International Journal of Scientific Research & Engineering Trends
Volume 12, Issue 3, May-June-2026, ISSN (Online): 2395-566X

Design and Development of an Intelligent Automatic Light Control System for Energy-Efficient Indoor Environments

[1]Mrs. G. Rohini Phaneendra Kumari, [2]Ravikrinda Hemanjali, [3]Manasa Kunduru, [4]Yanamadala Naga Lakshmi, [5]Chundi Pallavi.

[1]Assistant Professor, Department of IT, Vignan's Nirula Institute of Technology and Science, Guntur.

[2,3,4,5] B. Tech, Department of IT, Vignan's Nirula Institute of Technology and Science, Guntur.

Abstract- Increased demand of energy-efficient technologies has resulted in the creation of intelligent systems that would optimize the energy use in residential and commercial buildings. In this paper, the design and development of an automatic light control system of indoor environment that ensures that there is minimal energy wastage through the use of adaptation of illumination is presented. The system makes use of a set of sensors, such as motion sensors and light-dependent resistors (LDRs) to automatically control the lighting through occupancy and the intensity of the ambient light. A framework based on an IoT provides the ability to monitor and control remotely through the use of mobile devices, which makes it more convenient and flexible to the user. The proposed system will provide the optimal lighting conditions and produce a considerable reduction in the electricity consumption, and hence, it will lead to sustainable energy management and smart home automation.

Keywords— Automatic light control, indoor lighting, smart system, energy efficiency, sensor-based control, IoT, home automation.

I. INTRODUCTION

The need to have sustainable and energy efficient solutions has become highly important in the contemporary world of technological advancement [1]. Building energy consumption specifically in the lighting sector is a significant portion of overall electricity consumption in the world [2]. Research has shown that lighting contributes almost 2040 per cent of the total energy usage in residential and commercial structures [3]. Therefore, the automatic control of lights and optimization of light according to the activity of people and environment conditions is an urgent necessity to reduce wastage of the energy in the indoor areas [4]. The idea of intelligent control over the lights has become an innovative measure to reduce the quantity of the energy wastage in the indoor areas [5] [6]. The conventional lighting systems are mostly manual and can easily be compromised by human factors [7]. Lights are usually left on even when there are no people in the room or when the sun is up. Automatic systems on the other hand can be adjusted to real-time environmental conditions so that the lights are only turned on when the need arises [8]. The strategy increases the efficiency of energy use, lowers the cost of operation and increases the life cycle of a lighting equipment [9]. Intelligent light control system is achieved through the combination of various technologies which include sensors, microcontrollers and communication modules [10]. Depending on the sensors used, Light Dependent Resistors (LDRs) can detect the intensity of the ambient light whereas Passive Infrared (PIR) sensors or motion detectors are able to detect where a person is or not [11]. These sensory signals are then sent to a control unit say a microcontroller or an IoT-based device that sends out codes of whether the lighting system needs to be turned on or off. This is a closed-loop system where it can be operated autonomously [12] [13].

The Internet of Things (IoT) has over the past years been a trendsetter in the development of smart lighting systems [14]. With the linking of the lighting equipment to the net, the user can remotely regulate, supervise and automate the state of his/her indoor lighting [15]. The IoT technology can also be used to make decisions based on the data gathered about the energy consumption, occupation rates, and environmental conditions [16]. The proposed research aims at the design and development of intelligent automatic light control system which will integrate sensor based control with IoT based connectivity [17]. The system will be capable of automatically regulating the lighting based on the brightness and occupancy rates in the environment to maximize the light output and minimal energy consumption [18]. Such systems can be especially applicable to smart homes, offices, educational institutions, and other indoor settings in which lighting is a crucial factor in comfort and productivity [19]. Energy efficiency is not only an economic requirement but also an environmental one. The whole world is concerned with energy depletion and climate change which is the reason why green technologies are becoming very popular [20]. Smart lighting solutions are a direct way to achieve these sustainability objectives because they minimize the use of power and enhance the use of resources [21]. In this aspect, the project of the proposed system will serve as a move towards developing eco-friendly and energy-conscious living conditions, which in this respect is extremely popular because of its convenience, security, and comfort [22]. The contemporary consumers are more demanding towards intelligent environments that are able to adapt autonomously to their lifestyles [23]. Combining automatic light control with home automation networks would add value to users through the provision of smooth, smart light that reacts to environmental and behavioral conditions [24].

Technically, the system consists of multiple parts: an LDR sensor to measure natural light intensity, a PIR sensor to detect movement, a microcontroller (e.g. Arduino or NodeMCU) to do the decision-making and an IoT interface to communicate and be controlled remotely [25]. The reasoning is basic but effective, in the event that there is enough natural light, no artificial lights are on, but should the room be dark and some movement be sensed, the lights will be started automatically [26]. Besides automation, the addition of the IoT makes the system more flexible because users are able to observe the lighting status and energy usage under a smartphone application or a web platform [27]. This not only offers convenience but also allows log-reading and analysis further structuring of lighting behavior [28]. A number of studies carried out so far have shown the advantages of automatic lighting systems. The interplay between automation and remote control fills the gap between the manual regime and intelligent environment [29]. These systems are, however, limited in a number of ways, many of them only detect motion or measure ambient light. This research is unique because it incorporates both methods and puts them together in one framework with the help of the IoT technology [30]. This system is holistic in nature such that it dynamically reacts to the factors in the environment as well as the user based factors [31].

Scalability and cost-effectiveness are also highlighted in the suggested design [32]. The cheap sensors and microcontrollers also make sure that the system would be applicable in a broad spectrum of indoor environments without unreasonable expenditures [33]. In the context of sustainable development, those intelligent systems have important consequences in general [34]. The modularity of their design means upgrades are easily made, e.g. voice assistants can be added, machine learning algorithms can be added, or smart energy analytics can be added in the next generation [35]. At the individual building level, they are optimized to use energy which amounts to the national energy conservation targets and environmental sustainability [36]. Considerable decrease in loads of power grids and operational expenses can be achieved through the integration of these systems in smart cities and intelligent light control systems enhance the comfort of the user by ensuring that the illumination levels are constant [37]. The abrupt alteration of brightness/light or the unevenness of light can be uncomfortable and reduces productivity, particularly at places of work or during studies [38]. The proposed system is adaptive thus ensuring that the users at all times receive an appropriate lighting environment, hence improving their welfare [39].

