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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 using 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 like smart home environments are incorporated into daily life with the increasing popularity of IoT, to improve 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, 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 the last few years, smart home applications have become common since they make people's lives easier.

A smart home comprises internet-connected equipment with cutting-edge technology that residents can control from a distance. Smart home technology refers to household appliances like lighting, heating, air conditioning, and entertainment systems having key features like comfort, convenience, safety, and energy efficiency. Ubiquitous technologies like IoT, AI/ML, communication technologies, robotics, and image processing are used 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 suggests a smart home model using Arduino Uno as a central controller programmed using Arduino IDE. The controller is integrated with sensors like 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 later part of the paper. Evaluation of the proposed topic is performed using the Tinkercad application in the first phase to design and simulate the design and understand the strengths and flaws and a hardware setup in the second phase to evaluate the system under practical conditions and assess its operational behavior. The rest of the paper is organized 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 disaster and power management [2]. The system used three modes to convey commands to turn on and off electrical appliances and also take note of the time taken to switch ON/OFF the connected loads. The system development suggested implementing various hardware components such as the system's power supply, microcontroller, relays, switches, and loads, as well as the programming of 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 control of electrical switches using Node MCU (ESP32) microcontroller along with Relays remotely from the server.

A smart home automation system is developed with the use of embedded systems and IoT, a user-friendly Wi-Fi integrated ESP8266, and Raspberry Pi modules [4]. The system consists of inbuilt Wi-Fi technology for wireless communication which helps control various appliances, an L298N Motor Driver, and 4- 4- 4-channel relay modules for switching AC and DC home appliances [11]. The proposed

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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 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 need smartphones but since smartphones improve security it can be used. 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.

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 is developed where the model depicts the software development process as a linear and progressive flow [7]. The simulation methodology was employed during the study for the evaluation of the developed system. Ten trials were carried out to assess the implemented system's performance. 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 such as databases, communication queues, or storage, and the system is designed based on the use case accordingly. System implementation is done by writing Node MCU code, configuring cloud services, and integrating devices. The system has been tested, debugged, and optimized to improve performance. The system may need to scale as additional devices or users are added.

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

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

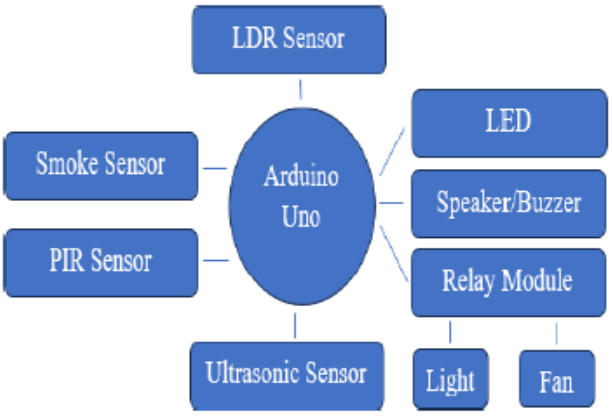
To improve the efficiency of management and operation of smart residential building systems and the problems to be solved by optimizing the operating mode of automation systems at the design stage [10]. A study has been conducted and the software and experimental results of the development of a "smart sensor" based on an Arduino controller are presented. The issues of expansion of management facilities are proposed and implemented. The problem is solved by using intelligent sensors in the control system. Software tools for the interaction of primary sensors in the software environment of the Arduino controller 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 Arduino UNO, it is a well-liked platform for creating microcontroller-based IOT applications, and it offers unique advantages and applications.

The design incorporates the following: a Light-Dependent Resistor (LDR), and Smoke Sensors, a relay that is used to combine the system with electrical devices. The relay module connects the desired circuit voltage which is high voltage with the Arduino voltage which is a low voltage. Combining all sensors with an Arduino forms a microcontroller for home automation. Different sensors sense the input and send it to the Arduino to process the input and provide outputs through output devices. The LDR sensor senses the intensity of light and provides input to Arduino accordingly if decrease in light level electric bulb connected to the board through the relay will turn on and when the intensity of light increases the bulb will turn off. The PIR sensor will sense any motion or movement in the home the centralized air-cooling system and lights and ambient lights will be switched on and off. The smoke sensor continuously senses if there is any smoke inside the house, if it detects the fire the buzzer will constantly beep until the smoke is put out. The ultrasonic sensor will help open and close doors automatically based on the detection of the distance of the object detected, if the distance is lower than the set distance the door opens else door closes All these state changes are informed with the help of a beep sound through the buzzer.

