Evaluation of Indoor Energy-Saving Optimization Design of Green Buildings Based on the Intelligent GANN-BIM Model

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The present research showcases the Indoor Energy-Saving Optimization Design of green buildings. This integrated approach synergizes a building’s Indoor Energy-Saving process based on the intelligent GANN-BIM model. The GANN-BIM model is driven by genetic algorithms (GAs), which include artificial neural networks (ANNs) along with building information models (BIMs). Building information modeling (BIM) is a technology that involves the modeling and management of digital representation of all forms of structural buildings. These intelligent models can be exchanged and extracted in the form of files and are mainly used for the designing and decision-making of a building. The BIM model is empowered as an intelligent technology by incorporating artificial neural networks (ANNs) and genetic algorithms (GAs). The main objective of the research is Indoor Energy-Saving by implementing an optimized design of green buildings. Green buildings can benefit from the GANN-BIM model’s ability to handle complex and conflicting design requirements while using less computational power during the evaluation of the proposed approach. There are a variety of new green building technologies being developed, but they all share a common goal: to reduce human health and environmental impact by maximizing energy, water, and other resource efficiencies; protecting occupant health; reducing waste; and decreasing pollution. The empirical results of GANN-BIM proved that the proposed model outperforms well in enhancing energy evaluation.

1. Introduction

Energy scarcity and environmental degradation have risen to the top of the global agenda in recent years. The building industry currently accounts for the majority of the world’s energy use of various kinds of resources like ores and wood, as well as the major source of environmental pollution [1]. According to the United Nations Environment Programme (UNEP), about 30–40% consumption of the world’s energy is done by the construction industry [2]. Approximately 38 percent of China’s overall societal energy demand accounts for the building industry [3]. In light of the current economic conditions, the construction industry is about to experience a major shift and upgrading. As for finding a path to sustainable growth, the industry has a hard time finding one [4], so that high resource consumption and environmental harm can be reduced by incorporating the investigation of the construction industry needs and implementing a sustainable development mode for operation. A decade ago, green building was still in its infancy, but it has since become the dominant trend in the worldwide construction sector [5]. Green architecture has not become a globally accepted concept for a variety of factors, including economic development, geography, and per capita resources. As defined by the US Environmental Protection Agency (USEPA), a green building is a building that is ecologically friendly and conserves resources throughout its entire lifecycle, from site selection through design and construction to use and decomposition [6]. When it comes to creating and maintaining a healthy building, BSRiA believes that the concepts of efficient resource consumption and ecological advantages are essential [7]. It is defined by the University of Hong Kong’s Building Energy Efficient Research that the environment of green buildings is an integrated approach that takes into account every resource available, including the building’s materials, fuels, and occupants [8]. Every component of the...
design of green buildings has an impact on the environment, posing a variety of problems and paradoxes that must be resolved. On June 1, 2006, China’s Ministry of Housing and Urban Development issued Assessment Standards for Green Architecture following China’s national context and the notion of sustainable development [9]. In the context of green buildings, resource conservation is reducing waste, reducing pollution, creating a healthy, appropriate, and efficient living environment, or coexisting peacefully with nature for the duration of the structure’s lifespan. “Green building” is defined in different ways in different nations, but the three most important aspects are an effective use of resources, healthy living conditions, and cohabitation with the natural surroundings [10]. The authors of [10] have also specified the creation of global standard for green building development. Many scholarly papers have been written on the subject as a response to this increased attention to green construction. As a result, it may be difficult to discern the study topic and status quo from hundreds of papers, which may pose a significant risk of overlooking important questions [11]. To remedy this issue, scientometric tools must be used to study this field [12]. Going through the existing literature can provide us an idea of the present research situation and development patterns in the topic. Green building energy-saving efficiency has been discovered in [13]. To achieve energy-efficient buildings, it is crucial to use the right green building products [14]. Since energy-saving theory and green construction concepts share a high degree of consistency, it is evident that this integration can be studied. There is a wealth of knowledge available on the topic of energy efficiency in construction. The pursuit of cutting-edge methods for conserving energy has long been a contentious topic. Passive, active-passive, and hybrid green energy-saving technologies are all available. HVAC (heating, ventilation, and air conditioning) and other renewable energy sources are two examples of cutting-edge energy-saving technology [15]. HVAC energy consumption can be reduced by employing passive technologies, such as proper building orientation, shading, thermal efficiency, and natural ventilation in the building envelope. According to these studies, lifecycle costs are not taken into account while designing green building envelopes [16]. From a cost- and energy-saving perspective, no one has investigated the design of the building envelope. These studies, however, do not unite the cost-cutting and energy-saving objectives [17]. There is no other way to arrive at the final architectural design plan but to intersect the sets of schemes corresponding to each of the objectives. The following undesired outcomes may occur in reality if energy saving and lifecycle cost are not taken into account while designing green building envelopes: high energy savings and high costs make promoting green building envelopes difficult, while low-cost envelopes make green building envelopes too commonplace and uncompetitive on both sides of the cost-benefit equation [18]. Green buildings’ energy-saving potential will be negatively affected by these unwelcome occurrences, which will hurt market-driven green buildings [19]. Consequently, it is imperative to maximize the green building envelope in terms of both energy saving and lifecycle cost. Green buildings strive to save energy in comparison to conventional structures. External and internal surroundings are divided by building envelopes in environmental-friendly structures [20]. There are two types of environments: those that can be changed and those that cannot. Internal climate control and modification necessitate energy usage. The external environment will be severely harmed if too much energy is used (namely, the natural environment). Energy savings can be achieved by optimizing building envelopes. Roofs, doors, windows, walls, and floors are all components of a green building envelope [21]. For each component, there are numerous subcategories because of the broad variety of materials. To design the greatest possible building envelopes, architects must employ the proper materials. Both the energy-saving and the lifecycle cost goals must be taken into account when making decisions about the building envelope. Function and cost can be brought together through the application of value engineering (VE), also known as value analysis. There has been a constant increase in the number of features available in building information modeling (BIM). Building information modeling, lifecycle cost analysis, energy-saving analysis, and value analysis are all used in this method [22]. A strong connection binds these four concepts together in a cohesive whole. There is a wealth of information in the architectural BIM for all of the models. Energy-saving and cost-benefit analysis models are intertwined in BIM envelope systems. When it comes to green buildings, finding the right balance between energy value and economic viability can be a challenge [23, 24]. In the subject of green building envelope optimization, this is a breakthrough. Using BIM-VE, this study recommends green building envelopes be optimized for energy saving and reduced lifecycle cost. Rather than focusing solely on lifecycle cost and energy saving, this new technique uses value engineering (VE) to achieve the dual goals of saving money and keeping energy. A lot of progress has been achieved in the implementation of the BIM platform. In [25], a novel hybrid model of digital twin-building information modeling (DT-BIM) is proposed. This model does the process of identifying the shortage of resources, analyzing requirement, performing decisions, making the resources, and updating all the processes in the database with the support of artificial intelligence (AI). This study focused on Indoor Energy-Saving Optimization Design of green buildings based on the intelligent GANN-BIM model.

