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Smart Energy Saving System for Classroom

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Abstract: *A smart lecture room system is an approach to a complete solution for both building managers and users from a classical lecture room. This proposed system focuses on saving energy by using smart technology to control appliances like lights and fans automatically. The system uses motion sensors to detect if people are in a room. If the room is empty, the system turns off the lights and fans, conserving energy that would otherwise be inefficiently used. Although this system is designed for classrooms, it can be used in many other places like offices, homes, and public spaces. In offices, it can manage meeting rooms and workspaces, only turning on lights and fans when needed. At home, it can reduce electricity use by controlling lights in common areas. Public places like libraries and airports can also use this system to save energy when areas aren't busy. It's easy to set up in existing buildings and can be scaled up for larger spaces. The technology uses PIR sensor to detect motion, once the motion is detected then camera starts to capture the video, the video is subdivided into frames by using according to the number of lights and fans in that room. After detecting motion in particular, the frame microcontroller gives a signal to relay and lights and fans in that area will be turned on. By saving energy based on whether people are present, this system helps lower electricity bills and reduces carbon footprint which protects the environment.*

Keywords: IOT, Smart Classroom, Energy Saving, ESP8266, Sensors

I. INTRODUCTION

Energy wastage is a significant concern in both residential and commercial areas, where inefficient management of lighting often leads to excessive energy consumption. Many buildings rely on traditional switches and timers, resulting in lights and fans remaining on in unoccupied rooms, which drives up energy bills and increases carbon footprints. As the demand for sustainability grows, there is a pressing need for innovative solutions to minimize energy waste. Smart Energy Management System addresses this challenge by using a camera and PIR (Passive Infrared) sensor to detect a person's presence in a room. This system automatically turns on and off lights and fans based on real-time presence, enhancing comfort while significantly reducing energy consumption. By integrating smart home technology, this project promotes a more sustainable approach to energy use in modern living and working environments. The proposed system aims to do the following actions:

- Determine the presence of a human in a room.
- Determine whether the devices in a room are turned ON or OFF.
- Control the devices by turning them ON/OFF based on human detection.
- Continuous monitoring of a room for entry/exit by any human.

This proposed system focuses on saving energy by using smart technology to control appliances like lights and fans automatically. The system uses motion sensors to detect if people are in a room. If the room is empty, the system turns off the lights and fans, conserving energy that would otherwise be inefficiently used. Although this system is designed for classrooms, it can be used in many other places like offices, homes, and public spaces. In offices, it can manage meeting rooms and workspaces, only turning on lights and fans when needed. At home, it can reduce electricity use by controlling lights in common areas. Public places like libraries and airports can also use this system to save energy when areas aren't busy. It's easy to set up in existing buildings and can be scaled up for larger spaces. The technology uses PIR sensor to detect motion, once the motion is detected then camera starts to capture the video, the video is subdivided into frames by using according to the number of lights and fans in that room. After detecting motion in particular, the frame microcontroller gives a signal to relay and lights and fans in that area will be turned on. By saving energy based on whether people are present, this system helps lower electricity bills and reduces carbon footprint which protects the environment.

II. LITERATURE REVIEW

1]An Author Several research works have recognized the significance of IoT technologies in energy conservation in several domains such as industry, transportation, health, smart cities, and education [4–7]. Some researchers focus on exploiting IoT technologies in energy conservation in the health domain. For example, Askari et al. [8] propose an Internet of Medical Things (IoMT)-based software-defined Wireless Body Area Network (SD-WBAN) communication system. In particular, the authors propose an energyefficient two-tire algorithm for real-time Non-Orthogonal Multiple Access (NOMA) scheduling where Walsh Hadamard (WH) codes are employed to lower interference. Other researchers focus on exploiting IoT technologies in energy conservation at the smart cities' domain. For example, Metallidou et al. [9] present a novel management system for smart buildings. In particular, the management system consists of several sub-systems including: (i) ventilation system, (ii) heating system, (iii) air conditioning system, (iv) Domestic Hot Water (DHW) system, (v) system for electrification, and (vi) lighting system. All these systems use a Wireless Sensor and Actuator Network (WSAN) to provide a number of functionalities related to controlling IoT devices with respect to European legislation as for energy efficiency.

Nahar et al. [10] present an energy-efficient system for smart rooms, namely, "EPSSR". In particular, authors propose to use an infrared sensor to detect whether the room is occupied or not and the room lighting will turn on or off accordingly. The infrared sensor is used as a counter and when the counter is equal to zero the lights are turned off. Other researchers focus on exploiting IoT technologies in energy conservation at the education domain. For example, Gupta et al. [11] showcased a loT-based autonomous power control system for energy conservation in classrooms. In particular, authors propose the use of sensors to automatically sense the occupancy of the classrooms and turn the lights on and off accordingly. Moreover, the system has two control modes: (i) manual where the user can switch on or off devices; and (ii) auto depending on the sensors.

