ISSN (E) 3007-3197
ISSN (P) 3007-3189
Publisher Name : COLLABORATIVE EDUCATIONAL LEARNING INSTITUTE
Frequency Of Journal: Bi-Annual
Annual Methodological Archive Research Review

VOL-3, ISSUE-1, 2025

Annual Methodological Archive Research Review

http://amresearchreview.com/index.php/Journal/about

[1]Rao Behram Umer
[2]Muhammad Asad Khan*
[3]Amanullah
[4]Muhammad Abdul Basit
[5]Mamoona Khalid
[6]Khaled Abdullah

IoT-Enabled Smart Lighting Control: A Niagara Software Framework

Rao Behram Umer
Department of Electrical Engineering University of Engineering & Technology, Taxila, Pakistan
behram.umer@students.uettaxila.edu.pk
Muhammad Asad Khan
Telecommunication Department, Hazara University, Mansehra, Pakistan
asadkhan@hu.edu.pk *(Corresponding Author)
Amanullah
Department of Telecommunication Engineering University of Engineering & Technology, Taxila, Pakistan
amanullahsasoli99@gmail.com
Muhammad Abdul Basit
Department of Telecommunication Engineering University of Engineering & Technology, Taxila, Pakistan
abdul.basit@uettaxila.edu.pk
Mamoona Khalid
Department of Electrical Engineering University of Engineering & Technology, Taxila, Pakistan
mamoona.khalid@uettaxila.edu.pk
Khaled Abdullah
Department of Electrical Engineering University of Management & Technology, Lahore, Pakistan
khaled.abdullahh1999@gmail.com

Abstract

The proliferation of Internet of Things (IoT) technologies is rapidly transforming building management systems, enabling unprecedented levels of automation, efficiency, and remote control. This research details the design and implementation of a smart lighting control system built upon the Niagara Software Framework, specifically utilizing the Centerline Server and Niagara Web Launcher. The core objective is to establish a robust, centralized, and scalable IoT solution for automating building lighting operations. The system integrates physical devices, such as BMT-D04 relay modules, into the Niagara platform, effectively creating a network of interconnected "things" that can be monitored and controlled remotely. This implementation achieves centralized control, significantly improving energy efficiency and operational convenience through scheduled automation and real-time command execution. The study provides a practical demonstration of integrating diverse hardware components into a unified software environment, highlighting the Niagara Framework's capability as a powerful IoT gateway and management platform for smart buildings. Furthermore, the work offers valuable insights into building management and explicitly suggests the system's inherent scalability and potential for future expansion into a comprehensive Building IoT (BIoT) ecosystem.

Keywords	Niagara Software, home automation, Transformer, Circuit Breaker, Relay Module (BMT-D04)

ISSN (E) 3007-3197
ISSN (P) 3007-3189
Publisher Name : COLLABORATIVE EDUCATIONAL LEARNING INSTITUTE
Frequency Of Journal: Bi-Annual
Annual Methodological Archive Research Review

VOL-3, ISSUE-1, 2025

I. INTRODUCTION

Building Management Systems (BMS) development has quickened because the market asks for smarter buildings to automate core functions, including lighting control and HVAC systems and security. Building expertise in lighting management represents an essential requirement for decreased power utilization, together with improved user satisfaction. The objective of this study involves establishing a lightning control system through Niagara software and its Centerline Server and Niagara Web Launcher for centralized monitoring and scheduling, and control capabilities. Employees worked on practical system development through an engineering training program.

The evolution of Building Management Systems (BMS) is now intrinsically linked with the Internet of Things (IoT), leading to the emergence of Building IoT (BIoT) solutions. BIoT involves the deployment of interconnected devices—the 'things'—to collect data and enable intelligent, centralized control over building operations. This paradigm shift moves beyond simple automation to create data-centric, adaptive environments. In this context, the objective of this study is not merely to establish a lighting control system, but to implement a foundational BIoT platform using the Niagara Software Framework. This approach leverages Niagara's capabilities as a powerful IoT Gateway to integrate field devices, enabling centralized monitoring, scheduling, and control capabilities essential for modern smart infrastructure.