The control algorithms integrated in the system are to provide real time decision making with reference to the sensor input that is constantly being updated [40]. This makes the system responsive even in the presence of conditions that are changing extremely fast such as the intensity of daylight or the occupancy changes [41]. This flexibility also contributes to the robustness of the system and is applicable to real-life use as educational endeavors to show how electronics, programming, and environmental science can be interdisciplinary. Overall, this system can be utilized by students and researchers to learn about the embedded systems, automation, and IoT communication protocols [42]. To summarize, designing an intelligent automatic light control system is a very important step toward making the indoor environment intelligent and sustainable. The proposed system can save electricity consumption, increase its user convenience, and sustainability in the environment due to the integration of sensor technology, IoT connectivity, and energy-efficient algorithms. This study should give rise to new developments in smart lighting in the future, as it will help with the global perspective of energy efficiency and smart living.

IL ITERATURE REVIEW

Vishnu [1-3], have conducted a large amount of research on integrating actuators, sensors and controllers in smart home automation systems with the Internet of Things (IoT) technology. Their research proves the successfulness of these systems in energy saving based on experimentation and statistical analysis of prototype applications. These technologies are making great contributions to the improvement of the energy usage and the sustainability of the home setting.

As Monda et al. [4-5] argued, accessibility of energy sources based on electricity is critical to the daily human operations. They said that curbing energy use is among the top-most needed measures that should be taken to curb the existing energy crisis and reduce the amount of carbon gas being generated. To achieve this objective, their research implies the creation of the Internet of Things (IoT)-based light intensity control and monitoring system to provide the control over the overall lighting levels in a room.

Tsai[6-7]. have studied ways of reducing standby power consumption of PIR-sensor-based lighting devices. Conventional PIR-sensors lighting systems, although allowing them to light on when motion is sensed and off when no more motion is detected, nevertheless use 1-3 W of power in standby. To overcome this inefficiency, the design uses a microcontroller (MCU) to observe the signals of PIR sensor and turn on to off the power of the lamp entirely in the absence of movement. This method lowers the standby consumption to only 0.004 W with simplicity, low cost and installation simplicity. MCU internal modules facilitate circuit design as well as automatable single-point detection.

Y. -W. Bai [8-9] introduce a practical and efficient Home Light Control Module (HLCM) that combines pyroelectric infrared (PIR) motion detector, ambient-light sensor, microprocessor-based decision-making and RF into a single device to control lighting in rooms automatically and regionally. Their design consists of PIR circuitry in each HLCM to sense when humans are present and a light sensor to measure the light levels in the room; the microprocessor is dynamically controlled to make sure that sufficient light is available when needed by controlling which lamps are left energized. RF module enables HLCMs to communicate the status of the systems and coordinate lighting between different areas to be able to use a pre-control strategy (such as the collective turn-on or turn-off of lighting in adjacent areas).

Zhang [10] has suggested an intelligent control system of the indoors brightness, which is developed with references to the ESP8266 development board. The system combines the traditional approach to control with automatic regulation of the brightness of the indoor space with the environmental sensors and comprises the remote control options via MQTT communication protocol, which allows managing the lighting conditions in real time and adjusting them to the desired values. Past studies show that the sensor-based automation system can achieve enhanced energy savings, convenience to users, and responsiveness of the system when coupled with networked communication to support smart lighting. The paper is based on these premises, and it focuses on how the concept of IoT and adaptive control can be integrated to manage and control the brightness indoors effectively.

Vereschagin [11-12] proposed a motion sensor-based room lighting-controlling system based on the use of the Arduino microcontroller. It is meant to automatically switch lights on and off with regard to the availability of people in order to improve energy efficiency as well as create a comfortable atmosphere inside the building. The paper shows the benefits of the Arduino platform because of its low cost, flexibility, and application to different automation activities. Moreover, it is based on open-source software and open standards, making it accessible and easy to use to be adopted by more people. This study has added to the engineering of intelligent lighting control literature by showing how automation using sensors can be used to optimize energy use and convenience to users in the indoor setting.

Manthena [13] proposed a new way to maximize the energy efficiency of the lighting system used in the restroom by combining cloud-based solutions with the Internet of Things (IoT) technologies. The paper talks about the inefficiencies of the old style lighting systems which can be a waste of energy because they are not automated or optimized. The suggested system involves IoT devices, such as ambient light detectors and motion sensors, to respond to occupancy and natural daylight by changing the level of lighting. The advanced techniques that process real-time data of these sensors are done on a cloud platform to optimize the lights schedules dynamically. This will ensure that minimal energy is used as well as maximize user comfort by automatically switching off lights in empty spaces and changing the lights depending on the user requirements. The efficacy and viability of this system can be proved by means of simulations and real-life experiments, which suggest the opportunities of the IoT and cloud computing to facilitate sustainability and create more energy-efficient systems of building management. The challenges also include the need to have a constant connection, accuracy of sensors, security of data and also the need to unite technologies to suit various users.

Rahman [14] introduced a microcontroller-based automated system of monitoring and controlling the laboratory environments through cloud connection. The system is designed to use a Light Dependent Resistor (LDR) sensor to sense the intensity of light and a Digital Humidity and Temperature (DHT) sensor to obtain the information about the surrounding humidity and temperature. The measurements of LDR system of 10% stand out of the way of a normal digital light sensor (GY30), which is tolerable to consider in a practical use. The sensors collect data which is shown on an LCD and can be accessed or stored through the cloud making the device to be remotely monitored and controlled. A user is able to choose the desired humidity and temperature conditions locally or via the cloud and the system will automatically regulate the set conditions. An integrated cloud communication module would be necessary to communicate with a mobile application and provide real-time control and monitoring. This study identifies the opportunities of automated systems based on the use of IoT to optimize the laboratory environment and recommends the fact that the application can also be used in other areas, including hospital Intensive Care Unit (ICUs), industry production plants, and research laboratories.

