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Implementation of Smart Home Automation System

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Abstract: ***The Internet of Things is a network of physical objects embedded with electronics, sensors, and programmed using software to establish connectivity and provide communication by exchanging data with users, manufacturers, and other IoT devices. Interconnected smart devices have become a ubiquitous part of daily lives. Innovative applications, such as smart home environments, are being integrated into daily life with the increasing popularity of IoT, enhancing convenience, comfort, energy efficiency, and safety. This paper presents a smart home automation system. In this work, the proposed smart home is initially simulated using the Tinkercad platform and later verified by hardware analysis. Smart home automation is efficiently achieved using various components with an Arduino Uno as a central controller which is integrated with various sensors (ultrasonic sensors to detect distance, PIR sensors to monitor the human presence, LDR sensors to adjust lighting, and smoke detectors to ensure fire safety) and other components like relays, transistors to manage high and low power devices, LEDs, push buttons to offer user control and feedback, and lights, buzzers, DC motors, servo motors to provide automation and mechanical movements.***

Index Terms: ***Internet of Things, Home Automation, Smart Homes, Arduino IDE***

I. INTRODUCTION

The Internet of Things is a network of physical objects used to send and receive communication information using the Internet or any other communication and network technology between the user and the manufacturer [1], and other connected devices, which helps in monitoring, coordinating, or controlling processes across the internet. IoT has become a revolutionary ecosystem that describes the network of

embedded systems and sensors that exchange data over a wired or wireless medium. In recent years, smart home applications have become increasingly prevalent, making people's lives easier.

A smart home comprises internet-connected equipment with cutting-edge technology that residents can control remotely. Smart home technology refers to household appliances like lighting, heating, air conditioning, And entertainment systems featuring key benefits such as comfort, convenience, safety, and energy efficiency. Ubiquitous technologies, including IoT, AI/ML, communication technologies, robotics, and image processing, are utilised to implement smart home applications. Many heterogeneous devices and sensors installed in smart houses monitor various physical factors and produce data that can be useful for applications.

This paper proposes a smart home model utilising Arduino Uno as the central controller, programmed using the Arduino IDE. The controller is integrated with sensors such as ultrasonic, PIR, LDR, and smoke detector sensors, which provide crucial data based on which automation and mechanical movements are performed by electrical home appliances. The overview of the placement and orientation of sensors and equipment is discussed in the latter part of the paper. Evaluation of the proposed topic is performed in two phases. In the first phase, the Tinkercad application is used to design and simulate the system, enabling an understanding of its strengths and weaknesses. In the second phase, a hardware setup is implemented to evaluate the system under practical conditions and assess its operational behaviour. The rest of the paper is organised as follows: literature survey, methodology, design description, evaluation, conclusion, and future scope.

II. LITERATURE SURVEY

A Wi-Fi-based home automation system was suggested to overcome the concerns of increased electrical disasters and power management [2]. The system utilised three modes to convey commands to turn on and off electrical appliances, as well as to record the time taken to switch on and off the connected loads. The system development suggested implementing various hardware components, including the system's power supply, microcontroller, relays, switches, and loads, as well as programming the system controller. The results of the system testing suggested that it is very effective in the remote control of electrical appliances.

An ESP32 microcontroller is used to develop a home automation system that implements the Internet of Things (IoT) using a Wi-Fi-based module that is interfaced with a JavaScript-based Android app that uses the HTTP request method to control the microcontroller [3]. Users can control home appliances from the comfort of their smartphone and additional manual switches. The provision of manual push buttons allows users to operate the relay module when the internet is unavailable. The paper suggests controlling electrical switches using a Node MCU (ESP32) microcontroller, along with Relays, remotely from the server.

A smart home automation system is developed using embedded systems and IoT, featuring a user-friendly Wi-Fi-integrated ESP8266 and Raspberry Pi modules [4]. The system consists of inbuilt Wi-Fi technology for wireless

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communication, which helps control various appliances, an L298N Motor Driver, and 4- 4- 4-Channel relay modules for switching AC and DC home appliances. The proposed system is operated with an Android-based application known as “Blynk”, which provides an easy-to-use GUI for the user. Blynk IoT is a visual programming platform that establishes a direct wireless connection between the user and the controller.