II. LITERATURE REVIEW

First, Home systems that are automated reduce the human involvement needed, which makes life better. While new models can be controlled from afar using Wi-Fi, older models such as Mitsubishi Electric's MSZ-HJ series do not have these features built in [1]. The combination of IoT and home appliances is making home automation more convenient, cozy and efficient. Some features of IoT include smart lighting, managing the environment, security, energy systems, entertainment and healthcare. However, the adoption of artificial intelligence is held back by worries about privacy and business hurdles [2].

The authors [3] address the usability challenges faced by users when evaluating smart home devices. The article describes the importance of creating a prototype and reviewing UI. It sets up a smart house system using a Raspberry Pi computer, servo motors, temperature sensors and an Android smartphone. The system relies on Telegram chatbots, Alice and Home Assistant, which are open-source and third-party solutions. The results highlight the various methods for transforming a home into a smart home and the user-friendly interfaces that facilitate this process.

In [4], IoT and AI have sparked increased interest in Smart Home Automation (SHAuto) as they bring together various services through interconnected devices. But if a device is hacked, it can reveal private information and dangerously affect privacy and safety. This article examines the key issues with SHAuto related to the way devices are controlled, the automation system used and how they communicate. This analysis indicates that guiding device communications can help in implementing secure access control solutions.

The way cities grow and maintain sustainability depends greatly on technology and automation. Living conditions have improved thanks to smart homes and they are now a part of modern Smart Cities too. In this review [5],[19] look at

ISSN (E) 3007-3197
ISSN (P) 3007-3189
Publisher Name : COLLABORATIVE EDUCATIONAL LEARNING INSTITUTE
Frequency Of Journal: Bi-Annual
Annual Methodological Archive Research Review

how using intelligent systems and the expertise of experts can turn smart homes into sustainable cities. It looks in detail at the ways modern smart homes use new technology and how urban areas are changing because of it. It brings attention to how using smart home technology can help shape smart cities in the future. Through the analysis of Federated Learning, Digital Twin and Embedded Edge computing, it is possible to find useful ideas for improving both planning and infrastructure in smart cities.

Home automation [6],[14]is on the rise because it helps us get more done and spend less time managing things manually. Many devices, including air conditioners, TVs, fans, lights and emergency systems, can operate through it. The study involves examining a device controlled by Bluetooth that has a range of 100 meters and can switch appliances. The paper [7] presents a unified API framework to link smart buildings to HVAC control systems. It is made up of three parts: data integration, machine learning algorithms and HVAC system control. At the beginning, energy use dropped by 27% compared to traditional BMS systems, supporting the growth of smart buildings.

People are turning to home automation systems because they are easy to use, make life comfortable and save energy. Using automation to control curtains allows us to use more natural sunlight, which can help save energy and make the house more comfortable. Using curtains that must be pulled by hand can be a challenge for both elderly and disabled people. The system works by using LDR sensors on an Arduino Uno to control when the curtains open or close automatically based on the surroundings. To control the system, you simply use a DC motor alongside physical buttons, which makes it an affordable way to use smart home tech in [8].The authors discuss [9], [18] that Wireless methods are being used by more researchers are using the ESP module from Espressif Systems. To test communication channels, they set up a software environment with a NodeMCU module on an ESP8266 and the Arduino IDE. It was found that MQTT is more suited for real-time sensor systems and comes with tested code for quick setup. The paper [10], [11] explores the structure of optical fiber broadband networks, their main characteristics, current issues and ways to identify and handle those issues. It presents Smart Home Automation using Arduino and Wi-Fi, focusing on cutting power consumption and managing loads. The authors in [12],[13] set out to use Bluetooth technology in a home automation system, enabling control and sharing from a remote device. Android smartphone software is programmed, and the circuit is designed using Arduino microcontrollers in this phase.

In [15], [16], the work presents an optical fiber (OF) based wire system used to measure up devices. It designs a scheme of intelligence optical fiber wiring ultra-large capacity, simulates the scheduling and anti-winding automatically, and proposes an intelligent optical fiber-wire linking scheme by alarm. The system employs a robot-arm to remotely intelligent hopping and inspection of fibers and find defects. Convolutional Neural Network and Fuzzy Logic model recognize and categorize winding conditions. The approach results in a gap state detection accuracy above 98.67% and a 100% overlapped line recognition, making it a favourable alternative to manual winding. It is the initial work involving application of optical fiber wires in a multiplex and combined process.

