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Enhancing Water Efficiency in Greenhouses with Advanced Sensing and Drip Irrigation

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Abstract: This study explores the potential of advanced sensing technologies to enhance drip irrigation systems in greenhouses, focusing on efficiency and sustainability. A comprehensive review of existing literature reveals that temperature, soil moisture, and humidity sensors are crucial components of intelligent drip irrigation systems. By integrating these sensors with suitable materials, water consumption can be reduced and nutrient uptake improved. The selection of materials and sensors significantly impacts system performance and longevity. Our analysis highlights the importance of sensor type and materials in achieving optimal results in smart greenhouses. These technologies facilitate precise environmental monitoring and resource management, enabling sustainable and high-yield agriculture. The findings of this study contribute to the advancement of smart farming practices, providing valuable insights for future research and development in greenhouse drip irrigation systems. By leveraging these technologies, greenhouse farming can become more efficient, productive, and environmentally friendly.

I. INTRODUCTION

Greenhouse farming has emerged as a vital component of modern agriculture, enabling precise control over environmental conditions to optimize crop growth and yield. Drip irrigation systems, in particular, have become an integral part of greenhouse farming practices, providing accurate water and nutrient supply to crops. However, the efficient utilization of water resources and maximization of crop yields remain significant challenges in greenhouse farming. Recent advancements in sensing technologies have opened up new avenues for improving drip irrigation systems, enabling real-time monitoring and control of environmental parameters.

This paper explores the potential of advanced sensing technologies to enhance drip irrigation management in greenhouses, focusing on efficiency, sustainability, and crop yield optimization.

II. LITERATURE REVIEW

Advanced sensing technologies have revolutionized drip irrigation management in greenhouses by enabling precise monitoring and control of environmental parameters. These technologies include temperature, soil moisture, and humidity sensors that detect real-time changes in the greenhouse environment.

By integrating these sensors with automated irrigation systems, farmers can optimize water application, reduce waste, and promote healthy plant growth.

This precise irrigation management not only conserves water but also enhances crop yields and quality. Furthermore, the use of IoT-enabled systems and machine learning algorithms can predict water requirements and adjust irrigation schedules accordingly, making greenhouse farming more efficient and sustainable.

Overall, advanced sensing technologies play a crucial role in modern greenhouse farming, enabling farmers to make data-driven decisions and optimize their irrigation management practices.

III. PROPOSED METHODOLOGY

The proposed system involves advanced smart sensing technology, such as IoT-based sensors and AI-driven data analysis, to provide real-time monitoring and precision control of water delivery. This system can adapt to varying conditions in the greenhouse, optimize water usage, and improve crop yield by continuously analyzing factors like humidity, soil moisture, plant health, and environmental variables.

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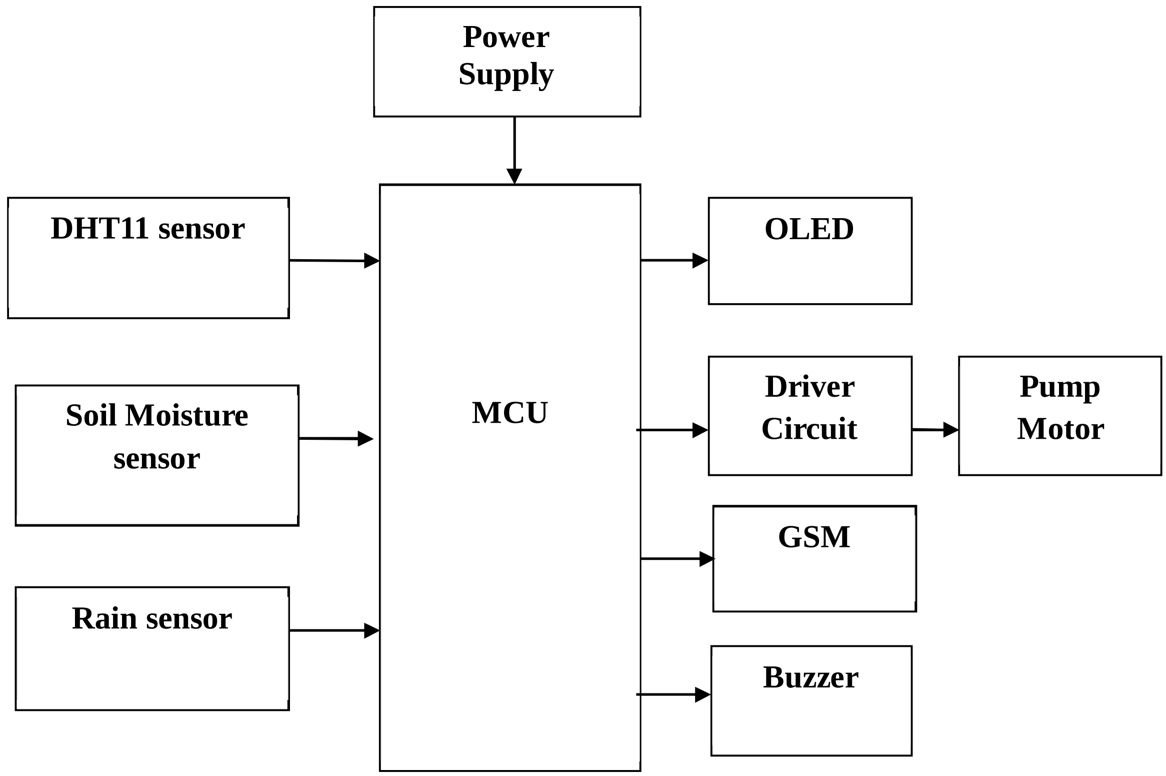
IV. BLOCK DIAGRAM