A home automation system controlled by Smart Android applications is implemented to improve

the security of the home. The home appliances can be controlled using a simple GSM-based phone, by sending AT Commands through the phone [5]. The model does not require smartphones, but since smartphones enhance security, it can be utilised. The application can control the entire home’s appliances, and the special function is Ultra Panic Mode. When the panic mode is “Enabled”, the user’s data can be used appropriately.

An advanced smart home with an improved security system is introduced using the Internet of Things (IoT). The user can control and monitor the system using web-based interfaces like IFTTT or by using smartphone applications like Blynk [6].

A mobile-based system for home automation has been developed, where the model depicts the software development process as a linear and progressive flow [7]. The simulation methodology was employed during the study to evaluate the developed system. Ten trials were conducted to evaluate the performance of the implemented system. To assess the system's reliability, the mean time to failure was utilized. During performance analysis, the study's system was found to outperform the two other approaches.

Use of cloud environment and Node MCU to achieve home automation, where a cloud platform is used to manage and control the home automation system [8]. The cloud platform offers various services, including databases, communication queues, and storage, and the system is designed accordingly based on the use case. System implementation involves writing Node MCU code, configuring cloud services, and integrating devices. The system has been thoroughly tested, debugged, and optimised to enhance its performance. The system may need to scale as additional devices or users are added.

To fully realise the potential of ML in IoT and provide homeowners with tremendous and unexpected benefits, the authors aim to explore ML in IoT smart home automation by classifying home automation applications. A taxonomy of machine learning (ML) for

Smart homes based on their application [9]. The research also includes related surveys and literature reviews, as well as open challenges and issues, along with detailed future directions.

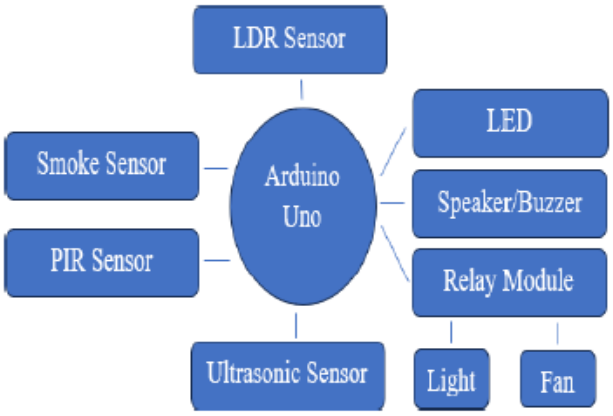
To improve the efficiency of management and operation of innovative residential building systems, and the problems to be solved by optimizing the operating mode of automation systems at the design stage [10]. A study has been conducted, and the software and experimental results of developing a "smart sensor" based on an Arduino controller are presented. The issues of the expansion of management facilities are proposed and implemented. The problem is solved by using intelligent sensors in the control system. Software tools for interacting with primary sensors within the Arduino controller's software environment have been developed. The issues of choosing software tools for remote control of these objects are discussed.

III. PROPOSED APPROACH AND METHODOLOGY

This section discusses the smart home automation model, which focuses on designing an intelligent home automation system that includes door sensors, automated lights and fans, smoke detection kits, alarms, and human presence monitoring. The model is built using an Arduino UNO, a well-liked platform for creating microcontroller-based IoT applications, offering unique advantages and applications.

The design incorporates the following components: a Light-Dependent Resistor (LDR), smoke sensors, and a relay used to integrate the system with electrical devices. The relay module connects the desired circuit voltage, which is high voltage, to the Arduino voltage, which is a low voltage. Combining all sensors with an Arduino forms a microcontroller for home automation. Different sensors detect the input and send it to the Arduino, which processes the input and provides outputs through output devices. The LDR sensor senses the intensity of light and provides feedback to the Arduino accordingly. If the light level decreases, the electric bulb connected to the board through the relay will turn on. Conversely, when the light intensity increases, the bulb will turn off. The PIR sensor will sense any motion or movement in the home. The centralised air-cooling system and lights, as well as ambient lights, will be switched on and off accordingly. The smoke sensor continuously senses the presence of smoke inside the house. If it detects a fire, the buzzer will constantly beep until the smoke is extinguished. The ultrasonic sensor will help open and close doors automatically based on the detection of the object's distance. If the distance is lower than the set distance, the door opens; otherwise, the door closes. All these state changes are communicated through a beep sound via the buzzer.

