Smart office system: A review

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***Abstract*— The evolution of smart office systems is examined, along with research trends and breakthroughs, in this survey of the literature. Smart office solutions improve workplace productivity, comfort, and efficiency by utilizing data analytics, artificial intelligence (AI), and Internet of Things (IoT) technology. The analysis highlights essential elements of smart office systems that support an adaptable and user-centered work environment, such as occupancy sensors, climate management, intelligent lighting, and smart furniture. The integration of these technologies with the current office infrastructure, data security and privacy issues, and the effects of smart office systems on organizational outcomes and employee well-being are all covered in this article. It also outlines future research directions that should be pursued to optimize smart office systems for seamless human-machine interaction, energy efficiency, and customisation. This thorough analysis attempts to give researchers and practitioners interested in the changing field of smart office technologies and their consequences for contemporary workplaces a basic grasp.**

Keywords—, literature review, smart office, Office Automation, Ai.

I. INTRODUCTION

The An extensive analysis of the studies, advancements, and patterns around the incorporation of technology in office settings may be found in a review of the literature on smart office systems. The Internet of Things (IoT), artificial intelligence (AI), and data analytics are just a few of the technologies that a smart office system uses to improve workplace productivity, comfort, and efficiency. Through the automation of repetitive operations and the promotion of improved communication and collaboration, these systems are intended to maximize resource utilization, enhance energy efficiency, and improve the working environment for employees. The examination starts off by examining how office automation has changed over time and how traditional workplace setups have given way to smart surroundings. It looks at how the development of intelligent systems that can monitor, control, and optimize different aspects of the office environment—such as lighting, security, HVAC, and even employee wellness—has been made possible by technological advancements, particularly in the areas of IoT and AI. The literature review also examines several smart office system components, including smart workspaces, smart lighting, smart climate control, and smart security systems, outlining their features, advantages, and possible drawbacks. It goes on how sensors and Internet of Things (IoT) devices gather data, how AI algorithms process and analyze data, and how cloud computing stores and organizes massive datasets. The review also explores how smart office solutions affect employee happiness and organizational productivity. It takes into account research that demonstrate how these technologies can lower energy expenses, improve space management, and create an atmosphere that is more responsive to employees' requirements and adaptable. The review also discusses the possible drawbacks, such as data security risks, privacy problems, and expensive implementation upfront. The literature analysis on smart office systems concludes by providing a thorough summary of the state of the field's research at this time and outlining the advantages and disadvantages of implementing smart technology in office settings. It emphasizes the need for more study, especially in fields like cybersecurity, user acceptance, data privacy, and the long-term viability of smart office efforts.[29]

The following are the goals of this review of the literature:

1. To comprehend the condition of smart office systems and the technologies that are utilized today.

2. To assess the advantages and difficulties of putting smart office solutions into place.

3. Examine real-world instances and case studies of smart workplace setups.

4. To determine current and upcoming research topics, gaps, and trends in the field of smart office systems.

This literature analysis will offer a thorough grasp of how smart office systems are influencing the modern workplace and their ability to spur creativity and efficiency in organizational settings through a methodical examination of scholarly and industrial sources.

II. LITERATURE REVIEW

The majority of an organization's technical, financial, and administrative functions are carried out in its office. Figure 1 illustrates how office appraisals have evolved every ten years since they began in the 1950s (Chen, 2020). To gather and examine information regarding the features, purposes, and results of a program, an office evaluation is necessary (Zint et al., 2012)[1].

