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Construction of Green Buildings by using AI in the Civil Engineering Field

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Abstract: ***A branch of computer wisdom called Artificial intelligence (AI) deals with the study, creation, and use of intelligent machines. This includes the description of recently developed ideas and styles for the development and perpetuation of AI in civil engineering and also gives an overview of the field's advancement. With the tremendous development and advancement in big data, deep literacy, and machine literacy technologies, it has been used effectively and successfully in colorful sectors of civil engineering. The important areas of artificial intelligence exploration in civil engineering include structural operation and conservation, as well as design optimization. Data collection, sustainability assessment, and productivity are just many advantages and prospects that the use of AI in civil engineering offers to civil masterminds.***

With the use of digital technology, the construction trend has now been converted into bone that emphasizes sustainability. The use of computers in civil engineering is primarily concentrated on numerical, algorithmic computations, which is unhappy for working with the empirical and inadequately structured problems that arise in factual practice and are handled by expert systems and artificial intelligence.

Keywords: Artificial Intelligence, Big Data and Data Mining, Building Automation System, Artificial Neural Network, Building Information Modelling.

I. INTRODUCTION

The construction assiduity has a significant impact on the terrain and mortal health. The construction assiduity is a huge consumer among the diligence that consumes energy encyclopedically. The construction assiduity consumes 40 % of the world's total energy product, 12%- 16% of available water coffers, 32% of non-renewable coffers 25% of renewable coffers in trees, and 40% of raw accouterments. In addition to this, 30%- 40% of waste is generated and 35%- 40% of CO2 emigrations (Green Building Council Australia, 2006), which causes considerable global trouble and impacts the future development of humanity. This confirms the need for sustainable development in the construction assiduity, and green structure is the key to unleashing the revolution. Due to the need for invention in the assiduity, there's a global trend to support and promote green structure (Debrah et al. 2022).

The U.S. Environmental Protection Agency (US Environmental Protection Agency, Definition of Green Building, 2016) defines green structure as the practice of creating processes that are less environmentally dangerous and more resource-effective throughout the life cycle of a structure. The green structure also has a more specific description. Green erecting generally refers to the entire life cycle of the structure, considering the impact on the terrain and humans, to achieve further environmentally friendly structure accouterments with lower energy consumption compared to non-green structures. This generally results in an advanced position of inner air quality and considers the impact of colorful structure types, colorful structure accouterments, ornamental homestretches, and cabinetwork choices (Yudelson, 2009). According to the World Green Building Council (GBC), Green structure is a way to ameliorate people's quality of life (World GBC, 2021). still, throughout its whole life cycle, it can reduce construction costs and give a quality terrain, If a structure is constructed according to green structure norms. It reduces energy consumption and can enhance carbon impartiality to alleviate the hothouse effect. When a structure is erected under green structure guidelines, it can lower construction costs and produce a quality terrain. Due to the advantages of green structures, which are attracting attention from experimenters worldwide, numerous review studies have surfaced (Zuo & Zhao, 2014; Darko & Chan, 2016; Debrah et al., 2022).

These studies cover a wide range of motifs, including emphasizing the state of the art and future needs in the field of green structure, probing certain corridors of green structure-related difficulties in a specific nation, and probing certain aspects of green structure backing.

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There's no mistrustfulness that these studies are useful, but they're also bloodied in that they don't look deeper into the direction of armature and artificial intelligence. This exploration presents and discusses the conception of artificial intelligence (AI) in green construction. AI is a new specialized wisdom that studies and develops propositions, styles, technologies, and operation systems for bluffing, extending, and expanding mortal intelligence. Intelligent electronics and software systems serve as exemplifications of artificial intelligence in the armature (Adunadepo & Sunday, 2016). Software systems in the early stages of the design of the structure through Building Information Modeling technology to model the structure simulation collision, etc., and intelligent bias can describe changes in the spatial terrain, and in this case, acclimate and optimize the structure's energy consumption, etc. AI technology is continuously evolving, and its operation to green structure-related problems can give numerous creative results. In this paper, AI and Green's structure were searched in Google Scholar as keywords, and representative related papers were named for review, substantially from the following four aspects fuzzy rules and knowledge discovery, big data and data mining, intelligent optimization, and erecting robotization systems.