The system design in Figure 1 illustrates the inputs sensed through the sensor, which serve as the system's input. Based on these inputs, the output is processed, and the corresponding action is taken.



[Fig.1: Block Diagram for Home Automation]

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IV. DESIGN DESCRIPTION AND EXPERIMENTAL SETUP

The following components are used for simulating the home automation experimental setup.

A. Arduino UNO

Arduino UNO as shown in
Figure 2 is an open-source hardware or software used for SMH processing. It is licensed under the GNU General Public License, allowing everyone to use it. There are various types of Arduino boards, but we have used the Arduino Uno in this example. The Arduino Uno is an integral part of the ATmega328P.

Microcontroller. It features a set of both digital and analogue input/output pins. It consists of 14 digital I/O pins and six analogue I/O pins. Out of 14 digital I/O pins, six are capable of PWM output. The setup is programmable using the Arduino Integrated Development Environment (Arduino IDE) via a Type B USB cable. The acceptable voltage range of the system is between 7 and 20 V, which can be supplemented through a USB cable.

[Fig.2: Arduino UNO]

B. Relay

Relay is a module that is similar to a switch. It is used to create a bridge between high-voltage (AC) devices and low-voltage (DC) devices, such as Arduino. It is used in breaking and connecting to a circuit, functioning as an electrical switch. It allows low-voltage connectivity, i.e., 5V provided by Arduino pins. The relay module may have one, two, four, or eight channels. The Relay Module is depicted in Figure 3.

If the sensor detects a decrease in light intensity, it activates the relay circuit, which in turn turns on the electric bulb or fan. Similarly, when the intensity of light increases or the temperature decreases, it switches the relay circuit to turn OFF the electric bulb or fan.

[Fig.3: Relay Module]

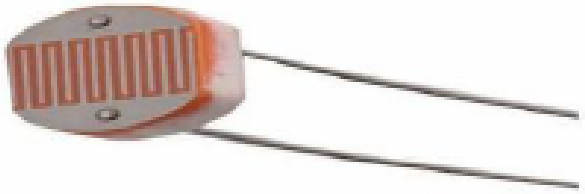
C. Ultrasonic Sensor

Ultrasonic sensors, as shown in Figure 4, are based on the principle of sound waves, which are emitted by a transducer and then reflected when they encounter an obstacle. The reflected signal is sensed as an input, and accordingly, based on the distance of the object, information is sent to open or close the door.

[Fig.4: Ultrasonic Sensor]

D. LDR Sensor

LDR Sensor is known as a light-dependent Resistor sensor. The sensor shown in Figure 5 interacts with the environment, providing the intensity of light available as input. If the light level decreases, it sends a signal to turn on the light, and when the light level increases, it sends a signal to turn off the light.



[Fig.5: LDR Sensor]

E. PIR Sensor

A passive infrared sensor (PIR sensor), as shown in Figure 6, is an electronic device that measures the infrared light emitted by objects within its field of view. Here, PIR sensors are used in PIR-based motion detectors, which, upon detecting movement, turn lights, fans, or other convenience devices on or off.

[Fig.6: PIR Sensor]

F. Smoke Sensor

A smoke sensor is a device that detects the presence of smoke in a specific area. If a fire breaks out, the input is sent, and the buzzer starts beeping continuously accordingly.

