

DEVELOPMENT OF A SMART HOME AUTOMATION AND WATERING SYSTEM USING IoT

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ABSTRACT

Home automation refers to the use of technology to monitor various aspects of a home. Using smart devices and apps, users can control things like lights, room temperature, security systems, and more from anywhere in the world. Home automation is becoming increasingly popular due to its convenience and energy-saving benefits. This paper describes the expansion of a smart home system using the Internet of Things (IoT). The system was developed to provide users with a convenient way to control their home appliances and monitor their home environment through the use of a variety of sensors. The soil moisture sensor measures the moisture level of the soil in order to irrigate the surrounding vegetation, while the ultrasonic sensor detects the presence of a person in the house. The light-dependent resistor (LDR) sensor uses the ambient light level to control light intensity, and the passive infrared (PIR) sensor detects movement. All of these sensors send data to the microcontroller, which uses the information to make decisions about how to switch ON or OFF the appliances. The system can also be controlled with a friendly graphical user interface (GUI). It allows users to view the current status of the appliances. It also provides an easy way to adjust the system's settings, such as the threshold for the soil moisture sensor. The GUI is designed to be intuitive and easy to use so that users can get the most out of the system. The evaluation of the smart home system was carried out and demonstrated functionality in accordance with expectations, effectively managing appliances autonomously based on sensor data. The development of this smart home automation system underscores the capabilities of Internet of Things (IoT) technology to enhance convenience, improve energy efficiency, and elevate the overall living standards for homeowners.

Keywords: Internet-of-things, microcontroller, sensors, smart home, sensor

INTRODUCTION

The Internet of Things is an important technology in our daily lives, and it has had a significant impact on individual lifestyle changes. Our interactions with our homes are rapidly changing as an effect of the Internet of Things (IoT) development in smart home automation. It is a simple

house designed to leverage contemporary technology to offer an increased number of services to people by making use of these technological advancements. Smart homes are equipped with devices connected to the internet that can be controlled remotely or programmed to perform tasks autonomously (Howedi & Jwaid, 2016). The Internet of Things has broadened the scope of automa-

tion systems with the fusion of various technologies. The use of IoT devices in the home enables the user to automate and control a diverse range of devices, which in turn enhances home security, energy efficiency, and overall convenience. We will explore the growth of an automated smart home using IoT devices for lighting, security, and irrigation, examining the integration of these systems for a unified smart home and the emerging technologies that continue to remodel home automation using IoT devices. In order to save resources, smart homes use appliances to perform activities, actions, and automatic routines. Integration of several smart appliances and devices under system control is made possible by home automation systems (Jabbar *et al.*, 2019). Smart home automation is the next big thing in the technology world. It aims to make life easier by providing a system where all home appliances can be controlled seamlessly from a single device. The popularity of smart homes is growing exponentially, and it is proposed that by 2021, there will be a lot more than 73 million smart homes around the globe (Adedoyin *et al.*, 2020).

Due to its ability to enhance living quality, home automation has grown in popularity over the past few decades. Most automation systems make extensive use of sensors, microcontrollers, smartphones, and various communication technologies. Simple household chores like turning on the lights, turning on the fan, or speed are challenging for older and physically challenged people. A home automation system that can remotely monitor and control electrical devices can satisfy all of these requirements. The time it takes to operate house appliances from anywhere is significantly reduced with the installation of a smart home system (Diwanji

et al., 2018).

Many techniques have been used to control home appliances wirelessly. The most popular approaches include speech recognition, Internet of Things (IoT)-based, Bluetooth-based, GSM-based, and voice recognition-based home automation. As technology develops, the use of smart home automation has increased, and the Internet of Things (IoT) has emerged as the primary technology for this application. The IoT has enabled home automation systems to be connected, intelligent, and remotely controllable. Yao-hua and Wei (2018) proposed the IoT technology for speech recognition, GSM, sensors and cameras. It is based on the Advanced RISC Machines (ARM) platform and all the devices are connected to the ARM microcontroller.

