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MICROCONTROLLER BASED SECURITY SYSTEM IN EDUCATIONAL SECTOR

Microcontroller-Based Smart Classroom Security System with Intelligent Lighting, Temperature Monitoring, and Automatic Fire Suppression.

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Abstract: Due to the constant usage of lighting systems, ceiling fans, lab equipment, and other electrical appliances, educational institutions use a large amount of electricity. Even when classrooms are empty, lights and fans are frequently left on, which wastes energy and raises operating expenses. Students, faculty, and institutional infrastructure are all at significant danger from fire hazards brought on by electrical malfunctions. Intelligent automation technologies that increase safety and energy efficiency are therefore becoming more and more necessary. an Arduino Uno microcontroller-based automatic security system for the educational sector. In order to provide intelligent classroom automation and fire prevention, the suggested system includes a Light Dependent Resistor (LDR), LM35 temperature sensor, fire sensor, relay module, buzzer, AC bulb, AC fan, and water pump.

A person's presence within the classroom is detected by the PIR sensor. The Arduino uses the LDR sensor to measure the ambient light intensity after occupancy is detected. The relay module automatically turns on the AC light if the classroom is dark. The lights stay off when there is enough natural light, saving electricity. The room temperature is continuously monitored by the LM35 temperature sensor. Only when two conditions are met at the same time—a human presence is detected and the room temperature is higher than 30°C—is the fan turned on. A fire sensor constantly scans the surroundings for fires to increase safety. When the Arduino detects a fire, it quickly sounds a buzzer to warn the residents. Then, using a relay module, it turns on a water pump to put out the fire. The water pump and buzzer are both automatically turned off after the fire is put out.

Index Terms - PIR sensor, LM35, LDR, fire sensor, relay module, energy conservation, Arduino Uno, smart classroom, embedded system, and educational automation.

I. INTRODUCTION

Intelligent automation systems that can minimize human labor, save electricity, and increase safety have been made possible by the quick development of embedded systems and sensor technology. Because lighting systems, ceiling fans, projectors, laptops, and lab equipment run all day, educational institutions are among the biggest users of electricity. These electrical appliances are operated manually in many establishments. Because of this, lights and fans frequently stay on even after classrooms are empty, resulting in wasteful energy use and higher electricity expenses.

In addition to energy waste, electrical short circuits, overheating, and unintentional fires present safety risks for educational facilities. The primary function of conventional fire safety systems is to sound alarms, but they also need human involvement to put out a fire. In addition to posing major threats to students and staff, a delayed response could result in damage to important infrastructure, papers, and equipment. Microcontroller-based automation provides a practical answer to these issues. It is feasible to autonomously manage electrical appliances and monitor occupancy, ambient conditions, and fire threats in

real time by integrating sensors with a programmable controller. These solutions enhance comfort, safety, and operational effectiveness in addition to lowering energy usage.

The central processing unit of the suggested Microcontroller-Based Automatic Security System for Educational Sector is an Arduino Uno microcontroller. The system integrates temperature-based fan operation using an LM35 sensor, automatic lighting control using an LDR sensor, and occupancy detection using a PIR sensor. A flame sensor and relay modules are used for automatic fire detection with a buzzer and water pump activation. The suggested solution combines energy management and fire protection into a single embedded platform, in contrast to many traditional automation systems that concentrate on a single feature. This integration offers a cost-effective solution appropriate for schools, colleges, universities, labs, and libraries while minimizing human intervention, lowering electricity usage, and improving classroom safety.

II. LITERATURE REVIEW

Due to rising energy consumption, safety concerns, and the requirement for intelligent infrastructure, automation in educational institutions has received a lot of attention. Using microcontrollers and sensors, researchers have created a variety of embedded systems to enhance security and automate electrical appliances. The most pertinent research on energy management, occupancy detection, temperature-based control, fire safety, and smart classroom automation is reviewed in this part.

A. Intelligent Energy Management Systems - Arduino-based automation systems have been suggested by a number of researchers as a way to lower building electricity use. These systems mostly use PIR sensors to detect human presence and turn on or off electrical equipment automatically. The findings show that by avoiding needless lighting system operation, energy consumption can be significantly reduced. Nevertheless, the majority of current systems merely take occupancy into consideration; ambient light conditions are not taken into account. As a result, lights could stay on even when there is enough natural light.