1.1. The Motivation of the Study. Implementation of building information modeling (BIM) and the recent emergence of AI applications provide several unique understanding and decision-making attributes throughout the product lifecycle of a building environment. The ability to relate online sensors used in a setting in real time has resulted in the description of the genetic artificial neural network (GANN) of green building design’s energy-saving optimization design. The primary objective of GANN is to synchronize the material reality with a digital environment for effortless management and control of a construction process, integration of systems, environmental monitoring, or other
efficient evolutions of life in energy-saving optimization design of green building design. To identify emerging technologies that will aid in the transformation of BIM to GANN, the author developed a levels leaderboard classification framework already based on the building lifecycle to match the exact state-of-the-art GANN forms to systematically classify the various studies. Implementations have been further classified at every level of this categorization based on the study locations.

2. Materials and Methods

2.1. Dataset. In this study, the energy dataset is considered for analysis and the collected data contain details about 12 different building shapes with the difference in the building properties. This dataset encloses 768 samples and 8 features for performing analysis and predicting the outcomes that are denoted by Y1 and Y2. This research focuses on multiclass classification. The building properties considered are as follows: X1-Relative Compactness, X2-Surface Area, X3-Wall Area, X4-Roof Area, X5-Overall Height, X6-Orientation, X7-Glazing Area, X8-Glazing Area Distribution, Y1-Heating Load, and Y2-Cooling Load. The features were considered using a literature review related to this research work.

2.2. Proposed Architecture. Wireless sensor networks (WSNs) are a group of self-configured and infrastructure-less communication model is used to monitor physical and environmental conditions. The monitoring conditions include temperature, sound intensity, wind direction, vibration, pressure, object's movement, illumination intensity, pollutant level, power-line voltage, chemicals present in the environment, and much more. It is necessary to collectively transfer their data to the central location where they can be observed and analyzed. Building information modeling (BIM) is a teamwork process using advanced technologies to generate data modeling of the building. The improved air quality in the building can be achieved by designing proper ventilation. Solar energy usage as a renewable source of energy is an essential model for greenhouse designs. The motion sensors play a crucial role by checking the room occupancy and deciding whether to turn the lights on/off. By checking the air conditioning and heating, the home’s automation system saves energy to a great extent. Consistent savings can be achieved using the programmable mode for the home’s temperature and lighting. This automation can be incorporated into any concept of the organizational building.