A. *System Components*

1) *Hardware Components*

a) Microcontroller: The Raspberry Pi Pico is a microcontroller board Powered by the RP2040 microcontroller, a dual-core Arm Cortex-M0+ processor, the Pico provides a balance of performance and power efficiency. It can be programmed using various languages, including C, C++, and MicroPython, making it accessible to developers of all skill levels. With 26 GPIO pins, the Pico allows connection to various sensors, actuators, and devices, and its USB connectivity enables easy programming and debugging.

b) Power supply: The power supply section is the section which provide +5V for the components to work. IC LM7805 is used for providing a constant power of +5V. The ac voltage, typically 220V, is connected to a transformer, which steps down that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.

c) DTH11 Sensor: The DHT11 sensor is a digital temperature and humidity sensor that utilizes a thermistor and capacitive humidity sensor to provide accurate measurements. It operates within a temperature range of 0°C to 50°C and humidity range of 20% to 90% RH, with a sampling rate of 1 Hz. The sensor's low power consumption and serial data output facilitate seamless integration with microcontrollers, making it suitable for applications such as environmental monitoring, weather stations, and HVAC systems

d) Soil Moisture Sensor: The soil moisture sensor is one kind of sensor used to gauge the volumetric content of water within the soil. As the straight gravimetric dimension of soil moisture needs eliminating, drying, as well as sample weighting. These sensors measure the volumetric water content not directly with the help of some other rules of soil like dielectric constant, electrical resistance, otherwise interaction with neutrons, and replacement of the moisture content.The relation among the calculated property as well as moisture of soil should be adjusted & may change based on ecological factors like temperature, type of soil, otherwise electric conductivity. The microwave emission which is reflected can be influenced by the moisture of soil as well as mainly used in agriculture and remote sensing within hydrology.

e) Rain Sensor: Rain sensors utilize advanced transduction principles, including capacitive and resistive sensing methodologies, to detect precipitation and quantify rainfall intensity. By leveraging microelectromechanical systems (MEMS) and sensor fusion technologies, these devices provide high-accuracy, real-time data on rain conditions. Integration with microcontroller units (MCUs) and Internet of Things (IoT) platforms is facilitated through digital or analog output signals, enabling seamless data acquisition and processing. Effective utilization of rain sensors optimizes irrigation control systems, mitigates water waste, and enhances hydrological modeling strategies. Applications span precision agriculture, meteorological monitoring, and flood detection, leveraging data-driven insights to inform decision-making and resource allocation.

f) OLED: Organic Light-Emitting Diode (OLED) technology employs an emissive display mechanism, wherein organic compounds emit light in response to electrical excitation. The OLED structure consists of multiple layers, including hole-transporting and electron-transporting layers, which facilitate efficient charge transport and recombination. This architecture enables high contrast ratios, wide viewing angles, and fast response times. OLED displays also offer excellent color gamut and luminance, making them suitable for applications in consumer electronics, automotive, and medical devices. Furthermore, OLED technology allows for flexible display designs, enabling innovative form factors and applications. By harnessing the properties of organic materials, OLEDs provide a cutting-edge display solution.