Martirano [12] proposes a lighting system for energy conservation in classrooms. In particular, the author proposes to use sensors to automatically sense daylight and occupancy of the classrooms. In addition, the author proposes two different control approaches including switching and dimming, and two control modes manual and auto for light switching and dimming.

Paudel et al. [13] present a contextaware architecture for energy conservation in a classroom environment. In particular, authors propose to use a Long Short-Term Memory (LSTM) to predict the classroom temperature and humidity based on classified activities of students to figure out when to turn on or off devices (i.e., lights, air conditioners, heaters, etc.), namely, a convolutional 3D network (C3D) model. Mohamad et al. [14] showcased an IoTbased energy smart saving classroom. In particular, the authors present a customized design for an IoT smart classroom for Universiti Tun Hussein Onn (UTHM) main campus. The smart classroom has a door lock system and an indoor and outdoor lighting control system. Furthermore, the system exploits a smartphone application with a Graphical User Interface (GUI) and WiFi connection to control IoT devices easily.

Diddeniya et al. [15] present a novel architecture for an IoT-based energy-efficient smart classroom system. In particular, authors propose to use a couple of sensors including: (i) Microsoft Kinect sensor to sense the classroom occupancy, (ii) Light Dependent Resistor (LDR) sensor to sense the light intensity in the classroom to control the lighting, and (iii) Digital Humidity and Temperature (DHT22) sensor to control the air conditioning of the classroom. Memos et al. [16] showcased a plan for a Revolutionary Interactive Smart Classroom (RISC). In particular, the implementation plan consists of three components including: (i) a cloud computing Learning Management System (LMS), (ii) data-transfer-application protocols, and (iii) connected components (e.g., tactile devices, virtual reality devices and other sensors). The planned smart classroom includes several services such as virtual classroom, augmented and cognitive sense, position, touch interaction, 3D design and modeling, and other services.

Ani et al. [17] propose an IoT-based smart classroom architecture. In particular, authors propose an image processing approach to check the occupancy of the classroom and determine when to switch on or off electrical devices such as lights and fans. The classroom is divided into two frames and one camera is used to check occupancy. In other words, when a student is present in frame 1 the electrical devices should turn on and the same goes with frame 2.

Pacheco et al. [18] present an osmotic IoT-based smart classroom architecture. In particular, authors propose a deep learning model for occupancy detection through cameras. The architecture consists of four layers including: (i) IoT layer that contains IoT devices and cameras, (ii) Edge layer that contains IoT hubs and mobile devices, (iii) Fog Layer that contains IoT and Vision servers, (iv) Cloud layer that contains Cloud data centers for computing the deep learning model. Banu et al. [19] propose an IoTbased Cloud integrated smart classroom system. In particular, the architecture of the proposed system consists of five layers including: IoT layer which consists of IoT devices such as camera, lights, sensors, air conditions, etc., (ii) Personal Digital Assistant (PDA) layer which consists of mobile phones, laptops, touchpads, etc., (iii) networking and storage which consists of a cloud server, routers, switches, etc., (iv) management layer which includes classrooms, and admin offices, etc., and (v) applications layer for teaching and management activities. Furthermore, the proposed system uses facial recognition for attendance.

Chan et al. [20] and Sun et al. [21,22] present an IoT-based smart classroom system. In particular, the system consists of two sub-systems including, (i) Radio Frequency Identification (RFID) attendance system with an admin web page and a lecturer web page, and (ii) Wireless Sensor Network (WSN) energy-saving system to provide the ability to switch on or off lights, air conditions, etc. Unlike previous works that focus on exploiting IoT technologies in energy conservation in the health or smart cities domains, our work focuses on exploiting IoT technologies in energy conservation in the education domain. In addition, previous works do not consider aggregating estimated energy consumption and estimated energy cost of IoT devices in real-time. In this work, we design an IoT-based energy conservation smart classroom system that allows the user to access and control IoT devices and view statistics related to the estimated energy consumption and estimated energy cost in real-time (e.g., IoT device, classroom, and education building). In particular, we propose an energy consumption and cost model that aggregates estimated energy consumption and estimated energy cost in Saudi Riyals (SAR) (i.e., according to SEC rates) for each IoT device, classroom, and education building in real-time. In addition, the model aggregates in real-time the estimated energy conservation percentage and estimated money-savings percentage compared to data collected when the system wasn't used. More details regarding our proposed system are elaborated in the following sections.

