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Home Security and Energy Efficient Home Automation System using Arduino

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Abstract - This paper presents a low-cost and efficient smart home automation system for energy management, security surveillance, and safety monitoring. The proposed system is designed to provide intelligent control of household appliances while reducing energy consumption and improving user convenience. An integrated micro web server with Internet Protocol (IP) connectivity enables remote monitoring and control of home devices through an Android-based smartphone application.The system utilizes multiple sensors such as a Light Dependent Resistor (LDR), temperature sensor, gas sensor, and Passive Infrared (PIR) motion sensor to automate appliance operations. The LDR controls lighting based on ambient light intensity, while the temperature sensor regulates fan speed or switching according to room temperature. The gas sensor detects leakage or hazardous gases and generates alerts to prevent accidents such as fire hazards.For security surveillance, an ESP32-CAM module is incorporated to capture images whenever motion is detected by the PIR sensor. The captured images are automatically sent to the authorized user through email for real-time monitoring. Experimental results demonstrate that the proposed system provides reliable performance, energy efficiency, enhanced safety, and cost-effectiveness. Hence, it is a suitable solution for modern smart homes and remote home management applications.

IndexTerms - Home Automation, Smart Home, Energy Management, ESP32-CAM, IoT, Android Application, Remote Monitoring, Security Surveillance, Gas Leakage Detection, PIR Sensor, LDR Sensor, Temperature Sensor.

I. INTRODUCTION

The Rapid Growth Of The Internet Of Things (Iot) Has Enabled Smart Home Technologies That Improve Convenience, Energy Efficiency, And Security. Home Automation Systems Allow Automatic Control Of Appliances And Remote Monitoring Through Smartphones.However, Many Existing Systems Have Drawbacks Such As High Installation Cost, Complex Configuration, And Limited Scalability. To Overcome These Issues, This Paper Proposes A Low-Cost Intelligent Home Automation System Using Arduino.The System Integrates PIR, Temperature, And Ultrasonic Sensors For Smart Operation. PIR Sensors Detect Human Presence For Automatic Lighting Control, Temperature Sensors Regulate Fans And Indoor Climate, While Ultrasonic Sensors Detect Obstacles Or Nearby Movement. The System Also Supports Remote Access And Monitoring Through Mobile Devices.The Proposed Solution Offers Energy Savings, Enhanced Security, Ease Of Use, And Cost-Effectiveness, Making It Suitable For Modern Residential Applications.

II. LITERATURE SURVEY

Several researchers have proposed smart home automation systems to improve energy efficiency, security, and user convenience using IoT technologies. Arduino-based automation systems integrated with PIR, temperature, and light sensors have shown effective control of lighting, fans, and household appliances while reducing power consumption. Wireless communication technologies such as Wi-Fi, Zigbee, and Bluetooth are widely adopted for remote monitoring and control due to their low cost and reliability. Raspberry Pi-based systems provide advanced processing capabilities for surveillance and real-time data management. Recent studies have also introduced machine learning techniques for intelligent energy optimization and secure communication methods to protect against cyber threats. Although existing systems offer significant benefits, many still face challenges such as high installation cost, limited scalability, complexity, and maintenance issues. Therefore, there is a need for a simple, affordable, and efficient smart home automation system with enhanced security and energy management features..

III. METHODOLOGY

3.1. EXISTING SYSTEM:

An embedded board physically connected all the home automation devices and, through integration with a personal computer (PC) based web server, provided remote access to the system. The use of Java technology, which incorporates built-in network security features, produces a secure solution. However, the system requires an intrusive and expensive wired installation and the use of a high end PC. [3] introduced a Bluetooth based home automation system, consisting of a primary controller and a number of Bluetooth sub-controllers. Each home device is physically connected to a local Bluetooth sub-controller. The home devices

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communicate with their respective sub-controller using wired communications. From the sub-controller all communications are sent to the primary controller using wireless communications. It is desirable for each home device to have a dedicated Bluetooth module. However, due to the fiscal expense of Bluetooth technology, a single module is shared amongst several devices. This architecture reduces the amount of physical wiring required and hence the intrusiveness of the installation, through the use of wireless technology. However, the architecture does not completely alleviate the intrusiveness of the installation due to the incorporation of some wired communications. Moreover the sharing of a single Bluetooth module between numerous devices has the disadvantage of incurring an access delay.