Dey *et al.* (2016) proposed a home system using smartphones and computers. The IoT devices are connected to the automation system and these devices are in turn connected to the cloud server which is handled by the house owner. This IoT system will use mobile devices to control and access the appliances from any remote location using the Internet. Mrinal *et al.* (2016) explained that the current generation life runs over the concept called automation as the things which are automated are said to belong to the next generation because they do not require human intervention for their working. Home automation technology gives the user the ability the control home appliances from any part of the world. The existing system allowed the user to control door locking and unlocking and sensing parameters like temperature, humidity, and light intensity while the preferred system was arranged to control the home appliances using Wi-Fi as a connection protocol and included functionalities

like a locking system with alarm, mosquito sensing system and smart water tanks.

Pavithra & Balakrishnan (2015) proposed the use of low-power communication protocols like Wi-Fi and Zigbee to communicate with a home automation network via an Internet gateway. The system uses a Raspberry Pi server system and Wi-Fi as a communication channel to operate household appliances from a smartphone. Somani *et al.* (2018) developed a system offers home automation capabilities using IoT to function smoothly. It also has a camera module and offers a break-in warning. The Android app transforms the phone into a universal remote controller for household appliances. Motion sensors provide security by sensing movement at the house's entrance and sending out a signal that includes a real-time photo of the entrance. The home's owner will receive this message online, allowing the app to initiate a notification. Thus, in the event of an intruder, the owner can activate the alarm or operate the appliances, such as opening the door for visitors. Raspberry Pi, a tiny computer that serves as the system's server, is used in the setup. There are two modules in a smart house. The components of home automation include a door controller, fanlight, and security module with motion and smoke sensors as well as a camera module.

MATERIALS AND METHODS

MATERIALS

The components used in the development of the system reported in this paper include ESP32 microcontrollers, a PIR sensor, a soil moisture sensor, light dependent resistor, a

12 V pump, a power pack and a plastic casing. The software used for this project is Arduino IoT cloud remote along with a wireless router that acts as a mobile Wi-Fi hotspot for the system.

HARDWARE COMPONENTS

The hardware components used in the developed system include:

- ESP32 Microcontroller
- PIR Sensor
- Light Dependent Resistor (LDR)
- Actuator
- Soil Moisture Sensor
- Pump

ESP32 MICROCONTROLLER: The ESP32, shown in Figure 1, represents a robust and cost-effective microcontroller engineered by Espressif Systems, and it is extensively utilized in Internet of Things (IoT) applications. As the successor to the widely acclaimed ESP8266, it boasts a range of advanced features and functionalities. The microcontroller is powered by a dual-core Xtensa® 32-bit LX6 processor, capable of operating at frequencies reaching 240 MHz, which facilitates efficient multitasking and enhances processing performance (Atif *et al.*, 2020). Its Wi-Fi capabilities adhere to the 802.11 b/g/n standards, allowing for seamless connectivity to Wi-Fi networks. It can operate in various modes, including Station mode, Soft-AP mode, and Wi-Fi Direct. Additionally, it supports Bluetooth v4.2, encompassing both Classic Bluetooth and Bluetooth Low Energy (BLE), thereby accommodating diverse wireless communication requirements.

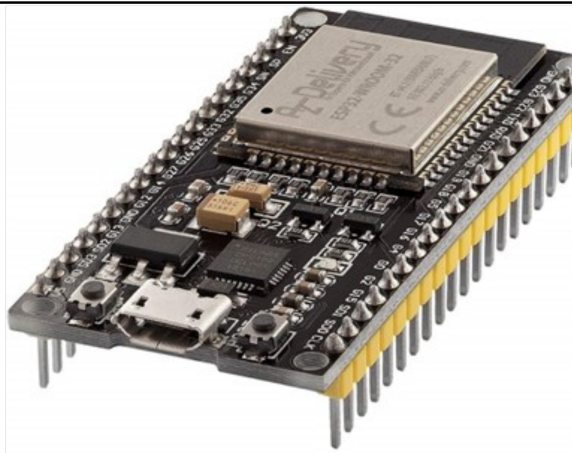


Figure 1: ESP32 Microcontroller (aranacorp.com)