III. METHODOLOGY

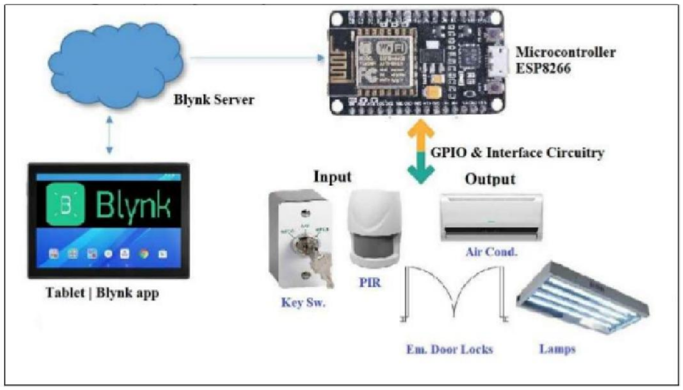

Fig1: Block Diagram of System

The classroom divided into sections. Any number of sections can be made depending upon the need. So, if classroom is big then number of sections can be increased. In this case we have considered four sections. So, the classroom is divided into four sections. Now for each section we have allotted one fan and one light. In every section we have kept four bench s and these four benches of each section is connected to the hub. For each section we have different hub. This is just to reduce the bulkiness of the system so that the system should not become so bulky. Each bench has IR sensors with short range to detect the presence of students. Here the sensors are connected in such a way that when a student will come and sit it will detect the presence of the student and will send the signal to the hub connected to it. Here one thing is to be noticed that when the student enters into the classroom and he is just standing there then no appliances will be on till he goes near the bench where his presence will be detected by the sensor Now when students' presence is detected sensor will send this data to controller and there processing and further action will be taken. Since by default system is in auto mode so based on the presence of student action will be performed i.e., according to the data receive from the sensor lights and fans will be switched on or off the above paragraph explain the all about the auto mode of the system which is also by default mode of the system. But to make it more user friendly we have also provided the manual mode so that user can access and control the system easily. Now for the manual mode we have made a website through which user can see the current status of the system as well as can control it. In manual mode, users can select the light and fans to be turned on or off. In Normal mode, the light and fans are turned on for all the sections where students are present System also automatically sets itself into the auto mode after a particular interval from the time it is configured into the manual mode. The hub has the OR gate. It takes the signals from all the benches and if any one of them is High, It gives the output as high. This eliminates the task of controller to scan all the benches to find the benches with students. Hubs Provide this information to the main controller. As shown above the section is divided in this way. The best thing about the system is that it can be accessed and controlled from anywhere and at any time. Once the user gets the access, he can manage the appliances from anywhere through website. Further the LDR sensors will continuously monitor the light in the classroom So it will check two conditions i.e., first it will ensure that if student is present or not it that student is present then it will ensure it there is enough light in classroom or not and only after getting that it will switch it on. Up to here we have understood the general working of t system. If we summarise à in brief then here data obtained from sensor is transmitted to hub from there it goes to controller where it is processed and through relays to appliances.

A. Component Used

The Smart Energy Management System utilizes several key components to achieve automated control of lights and fans in a classroom. The system's hardware components include PIR sensors, which detect motion by sensing changes in infrared radiation, signaling the presence of people Camera of esp32 cam module is also included, which can optionally be used for enhanced motion detection and occupancy recognition using image processing techniques The microcontroller, an esp32, acts as the primary controller, receiving signals from sensors, processing data, and sending commands to turn devices on or off The microcontroller is also responsible for handling network communication. Additionally, relay modules are used as electronic switches that allow the microcontroller to control high- power devices such as lights and fans. A Wi-Fi module (esp32 cam module) facilitates wireless communication between the system and external devices for remote monitoring and data logging.

B. ESP8266

The Lolin NodeMCU ESP8266 V3 WiFi Module is your key to unlocking the potential of the Internet of Things (IoT). If you're searching for a seamless and affordable IoT development solution in India, you've found it.This versatile NodeMCU V3 module brings IoT innovation to your fingertips, and you can conveniently purchase it online at the best price. Our NodeMCU V3 module is designed to cater to your IoT needs comprehensively.Equipped with a built-in Micro-USB interface, CH340 USB-TTL converter, and full I/O support, this module simplifies IoT development. It's compatible with the Arduino platform, making it a favorite among developers.

Simplifying IoT product prototyping, the NodeMCU ESP8266 V3 supports Lua scripting, GPIO (General Purpose Input/Output), PWM (Pulse Width Modulation), IIC (Inter-Integrated Circuit), 1-Wire, and ADC (Analog-to-Digital Converter) all in one board.