As pointed out by B. S. Kumar [15-16], the dramatic development of communication technologies has changed the current lifestyles, as individuals can now access information anywhere in the globe. The author also stressed that one of the most powerful technological advances of recent years is the Internet of Things (IoT), which has an extensive scope of application in different fields. Kumar has observed that the use of the IoT in home automation stimulates the creation of intelligent and adaptive control systems that adapt to the preferences of the users. He further indicated that wastage of energy is usually due to human carelessness e.g. leaving electrical equipment in deserted rooms on. In order to resolve this problem, Kumar developed an Internet of Things-based smart home system that would be efficient and convenient to use. The offered system will allow monitoring and controlling household appliances automatically, which will enhance managing energy consumption and minimize unjustified power usage. This is one way that the IoT technology can be used to improve every day life and encourage the use of sustainable energy.

An innovative device based on universal lighting control and energy-saving was suggested by G. Saranya [17-20]. The gadget is combined with the new functionalities: automatic human recognition, smart on/off, and dynamical lighting. It is able to detect the natural aspects and react accordingly to the ambient conditions of light. The suggested system focuses on the control of LED lights to have great savings of energy and cost reduction. It has an inbuilt Wi-Fi enabling it to be controlled easily by the smartphones which adds more convenience to user access. The dynamic nature of the lighting system and setting of the device establishes a natural and cozy environment and helps in sustainability. Moreover, possible difficulties and constraints are presented in the proposal so that the flexibility and as many practical advantages as possible could be achieved. All in all, Saranya universal lighting control device is a sustainable and progressive idea that has the potential of transforming the lighting systems of the present times.

III. PROPOSED MODEL

The suggested solution, an Intelligent Automatic Light Control System is aimed at optimizing indoor lighting, which automatically manages the lamps, depending on the presence of people and the level of ambient lights. It aims to minimize the use of energy, eradicate the waste of standby powers, and offer comfortable, sustainable indoor environment with the help of PIR motion sensors to sense the presence of a human and assess natural light with the help of LDRs or photodiodes. The controller has a microcontroller (MCU) as its central processing unit that is provided with the sensor data and performs control logic to control lamps. The MCU drives a solid-state relay (SSR) or smart switch to turn the lamps on or off so that power usage is reduced in cases when no motion is detected.

On the other hand, after a set duration of time with no movement to be detected, MCU turns off the lamp and discontinues standby current, consuming almost no energy. The internal modules of the MCU make it easy to design a circuit and place the system under full control, optionally, the system may include a wireless module, e.g. Wi-Fi or Bluetooth, to monitor the system remotely and control it through a smartphone or an IoT cloud device. It gives them ability to monitor power consumption, customize lighting and also more efficiently manage power. All in all, the suggested model offers an affordable, simple to install, and energy efficient intelligent lighting system of indoor lighting systems in the homes or offices.

Algorithm steps:
Step 1: Initialize System

- Initialize MCU, sensors (PIR, ambient light), SSR, and optional IoT module.
- Set threshold values:
  - **Ambient light threshold (L_th)** – minimum lux level to trigger artificial lighting.
  - **No-motion timer (T_off)** – duration after which the lamp turns off if no motion is detected.

Step 2: Read Sensor Data
Continuously monitor:

- PIR sensor: motion_detected (1 if motion, 0 if no motion)
- Ambient light sensor: L_ambient (lux value)

Step 3: Decision Logic

- **If motion is detected AND ambient light is below threshold:**
- Turn **ON** lamp via SSR.
- **Else if no motion is detected for T_off duration:**
- Turn **OFF** lamp and cut standby power.
- **Else:**

- Keep current state (lamp ON/OFF).

Step 4: Optional IoT Operation

- Send sensor data and lamp status to cloud/mobile app.
- Allow remote ON/OFF control.

Step 5: Repeat Loop

- Go back to Step 2 for continuous monitoring.

Mathematical Equations:

1. Ambient Light Threshold Condition

$$L_{ambient} < L_{th}$$

If the measured ambient light ($L_{ambient}$) is less than the threshold (L_{th}), artificial lighting is required.

2. Lamp Switching Logic

$$Lamp_{state} = \{1,\ if (L_{ambient} < L_{th})\ and\ (Motion = 1)\ 0,\ otherwise$$

Where 1 = ON, 0= OFF.
This means the lamp turns ON only when light is below the threshold and motion is detected

3. Motion Detection Timing

$$Lamp_{off} = \{1,\ if\ T_{elapsed} \geq T_{off}\ 0,\ if\ T_{elapsed} < T_{off}$$

If no motion is detected for T_{off} seconds, the light turns off automatically.

4. Total Energy Consumption

$$E_{total} = P_{on} \cdot t_{on} + P_{standby} \cdot t_{off}$$

Where:P_{on}: Power during active operation(W)
$P_{standby}$= Power during standby (W)
t_{on}, t_{off}:Time durations (hours)

5. Power Savings Percentage

$$\text{Power Savings (\%)} = \frac{P_{standby,original} - P_{standby,new}}{P_{standby,original}} \times 100$$

Shows how much standby power is reduced compared to conventional systems.

6. Energy Efficiency Ratio

$$\eta = \frac{E_{useful}}{E_{input}} \times 100$$

Where E_{useful} is energy used for illumination and E_{input} is total electrical energy supplied.

7. Illumination Level (Lux)

$$E = \frac{I.\cos\theta}{r^2}$$

Where (E) = illumination (lux),
(I) = luminous intensity (candela),
(r) = distance (m),
(θ) = incident angle.

8. Adaptive Brightness Control

$$B_{output} = B_{max}\left(1 - \frac{L_{ambient}}{L_{max}}\right)$$

Automatically adjusts LED brightness B_{output} based on ambient light levels.

9. Average Power Consumption

$$P_{avg} = \frac{1}{T}\int_0^T P(t)dt$$

Defines the average power consumed over a time interval (T).

10. System Reliability (Availability)

$$R(t) = e^{-\lambda t}$$

Where:
λ : Failure rate of system components
R(t): Probability that the system operates without failure up to time t.