PIR SENSOR: The PIR Sensor, often referred to as a passive infrared sensor and detects infrared light emitted by objects in its range of view. PIR sensors are designed to identify infrared radiation that is emitted by objects within their detection range, especially by warm entities such as humans and animals (Fig. 2). These sensors operate passively, meaning they do not produce radiation but rather detect the infrared energy present in their environment. The primary

element responsible for generating an electrical signal in response to this infrared radiation is the pyroelectric material. To improve sensitivity and extend the detection range, PIR sensors are fitted with a Fresnel lens, which concentrates the infrared radiation onto the sensor. Additionally, the circuitry of these sensors incorporates amplifiers and filters to refine the signal and reduce background noise.



Figure 2: PIR Sensor (forum.Arduino.cc)

LIGHT DEPENDENT RESISTOR (LDR): A photoresistor is a photosensitive electrical component, when exposed to light, the resistance changes. The LDR's

resistance varies across a wide range of orders of magnitude, becoming less as light intensity increases. LDRs are also known as photocells, photoconductive cells, or just

photocells. LDRs are made from semiconductor materials with high resistance. Photoconductivity is the fundamental mechanism by which photo resistors function. An optical phenomenon is called photoconductivity. The conductivity of the substance increases when light is absorbed by it. When light strikes a semiconductor material, its electrons in the valence band are energized to go to the conduction band. To cause the electrons to move from the valence band to the conduction band, the photons in the incident light must have energy higher than the semiconductor material's band gap. As the circuit is closed, the device experiences an increase in current

flow, which lowers the device's resistance.

SOIL MOISTURE SENSOR: One sort of sensor used to calculate the water content of the soil is a soil moisture sensor (Figure 3). By utilizing another characteristic of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a stand-in for the moisture content, soil moisture sensors determine the volumetric water content indirectly. To quantify free soil moisture using direct gravimetric methods, a sample must be taken, dried, and weighed. The volumetric water content is the amount of liquid water in relation to the volume of soil. It's usually expressed as a percentage. For



Figure 3: Soil Moisture Sensor (az-delivery.de)

SYSTEM SOFTWARE DESIGN AND COMPONENTS

Using a servo motor and sensors, the system software's primary function is to operate the lights, gate, and pump. The mobile unit and the microcontroller unit make up the two units that make up the system software. To get a response from the devices and sensors, the mobile unit is in charge of providing them with commands and control instructions. The gadgets are not controlled by this unit; they merely serve as a user in-

terface. The devices are controlled and the information gathered from the devices and mobile unit is prepared by the second unit, a microcontroller unit. When it comes to managing and interpreting data coming from and going to all of the system's elements, the microcontroller is regarded as the brain.

The software consists of a Wi-Fi connection to the system and an Android app for smartphones. The prototype's design is built on dependable, contemporary technologies

that let users manage several devices from any location in the globe.

SYSTEM ARCHITECTURE

The block diagram outlines the fundamental elements and structure of a smart home system. This system is engineered to deliver

sophisticated automation, control, and monitoring functionalities within a residential setting. Central to the system is the microcontroller, which acts as the primary processing and decision-making hub as shown in Figure 4. It plays a crucial role in integrating and managing the various sensors and actuators