(iii) Green buildings focus on reducing impacts on the environment by reducing energy and water usage, thus resulting in minimized environmental disturbances from the building. The main aspect of green buildings is their design to improve human health by creating healthy indoor environments. It is well evident from the recent studies that the health of the human occupants is more reasonable than the nongreen buildings. The ventilation of the building and the air quality of indoors play a vital role when human health is considered. The proper ventilation is provided at the design phase in the BIM models.

(iv) Green building should also focus that the wastes in landfills are considerably reduced. The water wastes from washing machines and dishwashing can be treated in an in-house water treatment plant and used for gardens, car washes, and flushing toilets.

(v) Implementing efficiency in material design and eliminating material waste at the design stage could reduce greenhouse gas (GHG) emissions. Recycling and reusing construction materials also lead to a reduction in GHG emissions. Discarding the building before they have reached the end of their useful life should be avoided. Switching from high-emission materials to natural materials like timber is a healthy practice in battling greenhouse gas emissions.
The technologies implemented in these processes include the following: Building information modeling (BIM) is a technology of digital transformation in the architecture, engineering, and construction which involves the modeling and management of digital representation of all forms of structural buildings. An artificial neural network (ANN) is a system that depicts the human brain is utilized in this research to perform continuous training of the system to predict the possible inconveniences in the system. The genetic algorithm (GA) with ANN provides genetic artificial neural network (GANN), which is utilized for training multiple sensor networks attached to the building to deliver optimized results. In this GANN, each type of sensor with different functionalities is considered to work together. These processes are represented in Figures 1 and 2.

In the proposed model, multiple sensors will be attached to the wireless sensor networks to monitor the building. The data collected in the building by the sensors will be updated in the intelligent server in order to perform the corresponding activities. Sample sensor networks attached to the intelligent network are represented in Figure 2.

2.3. Proposed Work. The challenging part is determining a delegate \( D_{xy} \) test that implies how large or small the network areas have to be, which is represented in the following equation:

\[
D_{xy} = \sum_{q=1}^{r} \text{max}_{\text{dmax}} K(E_q, K_r; D k^*) .
\]

The ability of \( E_q; K_r; D k^* \) to connect online sensors used for a \( q = 1, r = 1 \) configuration in real time has contributed to the description of Gmax of a green building design’s GANN resource optimization design as in the following equation:

\[
D_{test} = \sum_{q=0}^{r} \text{max}_{\text{dmax}} g(D: E_q; K; k^*) .
\]

Here, \( E_q \) and \( K_r \) are the current sets of effected and protected entry points. Also, \( g \) and \( q \) denote the number of highly sensitive building parts that are to be identified and designed to protect access locations up to time \( k \). Then, we have the following equation:

\[
D_{test} = \sum_{r=0}^{r} \text{max}_{\text{dmax}} K(D; E_q; K_r; k^*) .
\]

We eliminate time for the sake of clarity in the following equation by using matrix multiplication:

\[
D_{test} = \sum_{r=1}^{r} \text{max}_{\text{dmax}} K(E_q; K_r; D g^*) K(D, k^*) \sum K(E_q; K_r; k^*) .
\]

To determine the converter \( D \), the following equation is utilized:

\[
D_{test} = \sum_{r=1}^{r} \text{max}_{\text{dmax}} K(E_q; K_r; D k^*) K(D, k^*) .
\]

BIM technology, the variable \( K(E_q; K_r; D k) \) is the probability that includes the realizations of \( E_q \) and \( K_r \) gives a means of information for \( v \) and a protective \( g^* \) are obtained as a result. If \( K(D, k^*) \) is assumed to be homogenous, then BIM is equivalent to GANN but also BIM (Building Information Model) is being used to identify the probability as in equation (6). Building Information Models (IM) is being used to detect possibilities.

\[
K(E_q; K_r; k) = \sum_{\sigma \in D} K(\sigma|D,k). \quad (6)
\]

Here, \( \sigma \in \Omega(Dg^*, E_q; g_r) \) denotes the set of all possible dissemination classifications that provides \( E_q; K_r \) is represented using the following equation:

\[
D_{xy} = \sum_{q=1}^{r=1} \text{max}_{dmax} k(D_k, E_q, K_r). \quad (7)
\]