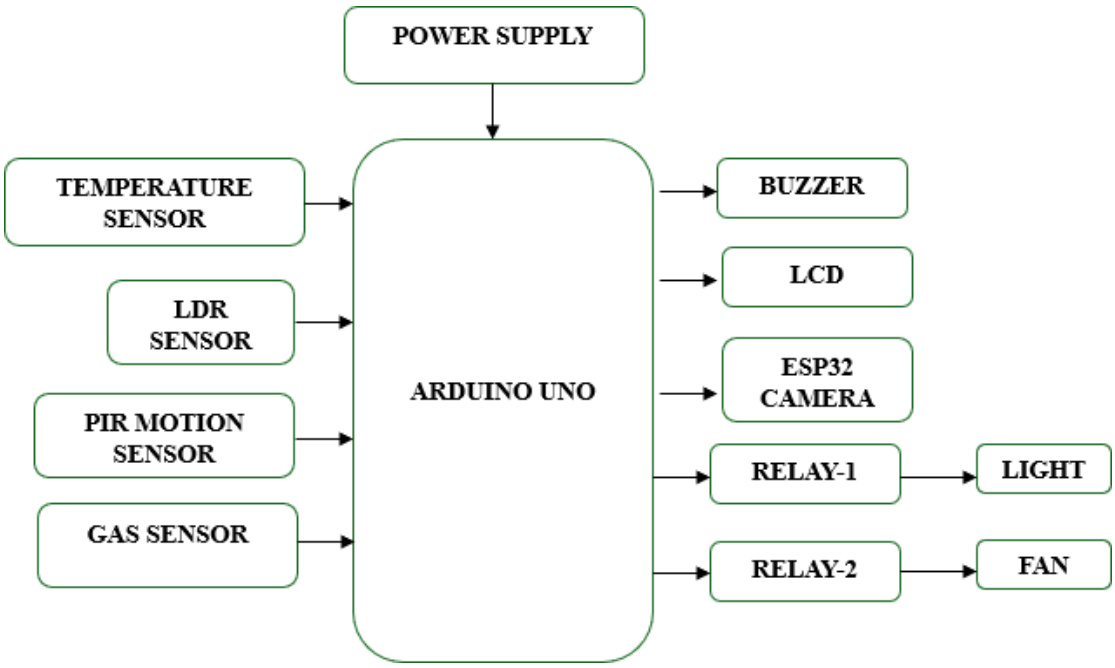
Disadvantages of Existing System

1. **High Cost** – Existing systems require expensive hardware components and installation charges.
2. **Complex Architecture** – The design and setup are complicated, making it difficult for common users to operate.
3. **Wired Installation** – Most systems need extensive wiring, which increases maintenance and reduces flexibility.
4. **Limited Scalability** – Adding new devices or upgrading the system is difficult.
5. **Lack of Network Interoperability** – Different devices may not communicate properly with each other.
6. **Interface Inflexibility** – User interfaces are not simple or user-friendly.
7. **Access Delay** – Shared communication modules like Bluetooth may cause delays in controlling appliances.
8. **Poor Security Features** – Existing systems may not provide strong protection against unauthorized access.
9. **No Energy Optimization** – Many systems focus only on control, not on saving electricity efficiently.
10. **No Advanced Surveillance** – Limited support for motion detection, camera alerts, or email notifications.