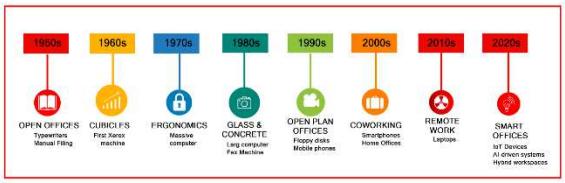

Fig. 1. Evaluation of an office

The size of the office affects how many employees are recruited. Because of this, the office plays an important function as a knowledge hub, alerting those in the vicinity to changes in the market. Because smart spaces may be used to interact with people, computers, and real items, they are becoming more and more popular in both academia and industry (Zeng et al., 2015)[5]. Akyol et al. use the term "smart space". (1999) [3] to emphasize the three essential components of a productive work environment that enable employees to do so: the value of the internet and the smart space it produces. A well-equipped workspace with Internet of Things (IoT) devices, such as numerous sensors connected online, is also referred to as a "smart office" (Shinde et al., 2020)[4]. According to Shinde et al. (2020), the smart bureau uses a machine and digital content to transfer information into electronic form, eliminate all paperwork, and computerize tasks. According to Tehseen et al. (2019)[6], smart workplaces are becoming more popular as a way to provide workers with a secure, sociable, stimulating, and intelligent environment. The various obstacles that technology poses to improving the Quality of Experience (QoE) are related to the smart space design (Zeng et al., 2015)[5]. Additionally, by combining knowledge and information sources to allow access from any place, smart offices reduce the need for decision-making (Ramos et al., 2010) [26]. Additionally, seats, workstations, PCs, and other equipment types are commonly seen in office space activities (Safian et al., 2012)[7]. Moreover, incredibly useful and versatile furniture can save space by utilizing techniques like concealed drawers and shelves under floors, walls, stairwells, or individual furniture pieces (Barbosa et al, 2016)[8] These methods reduce the area of the compartments while still enabling the room to be more fully furnished. Workplaces in Malaysia can now utilize a variety of smart office technology, including slimline desks, intelligent climate management, IoT sensors, smart lighting, smart meeting rooms, and interior monitoring. The Key Elements of the 2019 Smart Office (n.d.). Moreover, it promotes sustainability by reducing the need for building materials, waste generation, and energy for air conditioning in buildings (Barbosa et al., 2016)[8]. Depending on whether smart space makes work easier, faster, or more enjoyable than it now does, it may or may not be helpful in an office setting, according to Akyol et al. (1999)[3].

A brief overview of the current energy-saving systems that have been suggested by researchers in the past is given in this section. An Intelligent Lighting System for Energy Saving, for example, was given by Aniruddha Mukund Ghuge, Sachin R. Kale, and Akash Shahade [9].This study describes temperature-based fan speed controllers and power-saving systems for use in rooms without human occupants. Additionally, a smoke sensor for fire detection is included. A GSM-based wireless home and industrial automation security system has been presented by R. Anandan, B. Karthik, and Dr. T. V. U. Kiran Kumar [10]. This essay describes the usage of PIR, gas, smoke, and main fuse failure indicators in security systems. A message is sent to the user's cellphone number via a GSM module if the sensor detects someone. Using an ARM CPU and PIR sensor, Kirtika K. Lunawat and Prof. U. M. Gokhale proposed energy management and home appliance control [11]. This paper describes how to use an ARM CPU to save up to 25% on power. Dr. Mani Kumar C, G. Prem Chand, and M. Vishnu Chittan have all given presentations. A microcontroller-based building automation system using RTD sensors has been created to conserve energy through temperature-based air conditioning, lighting control, gas leak detection, and water flow management for gardening [12]. Additionally, A. Elakya, D. Thenmozhi, K. A. Yasir, D. Pavithram, and G. Thukkaram have proposed a Smart Distribution monitoring system with security that uses an Arduino and an Android interface via Bluetooth to monitor power and energy [13]. The design of an intelligent and effective light control system was presented by Arun Radhakrishnan and Vuttaradi Anand. A PIR sensor was also recommended to save power in the event that no one is in the room [14]. Additional approaches to energy-saving systems are based on Arduino Uno and Matlab [17], PIC18F4520 Microcontroller [18], Raspberry Pi and camera [16], and Zixbee and Microcontroller [15,16].

Ananda Maiti, et al. (2023) [17], This paper presents an innovative approach to designing privacy-preserving IoT sensors for smart workplace applications, focusing on enhancing employee health through discreet data collection. Traditional IoT solutions in office settings often face privacy issues due to the sensitive nature of the data gathered. The authors address this by introducing a specialized sensor that autonomously tracks sedentary behavior, monitoring employees' movements without needing personally intrusive data.

