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IOT-BASED HOME AUTOMATION SYSTEM USING ARDUINO UNO

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Abstract

This project shows the design and prototype of a better home automation system that uses WiFi technology to connect all of its parts. The proposed system has two main parts. The first is the software, which is the Internet of Things (IoT), which is the web server through the Blynk application. This is the part of the system that monitors users' home appliances. Users and system administrators can monitor the system from close by (via LAN) or far away (via the internet). The second part is the hardware interface module, which uses an Arduino UNO to connect to sensors in the right way and is the home automation system's actuator. The system is user-friendly since it can be managed and operated easily. The system has successfully operated as expected with the implementation of multiple sensors to actuate the system's operation. The proposed system has the potential to be commercialized due to its simplicity when applied to home automation systems.

Keywords: IoT (internet of things), HAS(Home Automation System), Arduino UNO, ESP8266, Smart application.

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Introduction

These days, things are easier than they were previously because the globe is advancing at a dizzying rate. Progressively more self-automated appliances emerged in the marketplace, increasing demand for smart devices and appliances (Balaji et al., 2020; Progress et al.,2019; Shohei et al.,2015). People prefer automatic devices over manual ones due to the advancing technology that could make their lives easier. Nowadays, people live in the age of automation, where most processes are now controlled by machines. Automation systems are now widely used in a variety of industries, where they play an important role in controlling a variety of process-related operations. Internet of things-based home automation systems are progressing towards mechanization processes, in which machinery equipment controls several systems at home with less human effort. Home automation systems entail the automated control of household appliances via a variety of technologies and controllers, such as desktops, laptops, and smart phones (Mandula et al., 2015; Sri Harsha et al., 2017).

In earlier research, two prototypes for home automation using Bluetooth indoors and Ethernet outdoors are shown. Both prototypes are made with an Arduino UNO module connected to a Bluetooth module and a WiFi Ethernet module to control the outputs through a communication interface. However, the project (Mandula et al., 2015) used many LEDs to look like different appliances, such as lights, a TV, a fan, and a washing machine. Due to that, the results obtained are quite unreliable.

The Arduino UNO microcontroller is widely used in much research relating to home automation systems or smart home systems (Iman et al., 2017). This is due to its simplicity and ease of use, other than its lower cost (Sri Harsha et al., 2017). Some works used Arduino UNO and Raspberry Pi, as well as voice commands such as Google Voice, Apple HomeKit, Alexa, and REST architecture to be constructed as home automation systems (Panwar et al., 2017; Garg et al., 2017). Based on the study in (Posholi et al., 2022), a system is designed and implemented to achieve this home control using the

concepts of IoT. The system allows the user to remotely monitor sensors and control loads in his home on a mobile via Blynk application and also Google Assistant using voice command control. The system is implemented using NodeMCU ESP8266 Wi-Fi module, Arduino Uno, 4 channel relay module, temperature sensor (DHT 11), LDR and PIR sensor. Another study was conducted in (Harsha et al., 2022), where the project is about a highly featured home automation system that incorporates a Raspberry Pi, Arduino UNO, Camera Module, a 7-inch LCD panel, and various other sensors. This model's main features include a gas leak detection system, an intrusion detection system, light control, real-time weather reports, a music player, and an image viewer.

In this work, it consists of two elements which are the software and the hardware interface modules. The software is an application of the web server, or Blynk Application, which is used to monitor the porch lighting of the house. While the hardware interface module consists of three main components, which are the sensors, control devices (Arduino UNO) and actuators. The sensors function to sense or detect data and send the signal to the main controlling device, which is the Arduino UNO. Once Arduino UNO receives the signal from the sensors, it actuates the outputs connected based on the programmed system. Actuators are the final operating devices that control the appliances in the home. This work is to be implemented for the porch lighting, control the fan in the living hall and turning on the exhaust fan in the kitchen of the house. A home automation system simplifies the operation of various household appliances while still conserving electricity. Home automation or building automation, which is based on the energy-saving principle, has made life much easier in recent years.

Methods

System Architecture

The development of this project is divided into two main parts, which are hardware architecture and software development. Both the hardware and software parts play an important role in making this system work properly and effectively. Figure 1 below shows the block diagram of the project.