3.2. PROPOSED SYSTEM:

Electricity is essential for all modern-day activities, and conserving energy has become a major challenge in the present situation. Existing systems do not effectively combine home security and energy efficiency at a low cost. To overcome these drawbacks, the proposed system is designed to provide both security and energy-saving features in a single smart solution using Arduino. The system helps common users by reducing energy wastage and improving home safety. It consists of two important modules: the home security system module and the energy efficiency system module. In the home security module, a PIR motion sensor is used to detect any intrusion or unauthorized movement. Whenever motion is detected, the ESP32 camera captures the image of the intruder and sends it to the authorized user's email for immediate alert and monitoring. In the energy efficiency module, the system provides intelligent control of lamps and fans. The Light Dependent Resistor (LDR) sensor is used for automatic lamp control based on surrounding light intensity, while the temperature sensor controls the operation of the fan according to room temperature. A gas sensor is also used to detect harmful gas leakage and provide safety alerts. Thus, the proposed system offers a low-cost, reliable, and efficient solution for smart home automation by integrating security, safety, and energy management features.

BLOCK DIAGRAM:



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HARDWARE REQUIREMENTS:

- Arduino uno
- Lcd
- Esp32 camera
- LDR SENSOR
- PIR MOTION SENSOR
- GAS SENSOR
- TEMPERATURE SENSOR

SOFTWARE REQUIREMENTS:

- ARDUINO IDE
- C LANGUAGE

3.3 PROJECTED IMAGE:

The image shows the **hardware prototype of a Home Security and Energy Efficient Home Automation System using Arduino** mounted on a wooden base. It is a practical implementation of a smart home project designed to provide automatic control of appliances and security monitoring.

At the center of the setup, the **Arduino Uno** board acts as the main controller that receives data from different sensors and controls the connected output devices. On the left side, a **16x2 LCD display** is used to show system status messages such as sensor readings, motion detection, gas alerts, or device conditions. On the top right side, a **power supply circuit with transformer** is used to convert AC power into regulated DC power required for the Arduino and sensors. Several sensors are connected in the system. The **PIR motion sensor** detects human movement or intrusion for security purposes. The **temperature sensor** monitors room temperature and automatically controls the fan. The **LDR sensor** senses surrounding light intensity and is used for automatic lamp control. A **gas sensor** can detect harmful gas leakage and trigger alerts. Relay modules are also connected to switch household appliances like bulbs and fans ON or OFF automatically.Overall, this prototype demonstrates a **low-cost smart home automation system** that combines security, safety, and energy management features using Arduino technology.

Advantages

- **Low Cost System** – Uses affordable components like Arduino and sensors, making it economical.
- **Energy Efficient** – Automatically controls lights and fans, reducing power wastage.
- **Enhanced Security** – PIR sensor detects intrusion and alerts the user.
- **Remote Monitoring** – ESP32 camera captures images and sends them through email.
- **Automatic Appliance Control** – Lamps and fans operate automatically based on sensor inputs.

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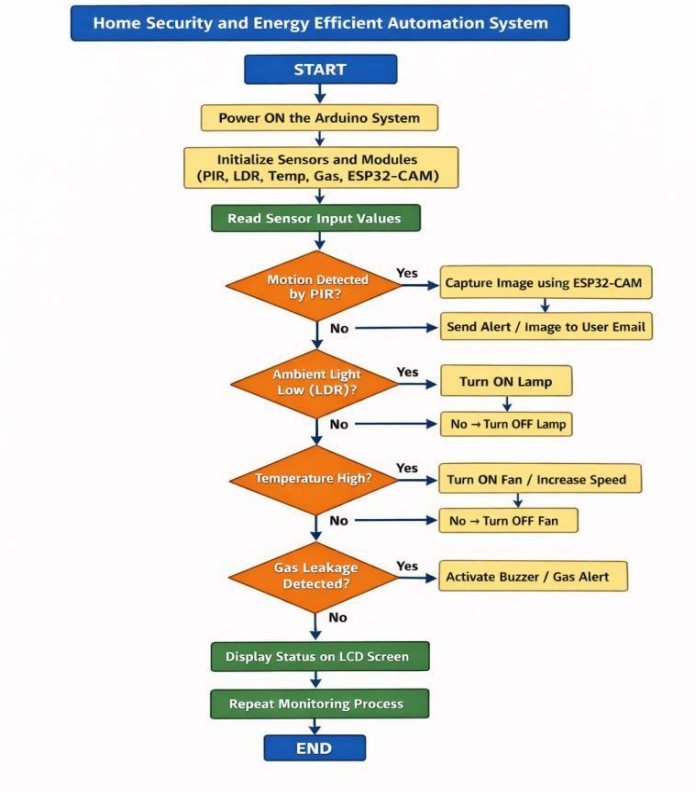
- **Gas Leakage Detection** – Gas sensor improves safety by detecting harmful gas leakage.
- **User Friendly** – Easy to operate and monitor using simple controls.
- **Reliable Performance** – Sensors provide continuous monitoring and quick response.
- **Reduced Human Effort** – Appliances are controlled automatically without manual operation.
- **Expandable Design** – Additional sensors and smart devices can be added in future.