Mudita Uppal,et al.(2021) [18] This paper introduces an IoT-based smart office system that utilizes machine learning (ML) to monitor and maintain the health of office devices, aiming to improve efficiency and reliability. The proposed architecture includes sensors for real-time data collection, cloud storage for data processing, and a recommender system for fault detection and management. Through ML, the system predicts potential faults in IoT-enabled devices, allowing for early intervention that enhances device longevity and reliability, ultimately contributing to user satisfaction and indoor comfort.

Zitong Wang .et al.(2024)[19] This paper examines how the TOGAF (The Open Group Architecture Framework) Architecture Development Method (ADM) can guide IoT integration in smart offices to enhance energy efficiency and sustainability. By analyzing TOGAF ADM's three core phases—business architecture, information system architecture (data and application architectures), and technology architecture—the study proposes a strategic framework for implementing IoT in a way that optimizes energy use without sacrificing operational efficiency. The research is theoretical and literature-based, aimed at organizations adopting or considering smart office solutions to support sustainable practices through structured IoT implementation.

The term "smart office system" describes how different IoT (Internet of Things)[19] gadgets and technology are integrated

to provide a productive and intelligent work environment. These solutions are designed to improve office spaces' general convenience, employee well-being, energy efficiency, and productivity.

This is a review of the literature based on studies that were completed by September 2021:

1. Smart Office Infrastructure and Architecture: Scholars have investigated the infrastructure and architectural style required for the successful implementation of smart office solutions. In order to build a coherent and scalable ecosystem, these studies frequently address the integration of sensors, actuators, communication protocols, and cloud computing platforms.

2-Energy Management and Sustainability: Optimizing energy utilization is another key component of the smart office concept, which aims to lower expenses and lessen the environmental effect of office buildings. Research has looked into the application of energy monitoring and management tools, smart lighting, and HVAC (heating, ventilation, and air conditioning) systems.

3-Indoor Environmental Quality (IEQ) and Occupant Comfort: The effects of smart office systems on indoor environmental quality—which includes things like temperature, air quality, and lighting—have been studied. One of the most important aspects of these research is evaluating the impact on occupant comfort and wellbeing..

4-Workplace Productivity and Collaboration: Improving worker productivity and collaboration is one of the main goals of smart office solutions. Research has examined how smart gadgets and technology can be integrated to enhance task management, teamwork, and communication in the workplace.

5-Security and Privacy: Data security and privacy are issues that are brought up by the implementation of smart office technologies. Research has concentrated on locating possible weak points and creating safe procedures to protect private data in smart office settings.

6-Human-Computer Interaction (HCI) and User Experience (UX): Studies have been carried out to assess how easy and user-friendly smart office technologies are to interact with. These studies examine user experiences with the goal of improving smart device and interface design and usability.

7-Case Studies and Real-World Implementations: There is a wealth of documentation available on case studies and actual smart office system implementations. These studies offer insightful information about the advantages and practical difficulties of implementing such technology in various work environments.

8-Integration with Artificial Intelligence (AI) and Machine Learning (ML): In order to provide predictive analytics, automation, and intelligent decision-making inside smart office systems, recent research has investigated the integration of AI and ML algorithms.

III. METHODOLOGYS

A method for performing literature reviews that gathers and assesses a variety of scientific papers or articles is called a systematic literature review (SLR). Including precise standards like keywords, database sources, and restrictions (such year, title, and subject) Peer-reviewed journals and articles published globally and internationally after 2010 made up the study's methodology. Consequently, the goal of the systematic literature study was to methodically illustrate earlier research on intelligent office interiors. This clever office design will result in a better understanding of employees, employers, and designers [20].

A. Case Studies and Practical Implementations

1. Case Study: Deloitte Amsterdam

The Edge," Deloitte's Amsterdam office, is frequently mentioned as one of the world's smartest structures. It maximizes the usage of IoT sensors and an AI-powered building management system for heating, lighting, and workplace. In comparison to conventional office buildings, the building has achieved a 70% reduction in energy use, while staff happiness and productivity have increased dramatically [30].