The system design in Figure 1 shows the inputs that are sensed through the sensor and work as the input for the system, according to the input the output is processed and the action takes place.



[Fig.1: Block Diagram for Home Automation]

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 open-source hardware or software which is used for SMH processing. It is

licensed under GNU's license so everyone can use it. There are different types of Arduino boards but here we have made use of Arduino UNO. The Arduino Uno is an important part of the ATmega328P.

Microcontroller. It has a set of digital along with analog input/output pins. It consists of 14 digital I/O pins and 6 analog I/O pins. Out of 14 digital I/O pins 6 are capable of PWM output. The setup is programmable with the help of Arduino Integrated Development Environment (Arduino IDE) through a type B USB cable. The acceptable voltage range of the system is between 7-20 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 (Arduino). It is used in breaking and connecting to a circuit and works as an electrical switch. It allows low voltage connectivity i.e., 5V provided by Arduino pins. There may be one, two, four, or eight channels in the relay module. The Relay Module is depicted in Figure 3.

If the sensor senses a decrease in the intensity of light, it switches the relay circuit and 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]

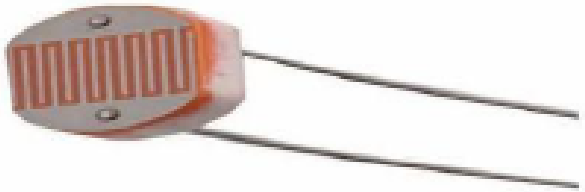
C. Ultrasonic Sensor

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 sends information 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 acts with the environment and gives us the intensity of light available as input and accordingly if the light level decreases, then it sends information to turn on the light, and when it senses the light level increases sends information 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 sensor that measures infrared light radiating from objects in its field of view. Here PIR sensors are used in PIR-based motion detectors, which on detection of movement will turn lights and fans or another convenience device on or off.

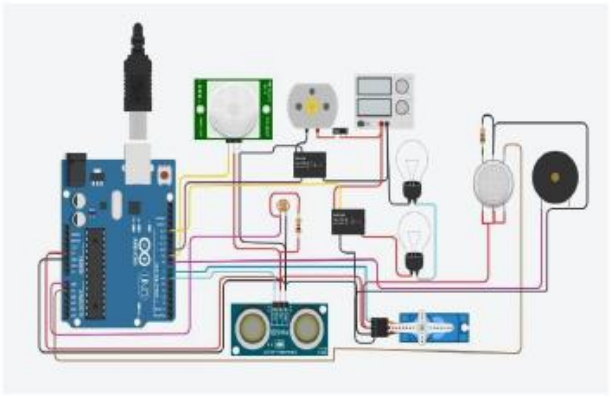
[Fig.6: PIR Sensor]

F. Smoke Sensor

A smoke sensor is a sensor that indicates if there is any smoke in the region. If there is any fire breakup then it sends the input and accordingly buzzer starts beeping continuously.

G. Software Circuit Model

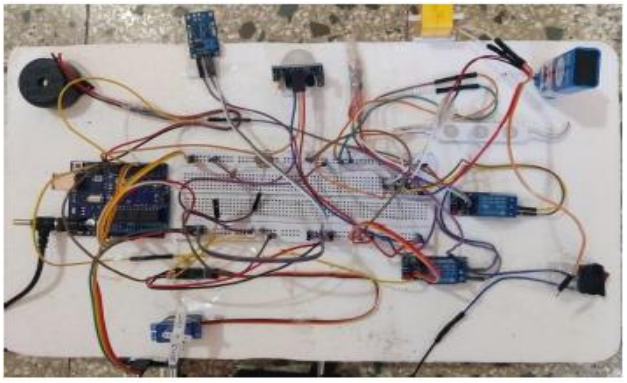
Figure 7 is the software model designed using Tinkercad where the Arduino and the sensors are configured for output presentation. This model was set up and tested to evaluate the system under practical conditions and assess its operational behavior.