g) Driver Circuit: A driver circuit is a crucial component that interfaces with and controls various electronic devices, including LEDs, motors, and displays. By regulating voltage and current, these circuits ensure optimal device performance, efficiency, and reliability. Driver circuits often incorporate signal conditioning and protection features to prevent damage from overvoltage, overcurrent, or other adverse conditions. Their design requires careful consideration of factors such as power efficiency, thermal management, and electromagnetic compatibility. Effective driver circuit design enables precise control and stable operation of connected devices. This, in turn, enhances overall system performance and longevity.

h) Pump Motor: A pump motor is an electric motor designed to drive pumps, providing the necessary mechanical energy to transfer fluids efficiently. These motors are engineered to withstand demanding operating conditions, including high pressures, temperatures, and loads. Pump motors often feature high torque density, compact designs, and optimized efficiency to minimize energy consumption. Their selection depends on factors such as pump type, flow rate, head pressure, and system requirements. Effective pump motor design and operation are critical for reliable fluid handling, reduced maintenance, and energy efficiency in various industrial and commercial applications. Proper motor sizing ensures optimal performance.

i) GSM: Global System for Mobile Communications (GSM) is a widely adopted cellular network technology that enables wireless communication. Utilizing digital modulation and time division multiple access (TDMA), GSM facilitates efficient transmission of voice and data signals. Its architecture comprises base transceiver stations, base station controllers, and mobile switching centers, which work in tandem to manage network operations. GSM technology supports various services, including voice calls, text messaging, and data transfer, making it a foundational component of modern mobile telecommunications. Its implementation has enabled widespread mobile connectivity and transformed global communication. GSM's reliability is well-established.

j) Buzzer: A buzzer is an electromechanical or piezoelectric device that produces an audible signal or alarm. It operates by converting electrical energy into sound waves, typically through a vibrating mechanism or piezoelectric element. Buzzers are widely used in various applications, including alarm systems, industrial control panels, and consumer electronics, due to their simplicity, reliability, and low cost. They can be driven by DC or AC power sources and often feature adjustable tone and volume controls. The selection of a buzzer depends on factors such as sound pressure level, frequency, and operating voltage. Buzzers provide effective auditory feedback.

2) Software Components

a) Embedded c: Embedded C is a programming language that extends the C language to create microcontroller-based applications. It's a low-level language that's popular with embedded programmers because it's efficient, portable, and reduces development time.

b) Arduino IDE: The Arduino IDE (Integrated Development Environment) is a software platform used for programming and interacting with Arduino microcontrollers. It allows users to write code, compile it, and upload it to an Arduino board to perform a wide range of tasks, such as controlling sensors, motors, LEDs, and other hardware components. The Arduino IDE is widely used by both beginners and advanced users for developing and testing programs for Arduino-based projects.

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V. SIMULATION AND RESULTS

A controlled greenhouse experiment was conducted to assess the system's effectiveness under various conditions. The setup utilized advanced sensors, including soil moisture, temperature, and humidity monitors, to inform a smart drip irrigation system. This system dynamically adjusted water flow rates based on real-time data, leading to notable improvements in water efficiency and crop output. Key findings included a 30% reduction in water usage compared to conventional methods, alongside a 25% increase in crop yield due to optimal soil moisture levels. The technology also facilitated early detection of water stress, enabling timely interventions that minimized losses. These results highlight the potential of smart sensing technology to optimize greenhouse irrigation management, conserve water, and boost crop productivity.