ISSN (E) 3007-3197
ISSN (P) 3007-3189
Publisher Name : COLLABORATIVE EDUCATIONAL LEARNING INSTITUTE
Frequency Of Journal: Bi-Annual
Annual Methodological Archive Research Review

VOL-3, ISSUE-1, 2025

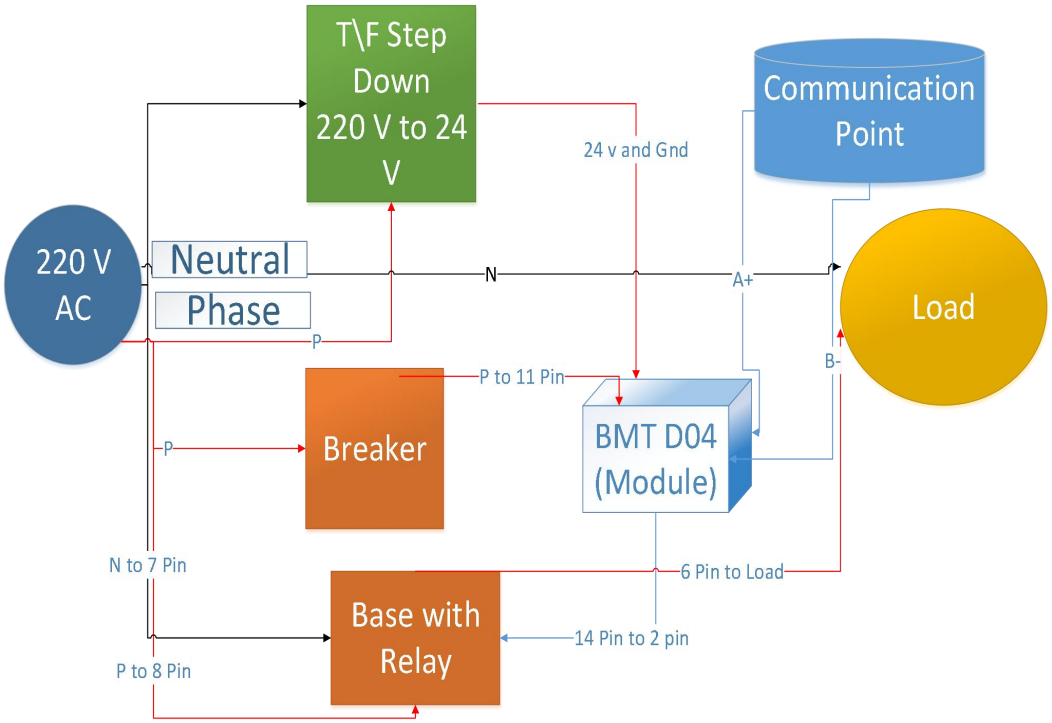


Fig. 1. The proposed system architecture of the Lightning Control System contains a Transformer and Relay Module (BMT-D04) alongside Load.

The paper [17] proposes an automated fiber-optic security system (FOSS) based on multi-channel CMOS-based image sensors that can sense a vibration implication on optical fibers. The system can be commercialized and its accuracy in the climatic conditions of Kazakhstan is very high, eliminating ageing electrical systems to send signalling.

III. STYLING SYSTEM ARCHITECTURE

The system architecture combines hardware components with software elements for achieving automated, reliable lighting control operations in Figure 1. Operating safety for control modules is ensured through the initial power supply transformation from 220V AC to 24V AC using a transformer. Electronic devices used in circuits require protection against overloads, which can be provided through a Miniature Circuit Breaker (MCB). The relay modules (DADCN G2R-2-SNDI-24VDC) interface with BMT-D04 controllers to enable switching of electric loads through control signals, as presented in Figure 2.

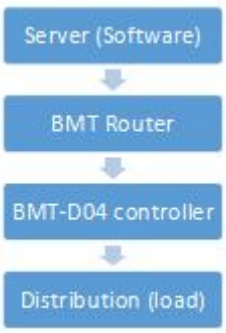


Fig. 2. Proposed Block diagram of the system

ISSN (E) 3007-3197
ISSN (P) 3007-3189
Publisher Name : COLLABORATIVE EDUCATIONAL LEARNING INSTITUTE
Frequency Of Journal: Bi-Annual
Annual Methodological Archive Research Review

The Centerline Server serves as a communication hub that enables interaction with the Niagara Web Launcher to support remote access capabilities. Modular expansion capabilities exist in this architecture because it does not require extensive rewiring to add new zones and devices.