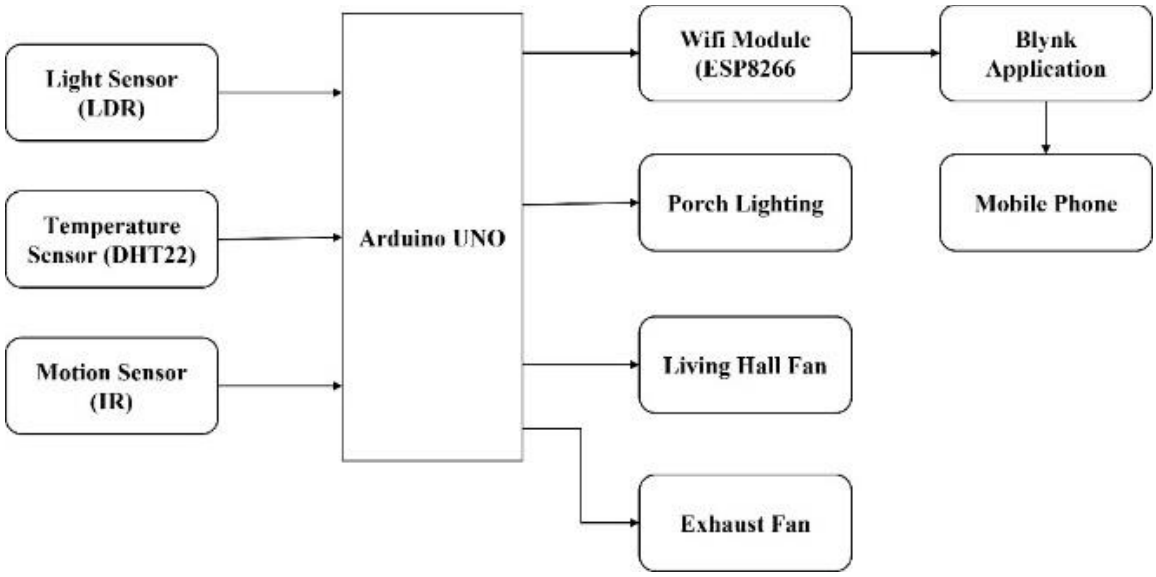


Figure 1. Block Diagram

Flowchart of IoT-Based Home Automation System

The flowchart in Figure 2 shows that, once the system is turned on, the LDR sensor continuously detects the light intensity and automatically turns on the porch lighting if there is insufficient light detected when the resistance is below 160Ω. Once the porch lighting is turned on, a notification is automatically sent to the owner's smartphone through the Blynk application for monitoring purposes. As for the temperature sensor (DHT22), if the temperature exceeds the limit, which is 30˚C, it will automatically turn on the exhaust fan. The DHT22 is mounted in the kitchen to ensure good airflow whenever the user uses the stove for cooking. Finally, for the motion sensor (IR), it will automatically turn on the fan in

the living room if motion is detected within its range, which is 6 cm.