Then, under reliable \( g \), the same strategy as in GANN and BIM is used, depending on the amount of feasible propagation sequence data in the following equation:

\[
D_{test} = \sum_{q=1}^{r} \text{max}_{\text{dmax}} K(D, k, E_q, K_r). \quad (8)
\]

Here,

\[
K(D, k, E_q, K_r) = \left| \Omega(D, k, E_q, K_r) \right| = \sum M(r + q)! \prod \left| K_{\mu}^r \right| - 1. \quad (9)
\]

Equation (9) represents the assumption that the number of possible propagation sequential nodes will provide all this information and also the context for \( D_{xy} \) and \( D_{test} \). At the same time, they ask for \( D_{xy} \) and \( D_{test} \) in the propagation center, where \( \left| K_{\mu}^r \right| \) is the number of requirements.

\( K_{\mu}^r \) is a subtree rooted at requirements Communication among \( i \) and \( j \) using BIM and GANNs is provided at the center of the framework. Let \( D(k) \) signify the detector set of the network in the following equation:

\[
D(k) = \sum_{x=1}^{k} D(k - 1) + \beta * x(k) \text{where} -1 \leq \beta \leq 1. \quad (10)
\]

The \( D(k) \) transverse, as well as longitudinal road systems, may become fractious at this point. The network elements have been supposed to move straight ahead, turn left and right, and is given as \( D(k - 1) \), and the network maintains an assured connection specified equation (11).

\[
\beta_i(k) = \sum_{i=1}^{k} r_{1i(k)} \int D(k - 1). \quad (11)
\]
The residual battery energy (\( r1 \)) and consumed energy (\( F1 \)) of an access point are being shown somewhere else at time \( k \). Then, we get the following equation:

\[
DTBIM = \sum_{i=1}^{j} \left( \frac{K^i \text{us}}{\sum_{j \in q} (K^j \text{js})^\beta} \right)^\beta \geq 1. \tag{12}
\]

If the value of \( d(k) \) is less than zero, it indicates that its node is influencing counter (negative acceleration). Alternatively, it moves more quickly as follows:

\[
\text{if } d(k) < D_{\text{max}} \text{ then } s(k) = \int D_{\text{max}}. \tag{13}
\]

The term \( D_{\text{min}} \) denotes a minimum and maximum levels in equation (14) leaderboard classification framework to identify emerging technologies that will aid in the transformation of BIM to GANN.

\[
\text{if } d(k) < D_{\text{min}} \text{ then } s(k) = \int D_{\text{min}}. \tag{14}
\]

Figure 2: Architecture diagram of the GANN-BIM model.
$F_{1, r_1}$ identifies technological innovations that will aid in the conversion of BIM to GANN.

$$F_{1, r_1} = \sum_{j=1}^{i=1} F_1(i) \text{ where } i = 1, 2, \ldots, n. \quad (15)$$

In the following equation, GANN is implemented systematically to classify the various energy-saving optimization techniques in the designing of green buildings:

$$d.k. \int 1: \sum_{x_i \in s} x_i \leq x_y \text{ where } i = 1, 2, \ldots, n. \quad (16)$$

It is necessary to implement an intelligent smart healthcare client management and monitoring scheme. The suggested $\int 2$ in the following equation is a scheme that benefits from a GANN-BIM energy-saving system that is simple in use and starts enforcing decision making:

$$\int 2: \sum_{g_i \in s} \alpha_i \leq 1 \text{ where } \alpha_i = 1, 2, \ldots, n. \quad (17)$$

The $\int 3$ in the following equation indicates that the system’s organization is novel, as it tends to make use of sensor data as well as a BIM decision-making process:

$$\int 3: \sum_{g_i \in s} \beta_i \leq 1 \text{ where } \beta_i = 1, 2, \ldots, n. \quad (18)$$

Because the goal of $\int 4$ in the following equation is to lower the time delay of an energy economy, desirability is described in terms of time delay and lower time latency correlates to higher athleticism:

$$s_i = \frac{1}{g_i} \int 4: \psi_i^u \geq 0, \sum_{i=1}^{u} \forall i \in s. \quad (19)$$

### 3. Results and Discussion

In Figure 3, this research considers X1-Relative Compactness, X2-Surface Area, X3-Wall Area, and X4-Roof Area properties. The process of converting 3D scanning point cloud information from data of green building structures into a BIM model is called GANN-BIM, as shown in Figure 3. Academically, construction of bitmap image technology is still in its infancy, with no unified standard or implementation mode in place of energy-saving optimization design of green buildings. To assess data collection quality, GANN-BIM scanner parameters such as accuracy (45%), resolution accuracy (45%), and coverage (92%) are used. The distance range between the sensors is determined once the scanned building meets the scanning accuracy (refer to Table 1) and the satellite resolution requirements.