B. LDR-Based Automatic Lighting Control -Light Dependent Resistor (LDR) sensors have been widely used in automatic lighting systems for homes, offices, and streets. These systems gauge the amount of light in the area and adjust lighting fixtures accordingly. Despite increasing energy efficiency, LDR-based devices typically disregard human occupancy. In an empty room, lights might stay on just because it's dark outside. Overall energy savings are decreased by this restriction.

C. Fan Control Based on Temperature - The LM35 temperature sensor is used by a number of embedded systems to automatically control fans. Every time the temperature in the room rises above a certain point, the fan is turned on. These systems preserve thermal comfort, although they frequently overlook occupancy. Even when the room is empty, the fan keeps running, wasting electricity.

D. Systems for detecting fires -To identify dangerous situations, fire detection systems often use temperature, smoke, or flame sensors. Many commercial systems have audio alerts, but they rely on human intervention to put out the fire. Automatic fire suppression techniques are a feature of some sophisticated systems, although they are costly and consequently less appropriate for small educational institutions.

E. Intelligent Automation in Classrooms - Smart classrooms that incorporate appliance management, environmental monitoring, and occupancy detection are the subject of recent study. These systems enhance learning settings and increase energy efficiency. Nevertheless, a lot of published systems don't include integrated fire detection and automatic suppression features..

III. SYSTEM DESIGN

For classrooms, labs, libraries, and other educational settings, the suggested Microcontroller-Based Automatic Security System for Educational Sector is intended to offer an intelligent, automated, and energy-efficient solution. Based on the presence of people, the amount of light in the room, and the temperature, the system automatically regulates the functioning of electrical appliances. The system's main goals are to decrease manual electrical device operation, increase user comfort, and improve energy conservation. An Arduino Uno serves as the project's primary processing unit and controls the entire system. The PIR motion sensor, LDR (Light Dependent Resistor), and LM35 temperature sensor all provide constant input signals to the Arduino. These sensors gather temperature, light intensity, and room occupancy data in real time. The Arduino processes these inputs and uses a relay module to control the linked AC lamp and AC fan based on the logic that has been programmed. Electrical appliances may now operate automatically without the need for human interaction thanks to this design. Motion detection is the

system's initial step. By identifying variations in the infrared radiation that the human body emits, the PIR (Passive Infrared) sensor continuously scans the environment for the presence of a person. The PIR sensor instantly detects movement when someone enters the room and transmits a digital signal to the Arduino Uno. After interpreting this signal as room occupancy, the Arduino starts running the lighting and fan control algorithm. The Arduino prevents needless power use by keeping all connected electrical appliances turned off if it detects no motion, assuming the room is empty.

After motion is detected, the Arduino uses the LDR sensor to measure the amount of light in the area. Depending on how much light strikes its surface, the LDR adjusts its resistance. The LDR has a high resistance in the dark and a lower resistance in the light. After reading this analog value, the Arduino decides whether artificial lighting is necessary. The Arduino activates the relay module, which turns ON the AC bulb, if there isn't enough natural light in the space. If there is already enough light in the space, The Arduino maintains the AC bulb OFF and the relay de-energized. During the day, this automated lighting control helps cut down on wasteful electricity use. Simultaneously, the Arduino uses the LM35 temperature sensor to continuously check the room temperature. The output voltage of the LM35 is directly proportional to the ambient temperature in degrees Celsius. This value is read by the Arduino, which then compares it to the 30°C predetermined threshold temperature. Two factors determine the fan control. The temperature of the room must be higher than 30°C, and the PIR sensor must first detect human presence. The Arduino triggers another relay module, which turns ON the AC fan, when both requirements are met. If the temperature in the room is 30°C or lower Even when someone is there, the relay stays off and the fan doesn't run. By ensuring that the fan only runs when cooling is truly necessary, this dual-condition logic increases energy efficiency.

The suggested system's output control stage is made up of the relay module. The AC lamp and AC fan run on 230 V AC, whereas the Arduino Uno runs on 5V DC. Therefore, it is not possible to directly connect the Arduino to these appliances. Relay modules are therefore employed as electrically separated switches. The relay reliably turns on or off the high-voltage AC equipment when the Arduino provides it a low-voltage control signal.