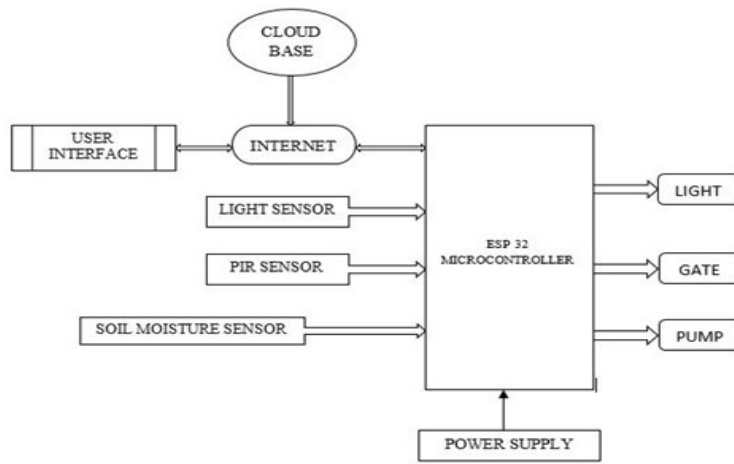


Figure 4: Architectural design of the Smart Home System

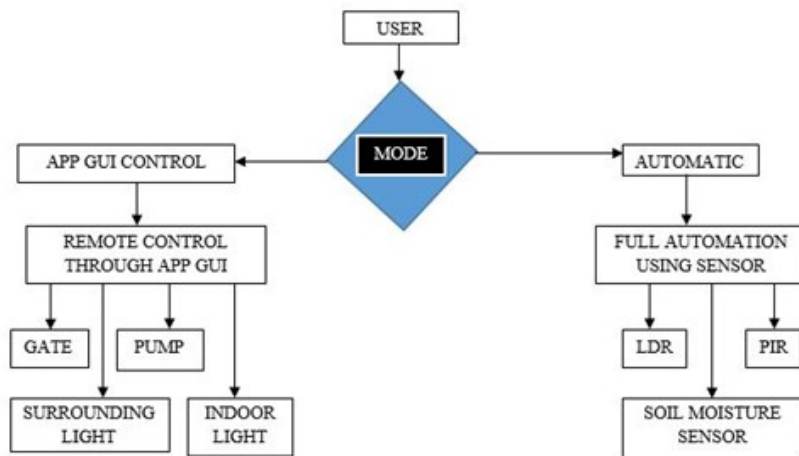


Figure 5: System Process Flow

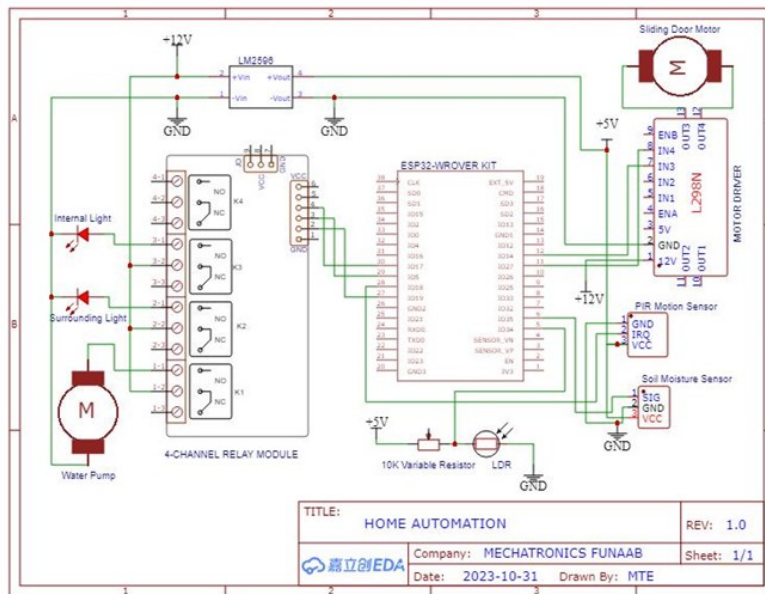


Figure 6. System Circuit Diagram

that constitute the smart home. These sensors are the light sensor, which assesses ambient light levels, and the PIR (Passive Infrared) sensor, which identifies movement within the premises. Furthermore, the soil moisture sensor measures the moisture content in the soil, allowing the system to enhance irrigation and watering processes. The power supply is essential for the dependable functioning of the entire smart home system. It delivers the requisite electrical energy to the microcontroller, sensors, and actuators, facilitating their proper operation. The integration of actuators, including the "Light" and "Pump" modules, illustrates the system's capacity to perform physical actions in response to data gathered by the sensors and commands from the user interface.