II. DIFFERENT TECHNIQUE & METHODOLOGY

A. Genetic Algorithms

It is one of the well-known evolutionary algorithms which imitate the survival of the fittest and the Darwinian theory of evolution in optimization. This has many applications in the field of civil engineering but there are still many areas that need more research and development. Through the development of genetic algorithms, various new mathematical tools are created which is one of the most recent application successes. Its use in the field of civil engineering application is increasingly widespread with the efficient advancement of computer technology. By using genetic algorithms, construction planners can create and assess optimal or nearly optimal construction schedule plans that can save project time and expense using a genetic algorithm-based optimization model for linear construction projects.

B. Artificial Immune System

For solving complicated engineering optimization issues in the real world, the artificial immune system activates a living organism’s adaptive immune system. Artificial Immune System is a method that solves the drawbacks of the conventional and artificial neural network-based approaches and is used for the analysis of civil engineering systems by combining the evolutionary algorithm with the least square method that determines feasible structures and the relevant constants for the structure. Various immune algorithms have been put out by realization forms but still, the investigation of how to use immune system traits is in its early stages. In the context of civil engineering applications, the immune system still requires development.

C. Artificial Neural Networks (ANN)

This can be described as a system of closely coupled adaptable simple processing units i.e. artificial neurons or nodes that have the capacity to carry out massively parallel computations for knowledge representation and data processing. This is a kind of simplified technical reconstruction of a biological neural network whose primary goal is to create a workable artificial neural network model in accordance with the theory of biological neural networks and activate some technically implemented intelligent activities of the human brain to address practical issues.

This is frequently used in structural optimization, health monitoring, structural control, characterization and modeling of structural materials, construction engineering, highway engineering, etc. This technology’s network consists of input, hidden, and output layers which are excellent for jobs involving inadequate data sets, hazy or missing information, and for extremely difficult issues where human judgments are frequently made intuitively.

D. Big Data

The quick advancement of big data technology has generated a lot of discussion in the fields of science, technology, industry, and even governments worldwide. Engineering, requires the adaption of data from numerous new sources, including sensors, wireless devices, GPS, and machine-to-machine streaming communication. The continuous, unstructured, and freedom from the strict structure of rows and columns that characterizes data makes it challenging for traditional approaches to handling. So, the applications of big data are urgently needed. The fundamental feature of big data applications is autonomous data with dispersed and decentralized controls since each data source is capable of generating and gathering information without needing or depending on any centralized control.

E. Big Data & Data Mining

Big data is also known as a huge quantum of information because of its five characteristics volume, haste, variety, value, and veracity. At the same time, it's useful data beyond what conventional databases can carry and can classify and break. With the development of technology, big data analysis is made possible using artificial intelligence, which can dissect structured, semi-structured, and unshaped data in big data (IBM, 2021), and the process of analysis is called data mining. Data mining is an algorithm grounded on artificial intelligence and computer wisdom to count, recoup, dissect, classify, and epitomize the retired information in big data. thus, data mining is a kind of decision-support process, and the results attained can be prognosticated for the future and can be applied to unborn opinions (Briga- Sá etal., 2021; Cheng & Ma, 2015).

In recent times, the speed of connection has increased, and the price of computers and the cost of data storehouses have dropped (Mehmood, 2019). With the combination of big data and artificial intelligence getting more sophisticated, green structures have been equipped with detectors and electricity and water inflow measures that can directly control the data.

Directors or tenants can use artificial intelligence technology to dissect this data and learn from the results to ameliorate the effectiveness of resource operation and reduce energy consumption to achieve low consumption, high effectiveness, and green (Palensky & Dietrich, 2011).