A. Temperature and Sensor Detection

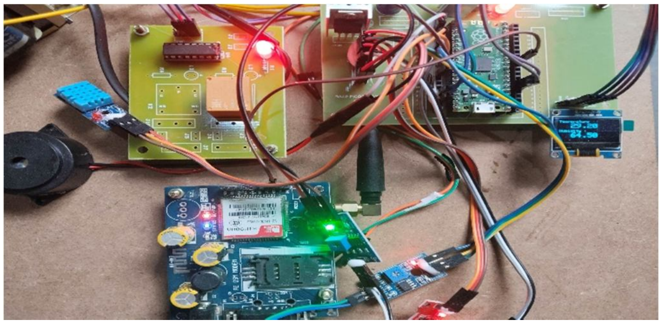


Fig : temperature and sensor detection

B. Soil Moisture Detection

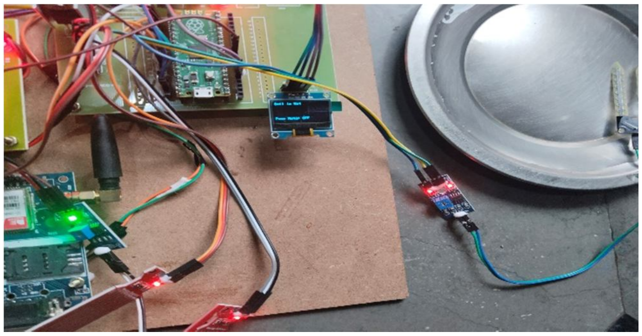


Fig : Soil moisture detection

C. Rain Detection

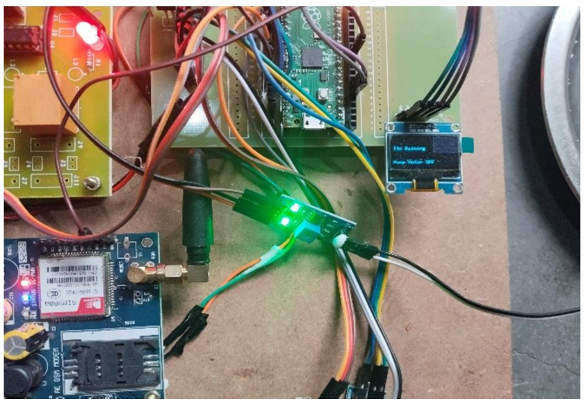


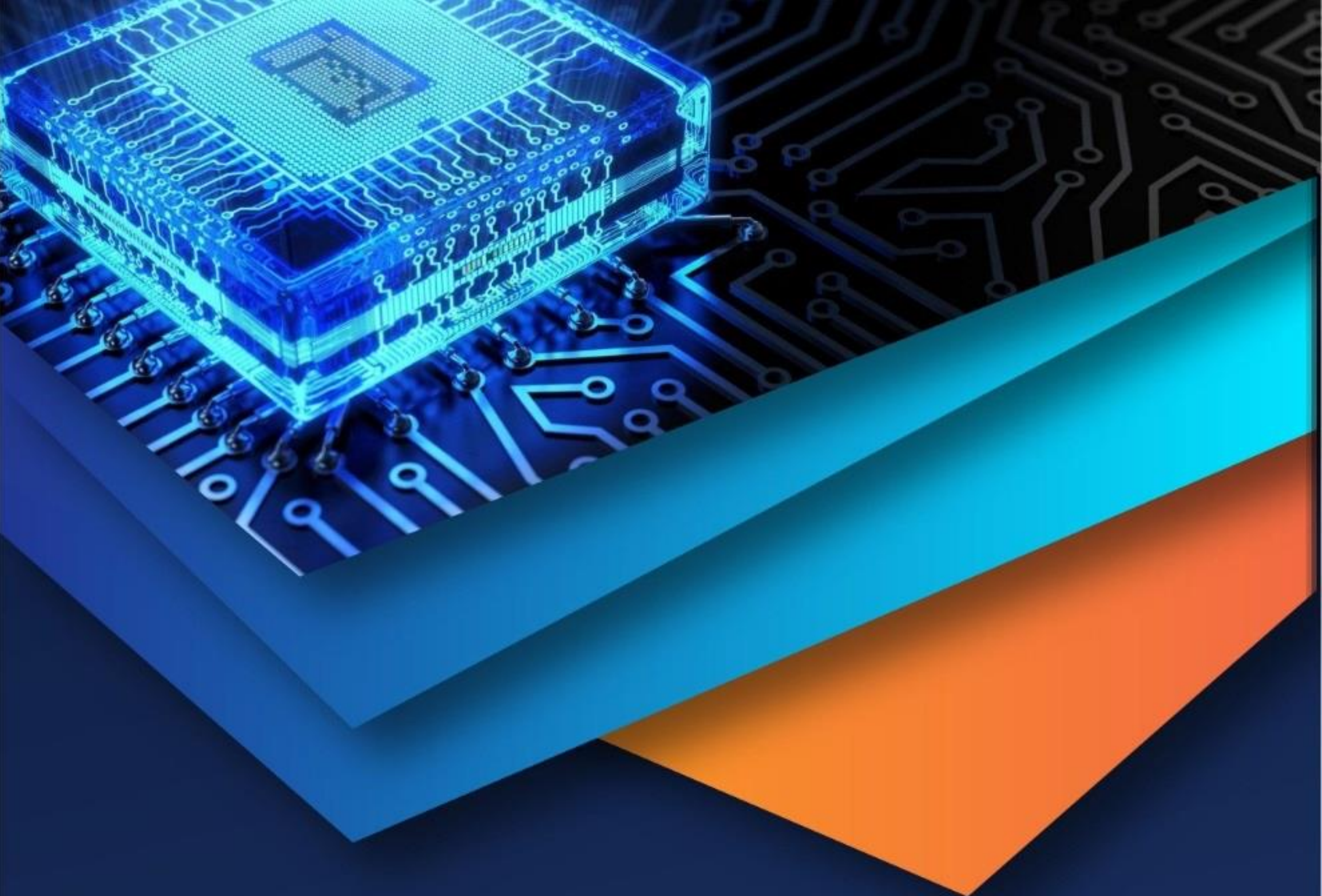
Fig: rain detection

VI. CONCLUSION

This study developed a wireless IoT-based drip irrigation system that overcomes limitations of previous systems, including high costs, limited range, and power requirements. The system collects real-time data on soil moisture, temperature, humidity, and soil temperature, enabling informed irrigation decisions. Field tests on brinjal crops in vertisols demonstrated the system's effectiveness, with significant water savings (35.1%) and improved plant growth compared to traditional ETc-based drip irrigation. Statistical analysis revealed significant differences in pumping time, water consumption, and plant growth between the two irrigation methods. The findings suggest that IoT-based drip irrigation can enhance water use efficiency and support growers in optimizing irrigation schedules.

REFERENCES

[1] Allen, R.G., Pereira, L.S., Raes, D. & Smith, M. (1998) Crop evapotranspiration-guidelines for computing crop water requirements-FAO irrigation and drainage paper 56. Fao, Rome, 300(9), D05109.
[2] Cobos, D.R. & Chambers, C. (2010) Calibrating ECH2O soil moisture sensors. Pullman, WA: Application Note, Decagon Devices.
