoring across multiple greenhouses. The system comprises data acquisition, wireless communication, and alarm modules, offering a cost-effective, scalable, and user-friendly solution for greenhouse environmental control compared to traditional methods.

The study in [8] is aimed to create a real-time monitoring system for tracking temperature and humidity using Arduino-based hardware and software. The system included various components like sensors, an LCD display, and an SD card module to record data, while also triggering alarms and LED indicators for extreme conditions. The research successfully tested the system in different environments and suggested potential enhancements, such as remote web-based monitoring and the integration of additional sensors for more comprehensive environmental data tracking.

These works highlight the importance of technology in greenhouse monitoring and agriculture. They showcase innovations such as wireless sensor networks, efficient line-following robots, and real-time environmental monitoring using Arduino-based systems. These advancements not only enhance precision and cost-effectiveness in greenhouse management but also pave the way for a more sustainable and productive future in agriculture.

PROPOSED WORK

Greenhouse Monitoring Robot is a blend of mobility and parameter monitoring. At its heart, this cutting-edge system is built upon two major components: the rover's dynamic movement capabilities and its sophisticated parameter monitoring functionality. Together, these components form the foundation of a powerful solution designed to navigate and meticulously observe the vast expanse of a greenhouse environment.

METHODOLOGY

Parameter Monitoring

Parameter monitoring, the heart of the greenhouse monitoring robot, incorporates a DHT11 sensor, renowned for its cost-effective and straightforward measurement of environmental conditions. This sensor utilizes a one-wire communication protocol and features humidity-sensitive capacitive technology and a temperature-detecting thermistor. It offers temperature measurement accuracy within $\pm 2^{\circ}\text{C}$ over a range of 0°C to 50°C and humidity measurement accuracy within $\pm 5\%$ over a range of 20% to 80% relative humidity, making it suitable for greenhouse monitoring. Its real-time data updates, facilitated by a rapid 2-second sampling rate, enhance its utility in dynamic settings. Furthermore, the DHT11's ease of use, sealed and pre-calibrated design for stability, and integration with microcontrollers like Arduino helped in easy monitoring of the parameters.

The system also employs an LCD 16x2 display module to present the collected environmental data. This module, with its two-line by 16-character configuration, serves as an intuitive information

display interface. It is used to showcase temperature and humidity, through a parallel interface with Arduino. It plays a pivotal role in conveying the information to users in these projects.

The DHT11 sensor and LCD 16x2 display module form an integrated system using an Arduino which facilitates seamless communication between its components and external devices within our Greenhouse Monitoring Robot, enabling comprehensive parameter monitoring and data visualization for effective greenhouse management.

Automatic Movement of Robot

The automatic movement of the greenhouse monitoring robot is achieved through the integration of various components, including IR sensors, DC motors, a L298N motor driver, Arduino, and batteries. These components work together to enable the robot to navigate its environment autonomously.

The concept of a line follower robot serves as the foundation for the movement control system. Line follower robots are designed to track and follow a line, typically a black or white line, using sensors and a control system. In this case, the robot is equipped with IR sensors that can detect variations in the surface, which allows it to follow a predefined path.

The IR sensors used in the robot's sensor section play a critical role in detecting the line. These sensors consist of IR transmitters and receivers (photodiodes). When the robot moves over a surface, the IR transmitter emits infrared light. If the surface is white, most of the light is reflected back to the photodiode receiver. However, if the surface is black, the light is absorbed, and minimal reflection occurs. This difference in reflected light is used to determine whether the robot is on a white or black surface. Figure 1 represents the block diagram.

The control section of the robot is managed by an Arduino. The output signals from the IR sensors are sent to the Arduino, which processes this information. Depending on whether the sensors detect a white or black surface, the Arduino sends commands to the driver section of the robot.

The driver section consists of a motor driver and two DC motors. The motor driver is essential because the Arduino cannot provide sufficient voltage and current to drive the motors directly. Instead, the motor driver amplifies the signals from the Arduino, allowing the motors to move accordingly.

The operation of the robot is straightforward. When both the left and right sensors detect a white surface, the robot continues moving forward. If the left sensor detects a black line, the robot turns left, and if the right sensor detects a black line, the robot turns right. The robot continues in the chosen direction until both sensors detect a white surface again, at which point it resumes forward movement. If both sensors detect a black line simultaneously, the robot stops.

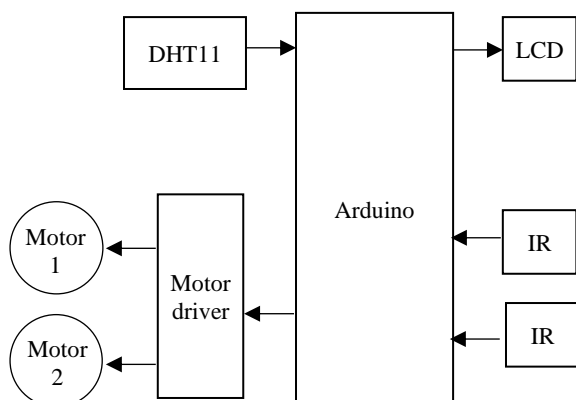


Figure 1. Block diagram.

The greenhouse monitoring robot's automatic movement is based on the principles of a line follower robot. It utilizes IR sensors to detect the surface beneath it, an Arduino for processing sensor data and controlling motor movements, a motor driver to power the motors, and batteries for the energy supply. This system allows the robot to navigate autonomously within the greenhouse, following predefined paths and responding to changes in the surface to ensure efficient monitoring and control of the environment.