IV. METHODOLOGY

Microcontroller-Based Automatic Security System for Educational Sector uses sensors interfaced with an Arduino Uno to automatically monitor classroom occupancy, light intensity, and room temperature. By dynamically adjusting the AC fan and lamp based on human presence and environmental factors, the technology is intended to lower electricity usage and create a comfortable environment. The PIR motion sensor, LDR (Light Dependent Resistor), LM35 temperature sensor, and relay modules are among the connected components that the Arduino Uno first powers on and initializes. The Arduino continuously runs the control program and keeps an eye on every sensor's output in real time. Motion detection is the methodology's initial phase. The surrounding area's infrared radiation is continuously detected by the PIR sensor. The PIR sensor senses movement when someone enters the room and transmits a digital signal to the Arduino Uno. The Arduino keeps the AC fan and light bulb turned off if it detects no motion, assuming the room is empty. When the classroom is empty, this stops needless electricity use. The Arduino uses the LDR sensor to measure the light intensity once motion has been detected. The LDR gauges how much light is present in the space. The Arduino triggers the relay module to turn on the AC bulb if the light intensity falls below the predetermined threshold, signifying that the space is dark. The Arduino, however, keeps the lightbulb off if there is already enough artificial or natural light. The effective use of electricity is ensured by this automated lighting control.

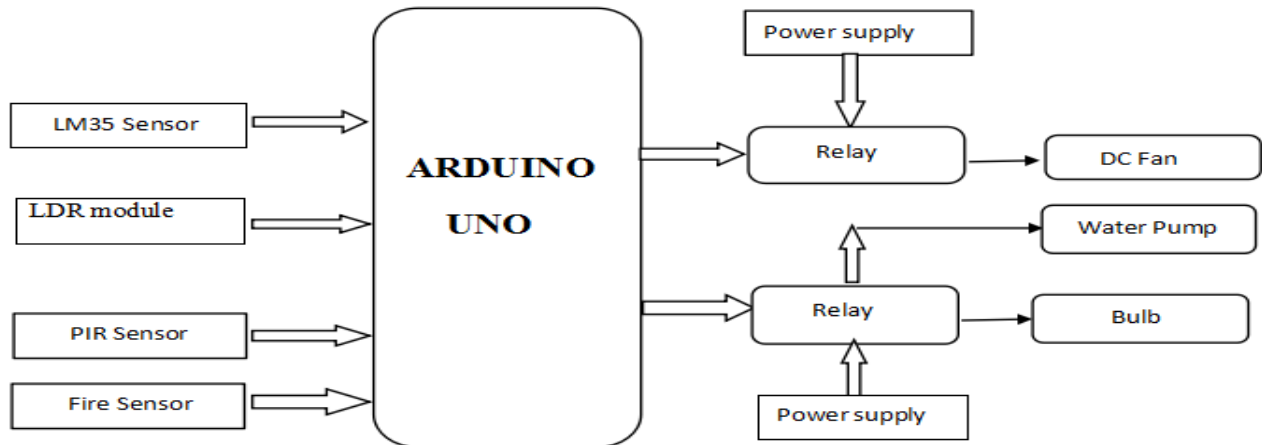
The LM35 temperature sensor is then used by the Arduino to determine the room temperature. The Arduino receives the corresponding analog voltage from the sensor, which continuously detects the surrounding temperature. The measured temperature and the predetermined threshold value of 30°C are compared by the Arduino. The Arduino activates the relay module to turn on the AC fan if the temperature is higher than 30°C and the PIR sensor has already detected motion. The fan stays off even when someone is around if the temperature is 30°C or lower. This dual-condition logic increases energy efficiency and stops the fan from operating needlessly. The high-voltage AC appliances and the low-voltage Arduino circuit are connected via the relay modules. Without requiring a direct electrical connection between the microcontroller and the AC supply, the Arduino sends control signals to the relay modules, which securely turn the AC fan and light on or off.

This monitoring procedure is repeatedly carried out in a loop by the Arduino. It periodically updates the outputs based on the status of the PIR, LDR, and LM35 sensors. Regardless of room temperature or light intensity, the Arduino automatically deactivates the relay modules and turns off the