3.4 FLOW CHART

The flow chart illustrates the working process of the Home Security and Energy Efficient Home Automation System using Arduino. The system begins by powering ON the Arduino controller and initializing all connected sensors and modules such as PIR sensor, LDR sensor, temperature sensor, gas sensor, LCD display, and ESP32-CAM. After initialization, the controller continuously reads input values from all sensors. If the PIR sensor detects motion, the ESP32-CAM captures an image and sends an alert message or image to the user through email for security monitoring. Next, the LDR sensor checks ambient light intensity; if the light level is low, the lamp is automatically switched ON, otherwise it remains OFF. The temperature sensor then monitors room temperature, and if the temperature is high, the fan is turned ON or its speed is increased, otherwise it is turned OFF. The gas sensor checks for gas leakage, and if harmful gas is detected, a buzzer or alert system is activated for safety. Finally, the system displays all current status information on the LCD screen and repeats the monitoring process continuously, ensuring automatic control, security, and energy efficiency.



IV. RESULTS&DISCUSSOIN RESULT:

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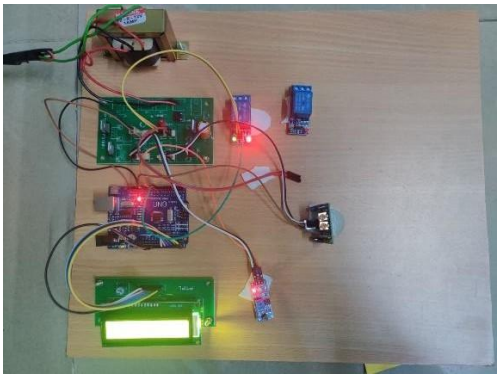

DISCUSSION:

The proposed Home Security and Energy Efficient Home Automation System using Arduino is designed to provide a cost-effective and intelligent solution for modern households by integrating automation, security, and energy management into a single platform. The system uses an Arduino Uno as the main controller, which continuously monitors inputs from various sensors such as PIR for motion detection, LDR for light intensity, temperature sensor for climate control, and gas sensor for safety. Based on the sensor data, the system automatically controls household appliances like lights and fans, thereby reducing energy consumption and improving efficiency. For security purposes, the PIR sensor detects human movement and triggers the ESP32-CAM module to capture images and send them to the user via email, enabling real-time monitoring. Additionally, the gas sensor ensures safety by detecting harmful gas leaks and generating alerts. This system not only minimizes human effort but also enhances convenience, safety, and energy savings, making it an ideal solution for smart home applications.

Applications

- Neonatal Intensive Care Units (NICU)
- Rural healthcare centers
- Home monitoring of newborns
- Smart hospitals
- Telemedicine support systems

V. CONCLUSIONS

The IOT facilitates numerous benefits to the society and from our paper we can provide and prove the strength of IOT that is capable to contribute the services for the purpose of building vast no. of applications and help to implement them on the public platform. This design provides moderate and less expensive way of sensing, monitoring and controlling system in the field of domestic and as well as industrial standard to implement IOT. At a final note, we conclude that IOT leads to become universal in every aspect. This paper will be very beneficial in our normal day to day life and will bring much needed innovation in his fast changing world of technology where people prefer to have control over things using the smartphones which will bring ease to their routine life.

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