The flow chart showcases the operational modes and features of a comprehensive smart home system. The user can choose between two primary modes: App control

Interface and Automatic (Figure 5). In the App/UI Control interface, the homeowner retains direct control over specific components, such as the gate and pump. This level of granular control allows the user to intervene and make on-demand adjustments to the home's operations as necessary. Conversely, the Automatic mode enables the smart home to operate autonomously, leveraging sensor data to optimize various aspects of the home. The PIR (Passive Infrared) sensor and soil moisture sensor provide the system with real-time information about occupancy and environmental conditions, respectively. Based on this data, the system can automatically control the surrounding and indoor lighting, as well as manage water-related tasks like irrigation. This automation feature enhances energy efficiency, convenience, and overall home management without requiring constant user intervention.

The circuit diagram presented in Figure 6 shows a comprehensive home automation

system, integrating various components and functionalities to provide advanced control and monitoring capabilities within a residential setting. The microcontroller is connected to multiple sensors and actuators, allowing it to gather data and execute commands to automate various aspects of the home. The diagram depicts the integration of a water pump, indicating the system's ability to control and manage water-related tasks, such as irrigation or water management. Additionally, the inclusion of a relay module suggests the system's versatility in controlling and switching different electrical loads, enabling the automation of lighting, appliances, or other household devices.

CLOUD-BASED IOT

This project made use of a cloud-based Internet of Things to enable end users to monitor and operate their household appliances. The user GUI or automatic modes of operation for this smart home system will be selected at setup. The sensors interfaced with the microcontroller would control the state of the flowerpot and lights in automatic mode, while the user would control the status of the household appliances in user GUI mode.

LIGHT SURROUNDING LIGHTS:

Once the system is in automated mode, the surrounding light turns off during the day because the light sensor (LDR) detects ambient light. When the light sensor (LDR) detects darkness, it lowers its resistance, turning on the outdoor light condition during the night. The user's input determines the condition of the system when it is in user GUI mode.

IRRIGATION PUMP

The system is designed to start the pump whenever the soil moisture level is above

the sensor value of 750 and stop the pump whenever the moisture is at 500 which indicates that the soil is wet enough for the lawn and the flower being grown. The sensor picks the reading of the moisture of the soil and sends the value to the ESP32 microcontroller, the sensor reading is compared to the pre-set value reading. If the moisture of the soil is less, then the microcontroller will send a command to START the pump, and when the soil moisture equals the pre-set value the microcontroller will send a signal to STOP the pump. Also in the user GUI mode, the user decides either to start the pump or stop it from watering the lawn on the App user interface.

GATE

The gate will always be in user GUI mode as only authorized users will be permitted to control the gate for security purposes. The owner decides when an intruder status is noticed to either open the gate or close the gate directly from their devices anywhere they are in the world as long as the device is linked to the Internet.

TESTING

The thorough testing of components within a home automation system is vital for guaranteeing its dependable and efficient functionality. Initially, each component must be tested separately, which includes the microcontroller, sensors, and actuators. This stage emphasizes the verification of each element's proper operation, ensuring that the microcontroller effectively communicates with the sensors and issues commands to the actuators. Calibration of the sensors is a critical component of this phase, as it ensures the accuracy of data input and the correct activation of automated processes. Following the validation of individual components, the subsequent phase involves testing the inte-

gration of the complete system, where various scenarios are simulated to verify the smooth interaction among the different components. This integrated testing phase validates the automation logic and assesses the system's capability to make informed decisions based on sensor data and execute the intended actions.

The cloud application was accessed to test the user interface, making sure that every

feature operated as intended. The ON/OFF buttons on the application (Figure 7) could be used to control the pump, gate, indoor light, and surrounding light. The indicators for human presence, light intensity, and intruders all functioned as intended, providing real-time status updates on the sensors. The system's components were all functioning flawlessly, and it was prepared for implementation.