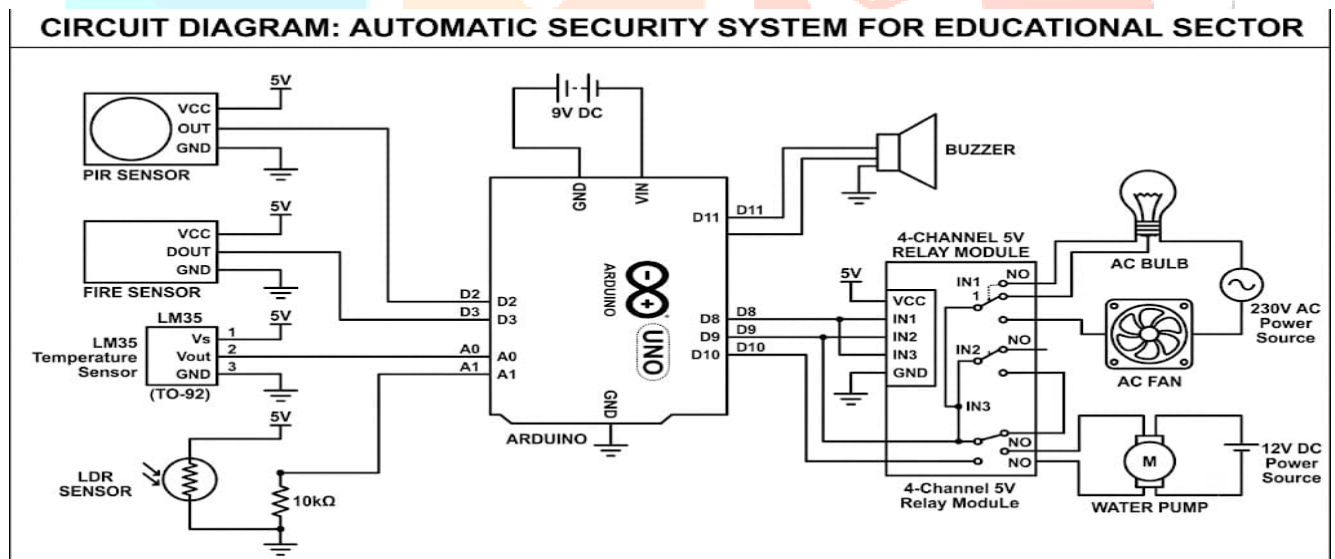
AC fan and bulb when no motion is detected for a certain amount of time. For educational institutions, the suggested methodology offers a straightforward, dependable, and affordable automation technique. The system reduces manual labor, enhances user comfort, saves electricity, and promotes the creation of smart classrooms by combining motion detection, automatic lighting management, temperature-based fan control, and relay-based switching.