IoT Architectural Mapping

The system architecture can be mapped directly onto a three-tier IoT model, clearly defining the role of each component in the BIoT ecosystem (Figure 1 should be updated to reflect this layering).

1. Sensing/Actuation Layer (The 'Things'): This layer comprises the physical devices responsible for interaction with the environment. In this system, the Relay Modules (BMT-D04) function as the primary actuators, switching the electrical loads (lights). While the current implementation focuses on actuation, these devices represent the edge nodes of the network, ready for integration with sensors (e.g., ambient light, occupancy) to complete the sensing capability.

2. Network/Gateway Layer: The Niagara Centerline Server serves as the critical IoT Gateway. Its primary function is to bridge the local, proprietary communication protocols (like BACnet) used by the field devices to the wider IP network. It performs essential functions such as device discovery, protocol translation, data aggregation, and secure communication channeling to the application layer.

3. Application/Cloud Layer: The Niagara Web Launcher provides the application interface, allowing authorized users to remotely monitor the system status, submit real-time commands, and manage scheduling routines. This layer represents the user-facing component of the BIoT solution, providing centralized control and data visualization capabilities accessible from any web-enabled device."

IV: NIAGARA SOFTWARE FRAMEWORK

Niagara software functions as the core infrastructure which provides the means to manage devices and monitor systems in real-time, as well as automate control processes. Crucially, the Niagara Framework functions as a sophisticated IoT middleware platform. It abstracts the complexity of integrating diverse hardware by providing a unified data model and a standardized communication layer. While BACnet serves as the essential local area network protocol for building automation functions, Niagara acts as the protocol translator, or IoT Gateway, enabling the data from these field devices to be securely accessed and managed over standard IP networks (e.g., via HTTP/HTTPS for the Web Launcher). This capability is fundamental to the system's scalability and remote accessibility, positioning the entire solution firmly within the BIoT domain.

BACnet serves as the standard communication protocol that Niagara provides for building automation functions. Niagara provides essential capabilities which let operators conduct device searching and address identification along with real-time display of data and scheduling capabilities and alarm system control. Authorized users can control and monitor lighting circuits through the Niagara Web Launcher since it features a browser-based GUI for remote operation. The flexible nature of Niagara enables trouble-free device integration of diverse equipment suitable for operations involving multiple device types.

ISSN (E) 3007-3197
ISSN (P) 3007-3189
Publisher Name : COLLABORATIVE EDUCATIONAL LEARNING INSTITUTE
Frequency Of Journal: Bi-Annual
Annual Methodological Archive Research Review

VOL-3, ISSUE-1, 2025



Fig. 3. Device discovery and identification

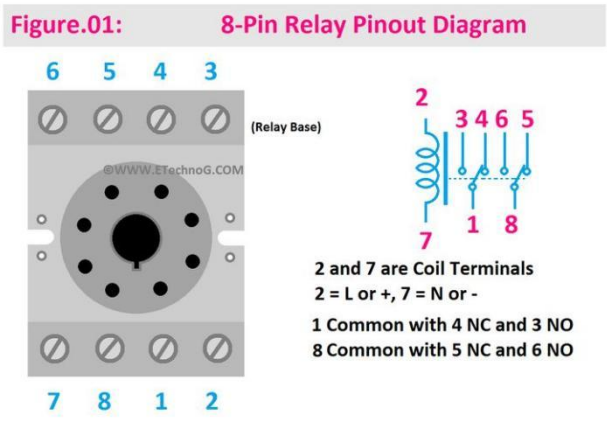
V: DEVICE DISCOVERY AND CONFIGURATION

The beginning of operational procedures started with installing physical BMT-D04 modules and relays into place. Each module contained a specific hexadecimal address, which the BACnet Network processed through decimal conversion to integrate into Niagara. Using device discovery commands, the system located every active module for integration into the network, as shown in Figure 3.

