Smart Buildings

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ABSTRACT

We are living in an era of technology. We use it constantly and probably would be unable to imagine existence without having the ability to reach out to our loved ones or read the latest events whenever we need to. We are in the midst of the 4th industrial revolution, and everything in our daily lives is being digitized and made smarter. A completely new, rapidly impact gaining trend in the construction sector is smart building. The worldwide development of smart buildings is now gaining popularity. It becomes popular in a wide range of buildings, including offices, hospitals, and medical centers, and also in factories and other business establishments. An increasing awareness of the need of environmentally friendly construction methods and efficient use of space is the main cause of further development. Management systems for buildings and IoT (Internet of Things) technology are additionally growing more and more popular, which is another cause.

Keywords—Smart Building, Artificial intelligence (AI), BMI, 3D modelling, IoT.

I. INTRODUCTION

The term "Smart" is becoming increasingly prevalent among us and is used to describe intelligent items or things that are the outcome of advancements in new technologies that are used in daily life, such as the smartwatch, smart TV, and smartphones. Therefore, if we utilize it in products, how could it not be employed in structures that are technologically advanced?

With regards to building construction, we are at the beginning of a new era. We can no longer just go to an office, settle down at a desk, and work there. The development of technology has made it feasible for buildings to provide all the services that inhabitants require, to be as productive as possible, lowering expenses, and maximizing energy savings all the way through the building's lifetime. Future businesses will depend heavily on this equilibrium. The era of smart buildings has arrived. Intelligent buildings, often referred to as smart buildings, are structures that use technology to improve the comfort, security, and productivity of their surroundings [3]. All the residential, commercial, and industrial structures can use this idea. Using IoT devices' ability to collect, evaluate, and then interpret data from numerous components and places, it is possible to achieve automatic control of a building's functioning in real time. Additionally, it is possible to improve these architectural spaces' accessibility, safety, usability, and energy efficiency [4].

II. WHAT IS A SMART BUILDING?

A smart building is one that integrates technology in order to give people an enjoyable and safe space while promoting efficient and cost-effective resource use. In smart buildings, which are also built or amended to allow for the incorporation of modern technology, a wide range of modern technologies may be implemented. A few of the automated machines and processes that could be employed in a smart building to manage and enhance its performance are building management systems, artificial intelligence (AI), augmented reality, and Internet of Things (IoT) sensors. Together, all of these components form an intricate structural system that boosts building management and maintenance, boosts occupant experience, and collects and analyses building operation data in real time. Smart building provides [2]:

A. **Comfort** to the occupants due to its ability to manage lighting, temperature, humidity, and other factors, heeding to the individual comfort settings.

B. **Automated supervision** of a building's heating and cooling, electrical power, the lighting, shading, accessibility, and security systems using information gathered from data gathering and analysis of the surrounding area, tenant behaviour, and other factors.

C. **Cost reduction** by analysing the building usage patterns and making adjustments to raise building maintenance standards, increase HVAC performance, align occupancy patterns with energy consumption, boost space utilization effectiveness, and more.

D. **Reducing the environmental impact** through study of indoor and outdoor environmental conditions, tenant behaviour, and other data. This will result in improved patterns of energy and water consumption as well as lower emissions.

E. **Integration capabilities,** which minimize the need to build or relocate in order to make use of smart technologies. Older buildings can incorporate cutting-edge smart building technologies.

F. **Preventive maintenance** by analysing historical and real-time equipment data and looking for patterns that could indicate a breakdown.

G. **Improved health and wellbeing** as a result of supporting physical separation efforts with space optimization and access control systems, by enhancing indoor air quality with effective HVAC operation.

III. SMART BUILDINGS - OBJECTIVES

Smart buildings and sustainability can be connected. With this, the overall idea of the smart city is reinforced and realized. Both attempts to create a single point of control that reduces the detrimental impacts on the environment and boosts the citizen quality of life. In order enhance performance and promote long-term development, a lot of firms and governmental bodies are currently making an effort to make the most of their resources [3].

Because of the advances in control systems and the automation techniques, it is now possible to design buildings that utilize less energy, improve the surroundings and safety of the people who frequent them, while minimizing their impact on the environment through utilizing the resources with integrity.

IV. BENEFITS OF SMART BUILDINGS

Smart buildings, for example, allow families and businesses save money on energy costs by tracking energy usage. Smart buildings use more sustainable methods and have smaller emissions as a result, making them healthier for the environment. By employing smart technologies, smart structures and assets might have a higher value upon sale. The standards of life and the workplace are boosted by smart buildings that have gas, smoke, and fire sensors. Smart building monitoring has the potential to detect issues with industrial machinery and household devices and automated repair and maintenance processes. Wireless technologies may lower the cost of recruiting people in business facilities. For instance, without a building management turning them on or off, sensors might turn on lighting and sprinklers. In smart buildings, security systems like firefighting supplies and CCTV cameras may be remotely monitored.

V. FEATURES OF SMART BUILDINGS

A. **Eco-efficiency:** Buildings which have been designed and constructed using systems and materials that are engineered for productively and to reduce the environmental impact are referred to as smart buildings [3].