V. IMPLEMENTATION

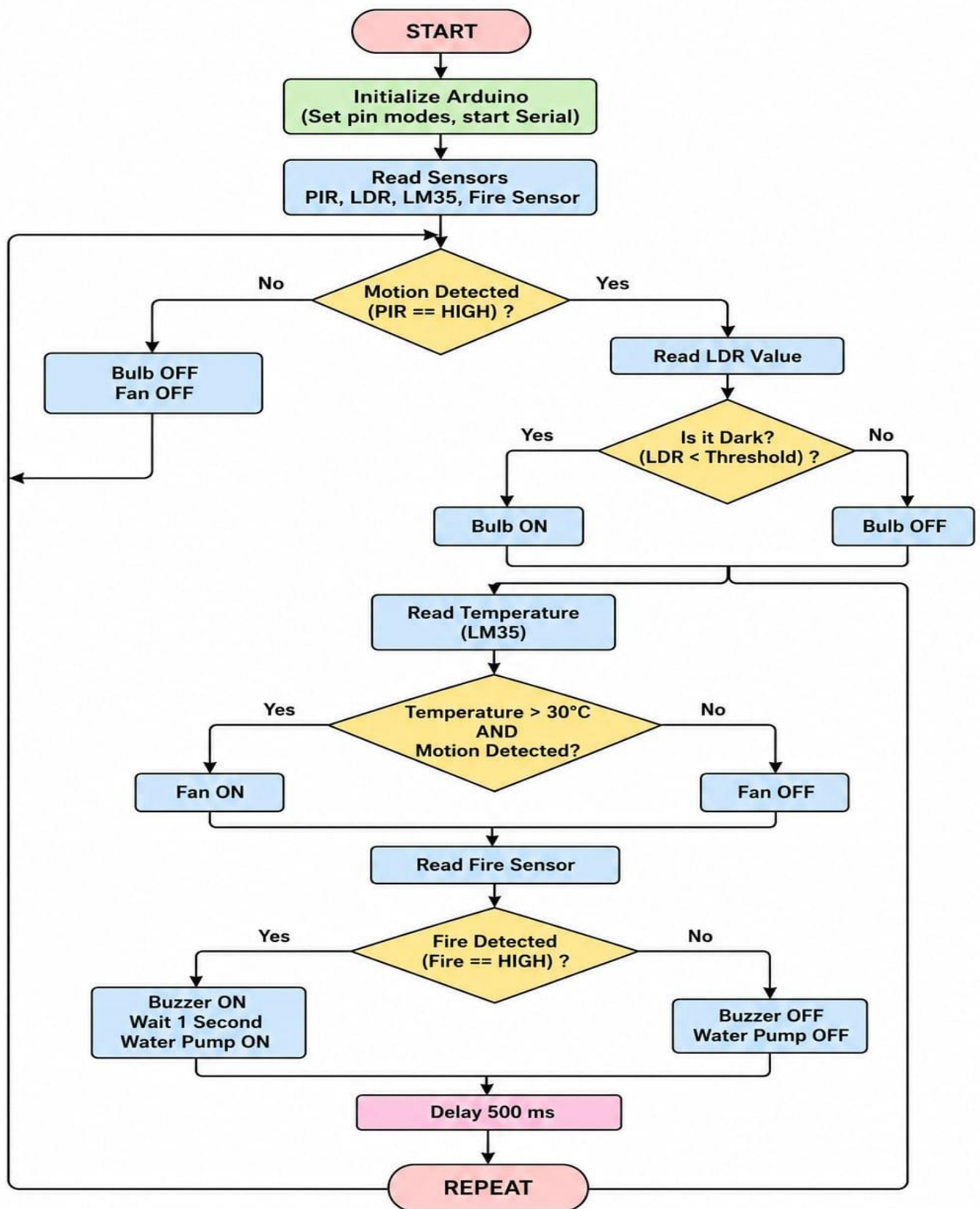
4.1 Block Diagram



4.2 Circuit Diagram



4.2 Flow Chart



VI. RESULTS & DISCUSSION

Using an Arduino Uno microcontroller integrated with a PIR sensor, LDR sensor, LM35 temperature sensor, fire sensor, relay modules, AC lamp, AC fan, buzzer, and water pump, the Microcontroller-Based Automatic Security System for Educational Sector was successfully designed. The system responded appropriately to various environmental circumstances and functioned in accordance with the programmed logic. Only when the ambient light level was low, as determined by the LDR sensor, did the PIR sensor detect motion and turn on the lighting system when someone entered the room. If there was enough natural light, because the AC light stayed off, less energy was wasted. In order to ensure effective use of electrical energy, the LM35 temperature sensor continuously monitored the room temperature and only turned on the AC fan when motion was detected and the temperature rose beyond 30°C. Additionally, the fire detection module worked well by detecting the presence of fire, promptly sounding the buzzer to warn the inhabitants, and then turning on the water pump via the relay module to aid in putting out the fire. Both the water pump and the buzzer were automatically turned off when the fire was no longer detected. The system operated safely. The relay modules' dependable separation between the high-voltage AC appliances and the low-voltage Arduino controller. All things considered, the proposed system effectively combines environmental monitoring, fire safety, energy management, and security into a single automated platform. The project shows how a low-cost microcontroller-based solution can minimize human intervention and lower electricity consumption while greatly improving the safety, security, and energy efficiency of educational facilities like classrooms, labs, libraries, and offices.

VII. ADVANTAGES

1. Strengthened Security –

Using a PIR motion sensor, the system continuously monitors classrooms, labs, libraries, and other educational institutions. The technology automatically detects movement and turns on the necessary appliances whenever someone enters the room. By guaranteeing that room occupancy is tracked without the need for human monitoring, this enhances security.

2. Conserving Energy –

The system's capacity to cut down on wasteful electricity use is one of its main benefits. Only when the room is completely dark can the AC bulb switch on thanks to the LDR sensor, which measures the amount of ambient light. The light stays off if there is enough natural light, saving electricity.

3. Smart Fan Management –

The AC fan is turned on by the system in response to both room temperature and occupancy. Only when someone is in the room and the temperature rises over 30°C does the fan turn on. The fan stays off if either requirement is not met. When compared to traditional manually controlled fans, this sophisticated control drastically lowers electricity consumption.

4. Fire Detection Automation –

The integrated fire sensor keeps an eye out for flames all the time. When a fire is detected, the system detects the emergency right away and starts defensive measures without the need for human participation. This makes it possible to react to fire incidents more quickly.