G. Software Circuit Model

Figure 7 is the software model designed using

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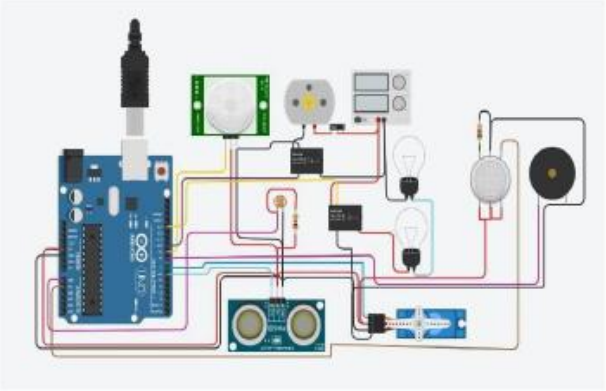
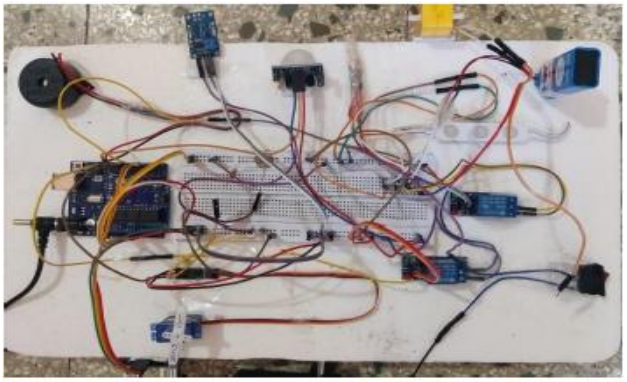
Tinkercad, where the Arduino and the sensors are configured for output presentation. This model was set up and tested to evaluate the system under practical conditions
and assess its operational behavior.



[Fig.7: SMH Software Model]

H. Hardware Circuit Model

Figure 8 illustrates a hardware setup for a smart home automation system, where the Arduino serves as the central processing unit for the circuit, controlling various sensors and actuators. The control of Arduino is facilitated using the Arduino Integrated Development Environment (IDE), which provides for writing, compiling, and uploading code to the Arduino microcontroller. The IDE also offers a wide range of libraries that support the integration of various sensor modules. The setup includes a breadboard, where components are interconnected without the need for soldering, and multiple modules, such as servo motors, relays, and LEDs, which are used to control and indicate the status of different devices. Sensors, including a PIR sensor, an Ultrasonic sensor, an LDR sensor, and a Smoke sensor, are integrated into the system to gather environmental data. The Arduino processes this data and triggers corresponding actions such as activating motors or relays to control doors, lights, or other appliances. The experimental setup has been tested to evaluate the system's operational behavior under practical conditions, ensuring the effective automation of various home functions. This complex wiring setup exemplifies an integrated approach to home automation, controlled by Arduino, to enhance the functionality and convenience of a smart home environment.

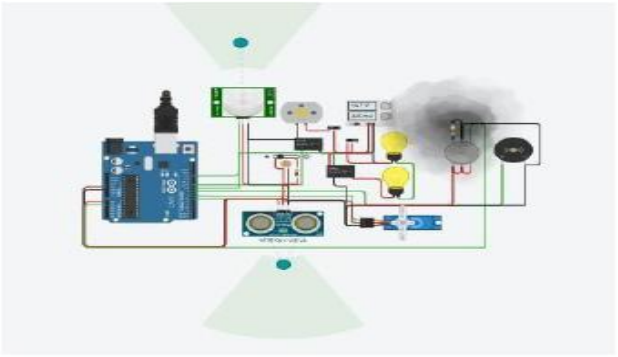


[Fig.8: SMH Hardware Model]

V. RESULTS AND ANALYSIS

A. Software Model Analysis

Figure 9 is the proposed software model under simulation. Here, when the system is in simulation mode, all sensors are activated based on their properties. A combination of all these sensors working together helps in better coordination between appliances, yielding a sophisticated automated experience for the user.

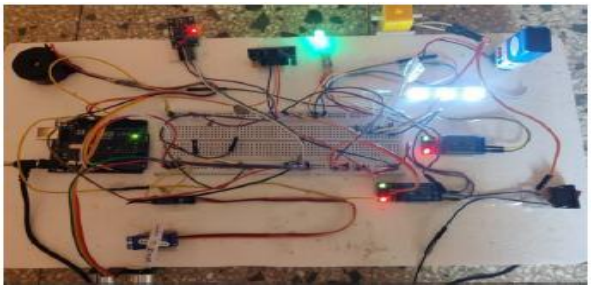


[Fig.9: Software Model Simulation Results]

B. Hardware Model Analysis

Figure 9 represents the hardware model of the Smart Home Automation System under simulation. In this setup, the Arduino microcontroller manages various sensors and actuators to simulate real-world automation scenarios. The functionalities of multiple sensors are analysed, for instance, in the model, where the default distance of the ultrasonic sensor is set to 35 cm. In contrast, when an object is closer than 35 cm to the sensors, the automated door opens and closes. The computerised door in the model is represented by a servo motor connected to the ultrasonic sensor. These distances can be adjusted according to specific requirements. The PIR sensor in the model, which is connected to the LED lights and the motor that supposedly depicts fans and lights, acts as a closed circuit only when the sensor detects motion within its range. The functionality of the PIR sensor is shown in the Table.