The system architect divided the devices into different functional areas that included corridors and external lighting systems. The operational validation tests demonstrated the correct functioning of relays in switching loads after discovery to create a dependable communication system for the entire building.

VI: RELAY AND LOAD OPERATION

The system uses relay operation as its main control method to perform switching tasks. The relay coil accepts a 24V control signal, which triggers it to close the circuit, thus enabling 220V AC to activate the connected lighting devices, as shown in Figure 4[6].



(a)

ISSN (E) 3007-3197
ISSN (P) 3007-3189
Publisher Name : COLLABORATIVE EDUCATIONAL LEARNING INSTITUTE
Frequency Of Journal: Bi-Annual
Annual Methodological Archive Research Review

VOL-3, ISSUE-1, 2025



(b)

Fig. 4. Relay with Base Configuration in (a) and (b)

Safety along with easy maintenance was enhanced using standard base sockets that housed relays. Relay functionality was tested through the Niagara Web Launcher platform, which enabled the execution of manual and automated switching commands, leading to successful confirmation of system readiness for both timed automation and real-time control actions.

VII: TIME SCHEDULING AND AUTOMATION

Through automated scheduling of lights, there is a reduced need for human interaction, while energy efficiency improves drastically. The system brought lights on and off based on building use patterns, as shown in Figure 5.

The system activated common lights within a specified business period and automatically turned them off after business hours concluded. The system included programmed schedules that operated on specific days and during public holidays.

VIII: CENTRAL MONITORING AND CONTROL VIA CENTERLINE SERVER

The Centerline Server is the architectural cornerstone of the system, functioning as the primary IoT Gateway and central data hub for the entire Building IoT (BIoT) solution. It is responsible for aggregating, storing, and managing all real-time operational data, device configurations, and scheduling routines, as depicted in Figure 6.

A. Role as IoT Gateway and Data Hub

The Centerline Server's primary function is to act as the crucial bridge between the local control network (where field devices communicate via protocols like BACnet) and the wider IP network. It performs essential protocol translation, converting the low-level device data into standardized data objects that can be securely accessed and managed over the internet. This centralization is vital for a scalable BIoT deployment, as it provides a single point of access for all device data and control logic.

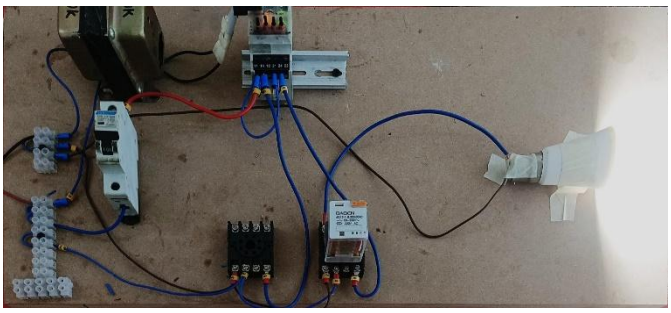
The server stores a comprehensive historical record of all system events, including relay state changes, manual overrides, and communication diagnostics. This centralized data repository is the foundation for future data-driven applications, enabling:

• Real-time Monitoring: Continuous collection and display of the current state of all connected "things."

• Data Aggregation: Consolidation of data from multiple devices for holistic system oversight.

ISSN (E) 3007-3197
ISSN (P) 3007-3189
Publisher Name : COLLABORATIVE EDUCATIONAL LEARNING INSTITUTE
Frequency Of Journal: Bi-Annual
Annual Methodological Archive Research Review

• Redundancy and Fault Tolerance: The server maintains secure communication pathways with user interfaces, ensuring system reliability and promoting fault tolerance benefits that streamline management and reduce the need for field maintainers.



B. Remote Access via Niagara Web Launcher

The Niagara Web Launcher provides the user-facing application layer, offering a browser-based Graphical User Interface (GUI) for remote operation (as depicted in Figure 6). By connecting securely to the Centerline Server, the Web Launcher allows authorized users to experience smooth access to all system functions, including:

• Command Submission: Real-time manual control over lighting circuits, overriding automated schedules when necessary.

• Status Oversight: Visual confirmation of device status, schedule execution, and alarm notifications.

•. Configuration Management: Remote adjustment of device parameters and scheduling routines.