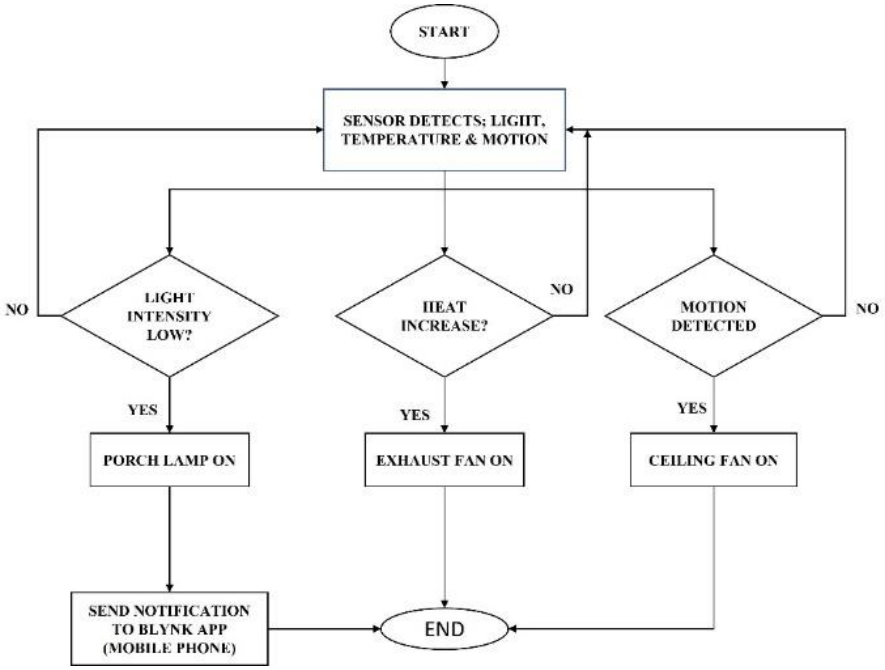


Figure 2. Flowchart of Project.

Home Automation System Component

The project consists of important hardware components and constructions. Those include the microcontroller board, which is the Arduino UNO, a light-dependent resistor (LDR), IR sensor, a temperature and humidity sensor, and a WiFi module.

1) Arduino UNO: The Arduino UNO is a microcontroller board based on the AT-mega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The UNO differs from all preceding boards in that it does not use the FTDI USB-to-Serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. The UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. "UNO" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The UNO board and version 1.0 of the Arduino software (IDE) were the reference versions of Arduino; they have now evolved into newer releases. The UNO board is the first in a series of USB Arduino boards.

2) LDR Sensor Module: A LDR sensor module is used to detect the intensity of light. It is associated with both an analogue output pin and a digital output pin, labelled as AO and DO, respectively, on the board. When there is light, the resistance of LDR will decrease according to the intensity of the light.

3) IR Sensor: An infrared sensor (IR sensor) is a radiation-sensitive optoelectronic component with a spectral sensitivity in the infrared wavelength range 780 nm–50 µm. IR sensors are now widely used in motion detectors, which are used in building services to switch on lamps or in alarm systems to detect unwelcome guests.

4) DHT22: The DHT22 is a basic digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin, no analogue input pins needed.

5) ESP8266: The ESP8266 WiFi Module is a self-contained SOC with an integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions to another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning you can simply hook this up to your Arduino device and get about as much WiFi-ability as a WiFi Shield offers (and that's just out of the box)! The ESP8266 module is an extremely cost-effective board with a huge, and ever-growing, community. This module has powerful enough on-board processing and storage capabilities to allow it to be integrated with the sensors and other application-specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, including the front-end module, which is designed to occupy minimal PCB area. The ESP8266 supports APSD for VoIP applications and Bluetooth co-existence interfaces; it contains a self-calibrated RF, allowing it to work under all operating conditions and requiring no external RF parts. There is an almost limitless fountain of information available for the ESP8266, all of which has been provided by amazing community support. In the Documents section below, you will find many resources to aid you in using the ESP8266, even instructions on how to transform this module into an IoT (Internet of Things) solution.

Software development

In the software development, there are two software used, which are Proteus and Arduino Programming. Proteus is one of the free simulation tools that can be used as a platform for project research, especially for microcontroller purposes. Figure 3 below shows the construction of an IoT-based Home Automation System using Proteus. The LDR sensor has two pins on it, one pin is connected to VCC (power) 5V, another pin is connected to GND (ground) through a 1kΩ resistor. Between the resistor and GND pin, there is a wire loop to connect the A0 pin at the Arduino. Next, the IR sensor has three pins, which are GND, OUT, and VCC. The OUT pin is connected to pin 3 at the Arduino, and VCC is connected to the 3.3V power supply. After that, the DHT22 sensor has three pins. DATA/OUT pin is connected to pin 4 at Arduino, and VCC is connected to the 5V power supply. For LDR output, LEDs have two pins, which are anode (+) and cathode (-). The anode is connected to pin 10 of the Arduino through a 330 resistor, and the cathode is connected to the GND. Meanwhile, the IR sensor's output is the living room fan. The live wire of the fan is connected to pin 12 of the Arduino, and the other wire is connected to the GND. The DHT22 sensor's output is an exhaust fan. It has two wires, one of which is the live wire, which is connected to pin 10 on the Arduino, and the other wire is connected to GND. The Arduino UNO Board needs to be programmed using Arduino programming to give instructions to the PCI on how they need to work. The programming is very crucial because the programming code will instruct the microcontroller to make decisions when receiving signal from sensors.