[3] Dasgupta, A., Daruka, A., Pandey, A., Bose, A., Mukherjee, S. & Saha, S. (2019) Smart irrigation: IoT-based irrigation monitoring system. In: Proceedings of International Ethical Hacking Conference 2018. Singapore: Springer, pp. 395–403.
[4] Deshpande, P., Damkonde, A. & Chavan, V. (2017) The internet of things: Vision, architecture, and applications. International Journal of Computer Applications, 975(2), 8887–8814. Available from: https://doi.org/10.5120/ijca2017915722
[5] Evelyn, G.L., Montiel, J.E., Chadwick, C.A. & García, F.R.M. (2019) Architecture proposal for low-cost hydroponic IoT based systems. In: International Congress of Telematics and Computing. Cham: Springer, pp. 305–322.
[6] García, L., Parra, L., Jimenez, J.M., Lloret, J. & Lorenz, P. (2020) IoT-based smart irrigation systems: An overview on the recent trends on sensors and IoT systems for irrigation in precision agriculture. Sensors, 20(4), 1042. Available from: https://doi. org/10.3390/s20041042
[7] Goap, A., Sharma, D., Shukla, A.K. & Krishna, C.R. (2018) An IoT based smart irrigation management system using machine learning and open source technologies. Computers and Electronics in Agriculture, 155, 41–49. Available from: https://doi. org/10.1016/j.compag.2018.09.040
[8] Gu, Z., Qi, Z., Burghate, R., Yuan, S., Jiao, X. & Xu, J. (2020) Irrigation scheduling approaches and applications: A review. Journal of Irrigation and Drainage Engineering, 146(6), 04020007. Available from: https://doi.org/10.1061/(ASCE)IR. 1943-4774.0001464



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