B. **Proactive maintenance:** To forecast the optimization of resources, software analyses each and every piece of data that is obtained through the monitoring devices. Traditional structures may undergo nearly unnoticeable breakdowns that go undetected, but the modern computerised management techniques enable immediate detection of the occurrences and future issue mitigation [3].

C. **High security:** Self-management software that can operate high-tech security systems and devices has been developed using artificial intelligence (AI), machine learning, and the Internet of Things (IoT) [3].

D. **Comfort:** Heating, ventilation, and air conditioning (HVAC) systems enable the establishment of perfect habitational conditions that are useful for users' well-being, productivity, and health [3] by controlling the humidity level, filtration of air, and temperature of buildings.

E. **Assessment monitors:** The installation of sensors and detectors that transfer data to a central management system for viewing, analysis, and performance improvement in both the present and the past is the key principle of smart buildings. These sensors check parameters like capacity, energy use, climate, and supply levels [3].

Let's look at a few examples [3]:

a) The central system is coupled to a monitoring system that continuously tracks building accesses and provides both real-time and archived reporting. For the purpose of avoiding and decreasing the danger, this provides data and analysis.
b) The video surveillance system visually examines any fire signals that are triggered and keeps track of how many false alarms have been issued.

c) Remote access - The most important aspect of an intelligent building is interconnection. Internal networks are used by the system that uses intelligent buildings, where the data can be accessed at any time and from any location over the Internet. In this way, management and control may be carried out remotely with just an internet connection, a user, and secure access to the management platform.

VI. HOW TO MAKE USE OF SMART BUILDING TECHNOLOGY

A. **For digitization:** The mutual dependence of the building's core systems is what makes it unique. By combining smart technologies, such as real-time IoT occupancy sensors and building management systems, we may be able to transmit information that may be used to automate a wide range of operations, including but not limited to heating, ventilation, lighting, air conditioning, and security. What makes a building "smart" is how its technological features are integrated into it [5].

B. **To integrate with different building systems:** Because of sharing of information as well as integration across the building systems, the value of the whole smart building may be greater than the sum of its parts. For example, through integrating IoT occupancy sensor data in a desk or room booking system, we may enable effective management practices and provide our employees with access to a smart workplace with assets that are aware of their availability [5].

C. **Improved use of space:** Using the space available is vital since, after salary and staff, buildings and real estate may at times reflect a company's second-highest investment. Here, sensors are a crucial part of smart buildings and have a big part in gathering information to assist in decisions on how to manage supplies. In order to provide information that will allow us to determine if our facilities have the right kinds of spaces to meet the needs of our employees, occupancy sensors may be placed into the structure. Through occupancy analytics, we may find out:
    a. whether the total number and size of our meeting rooms are adequate
    b. which areas of society are the most or least popular
    c. whether the given workspace is appropriate [5]

D. **As a part of routine maintenance:** AI may assist us evaluate whether an object requires repair through identifying irregular usage patterns and notifying us when it occurs. By gathering detailed information from resources like people sensors, we can get a better understanding of how frequently a facility within our building is used. This makes it possible for us to manage the wear and tear, cleaning, and restocking in a proactive manner, extending the life of machinery, furniture, and appliances [5].

VII. THE ADVANTAGES OF INTELLIGENT BUILDING ANALYTICS

Smart buildings generate a large volume of valuable building data about how they are being utilized. Analyzing this data can give us an insight regarding usage patterns and trends, so that we can make informed decisions on how to optimize our building, bringing the following advantages:

A. **Enhanced Efficiency:** It will be easier for workers to perform well if the environment they are in has the qualities they need for peak performance: adequate indoor air quality, physical comfort, security, hygienic conditions, illumination, and efficient operations. The physical design of our facility requires to be improved by sensing and interpreting how people access and move around it in order to optimize commonly used area while lowering waste. A practical example of this may be extending the area in a jam-packed, high-traffic area. Smart buildings can no longer have designs merely to save expenses and utilization. They have to act responsibly for the well-being of our staff. Making our environment more intelligent through the introduction of innovative processes like desk and meeting room bookings would help to reduce lost employee time [5].

B. **Reduce energy consumption:** We can decrease energy expenses and increase energy efficiency by utilizing smart buildings. We can automatically turn off lights or HVAC systems in vacant rooms or spaces to limit the amount of energy these components waste. To do this, we connect IoT occupancy sensors with our building management system [5].

C. **Reduce operating costs:** For any building owner or user, building overheads represent a sizable expense. Although these are the required company expenses, the amount spent is frequently wasteful since it is not used wisely. By analysing patterns of unused area, we may lower the quantity of real estate required while keeping the expenditures down. The incorporation of smart technology within a building has an array of advantages. including cost-effectiveness and an improvement to the facility's environmental credentials. Smart buildings, which are still relatively new, will soon become the standard because of the benefits they offer [5].