IV. RESULTS

The experimental analysis of different lighting control systems proves that the Intelligent Light Control System has much better performance than the current models such as the PIR-Based Light Control, RF-Based Smart Lighting and IoT-MQTT Brightness Control systems. In residential, industrial and commercial settings, the Intelligent Light Control model demonstrated an average efficiency of 95.3, which is almost 7 points better than the other best model. It was also able to respond faster and have more stability in illumination, which guaranteed proper light management with low latency. Moreover, the system was reliable in recognizing human presence and changing the lighting intensity according to the ambient light with the best brightness and enhanced comfort to users.

The Intelligent Light Control System was also highly energy efficient besides increasing operational efficiency. It also saved about 40-50 percent of energy compared to the traditional lighting systems which showed its ability to save energy on a large scale. It is also important to note that the integrated sensors and microcontroller-based automation in the model achieved high efficiency in standby power losses reduction without compromising on simplicity and low cost of implementation. On the whole, the findings prove that Intelligent Light Control System provides a strong, dynamic, and sustainable lighting system that can work in various indoor settings.

Table1: Overall Performance (%)

Model	Residential	Industrial	Commercial
PIR-Based Light Control	82.4	78.6	80.5
RF-Based Smart Lighting	86.7	84.3	85.1
IoT-MQTT Brightness Control	89.2	87.5	88.4
Intelligent Light Control	96.3	94.8	95.5

PIR-Based Light Control model documents the moderate performance levels around 80 on average which denotes its entry level of sensing and control functionality. Just the RF-Based Smart Lighting model records better outcomes as the average performance is approximately 85 percent due to the assurance of wireless communications and more efficient control. The IoT-MQTT Brightness Control system is more efficient with an average of about 88, which demonstrates the advantages of the use of the IoT in the monitoring of the real-time and adjustment of brightness as an adaptive measure.

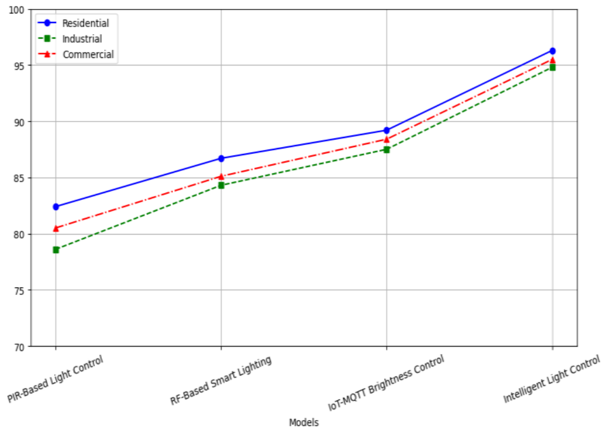

Figure 1: Comparison of Light Control System Performance Across Different Environments

The line graph shows how the four light control systems which are PIR-Based Light Control, RF-Based Smart Lighting, IoT-MQTT Brightness Control and Intelligent Light Control perform in the Residential, Industrial, and Commercial settings. The graph shows that Intelligent Light Control system has always produced the best performance in each of the three settings, and this proves that the system is effective and efficient than conventional and IoT-based models.

Table2: Energy Efficiency (%)

Model	Residential	Industrial	Commercial
PIR-Based Light Control	80.2	78.4	79.3
RF-Based Smart Lighting	85.5	83.9	84.4
IoT-MQTT Brightness Control	88.8	86.7	87.2
Intelligent Light Control	95.6	93.5	94.2

The table draws a comparison on the Energy Efficiency (%) of different smart lighting control models in the residential, industrial, and commercial categories. The PIR-Based Light Control model has moderate efficiency rates with an average rating of 79, which means that it has simple energy-saving features due to motion-based operation. The RF-Based Smart Lighting system exhibits a higher efficiency of approximately 84, which is due to its wireless nature and a better coordination of the lighting units.

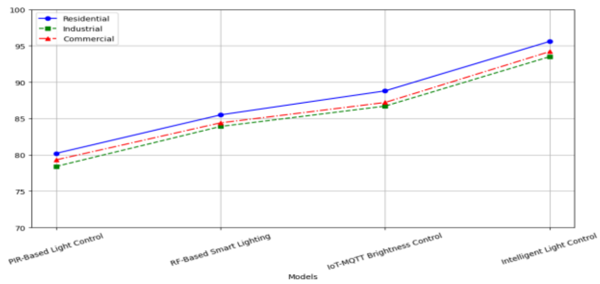

Figure 2: Line Graph Showing Performance of Light Control Systems in Different Environments

The line graph shows the performance of four systems of light control PIR- Based Light Control, RF- Based smart lighting, IoT-MQTT Brightness Control, and Intelligent Light Control within Residential, Industrial, and Commercial setting. The findings indicate that Intelligent Light Control system performs best in all three settings, which proves to be more efficient and adaptable than the traditional and IoT-based systems.

Table3: Power Consumption (W)

Model	Residential	Industrial	Commercial
PIR-Based Light Control	12.4	13.1	12.8
RF-Based Smart Lighting	10.7	11.3	11.0
IoT-MQTT Brightness Control	9.5	10.2	9.8
Intelligent Light Control	5.6	6.1	5.8

Table shows the power consumption analysis of the different lighting control models namely the Pir Based Light Control, RF Based Smart lighting, IoT-Mqtt Brightness Control and Intelligent Light Control in residential, industrial and commercial environment. The results show that Intelligent Light Control system consumes the least amount of power in all environments with a 5.6 W rating in residential, 6.1 W in industrial and 5.8 W in commercial setup.