[Fig.7: SMH Software Model]

H. Hardware Circuit Model

Figure 8 depicts a hardware setup for a smart home automation system where the Arduino acts as the central processing unit for the circuit and controls different sensors and actuators [12]. The control of Arduino is facilitated using the Arduino Integrated Development Environment (IDE) which provides writing, compiling, and uploading of code to the Arduino microcontroller [13]. The IDE also provides a wide range of libraries that support the integration of various sensor modules. The setup includes a breadboard, where components are interconnected without soldering, and various modules like servo motors, relays, and LEDs which are used to control and indicate the status of different devices. Sensors including PIR sensor, Ultrasonic sensor, LDR sensor, and 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 illustrates an integrated approach to home automation under the control of Arduino to enhance the functionality and convenience of a smart home environment.

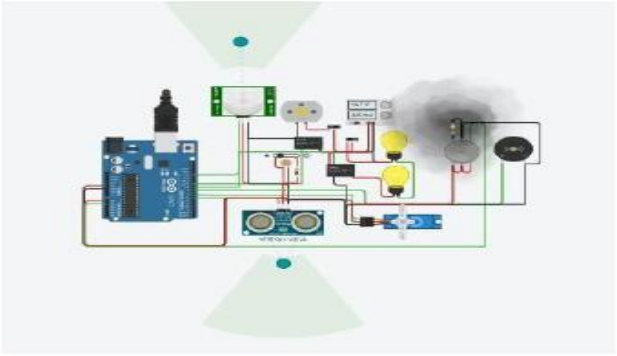


[Fig.8: SMH Hardware Model]

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 the sensors are activated based on its properties. A combination of all these sensors working together helps in better coordination between appliances and yields a sophisticated automated experience for the user.

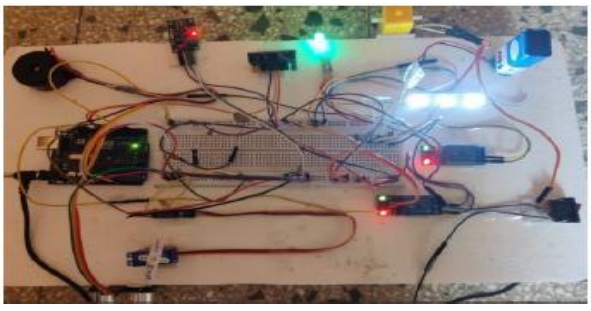


[Fig.9: Software Model Simulation Results]

B. Hardware Model Analysis

Figure 9 represents the hardware model of the Smart Home Automation System under simulation [14]. In this setup, the Arduino microcontroller manages various sensors and actuators to simulate real-world automation scenarios. The functionalities of various sensors are analyzed for instance in the model the default distance of the ultrasonic sensor the default is set to 35 cm whereas when an object distance is closer than 35 cm to the sensors, the automated door opens and closes, the automated door in the model here is represented by a servo motor connected to the ultrasonic sensor. These distances can be modified based on the requirements. The PIR sensor in the model which is connected to the LED lights and the motor which supposedly depicts fans and lights acts as a closed circuit only when the sensor detects any motion within the range. The functionality of the PIR sensor is shown in Table.

1. Similarly, to automate the light intensity and ambiance the LDR sensor is used, initially during the 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 that is greater than the threshold value the buzzer connected starts buzzing for a specified time duration alerting the emergency. Table 2. Summarizes the operation states of a smoke detection unit.



[Fig.10: Hardware Model Simulation Results]

The values specific to the individual sensors are shown in Table 1 below. The adaptability of sensor thresholds allows a tailored automation experience that ensures the system meets the diverse needs of a user. 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 implemented using the Tinkercad software simulation tool, followed by hardware implementation. The use of Arduino UNO has enabled us to control all electronic devices such as bulbs, fans, safety systems, alerts, and buzzers.

In case of fire or smoke break out. The smart home system works smoothly and intelligently to reduce human effort and save energy efficiently.

The same work can be extended by further adding SMS control with mobile alert indication, remote sensing using Bluetooth to control the system for short-range, 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 has no 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 has been conducted without any external sway.
- **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.
- **Authors 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 is geared for smart home automation toward 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 autonomously manage home functions, provide real-time user notifications, and integrate with IoT

platforms for a fully connected living experience. His research reflects a strong dedication to advancing smart solutions that improve quality of life and exemplifies his enthusiasm for integrating technology with everyday applications.

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