1. Similarly, to automate the light intensity and ambience, the LDR sensor is used. Initially, during setup, a constant value of 400 is assigned to the LDR, which can be used as the minimum value of the sensor. A light intensity value of 500 or greater is required for the sensor to operate the light appliances. The smoke sensor is another component that acts as a safety device. Initially, during setup, a constant value is assigned as a threshold value. When the sensor reads a value greater than the threshold value, the buzzer connected starts buzzing for a specified time duration, alerting to the emergency. Table 2. Summarizes the operation states of a smoke detection unit.



[Fig.10: Hardware Model Simulation Results]

The values specific to each sensor are shown in Table 1 below. The adaptability of

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sensor thresholds enables a tailored automation experience that ensures the system meets the diverse needs of users. Overall, the hardware model demonstrates the potential for real-world application in a modern home environment.

Table 1: Operating States of PIR Sensor

Light Intensity	Person in Room	Light	Fan
Day	Yes	OFF	ON
Day	No	ON	OFF
Night	Yes	ON	ON
Night	No	OFF	OFF

Table 2: Operating States of Smoke Sensor

Smoke Detected	Buzzer/Alarm
Yes	ON
No	OFF

VI. CONCLUSION

The proposed system was initially designed and simulated using the Tinkercad software, followed by hardware implementation. The use of Arduino Uno has enabled us to control various electronic devices, including bulbs, fans, safety systems, alerts, and buzzers.

In the event of a fire or smoke breakout. The smart home system operates smoothly and efficiently, reducing human effort and saving energy.

The same work can be further extended by adding SMS control with mobile alert indication, remote sensing using Bluetooth for short-range control, and Wi-Fi control for long-range control.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/Competing Interests:** Based on my understanding, this article does not have any conflicts of interest.
- **Funding Support:** This article has not been sponsored or funded by any organization or agency. The independence of this research is a crucial factor in affirming its impartiality, as it was conducted without any external influence.
- **Ethical Approval and Consent to Participate:** The data provided in this article is exempt from the requirement for ethical approval or participant consent.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Author's Contributions:** The authorship of this article is contributed equally to all participating individuals.

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Pavankumar Patil is a dedicated MTech student in Computer Network Engineering at RV College of Engineering, specializing in security, wireless communication, and IoT systems. With a strong interest in advancing technology for modern applications, his research focuses on smart home automation, creating systems that enhance convenience and efficiency in everyday life. He is involved in developing a smart home automation system that leverages Arduino technology and advanced sensors for seamless control of appliances, energy optimization, and enhanced security. The system aims to manage home functions autonomously, provide real-time user notifications, and integrate with IoT platforms for a fully connected living experience. His research reflects a strong dedication to advancing innovative solutions that improve quality of life, exemplifying his enthusiasm for integrating technology with everyday applications.

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performance computing. She has worked on consultancy projects funded by Cisco Pvt. Ltd., Citrix R&D India Pvt. Ltd., and Samsung Pvt. Ltd. Additionally, she has collaborated on a research project funded by the Government of Karnataka's K-Tech Centre of Excellence in Cybersecurity (CySecK). She has been recognised as a Research Supervisor at Visvesvaraya Technological University (VTU) and guides research scholars in the Ph.D. program. She has published over 28 papers in both international journals and conferences. She serves as a member of the editorial board for open-access, peer-reviewed international journals and has worked as a reviewer for several IEEE international conferences and Scopus journals. She has served as an advisory and technical program committee member and has chaired sessions for several IEEE international conferences. She has been awarded a Certificate of Excellence for completing a project with Samsung PRISM from January 2021 to February 2022. She is certified as a Top Performing Mentor (Jul-Oct 18) for the NPTEL course by IIT Madras.

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