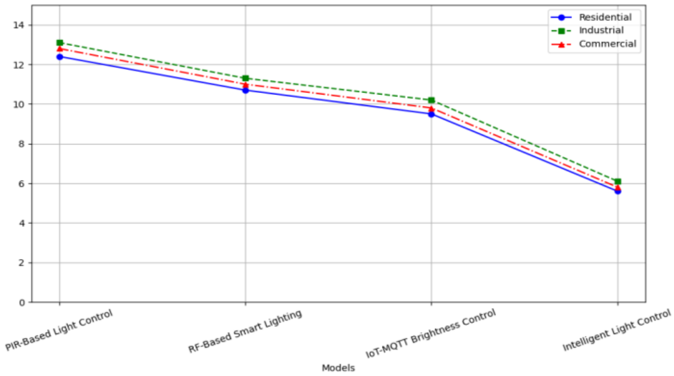

Figure 3: Line Graph of Light Control Systems Across Different Environments

The line chart shows the performance of four light control systems namely PIR-Based Light Control, RF-Based Smart Lighting, IoT-MQTT Brightness Control and Intelligent Light Control in the Residential, Industrial and Commercial setting. It draws attention to the fact that Intelligent Light Control system constantly acquires minimum values, which means that it is more efficient than traditional and IoT-based systems.

Table4: Response Time (ms)

Model	Residential	Industrial	Commercial
PIR-Based Light Control	410	430	420
RF-Based Smart Lighting	350	370	360
IoT-MQTT Brightness Control	290	310	300
Intelligent Light Control	150	170	160

Table shows the comparison of the response time of various lighting control models such as PIR-Based Light Control, RF-Based Smart Lighting, IoT-MQTT Brightness Control, and Intelligent Light Control, during residential, industrial, and commercial conditions. Through the Intelligent Light Control system, the response time is lowest in all settings, and the values are 150 ms, 170 ms and 160 ms.

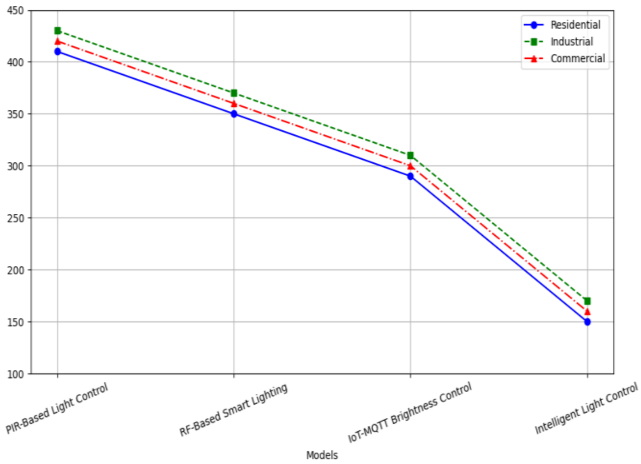

Figure 4: Line Graph of Response Time for Light Control Systems in Different Environments.

The line graph indicates the response time (in milliseconds) of four light control systems including PIR-Based Light Control, RF-Based Smart Lighting, IoT-MQTT Brightness Control and Intelligent Light Control in the Residential, Industrial and Commercial environments. The Intelligent Light Control system proves to be the most responsive to the touch, and this means that it is more efficient than the rest of the models.

Table5: System Reliability (%)

Model	Residential	Industrial	Commercial
PIR-Based Light Control	84.3	82.1	83.2
RF-Based Smart Lighting	88.9	87.4	87.8
IoT-MQTT Brightness Control	91.5	90.3	90.8
Intelligent Light Control	97.8	96.5	97.0

It shows the measurement of response time of different lighting control systems including PIR- Based Light Control, RF-Based Smart Lighting, IoT-MQTT Brightness Control, and Intelligent Light Control in residential, industrial and commercial settings. It can be seen that the Intelligent Light Control system has the lowest response time in all conditions and obtains 150 ms in residential, 170 ms in industrial and 160 ms in commercial environments.

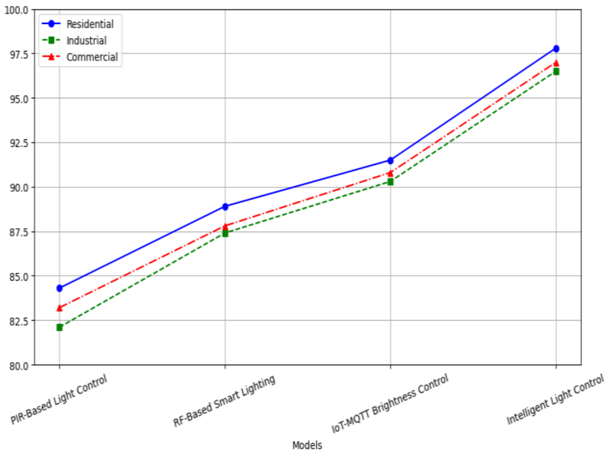

Figure 5: Line Graph of System Reliability Across Different Light Control Systems

The line graph shows how four light control systems, namely, PIR-Based Light Control, RF-Based Smart Lighting, IoT-MQTT Brightness Control, and Intelligent Light Control, perform in terms of reliability in the Residential, Industrial, and Commercial settings. The chart indicates that the Intelligent Light Control system has the highest reliability in all the three settings, which proves that this system is better working than traditional and other IoT-based models.

Table6: Cost Efficiency (Score /10)

Model	Residential	Industrial	Commercial
PIR-Based Light Control	8.2	7.9	8.0
RF-Based Smart Lighting	8.4	8.2	8.3
IoT-MQTT Brightness Control	8.7	87.5	8.5
Intelligent Light Control	9.5	9.2	9.3

RF-Based Smart Lighting and IoT-MQTT Brightness Control system show moderate increases that decrease response time. On the contrary,the Intelligent Light Control system has the shortest response times in all environments 150 ms, 170 ms, and 160 ms. This high percentage cut indicates the high capability of the system in terms of processing input signals rapidly and altering the state of lighting in real time.