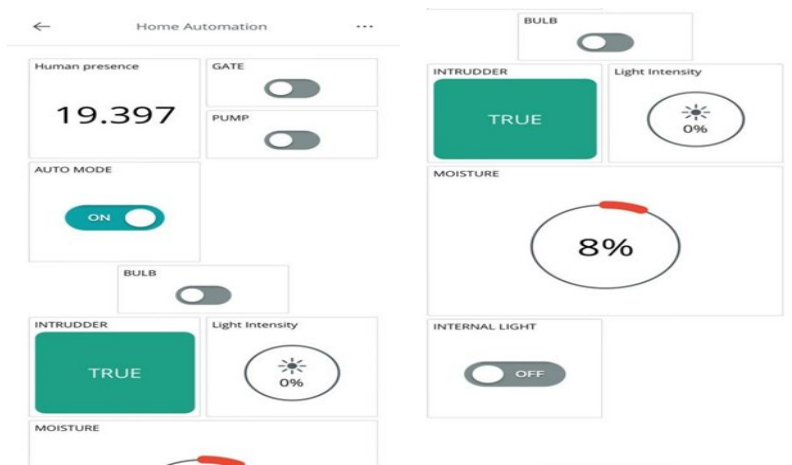


Figure 7: Mobile interface

CONCLUSION

The research emphasized the development of an intelligent home automation system that utilizes a variety of sensors and Internet of Things (IoT) technologies, enabling users to effortlessly manage and monitor their living environments. This system incorporated several types of sensors, including soil moisture sensors, light-dependent resistors (LDR), and passive infrared (PIR) sensors, which were employed to collect data regarding soil moisture content, human presence, ambient light intensity, and motion detection.

The implementation of this sensor network

enhanced the system's capability to autonomously control household appliances based on the existing environmental conditions. The ESP32 microcontroller processed the sensor data to ascertain the appropriate moments for activating or deactivating household devices. This automated control mechanism not only optimized energy consumption but also provided users with a seamless, hands-free experience.

Key features such as the incorporation of diverse sensors, intelligent control mechanisms, and an intuitive user interface are essential elements that could be further developed in future iterations of smart home

technology. In summary, this research provides valuable insights into the practical implementation of IoT-driven smart home systems.

REFERENCES

- Adedoyin, M. A., Shoewu, O. O., Adenowo, A., Yussuff, A., Senapon, M.** 2020. Development of a Smart IOT-based Home Automation System. *DEVELOPMENT*, 5(2), 25-37.
- Atif, M., Muralidharan, S., Ko, H., Yoo, B.** 2020. Wi-ESP—A tool for CSI-based device-free Wi-Fi sensing (DFWS). *Journal of Computational Design and Engineering*, 7(5), 644-656.
- Dey, S., Roy, A., Das, S.** 2016, October. Home automation using the Internet of Things. In *2016 IEEE 7th Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON)* (pp. 1-6). IEEE.
- Howedi, A., Jwaid, A.** 2016, December. Design and implementation prototype of a smart house system at low cost and multi-functional. In *2016 Future Technologies Conference (FTC)* (pp. 876-884). IEEE.
- Jabbar, W. A., Kian, T. K., Ramli, R. M., Zubir, S. N., Zamrizaman, N. S., Balfaqih, M., Alharbi, S.** 2019. Design and fabrication of smart home with internet of things enabled automation system. *IEEE access*, 7, 144059-144074.
- Mrinal, M., Priyanka, L., Saniya, M., Poonam, K., Gavali, A. B.** 2016. Smart home—automation and security system based on sensing mechanism. In *2017 Second International Conference on Electrical, Computer and Communication Technologies (ICECCT)* (pp. 1-3). IEEE.
- Pavithra, D., Balakrishnan, R.** 2015, April. IoT-based monitoring and control system for home automation. In *2015 global conference on communication technologies (GCCT)* (pp. 169-173). IEEE.
- Diwanji Shraddha, Saudamini Patil, Priya Shinde, Prof. H.D. Shinde** 2018. IoT Based Smart Home. *International Engineering Research Journal*, page (1-3). AISSMS's Institute of Information Technology. ISSN: 2395-1621.
- Somani, S., Solunke, P., Oke, S., Medhi, P., & Laturkar, P. P.** 2018, August. IoT-based smart security and home automation. In *2018 Fourth International Conference on Computing Communication Control and Automation (ICCUBECA)* (pp. 1-4). IEEE.
- Yaohua, X., Wei, L.** 2018, June. The Smart Home System Based on ARM Platform. In *2018 International Conference on Smart Grid and Electrical Automation (ICSGEA)* (pp. 144-146). IEEE.

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