As an illustration, the light detector is used to control the movement of canopies and window tones. The detector continuously collects data from the sun, and AI analyzes the light intensity through algorithms to determine whether the coming action is to open the shade or turn on the light to fill in the light. But through the collection of a large quantum of data for data mining, the conformation of law can be automatically acclimated, which in turn can reduce the use of detectors, for further extreme energy saving (Mehmood, 2019). Kim etal. (2021) used data mining ways to prize internal connections and patterns of interest from a large database.

The case study conducted in their paper shows that data mining- grounded energy modeling can help design brigades discover useful patterns during the design phase to ameliorate the energy effectiveness of erecting designs. What styles can be used to determine if a structure meets the criteria for a green structure? Over time, big data mining has developed numerous operations for green structure standing, erecting energy protuberance, green structure modeling, and cost vaticination and control. As shown in Table II, there are artificial neural networks (ANN), convolutional neural nets (CNN), K- Nearest Neighbors (KNN), multiple direct retrogression (MLR), support vector machines (SVM) or retrogression (SVR), ensemble styles, association rule mining (ARM), cluster analysis and logistic regression, and backpropagation neural networks, independently. ANN is a complex network structure formed by numerous connected neurons, an algorithm that simulates the organizational structure and functional functions of the mortal brain. It can be applied to the cost computation of green structures by forming a neural net of colorful factors to make a model.

This allows for estimating the cost of green structures, and measuring the performance of green structures and standing green structures (Lu et al., 2021; Tatari & Kucukvar, 2021; Son & Kim, 2015; Juan et al., 2017). Gonzalez and Zamarreno use an ANN model to prognosticate the short-term electrical cargo consumption of structures. The topmost advantage of this model is that it uses minimum coffers, but its simplicity and delicacy are like other soothsaying styles. Among colorful styles of neural network configuration, back propagation neural network (BPNN) is the most mature and extensively used, which combines feedforward multilayer perceptron with BP algorithm (Lu et al., 2021; Gardner & Dorling, 1998) and is substantially used for performance vaticination of green structures to calculate compressive strength of concrete and energy consumption. It also shows the part of data mining in green structure as a crucial decision-making algorithm that no longer needs to go through trial and error to arrive at the result by assaying large quantities of data (Debrah, 2002).

In addition to this, there's a system of combining multiple models and voting to reach a final decision (Pan & Zhang, 2021). As an illustration, Ma & Cheng (2017) used BIM technology combined with arbitrary timber to prognosticate the environmental impact of structures.

BIM technology enables digital modeling and provides participated data and applicable information to grease the combination and analysis of multiple models to arrive at final opinions. Data mining is only part of the personification of artificial intelligence in green structures, while intelligent optimization is a more egregious reflection of how artificial intelligence can help the development of the construction industry.

Table I: -References For Big Data & Data Mining.

METHOD	PURPOSE	STUDIES.
ANN	GB energy consumption forecasting and cost control GB Performance Rating Construction progress analysis Measuring Concrete strength Clarify GB impact factors.	Lu et al.2021; Tatari & Kucukvar,2021; Son & kim,2015; Juan et al., 2017; son & kim, 2015; Ganes & Muthukanna, 2021.
CNN	The value of BIM technology in GB Indoor temperature modeling-related tests.	Wen et al, 2020; Elmaz et al., 2021.
KNN	Connecting BIM and LEED Technologies for Green Buildings.	Jalaei et al., 2021.
MLR	Complete LEED credits GB price budget and cost control.	Cheng & Ma.2015; Juan, 2017.
SVM/SVR	GB performance rating GB design perfection selecting target LEED points through project information and climate factors.	Son & kim,2015; Wen et al, 202; Chen & Yang, 2017; Jun & Cheng, 2017.
NLP	Attention and emotion analysis of GBs organize and categorize GB material information determining satisfaction with LEED certified buildings.	Liu & Hu, 2019; Hong et al., 2019; Guo et al.,2021.
CBR	Complete LEED credits support GB retrofit decision.	Cheng & Ma, 2015; Zhao et al., 2019.