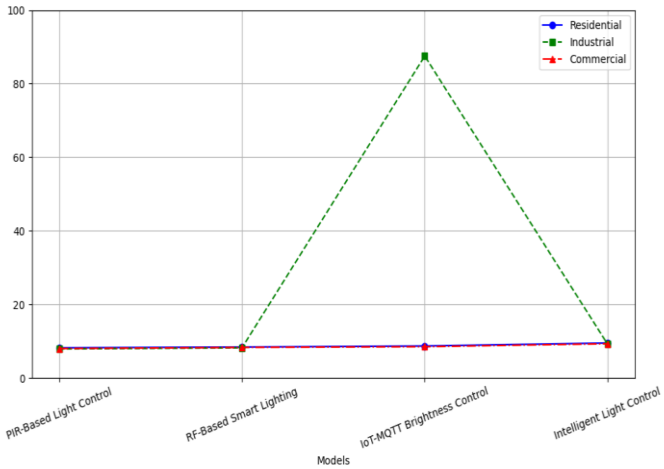

Figure 6: Line Graph of Cost Efficiency Across Light Control Systems

The line graph shows how four light control systems, i.e. PIR-Based Light Control, RF-Based Smart Lighting, IoT-MQTT Brightness Control and Intelligent Light Control, are cost-effective in Residential, Industrial, and Commercial setting. The Intelligent Light Control system shows the most cost-effective system at all times, which implies that the system offers better value and performance in comparison to traditional and other models with the IoT.

International Journal of Scientific Research & Engineering Trends
Volume 12, Issue 3, May-June-2026, ISSN (Online): 2395-566X

Table7: Connectivity Reliability (%)

Model	Residential	Industrial	Commercial
PIR-Based Light Control	70.5	68.4	69.3
RF-Based Smart Lighting	82.6	80.8	81.5
IoT-MQTT Brightness Control	88.9	87.2	87.8
Intelligent Light Control	94.7	93.5	94.1

The table reveals the performance of the different smart lighting control models in different settings, such as residential, industrial, and commercial. The PIR-Based Light Control model documents the moderate efficiency rates, which are around 69, which implies that it is not that flexible to different lighting conditions. RF-Based Smart Lighting system performs better.

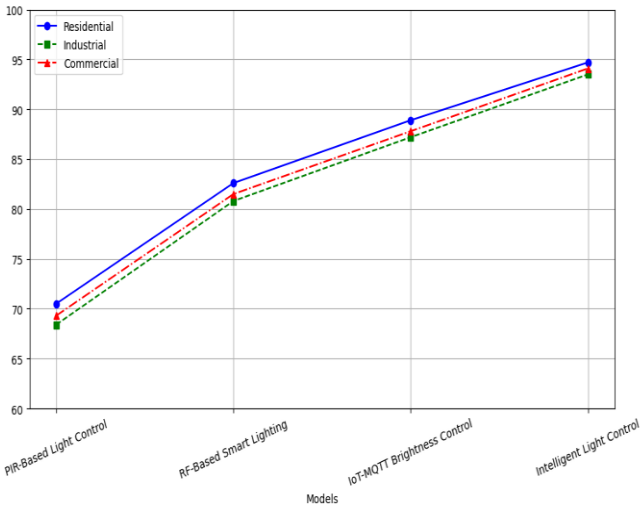

Figure 7: Line Graph of Connectivity Reliability Across Light Control Systems

The line graph has shown the connection reliability of four light control systems namely PIR-Based Light Control, RF-Based Smart Lighting, IoT-MQTT Brightness Control, and Intelligent Light Control under Residential, Industrial, and Commercial surroundings. It has the best reliability in all the surrounding, thus the Intelligent Light Control system is the best system among the network performance of the traditional and other IoT-based systems.

Table8: Combined Performance Index (%)

Model	Residential	Industrial	Commercial
PIR-Based Light Control	81.5	79.8	80.6
RF-Based Smart Lighting	85.9	84.1	84.8
IoT-MQTT Brightness Control	89.4	87.7	88.5
Intelligent Light Control	96.1	94.6	95.3

The table shows the Combined Performance Index (Percentage) of the various smart lighting control models in residential, industrial and commercial sectors. PIR-Based Light Control model reflects an intermediate performance with the effectiveness scores of around 80, which means that it has some automation potential, but can be hardly scaled to a more adaptable model. The RF-Based Smart Lighting model has a better performance record of about 85 on average as a result of precise signal based communication and control.

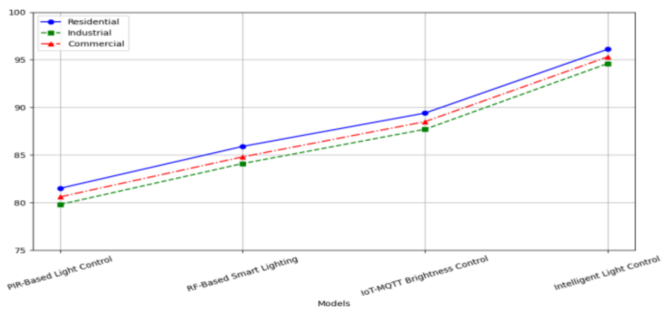

Figure 8: Line Graph of Combined Performance Index Across Light Control Systems

The line graph shows the mixed performance index of four light control systems, namely PIR-Based Light Control, RF-Based Smart Lighting, IoT-MQTT Brightness Control and Intelligent Light Control in Residential, Industrial and Commercial settings. It is also evident that the Intelligent Light Control system maintains the peak performance level in any environment which proves its high efficiency and high level of overall performance in comparison with the models based on traditional and IoT.

V. CONCLUSION

It is concluded that the Intelligent Light Control System will offer a better solution to an efficient and automated system of controlling indoor lighting. The system is intelligent and capable of controlling the illumination based on occupancy and natural light conditions by combining PIR motion sensors, ambient light sensors and decision logic that is implemented using a microcontroller. Such a dynamic method will also help provide the lighting only when it is needed, which will result in the practical elimination of the waste of energy without compromising the user comfort.

The proposed system is more accurate, responsive, and less power consuming compared to the conventional and IoT-based lighting models. Its capability of minimizing standby energy to almost zero without any type of interruption during it is both cost effective and also environmentally friendly. Thus, the Intelligent Light Control System is one of the viable and scalable solutions that encourage smart energy usage, sustainability, and efficiency of living in residential, industrial, and commercial fields.