This remote accessibility is a defining characteristic of an IoT system, ensuring that the building's lighting infrastructure can be managed efficiently from any location, thereby enhancing operational convenience and responsiveness. The unified system design, centered on the Centerline Server, ensures that the complexity of the underlying hardware is abstracted, presenting a simplified, powerful interface to the end-user.

IX: RESULTS AND OBSERVATIONS

System reliability reached a high level during the execution of programmed schedules with remote commands and load switching operations. The system allowed real-time tracking to perform preventive maintenance, and historical analysis allowed additional energy improvements as shown in Figure 7.

The debugging process, along with device configuration, enabled the successful elimination of practical issues like address mapping problems and communication failures. The project showed that Niagara software makes it possible to develop intelligent home and commercial lighting systems which scale across multiple addresses.

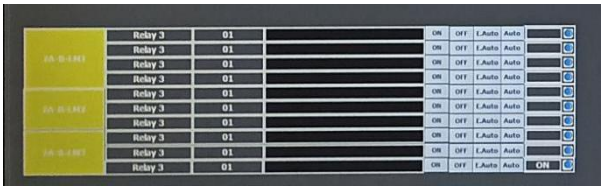


Fig. 6. A real-time display from Niagara Web Launcher shows the status of each lighting zone with available control features

.

ISSN (E) 3007-3197
ISSN (P) 3007-3189
Publisher Name : COLLABORATIVE EDUCATIONAL LEARNING INSTITUTE
Frequency Of Journal: Bi-Annual
Annual Methodological Archive Research Review

The system's operation generates a continuous stream of data points critical for BIoT analysis. The primary data collected includes the real-time state of each relay (ON/OFF), the timestamp of each state change, and the command source. The collected data is aggregated and time-stamped by the Niagara controller (IoT Gateway), which performs a degree of Edge Computing by filtering transient noise and converting raw device status into standardized data objects before transmission to the Centerline Server.

The Centerline Server acts as the central data repository, storing the historical data for long-term analysis. Furthermore, the data volume for a single lighting system is modest; the architecture is designed to handle the high velocity of state-change events across a large number of devices, demonstrating the system's scalability for a full-scale BIoT deployment. The ability to track and log every operational event provides the necessary foundation for future predictive maintenance and energy optimization algorithms based on machine learning.

X. CONCLUSION AND FUTURE WORK

The research successfully demonstrates the efficacy of using the Niagara Software Framework, along with the Centerline Server and Web Launcher, to implement a centralized and reliable smart lighting control system. The established system moves beyond conventional building automation by leveraging the Niagara platform as a powerful IoT Gateway, effectively bridging the local BACnet-based control network with the wider IP network. This architectural approach, which enables remote access, centralized scheduling, and modular expansion, significantly boosts both operational efficiency and energy savings. The successful integration of the BMT-D04 relay modules confirms the system's ability to function as a robust and scalable Building IoT (BIoT) platform.

The system's reliability in executing programmed schedules and handling remote commands was validated, providing a foundation for data-driven building management. The ability to track and log every operational event is a critical feature, positioning the system for advanced analytics and maintenance strategies.

Future work will focus on fully realizing the BIoT potential of this platform and expanding its scope to create a truly autonomous smart environment.

REFERENCES

[1] Śniadkowski, M., Stachyra, G. and Wójcicka-Migasiuk, D., 2025. Enhanced air conditioning control for the smart home. *Advances in Science and Technology. Research Journal*, *19*(1), pp.160-164.

[2] Anusha, P., Vijay, P.D., Reethika, V., Karthikeya, G.G.S. and Burugari, V.K., 2025. Unveiling the potential: An in-depth analysis of Empowering smart homes through IoT-based sensing and monitoring platforms for enhanced automation. In *Challenges in Information, Communication and Computing Technology* (pp. 613-618). CRC Press.

[3] Faizrakhmanov, R., Bahrami, M.R. and Platunov, A., 2025. Prototype, method, and experiment for evaluating usability of smart home user interfaces. *Computer Standards & Interfaces*, *92*, p.103903.

[4] Tay, S.W., Zhang, N. and AlJanah, S., 2024. A problem analysis of smart home automation: Toward secure and usable communication-based authorization. *IEEE Access*, *12*, pp.18103-18121.