2. Case Study: Cisco

Cisco's Toronto headquarters put in place a sophisticated smart office system that included big data analytics, AI, and IoT devices. The system offers up-to-date information on staff preferences, energy usage, and space utilization. Cisco has experienced a 27% boost in energy efficiency as a result, and better space management has enabled better planning and resource allocation.

B. Search Process

The search process is a crucial component of the results found in the literature. Because it draws from multiple sources, any unnecessary information or specs are required. Furthermore, limit or expand the analysis's purview. A few things to consider include specific databases, sections of articles (titles, full-text, or abstracts), constraints and filters, and Boolean usage. The results of the literature are helpful in comparing and contrasting the knowledge levels of academics. For instance, this analysis's specific use of keywords and abstracts allowed for the identification of research works on the smart office. The article's key lesson on smart workplace decor is to prioritize [2].

TABLE I. A LIST OF THE KEYWORDS, SEARCH DATABASES, AND INCLUSION STANDARDS THAT WERE APPLIED TO THE LITERATURE REVIEW

Search database	Keywords	Inclusion criteria
• Google Scholar • Science Direct • IEEEXPLOR	Smart office Smart office system	Title, Abstract. Academic journals and publications published between 2009 and 2023.

IV. Including and Excluding

Only three databases pertinent to the study are reviewed to gather comprehensive literature on the subject. Among these, IEEE Xplore is a primary source for high-quality research in engineering, computing, and technology fields, making it highly relevant to studies on smart office systems. Google Scholar also serves as a widely used tool for accessing scholarly literature across disciplines. Additionally, ScienceDirect provides access to peer-reviewed, publicly available, high-caliber scientific publications. The primary search term utilized was "smart office".

TABLE II. A LIST OF THE RESULTS CONTAINING THE REQUIRED KEYWORDS COMPILED FROM FOUR DATABASES.

Database	keywords	Number results
Google Scholar	Smart Office System	145,000
ScienceDirect	Smart office	58,604
IEEEXPLOR	Smart office	1,149

An overview of the international article's research papers on smart offices:

Several research studies have explored various aspects of smart office systems, utilizing different methodologies to analyze their effectiveness and impact. The study "An Effective Energy Management System for Smart Office Cubicles using IoT" by Rao Musala et al. (2018) employed model analysis to demonstrate a novel approach for conserving energy and automatically controlling electrical equipment in office cubicles. This study highlights the benefits of monitoring cubicles individually rather than the entire office space, emphasizing the affordability and functionality of the proposed model due to the use of microcontrollers like Node MCU. Additionally, the model includes a web page for monitoring and managing office security and appliances.

Pilipová and Vilčeková (2013), in their study "Comfort, Performance, Indoor Environment, Smart Building," used questionnaires to assess users' perceptions of the indoor environment in a smart building. The findings indicated a positive perception of the monitored factors, with no significant negative effects on comfort. Employees rated the work environment highly in terms of quality and tolerability, although privacy was noted as a concern. The study also found that rest areas, visual contact with the outside, and interaction with indoor and outdoor plants positively impacted users' comfort and performance.

Ryu et al. (2015) conducted a prototype analysis in their study "Integrated Semantics Service Platform for the Internet of Things: A Case Study of a Smart Office." This study presented an integrated semantic service platform (ISSP) to enable ontological models across multiple IoT-based service domains within a smart city. The ISSP was used to create a prototype service for an intelligent office, demonstrating its ability to deliver a customized work environment based on user input via smartphones.

In the study "Services and Applications for Smart Office Environments: A Survey of State-of-the-Art Usage Scenarios," Röcker (2010) performed a scenario analysis to review cutting-edge application possibilities for smart office environments. The research identified indicative features and services for future office systems, revealing that the vision for smart office spaces is more concrete and defined than often perceived.

Furdik et al. (2013) combined prototype analysis and scenario analysis in their study "The Network Architecture Designed for an Adaptable IoT-based Smart Office Solution." Their evaluations focused on the suitability and overall acceptability of the proposed IoT network architecture for smart office systems, emphasizing its scalability and adaptability of installed devices.

Selvaraj (2017), in the study "Smart Office Automation System for Energy Saving," utilized model analysis to propose an energy-saving smart office automation system that is both affordable and easy to use. The study highlighted the system's fully automated nature, reducing concerns about managing electrical devices such as fans and lights, and described the system as robust, reliable, and low maintenance.