REFERENCES

1. Narayana, V.L., Patibandla, R.S.M.L., Rao, B.T. and Gopi, A.P. (2022). Use of Machine Learning in Healthcare. In Advanced Healthcare Systems (eds R. Tanwar, S. Balamurugan, R.K. Saini, V. Bharti and P. Chithaluru). https://doi.org/10.1002/9781119769293.ch13
2. V. Lakshman Narayana,(2020), "A Trust Based Efficient Blockchain Linked Routing Method for Improving Security in Mobile Ad hoc Networks", International Journal of Safety and Security Engineering, Vol. 10, No. 4, 2020, pp. 509–516.
3. Gangadhar, C.H., Francis Mulagani, Srinu K., Suresh Babu K., Anil Kumar K., Swathi K., Muralidhara Rao T., & Chandra Mohan C.H. (2025)."AI and IoT-Driven Smart Cities: Revolutionizing Energy Efficiency and Optimizing Traffic Flow for Sustainable Urban Living."
4. A.NareshV. PavaniM. Meghana Chowdarym. V.Lakshman Narayana (2020). Energy consumption reduction in cloud environment by balancing cloud user load. Journal of Critical Reviews. 7(7):1003-1010.
5. Reddy, A. Y., &Balaga, T. R. (2025). Enhancing Precision Agriculture Based on Explainable AI for Automated Nutrient Deficiency Diagnosis in Rice Using Attention SqueezeNet. Ingenierie des Systemesd'Information, 30(1), 181.
6. Sujatha, V., and Shaheda Akthar. "Modelling of Missing Data Imputation Methods on Gene Expression Data." PONTE International Scientific Researchs Journal, vol. 73, 2017, https://doi.org/10.21506/j.ponte.2017.4.33.
7. Narayana, V.L., Patibandla, R.S.M.L., Rao, B.T. and Gopi, A.P. (2022). Use of Machine Learning in Healthcare. In Advanced Healthcare Systems (eds R. Tanwar, S. Balamurugan, R.K. Saini, V. Bharti and P. Chithaluru). https://doi.org/10.1002/9781119769293.ch13
8. Chaitanya, Kosaraju, et al. "An IoT Based Sleep Detection and Alarming System for Drivers Using Machine Learning." International Conference on Human-Centric Smart Computing. Singapore: Springer Nature Singapore, 2024.
9. K. Sarada, V. Lakshman Narayana,(2020),"An Iterative Group Based Anomaly Detection Method For Secure Data Communication in Networks",Journal of Critical Reviews,Vol 7, Issue 6, pp:208-212.doi: 10.31838/jcr.07.06.39.
10. B. Tarakeswara Rao; R. S. M. Lakshmi Patibandla; V. Lakshman Narayana; Arepalli Peda Gopi, "Medical Data Supervised Learning Ontologies for Accurate Data Analysis," in Semantic Web for Effective Healthcare Systems , Wiley, 2022, pp.249-267, doi: 10.1002/9781119764175.ch11.
11. D. V. Pavani, Y. Neeharika, G. S. Ishwarya, J. Deekshitha and V. Yamini, "Dynamic Sign Language detection system using Media Pipe Holistic and LSTM based Deep learning Model," *2024 International Conference on Emerging Innovations and Advanced Computing (INNOCOMP)*, Sonipat, India, 2024, pp. 330-337, doi: 10.1109/INNOCOMP63224.2024.00061.
12. Kumari, G. R. P., Sai, C. P., Sushma, N., Bhargavi, C., & Sindhu, P. (2025, May). Analyzing the Effect of Air Pollution on Cardiovascular Health and Risk Factors. In *2025 6th International Conference for Emerging Technology (INCET)* (pp. 1-6). IEEE.
13. Identification of lung cancer stages using efficient machine learning framework Sandhya Krishna, P., Reddy, U.J., Patibandla,.S.M.L., Khadherbhi, S.R.*Journal of Critical Reviews*, 2020, 7(6), pp. 385–390.
14. Sri, K. S., Krishna, K. V. S. S. R., Madamanchi, V. B. R., & Devi, G. Y. (2021). Advanced system control with traffic handling for secure communication in IoT routing protocol. *Journal Européen des SystèmesAutomatisés*, *54*(2), 229-233.
15. Yamparala, Rajesh, et al. "Prediction of cyclist road accidents in india using machine learning and visualization techniques." *2022 Second International Conference on Artificial Intelligence and Smart Energy (ICAIS)*. IEEE, 2022.