ISSN (E) 3007-3197
ISSN (P) 3007-3189
Publisher Name : COLLABORATIVE EDUCATIONAL LEARNING INSTITUTE
Frequency Of Journal: Bi-Annual
Annual Methodological Archive Research Review

[5] Huda, N.U., Ahmed, I., Adnan, M., Ali, M. and Naeem, F., 2024. Experts and intelligent systems for smart homes' Transformation to Sustainable Smart Cities: A comprehensive review. *Expert Systems with Applications*, *238*, p.122380.

[6] Iyen, C., Ayomanor, B. and Orseer, D., 2024. Implementation of Bluetooth Enabled Home Automation System. *European Journal of Theoretical and Applied Sciences*, *2*(2), pp.310-318.

[7] Adepoju, S. and David, S., 2025. An Intelligent API Framework for Real-time Occupancy-Based HVAC Integration in Smart Building Management Systems. *Journal of Knowledge Learning and Science Technology ISSN: 2959-6386 (online)*, *4*(1), pp.61-70.

[8] Alistone, B.Y.U.K.U.S.E.N.G.E., 2024. *Design and implementation of GSM-based home automation* (Doctoral dissertation, DESIGN AND IMPLEMENTATION OF AN AUTOMATIC CURTAINS OPENING AND CLOSING CONTROLLER SYSTEM USING ARDUINO UNO).

[9] Chakraborty, S. and Aithal, P.S., 2024. Communication Channels Review For ESP Module Using Arduino IDE And NodeMCU. *International Journal of Applied Engineering and Management Letters*, *8*(1), pp.1-14.

[10] Liang, Y., Chen, H. and Wang, W., 2025, February. Analysis of network fault location and treatment method of optical fiber broadband system. In *International Conference on Optical and Photonic Engineering (icOPEN 2024)* (Vol. 13509, pp. 369-374). SPIE.

[11] Zaro, F., Tamimi, A. and Barakat, A., 2021. Smart home automation system. *International Journal of Engineering and Innovative Research*, *3*(1), pp.66-88.

[12] Amoran, A.E., Oluwole, A.S., Fagorola, E.O. and Diarah, R.S., 2021. Home automated system using Bluetooth and an android application. *Scientific African*, *11*, p.e00711.

[13] Padhiary, M., Saikia, P., Roy, P., Hussain, N. and Kumar, K., 2025. A review on advancing agricultural efficiency through geographic information systems, remote sensing, and automated systems. *Cureus Journal of Engineering*.

[14] Chanda, D., 2025. Optimizing AI and Robotics-driven Automation Systems: The Synergy of Data Engineering and Data Science in Scalable Intelligent Automation. *Journal of Electrical Systems*, *21*.

[15] Golovastikov, N.V., Kazanskiy, N.L. and Khonina, S.N., 2025, June. Optical Fiber-Based Structural Health Monitoring: Advancements, Applications, and Integration with Artificial Intelligence for Civil and Urban Infrastructure. In *Photonics* (Vol. 12, No. 6, p. 615). MDPI.

[16] Kovtun, A.A., Mekhtiyev, R.A. and Yurchenko, A.V., 2025. Automated fiber-optic security system to protect perimeters of various facilities from unauthorized access. *Russian Physics Journal*, pp.1-6.

[17] Zhou, M., Su, W. and Liu, D., 2025. Research on signal processing of intelligent routing check system of optical fiber distribution based on relay technology.

[18] Mitru, A., 2025. Data communication and software development for the automation of an industrial piston compressor. *REVUE ROUMAINE DES SCIENCES TECHNIQUES—SÉRIE ÉLECTROTECHNIQUE ET ÉNERGÉTIQUE*, *70*(1), pp.97-102.

ISSN (E) 3007-3197
ISSN (P) 3007-3189
Publisher Name : COLLABORATIVE EDUCATIONAL LEARNING INSTITUTE
Frequency Of Journal: Bi-Annual
Annual Methodological Archive Research Review

[19] Janz, C., You, Y., Hemmati, M., Javadtalab, A., Jiang, Z., Li, H. and Haoyu, F., 2025. Network digital twins for optical networks. *Optical Fiber Technology*, *89*, p.104068.