The study "Prototype of Smart Office System Using Based Security System" by Kao et al. (2018) employed both software analysis and prototype analysis to develop a smart office system prototype focusing on building security. The prototype integrated an autonomous robot created with Arduino Mega 2560, various sensors, and the Internet of Things (IoT) technology to enhance security through multiple detection mechanisms

Lastly, a study exploring temporal analytics in fog-cloud architecture for smart office health care proposed a novel fog-cloud architecture to monitor and evaluate various health metrics of individuals in a smart office environment. This model analysis introduced the Severity Index (SI), a probabilistic metric to assess the health impacts of different activities, highlighting the system's potential to enhance workplace health monitoring and management.

V. Results and Discussion

Here are the search results in IEEExplor for the years 2009 to 2024 for the word smart office.

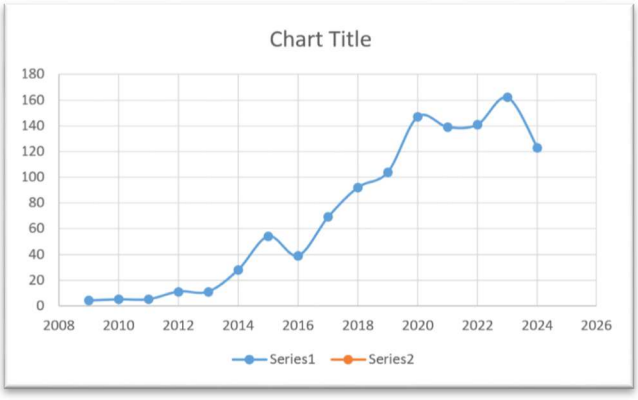

Fig. 2. Flow chart of Systematic Search Process in IEEExplorer

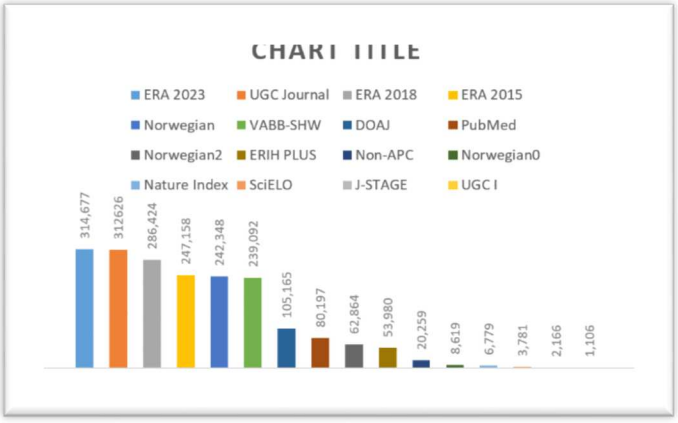

Fig. 3. Numbers of papers per journal.

Fig 4 shows the number of publications per journal. ERA 2023 has the most prominent number of publications in the field followed by UGC and ERA 2018.

VI. Future Work

This section discusses many approaches to creating a smart workplace

1. ESP32: we used the ESP32 microcontroller because it has a number of benefits. Its versatility—which comes with features like Bluetooth, Wi-Fi, touch sensors, ADCs, DACs, timers, and a Hall effect sensor—is one of its advantages. It is particularly powerful for a variety of applications because it has two 240MHz cores. Furthermore, the ESP32 is becoming more and more well-liked in the development community and in academics.

2. Ultrasonic sensor: we chose to employ an ultrasonic sensor because of its remarkable versatility in detecting objects of any color, texture, or transparency. Furthermore, in difficult environments where optical sensors can have trouble performing, such as those with dust, smoke, or fog, ultrasonic sensors excel.

3. RFID: By limiting access, tracking assets, keeping an eye on employees, enabling multi-factor authentication, protecting data, integrating with other security measures, and guaranteeing compliance, RFID sensors greatly improve security in smart office systems. Their capacity to furnish up-to-date information and comprehensive documentation renders them an indispensable constituent of an all-encompassing security plan in contemporary office settings

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