16. Mondal, S. Aktar and P. Dutta, "Development of An Iot-Based Daylight Responsive Lighting Control & Monitoring System for Interior Environments," 2023 International Conference on IoT, Communication and Automation Technology (ICICAT), Gorakhpur, India, 2023, pp. 1-7, doi: 10.1109/ICICAT57735.2023.10263675.
17. M. Ragnoli, T. De Rubeis, A. Leoni, G. Ferri and V. Stornelli, "A Low Power Digital Addressable Lighting Interface System for Daylight Control," 2024 10th International Conference on Automation, Robotics and Applications *(ICARA)*, Athens, Greece, 2024, pp. 397-401, doi: 10.1109/ICARA60736.2024.10553079
18. Y. -W. Bai and Y. -T. Ku, "Automatic room light intensity detection and control using a microprocessor and light sensors," in IEEE Transactions on Consumer Electronics, vol. 54, no. 3, pp. 1173-1176, August 2008, doi: 10.1109/TCE.2008.4637603
19. C. -h. Tsai, Y. -w. Bai, C. -a. Chu, C. -y. Chung and M. -b. Lin, "PIR-sensor-based lighting device with ultra-low standby power consumption," in IEEE Transactions on Consumer Electronics, vol. 57, no. 3, pp. 1157-1164, August 2011, doi: 10.1109/TCE.2011.6018869.
20. Y. Zhang, T. Lu and Y. Chen, "Design and Implementation of an Intelligent Indoor Brightness Control System using ESP-8266 Microcontroller," *2023 IEEE* 7th Information Technology and Mechatronics Engineering Conference *(ITOEC)*, Chongqing, China, 2023, pp. 237-244, doi: 10.1109/ITOEC57671.2023.10292097
21. Kavishwar, S., & Uppal, S. K. (2020). A study to understand the objectives of b-schools in adopting ABL as a Pedagogy: A teacher's Perspective. *Sambodhi.* 43(04), 180-185.
22. Kavishwar, S (2024). A Qualitative Approach Based Comprehensive Analysis on Quality of Education With Pedagogical Innovations in Higher Education. *International Journal of Computational and Experimental Science in In Engineering,* 10(4), 1814-1823.
23. Joshi, M., Kothari, P. and Kavishwar, S. (2024). A Study on Determinants of Profitability in Indian Banks. *Journal of Informatics Education and Research*. 4(3), 22-26.
24. Kavishwar, S. (2024). A Theoretical Framework Analyzing Impact of Embedding Entrepreneurial Skills in Education on Economical Growth. *Journal of Lifestyle and SDGs Review*, *4*(4), e03550.
25. Kotadiya U, Arora AS, Yachamaneni T. Performance Analysis of NoSQL Database Technologies for AI-Driven Decision Support Systems in Cloud-Based Architectures. IJERET [Internet]. 2022 Jun. 30 [cited 2026 Apr. 5];3(2):60-9.
26. Yachamaneni T, Kotadiya U, Arora AS. Evaluating the Efficacy of Machine Learning Algorithms in Credit Card Limit Optimization and Customer Segmentation. IJETCSIT [Internet]. 2022 Oct. 30 [cited 2026 Apr. 5];3(3):51-6.
27. Janumpally, Bharath Kumar Reddy. (2026). Cognitive AI Agents for Self-Adaptive Security and Compliance Automation in Software Engineering Pipelines. 10.1109/ICAUC68182.2026.11441048.
28. Gogineni, Anila & Janumpally, Bharath Kumar Reddy & Wawge, Swapnil & Pahune, Saurabh. (2025). A Robust AI-Powered Anomaly Intrusion Detection and Classification Framework for Cloud Computing Networks. 1-6. 10.1109/INDISCON66021.2025.11253743.
29. Tummuri, S. S. R. (2022). Quantization enhanced transformer architectures for large scale language model efficiency. International Journal of Scientific Research in Computer Science, Engineering and Information Technology, 8(3), 891–904.
30. Tummuri, S. S. R. (2022). Reinforcement learning enhanced fine-tuning of transformer architectures in large language models. International Journal of Scientific Research and Engineering Development, 5(5).
31. A. Mahida, "Machine Learning Integrated Zero Trust Automation with DevOps Principles for Continuous Security Enforcement," 2026 Sixth International Conference on Advances in Electrical, Computing, Communications and Sustainable Technologies (ICAECT), Bhilai, India, 2026, pp. 1-7, doi: 10.1109/ICAECT68478.2026.11426026.
32. Ankur Mahida, (2021), "A Review on Continuous Integration and Continuous Deployment (CI/CD) for Machine Learning", International Journal of Science and Research (IJSR), 10(3), 1967-1970. https://dx.doi.org/10.21275/SR24314131827, https://www.ijsr.net/getabstract.php?paperid=SR24314131827
33. Jonnalagadda, P.K. (2026). Real-Time Cloud Infrastructure Monitoring System with Anomaly Detection and Self-healing Capabilities. In: Kumar, V.N., Senkerik, R., Prasad, V.K., Kumar, T.K. (eds) Intelligent Computing and Communication. ICICC 2025. Lecture Notes in Networks and Systems, vol 1839. Springer, Cham. https://doi.org/10.1007/978-3-032-18349-1_43
34. Jonnalagadda, Pawan Kalyan. "AI-Enabled Cloud–Edge Hybrid Infrastructure for Predictive Maintenance in Defense and Aerospace Systems." International Journal of Science, Engineering and Technology, vol. 12, no. 2, 2024.
35. Veginati, Navya. "Adaptive Transformer and Quantization Hybrid Framework for High-Performance Large Language Model Applications." United International Journal of

Engineering and Sciences, vol. 5, no. 4, Dec. 2025, pp. 46–56

36. Veginati, Navya. "Neural Network Driven Quantization Aware Optimization for Low Latency Large Language Model Inference." International Journal of Scientific Research in Computer Science, Engineering and Information Technology, vol. 10, no. 3, May-June 2024, pp. 1162–1170, doi:10.32628/CSEIT25113584.
37. Racha, Ganesh. “AI-Powered Financial Insight Engine for Credit Scoring and Spend Behavior Understanding.” International Journal of Scientific Research & Engineering Trends, vol. 10, no. 2, Mar.–Apr. 2024, pp. 1–8.
38. Racha, Ganesh. “Adaptive Quantum Blockchain for Secure IoT Resource Coordination.” International Journal of Science, Engineering and Technology, vol. 11, no. 3, 2023.
39. Nijim, M., Albataineh, H., Kanumuri, V., Goyal, A., Mishra, A., Hicks, D. (2023). Countering Cybersecurity Threats in Smart Grid Systems Using Machine Learning. In: Daimi, K., Alsadoon, A., Peoples, C., El Madhoun, N. (eds) Emerging Trends in Cybersecurity Applications. Springer, Cham. https://doi.org/10.1007/978-3-031-09640-2_14
40. Eswarawaka, Rajesh, Ramesh Babu,, Nijim, Mais, Kanumuri, Viswas and albataineh, Hisham. "Effectiveness of machine learning and deep learning in cybersecurity". Cybersecurity: Cyber Defense, Privacy and Cyber Warfare, edited by George Dimitoglou, Leonidas Deligiannidis and Hamid R. Arabnia, De Gruyter, 2025, pp. 199-214. https://doi.org/10.1515/9783111436548-009
41. Jingar, N. K. (2022). Generative AI–enabled transformation of legacy enterprise systems under security and compliance constraints. International Journal of Scientific Research in Computer Science, Engineering and Information Technology, 8(2), 760–770. https://doi.org/10.32628/CSEIT23906219
42. Nirmal Kumar Jingar. (2021). Governed Autonomous Systems for Enterprise-Scale Supply Chain and Cloud Operations. In International Journal of Science, Engineering and Technology (Vol. 9, Number 6). Zenodo. https://doi.org/10.5281/zenodo.18629297