5. Quick Fire Alert-

The buzzer instantly sounds an alert to workers, instructors, and pupils when it detects a fire. By facilitating a safe evacuation and speeding up emergency response, the early warning reduces the possibility of accidents and property damage.

6. Automatic Suppression of Fire-

The relay module automatically turns on the water pump to spray water on the fire source when the alarm goes off. This prompt action lessens the likelihood that small fire incidents may spread throughout the building by controlling them in their early stages.

7. Completely Automated Function –

Without constant human oversight, the entire system operates automatically. Data from all connected sensors is processed by the Arduino Uno, which then uses predetermined conditions to control the electrical appliances. This automation reduces human labor and increases operational efficiency.

8. Economical Approach-

The Arduino Uno, PIR sensor, LM35, LDR, fire sensor, relay module, buzzer, and water pump are among the inexpensive and readily accessible parts used in the project. Because of this, the system as a whole is affordable and appropriate for use in educational institutions with tight budgets, such as schools, colleges, libraries, and labs.

VIII. LIMITATIONS & FUTURE WORK

8.1 Limitations:

1. **Restricted Motion Detection Range -**

The PIR sensor can only identify motion within its designated field of view and range. Movement behind obstructions or outside of this range might go undetected.

2. **Dependency on Ambient Conditions-**

Direct sunshine, shadows, or incorrect sensor positioning can all affect the LDR sensor's readings, which could have an impact on lighting control.

3. **Single Temperature Threshold -**

For fan operation, the system has a fixed temperature threshold of 30°C. Not every season or place will be appropriate for this level. Energy Constraints during Extended Cloudy Periods

4. **Limited Access Control -** Although the system can identify human presence, it is unable to differentiate between authorized and unauthorized individuals, rendering it inappropriate as a comprehensive access control solution.

8.2 Future Work:

To overcome these limitations and enhance system functionality, several directions for future development are proposed:

1. **IoT-Based Remote Monitoring –**

To provide real-time monitoring and control via a web dashboard or mobile application, integrate Wi-Fi modules like the ESP32 or ESP8266.

2. **SMS and Email notifications-**

When a fire or unlawful entry is detected, add GSM or Internet-based notification systems to automatically send notifications to authorized staff.

3. **Artificial Intelligence Integration-**

To enhance intrusion detection and spot unusual activity, use AI-based image processing and predictive analytics.

4. **Smart Building Integration-**

To manage lighting, ventilation, security, and emergency response from a single platform, integrate the system with the current Building Management Systems (BMS).

5. **Advanced Fire Suppression System-**

For better fire protection in larger educational facilities, swap out the basic water pump for an automated sprinkler system or intelligent fire suppression mechanism.

IX. CONCLUSION

The design and implementation of a Microcontroller-Based Automatic Security System for the Educational Sector, which combines energy management, fire safety, security, and environmental monitoring into a single automated platform, was successfully shown in this study. In order to provide intelligent and dependable operation, the system successfully used an Arduino Uno in conjunction with a PIR sensor, LDR sensor, LM35 temperature sensor, fire sensor, relay modules, AC bulb, AC fan, buzzer, and water pump. The created system reduced needless energy use by reliably detecting human presence, automatically controlling room lighting depending on ambient light conditions, and only turning on the fan when both occupancy and temperature surpassed a certain threshold. Additionally, the integrated fire detection system effectively detected fire dangers, sounded an alarm, and turned on the water pump automatically to suppress in times of emergency. The outcomes of the trial verified that the suggested system operates effectively under various operating situations with little assistance from humans. The system promotes energy conservation while enhancing the safety, security, and comfort of classrooms, labs, libraries, and other educational institutions by automating lighting, ventilation, and fire protection. The suggested method is affordable, dependable, and simple to apply at educational institutions because it makes use of easily available, inexpensive components. The suggested design has several advantages over traditional manual systems, such as temperature-dependent fan operation, intelligent occupancy-based appliance control, automatic fire detection and suppression, and less electricity waste. Future

improvements can overcome the system's shortcomings, which include its reliance on local sensors, lack of distant monitoring, and restricted scalability. The system's usefulness, dependability, and scalability can be further enhanced by integrating IoT technologies, cloud-based data logging, GSM or mobile notifications, RFID-based access control, CCTV monitoring, and sophisticated AI-based analytics.

X. REFERENCES

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