F. Building Automation System

A building automation system, a comprehensive system controlled, managed, and monitored by a computer, is an automatic management system in which building electromechanical systems are self-monitored, self-controlled, and self-regulated. Electricity, lighting, air conditioning, water supply and drainage, firefighting, broadcasting, and communication in the building are all part of the automation system. A large amount of data can be collected through centralized management and monitoring, and data mining and analysis can be used to better optimize building energy consumption and realize green buildings. Research over the years has focused on reducing the energy consumption of buildings, much of which is in the automatic regulation of lighting, HVAC, and other systems (O'Grady et al., 2021). While BAS manages the equipment in a building, the automation system ensures the operation of the equipment and improves the comfort and safety of the occupants (Lazim et al., 2015). Different sensors are used in different locations, and sometimes multiple sensors are used together to control energy consumption.

Some places that are less visited or do not need to stay, such as restrooms, roomy storage rooms, and some special function rooms, will use passive infrared sensors to reduce the energy consumption of lighting and HVAC. The study determined that total energy consumption could be reduced by 7% after use, and HVAC energy consumption by 1.2% (Gomes et al., 2019; Lin et al., 2019; Abdallah et al., 2016; Chan et al., 2017). However, the use of PIR sensors alone can lead to some unnecessary waste of resources because of their noise. Therefore, there is a combination of sensor use methods. For example, Mataloto et al. (2019) integrated motion detection sensors with RIP sensors and modified the detection circumstances so that motion could be detected more accurately, as well as controlling lighting systems and HVAC to reduce energy consumption.

In addition, automation in a green building generates a lot of data, through which it is easy to distinguish where improvements are needed and where anomalies occur. Building automation systems provide two functions for green buildings. The energy consumption for a certain period is first predicted, after which the actual data is compared with the predicted value to determine whether there are any anomalies. Simply put, it is to determine whether an abnormality occurs at a certain point in time or stage, and this function is called "point abnormality detection". The presence of anomalies is determined by the larger context, such as weather (Zhu, 2019). Machinery will inevitably break down, so building automation systems cannot be done without the help of artificial intelligence, just like many smartwatches nowadays, which can detect the state of the human body. Some sensors may develop defects over time, or people may inadvertently damage them, which can lead to unnecessary energy consumption. As a result, numerous artificial intelligences are being used in building automation systems to ensure proper machinery performance and to reduce unnecessary or inefficient energy usage. Table II lists some relevant information on building automation systems.

Table II: -References For Building Automation System.

METHOD	PURPOSE	STUDIES.
light sensors.	Balance natural lighting and electric lighting to reduce energy consumption in buildings.	Iwata et al., 2017.
Thermostat.	Detects relative humidity, air velocity and temperature to adjust temperature to reduce energy consumption.	Homod et al., 2018.
Expert system.	Detection and control of outdoor lighting systems: diagnosis of faults.	Atis & Ekren, 2016.
Deep Learning model.	Estimating the efficiency of GB natural ventilation system, Energy consumption of budget buildings.	Park & Park, 2021.; Ding et al., 2021.
Machine Learning model.	Optimize building energy structure.	Briga-sa, 2021; Yang et al. 2015; Goncalves et al., 2020.
Bluetooth Wi-Fi.	Intelligent control from a distance for wireless connection.	Mataloto et al., 2019.

III. APPLICATIONS OF AI IN CIVIL ENGINEERING

A. Construction Engineering and Management

The behavior of cement-based materials subjected to single, double, or multiple injuries can be modeled using complicated structures with well-defined input and output data sets using a computational method based on artificial intelligence (AI) called Neuro-Fuzzy Inference Systems. Additionally, it can be utilized to create construction management plans that reduce project costs and length. In cases of the planning stage, the automated machines may examine a potential construction site to gather sufficient data to create 3D models, blueprints, and project plans. Before this, it used to take weeks to finish but now with AI, it just takes a day.

B. Structural Engineering

Artificial Intelligence is used to create computational components that analyze human mental processes and replicate them. Sub-structuring techniques, harm recognition approaches, and static and dynamic substructure methods to quantify the harmed elements based on a full and partial estimation are used for a larger scale of artificial intelligence in the field of civil engineering.