RESULTS

We have successfully recorded several temperature and humidity values using our greenhouse monitoring robot. Figure 2 Shows Picture of the project we were able to build and the Figure 3 displays the subset of values that we were able to capture during our monitoring process.

The Table 1 [9] presents temperature and humidity readings from the greenhouse. Analyzing this data reveals insights into the greenhouse environment, aiding plant growth strategies and overall management.

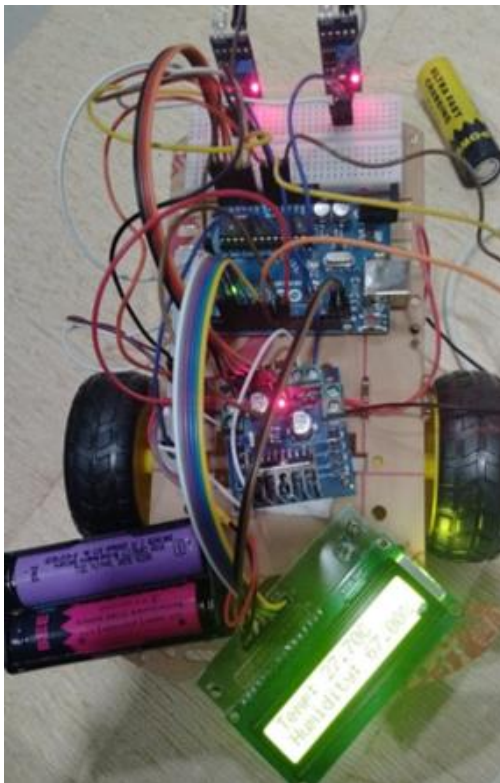


Figure 2. Green House Monitoring Robot.



Figure 3. Temperature and humidity values obtained.

Table 1. Readings of the greenhouse

Months	Mean temp Max.	Mean temp Min.	Mean Relative Humidity Min. %	Mean Relative Humidity Max. %
January	39.3	22.07	48.92	90
February	35.45	18.69	52.08	84
March	35.84	16.69	52.7	84
April	42.13	29.69	54.69	83

CONCLUSION

Our project introduces an innovative robotic solution to greenhouse monitoring and management, using technologies such as the DHT11 sensor for real-time temperature and humidity monitoring, SG90 servo motors for autonomous navigation, and the L298N motor driver IC for obstacle detection. This platform revolutionizes agricultural practices by optimizing greenhouse conditions, resulting in enhanced crop growth and resource efficiency. Looking ahead, the project's potential for expansion includes integrating GSM technology for real-time alerts and control, allowing proactive management of environmental parameters. Additionally, incorporating various sensors for light intensity, soil moisture, CO₂ levels, and nutrient levels offers data-driven insights for maximizing crop yields and sustainable agricultural practices, cementing the role of technology in shaping the future of agriculture.

REFERENCES

1. T. Ahonen, R. Virrankoski and M. Elmusrati, "Greenhouse Monitoring with Wireless Sensor Network," 2008 IEEE/ASME International Conference on Mechatronic and Embedded Systems and Applications, Beijing, China, 2008, pp. 403–408, doi:10.1109/MESA.2008.4735744.
2. Ardiansah, Irfan & Bafdal, Nurpilihan & Suryadi, Edy & Bono, Awang. (2020). Greenhouse Monitoring and Automation Using Arduino: a Review on Precision Farming and Internet of Things (IoT). *International Journal on Advanced Science, Engineering and Information Technology*. 10. 703. 10.18517/ijaseit.10.2.10249.
3. Chowdhury, N. H., Khushi, D., & Rashid, M. M. (2017). Algorithm for Line Follower Robots to Follow Critical Paths with Minimum Number of Sensors. *International Journal of Computer (IJC)*, 24(1), 13–22.
4. M. Pakdaman, M. M. Sanaatiyan and M. R. Ghahroudi, "A line follower robot from design to implementation: Technical issues and problems," 2010 The 2nd International Conference on Computer and Automation Engineering (ICCAE), Singapore, 2010, pp.5–9, doi: 10.1109/ICCAE.2010.5451881
5. H. U. Zaman, M. M. H. Bhuiyan, M. Ahmed and S. M. T. Aziz, "A novel design of line following robot with multifarious function ability," 2016 International Conference on Microelectronics, Computing and Communications (MicroCom), Durgapur, India, 2016, pp. 1–5, doi: 10.1109/MicroCom.2016.7522507.
6. TongtongYin, WenjieFeng and ZheyongLi, "Temperature and humidity wireless sensing and monitoring systems applied in greenhouse," Proceedings of 2011 International Conference on Computer Science and Network Technology, Harbin, China, 2011, pp.857–861, doi: 10.1109/ICCSNT.2011.6182097
7. Zhang LC, Hu XL, Wei YG, Chen YY. System Design of Greenhouse Temperature and Humidity Monitoring and Alarming. *AMM* 2014;541–542:1338–49
8. Zhang, Li Cai, Xue Lun Hu, Yao Guang Wei, and Ying Yi Chen. "System Design of Greenhouse Temperature and Humidity Monitoring and Alarming." *Applied Mechanics and Materials* 541–542 (March 2014): 1338–49.
9. Awuku, Bernard & Egyir, Michael. (2018). Growth and Yield of Sweet Pepper as Influence by Different Growth Media. *Greener Journal of Agricultural Sciences*. 8. 325–331. 10.15580/GJAS.2018.11.111118156.