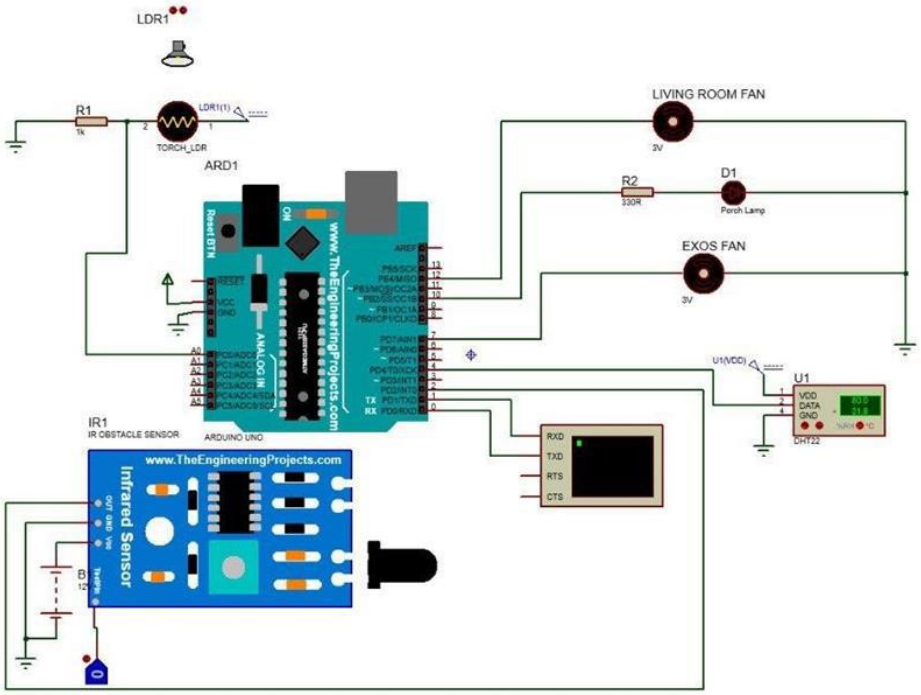
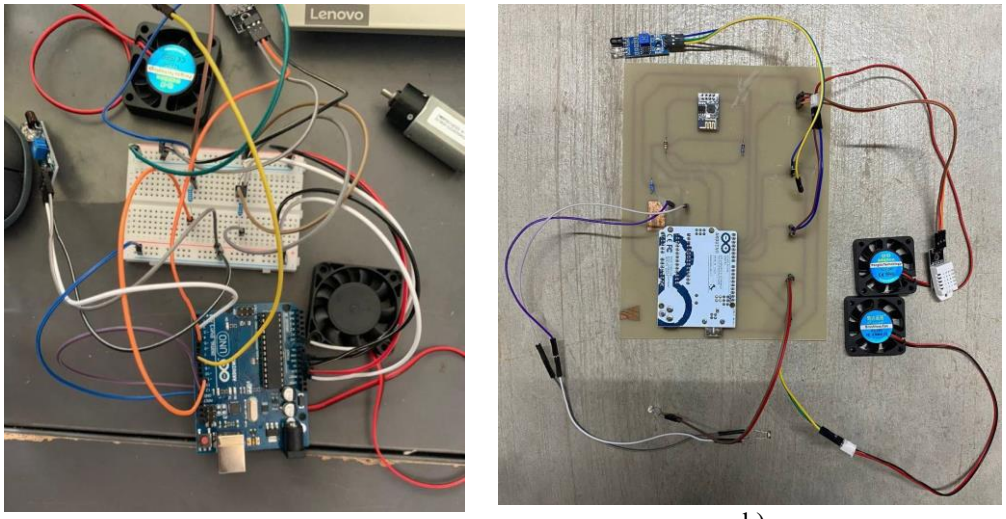


Figure 3. Schematic Diagram of Overall Project

Hardware development

This project is based on a mobile application called Blynk and an Arduino UNO. The WiFi module is used to send and receive data wirelessly. It is a simple and flexible home automation system with few electronic parts and no soldering. In this paper, the concept of home automation using the IoT is realised using a microcontroller-based Arduino board and an Android mobile phone. Since mobile phones are wireless communication devices, WiFi is used to connect the Arduino to the smart phone.