In Figure 4, AI technology is implemented for maintenance and repair schemes for existing green buildings to use a GANN to improve energy efficiency and reduce greenhouse gas emissions from buildings. This paper investigates the impact of the solar photovoltaic subsystem configuration angular position on energy consumption in green buildings and photovoltaic device electric generation in detail. The green building performance analysis for different methods in the context of energy consumption is performed in this research. The parameters X1 to X4 obtain the energy consumption of green buildings in overall performance analysis and the considerable accuracy in our proposed GANN-BIM method (refer to Table 2).

Figure 5 depicts a scan-to-BIM-based GANN evaluation AI method that analyses and simulates the effect of constructed building refitting systems on energy use in buildings and green building electricity production. The resulting changes comprise similar energy utilization. GANN-BIM descriptive statistics and Pearson correlation analysis with AI and WSN are given in Table 3. The properties of the building considered for evaluation in this research are as follows: X1-Relative Compactness, X2-Surface Area, X3-Wall Area, X4-Roof Area, X5-Overall Height, X6-Orientation, X7-Glazing Area, X8-Glazing Area Distribution, Y1-Heating Load, and Y2-Cooling Load.

In Figure 6, real-time energy monitoring and management of such a building are essential for creating effective and sustainable structures. Building energy quality management can benefit from BIM and GANN applications. We make a real-time visualization of energy consumption in buildings resulting in 17 percent of energy savings attributable to easier data acquisition, leading to improved control of lighting control systems. Likewise, integrating BIM and GANN in gadgets via sending open messages works with AI and WSN technology. Result analysis for energy consumption of GANN-BIM using the AI and WSN technology in green buildings are shown in Table 4.

In Figure 7, the viability of using AI and WSN techniques to predict the infrastructure based on data from the current model was discussed, as were the methodologies as...
well as challenges of smart building GANNs, which also suggested integration of BIM to analyze the energy usage of buildings. The performance analysis for GANN-BIM using AI and WSN technology in energy consumption of green buildings is shown in Table 5. From the table, it can be observed that the combined performance of GANN-BIM provides an improved result compared to the individual technology.

It can be seen that a substantial percentage of the existing system was classified under application areas of “Digital Twin,” and certain drawbacks overcome with the combination of GANN-BIM, which is supported with the simulations for tasks such as 4D building lifecycle simulations. It also aids in enhancing energy evaluation, which has been shown to help with the assessment of the building’s lifecycle and accomplish an improved and safe buildings.
Figure 5: GANN-BIM descriptive statistics and Pearson correlation analysis with AI and WSN.

Figure 6: GANN-BIM energy consumption using AI technology.

Table 4: Result analysis for energy consumption of GANN-BIM using AI and WSN technology.

| Building properties | GANN-BIM | Y1   | Y2   | Green building energy consumption |
|---------------------|----------|------|------|----------------------------------|
| X1                  | 0.978    | 15.89| 16.23| 7.92                             |
| X2                  | 10.34    | 14.56| 15.34| 9.23                             |
| X3                  | 16.76    | 19.12| 20.89| 14.67                            |
| X4                  | 17.36    | 25.87| 29.73| 16.12                            |
| X5                  | 19.67    | 26.32| 32.42| 17.65                            |
| X6                  | 20.12    | 24.76| 27.12| 18.23                            |
| X7                  | 19.45    | 26.78| 28.92| 17.34                            |
| X8                  | 20.67    | 24.56| 27.34| 18.23                            |
4. Conclusions

A building environment’s product lifecycle is enhanced by the implementation of building information modeling (BIM) and the recent emergence of AI applications. As a result of the ability to link online sensors used in a setting in real time, the energy-saving optimization design for green buildings using GANN was described. Green building design’s energy-saving optimization goal is to bring together the material reality and the digital environment in a way that makes it easy to manage and control the construction process, integrate systems, monitor the environment, and take other steps toward a more energy-efficient future of life. Classification of various studies in a way that matches the current state of the art in GANN forms and helps identify emerging technologies that will aid in the transformation from BIM to GANN. The study developed a levels leaderboard classification framework based on the building lifecycle. The results proved that the proposed model outperforms well in enhancing energy evaluation.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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