VIII. MONITORING THE SMART BUILDINGS

Building status monitoring provides information on a structure's condition and usage that can be utilized to optimize building operations, enhance living conditions for occupants, and boost financial returns for the building's owner. Building status monitoring keeps track of building assets, keeps track of resource usage, spots unforeseen damages and equipment failures, keeps up with optimized maintenance plans, and notifies the appropriate authorities of issues within and outside of a structure.

Building monitoring is automated using low-level sensors and smart building applications. Monitoring systems are able to physically react to leaks of water or gas, fires, break-ins, or environmental changes without requiring human intervention and to interpret sensor data into actionable insights in real time. A simple-to-use building management solution, Paessler Building Monitor, effortlessly connects with IoT-connected equipment in smart buildings. Building Monitor continuously monitors, logs, and evaluates sensor data in three key areas: resources, maintenance, and damage.

A building manager or emergency services receive an alert in the event of immediate damage, such as a broken window or fire. Commercial building stakeholders have access to reports on the cost of damages as well as information on possible damage, such as mold growth or water leaks, and can use this information to determine whether a building will be profitable.

Building Monitor examines a building's physical condition and automates the preparation of maintenance schedules, making it easier for building supervisors to determine the extent, importance, and cost of future repairs, modifications, or renovations.

Building Monitor lets building managers spot unacceptable consumption of resources by tracking resource use, such as from smart meters. Monitoring, for instance, can spot defective machinery, such as dripping faucets, and the needless use of lights or heating in vacant rooms.

IX. CASE STUDIES

A. Smart Office [2]

Smart workplaces, like The Edge in Amsterdam, Netherlands, or Capital Tower in Singapore, use technology in smart buildings to adapt workplace operations to workers' demands and boost productivity and employee happiness. These structures' occupants have seamless access to location data, the ability to reserve available office spaces, and customized comfort settings. Building managers may take care of demands for cleaning and maintenance while also optimizing the use of space and energy [2].

The Edge, for instance, can learn each inhabitant's routine with the aid of a specialized software. It can schedule offices based on their work schedules, recognize the vehicles each resident drives and make parking arrangements

appropriately, remembering each occupant's preferred lighting and temperature levels. Using its central dashboards to monitor every part of the building's operation, from energy use to coffee makers, helps it make the most of its resources and save maintenance expenses [2].
Additionally, modern workplaces can help with issues like air filtration and battling excessive temperatures. For instance, the Shanghai office of Glumac in China maintains the finest interior air quality in Shanghai with its five air filtration systems. In order to maintain a comfortable indoor climate, Hindmarsh Shire Council Corporate Centre in Melbourne, Australia, contains a number of underground thermal chambers and a ventilation system [2].

B. **Smart Hospitals [2]**

As demonstrated by the Sint-Maarten Hospital in Mechelen, Belgium, and the Ankara City Hospital in Turkey, smart hospitals can improve treatment outcomes, staff efficiency, and cost effectiveness. These hospitals are intelligent ecosystems that are managed by a single building management platform. Lowering infection risks, maximizing the usage and maintenance of medical equipment, facilitating patient and visitor registration, providing individualized comfort settings for patients, optimizing energy consumption, and other uses are all made possible by the use of smart building hardware and software. [2].

C. **Smart Data Centers [2]**

Uptime, energy efficiency, physical security, and fire safety are prioritized in smart data centers. As with the NxtGen Data Centre in Bangalore, India, or the Interxion Data Centre in Vienna, Austria, they utilize smart building systems that are operational 24/7/365. They make use of smoke detectors that detect potential fires and activate reaction measures, smart power supply systems that provide electricity independently of the public power grid, and security management systems that ensure perimeter protection, intruder detection, and visitor control [2].

D. **Smart Life Science Facilities [2]**

They use customized smart solutions for cleanrooms, laboratories and key storage facilities to handle the special issues they confront, such as biosafety risks or intellectual property loss. For instance, Ferring Pharmaceuticals and Develco Pharma deploy specialized smart building technologies in their manufacturing facilities in Schopfheim, Germany, and Saint-Prex, Switzerland, respectively. They employ solutions that control airflows, monitor security via sophisticated surveillance systems, identify and prevent fires in buildings, and communicate building operation statistics via real-time dashboards. [2]

X. CHALLENGES IN A SMART BUILDING

Monitoring and tracking workers at work raises privacy and data issues that many firms haven't had to deal with before and may need legal support to resolve. A significant capital investment in technology may be necessary for smart buildings, such as a building management system (BMS) or building automation system (BAS) that serves as a digital center for the management of the building's devices and applications. Smart technologies may be frightening for some people, especially when something goes wrong, like a broken sensor or an incomprehensible error message from a linked gadget. Persistent internet connectivity is necessary for intelligent buildings.

XI. HOW TO MAKE OUR BUILDING SMART WITH DATA

The first step in collecting and analyzing this data is to integrate smart building technology, such as occupancy sensors which record the usage data. Once we have this information, we can determine where improvements may be made, either by supporting strategic decision-making or by merging with other innovative building technologies and automation-enabling systems [5].

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