A suitable Wi-Fi based Android application, Blynk, is used because it has a user-friendly interface and can work efficiently with Arduino to monitor home appliances via smart phone. The Blynk application could be characterised as creating one or more projects. Each project can contain graphical widgets, like virtual LEDs, buttons, value displays, and even a text terminal, and can interact with one or more devices. The Arduino controller is programmed to interact with the Blynk application. The Wi-Fi module (ESP8266), light sensor (LDR), temperature sensor (DHT22), and motion sensors (IR) are connected directly to the Arduino microcontroller as shown in Figure. 4. Once home appliances are connected to the Arduino board, they can be controlled and monitored easily using the Blynk application on any enabled smart phone.



a) b)

Figure 4. a) Breadboard component construction, b) PCB Board component construction

Result and Discussion

After building the hardware part successfully, it is tested. All results met expectations and are written down in Table 1. The prototype shown in Figure 5 turned out to function properly and as expected. After establishing a connection with the WiFi module (ESP8266), the dedicated home appliances could be monitored wirelessly. The objectives of this project have been successfully achieved to monitor home appliances remotely using the Blynk application. The system design and architecture discussed are represented by the prototype construction, and the basic level of home appliance remote monitoring has been implemented.

Based on the results recorded in Table 1, the light intensity of the LDR sensor is set to turn on the porch lighting once the resistance reaches a value below 160Ω. It is shown that at 160-200Ω, the lighting is turned off. Furthermore, the temperature sensor DHT22 can measure the temperature and automatically turn on the exhaust fan in the kitchen for better ventilation whenever the temperature approaches 30˚C. The motion sensor (IR) could also detect if there is any motion in the living room area within a range below 6cm and automatically switch on the fan. The distance of the motion sensor is programmed to turn on the fan at a shorter distance due to the small-scale construction of the prototype. For real-time application, a suitable distance could be set based on the area of the living room.

Figure 5. Prototype of IoT-Based Home Automation System

Table 1. Experimental Result of Sensors Table Type Styles

LDR Sensor		IR Sensor		DHT22	
Light Intensity	LED	Distance	Living Hall Fan	Temperature	Exhaust Fan
200Ω	OFF	10 cm	OFF	24˚C	OFF
180Ω	OFF	8 cm	OFF	26˚C	OFF
160Ω	OFF	6 cm	OFF	28˚C	OFF
140Ω	ON	4 cm	ON	30˚C	ON
120Ω	ON	2 cm	ON	32˚C	ON

Conclusion

In conclusion, a home automation system integrates household electrical appliances with each other. The techniques utilised in home automation include those used in building automation as well as the control of domestic activities such as TV, fans, electric tubes, refrigerators, and washing machines. After some studies on previous research and other existing works, better understanding, and ideas regarding the environmental conditions in a household are gained. The main objective of this project is to eliminate most of the human interaction and effort involved in controlling the home appliances by providing intelligent systems. Other than that, by using multiple sensors to activate or deactivate the appliances, energy could be saved.

For future recommendation, Node MCU is suggested to be utilized in order to build this project. Node MCU it is an open-source platform based on ESP8266 which can connect objects and let data transfer using the Wi- Fi protocol. In addition, by providing some of the most important features of microcontrollers such as GPIO, PWM, ADC, and etc, it can solve many of the project's needs alone. Other than that, more appliances could be connected as the output to be controlled in the system. In this project, the WiFi module is applied to send signal for notification via Blynk Application for monitoring purposes only. Hence, in future advance feature on controlling the activation of the appliances through the Blynk Application could be implemented.

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Author Contribution

Mohammad Ammar Aiman Hashim - project implementation, data curation; Mohamad Aiman Mohd Fauzi - project implementation, data curation; Mazratul Firdaus Mohd Zin - Supervision, Writing – review &editing; Ku Siti Syahidah Ku Mohd Noh – review & editing.

Conflict of Interest

Authors declare no conflict of interest.

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