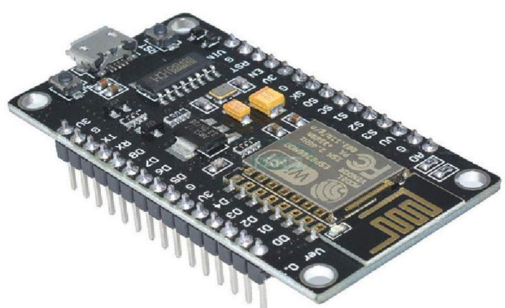

Fig2: ESP8266

C. PIR Motion Sensor

The HC-SR501 PIR Motion Sensor Module is used to detect the motion of a human body within the sensor's range. It is often referred to as a PIR sensor, "Pyroelectric", "Passive Infrared" and "IR motion sensor" device. This PIR motion sensor module has an onboard pyroelectric sensor, conditioning circuitry, and a dome-shaped Fresnel lens.The HC-SR501 PIR Motion Sensor requires 4.5 ~ 20V DC voltage. This PIR sensor's tiny size and sturdy design make it ideal for a variety of applications, including burglar alarms, automatic lighting control systems, and DIY motion-sensing technology projects.

Fig 3: PIR Motion Sensor

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D. LDR

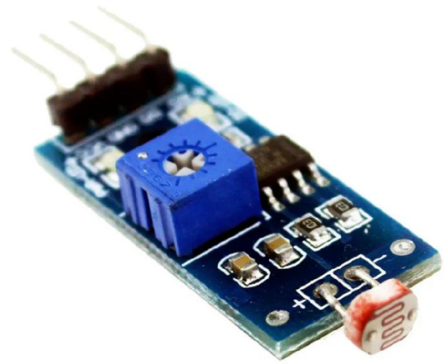

Fig 4: LDR

The LM393 Photosensitive LDR Light Sensor Module 4 Pin helps detect light and control brightness. It uses an LM393 voltage comparator, which gives a clear output signal. You can adjust the light sensitivity with a small dial, making it easy to use for different brightness levels. This module works with a 3.3V to 5V power supply and gives a digital output, making it perfect for detecting light levels around it. It can directly control relay modules or act as a light-activated switch for various projects.

E. DHT11 temp humidity sensor

The DHT11 Humidity and Temperature Sensor Module, commonly referred to as the dht11 sensor, is capable of sensing both temperature as well as humidity. This makes it ideal for DIY electronics projects and automation systems using platforms like Arduino and Raspberry Pi.

The output of the dht 11 temperature sensor module is in the form of a digital signal on a single data pin. The sensing update frequency is measured every 2 seconds (0.5Hz). The DHT11 Sensor Module can be easily interfaced with any microcontroller such as Arduino, Raspberry Pi, and others.

This sensor module integrates the dht 11 sensor and other required components on a compact PCB. The DHT11 sensor includes a resistive-type humidity measurement component, an NTC temperature measurement component, and a high-performance 8-bit microcontroller inside, delivering calibrated digital signal output.

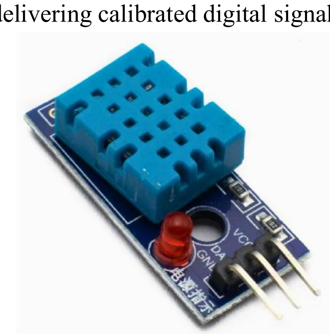

Fig5: Temp humidity sensor DHT11

IV. CONCLUSION

Energy saving is energy creation. The proposed system focuses on saving sufficient amount of energy and implementing the sensors at micro level to increase efficiency of the system. It will allow us to use the energy in more efficient way and will contribute to reduce the huge amount. The proposed system met our expectation and can contribute in saving huge amount of wastage of energy.

In the model, as we have placed IR module on the back side of the bench. So basically, the working of this model is that, each bench has IR sensors with short range to detect the presence of students. Here the sensors are connected in such a way that when a student will come and sit it will detect the presence of the student and will send the signal to the hub connected to it. Here one thing is to be noticed that when the student enters into the classroom and he is just standing there then no appliances will be on till he goes near the bench where his presence will be detected by the sensor Now when students' presence is detected sensor will send this data to controller and there processing and further action will be taken.

Future Scope:

Energy saving is energy generating. Huge amount of energy can be saved using this system. But this of course can not eliminate wastage of energy completely however there is scope of further modification of this project. This can be done by using temperature sensors which will sense the temperature of the room and if the temperature is normal then it will not switch on the fans.

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