C. Transportation Engineering

Focusing on the failure traits of highway slopes, an empirical model can be used for evaluating the possible failure of highway slopes. For addressing complex transport networks, a technique named agent-based modeling (ABM) is more effective than conventional modeling techniques. For handling the issues about transportation technologies, a Knowledge-Based System (KBS) is employed.

D. Structural Damage Detection

A neural network named Faster Region-Based Convolutional Neural Network (Faster R-CNN) is a structural visual inspection technique that simultaneously and in real-time identifies different types of surface damage: bolt corrosion, delamination, steel corrosion, concrete cracking, etc.

E. Quantity Surveying

Artificial Neural Networks are perfectly suited for building decision aids with analogy-based problem-solving abilities for surveying difficulties. The model design, training, and testing are defined by the adjustments to generalization made using the Genetic Algorithms technique.

F. Geotechnical Engineering

By using a general model of neural network regression, the capability for non-linear liquefaction can be evaluated and this model can be used by geotechnical.

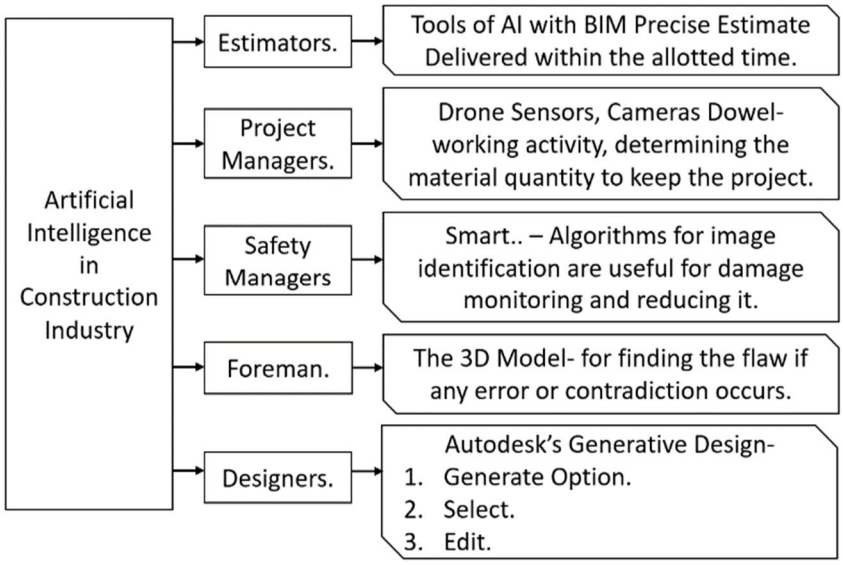

Fig. 01: - Application Of Ai In Construction Industry.

IV. SUMMARY

At present, domestic artificial intelligence (AI) technology is in its nascent phase of evolution, exhibiting specific technical shortcomings in its practical implementation. However, these deficiencies become negligible when considering their impact on the instructional content of civil engineering. By judiciously leveraging AI technology, educators have the potential to markedly enhance students' practical skills. This strategic integration can facilitate more effective completion of civil engineering major coursework, expediting the development of a new cohort of proficient professionals for societal benefit.

V. CONCLUSION

This study is to propose the use of artificial intelligence in green buildings for the future development of the construction industry, to reduce energy consumption, and enable the transformation and development of the construction industry. A literature review is conducted to analyze the role of artificial intelligence in green building and its help to the development of the construction industry through four perspectives. Research on fuzzy rules and knowledge discovery, big data and data mining, intelligent optimization, and building automation systems has solved some decision-making problems in green building, provided concrete insights into green building-related information, and confirmed that the use of artificial intelligence technology in green buildings is a trend that has strong support for the development direction of the construction industry. As the issue of green building continues to be raised, and AI technology matures, in the future attention should be paid to the question of whether AI technology itself has a greater impact on green building and how this is to be optimized.

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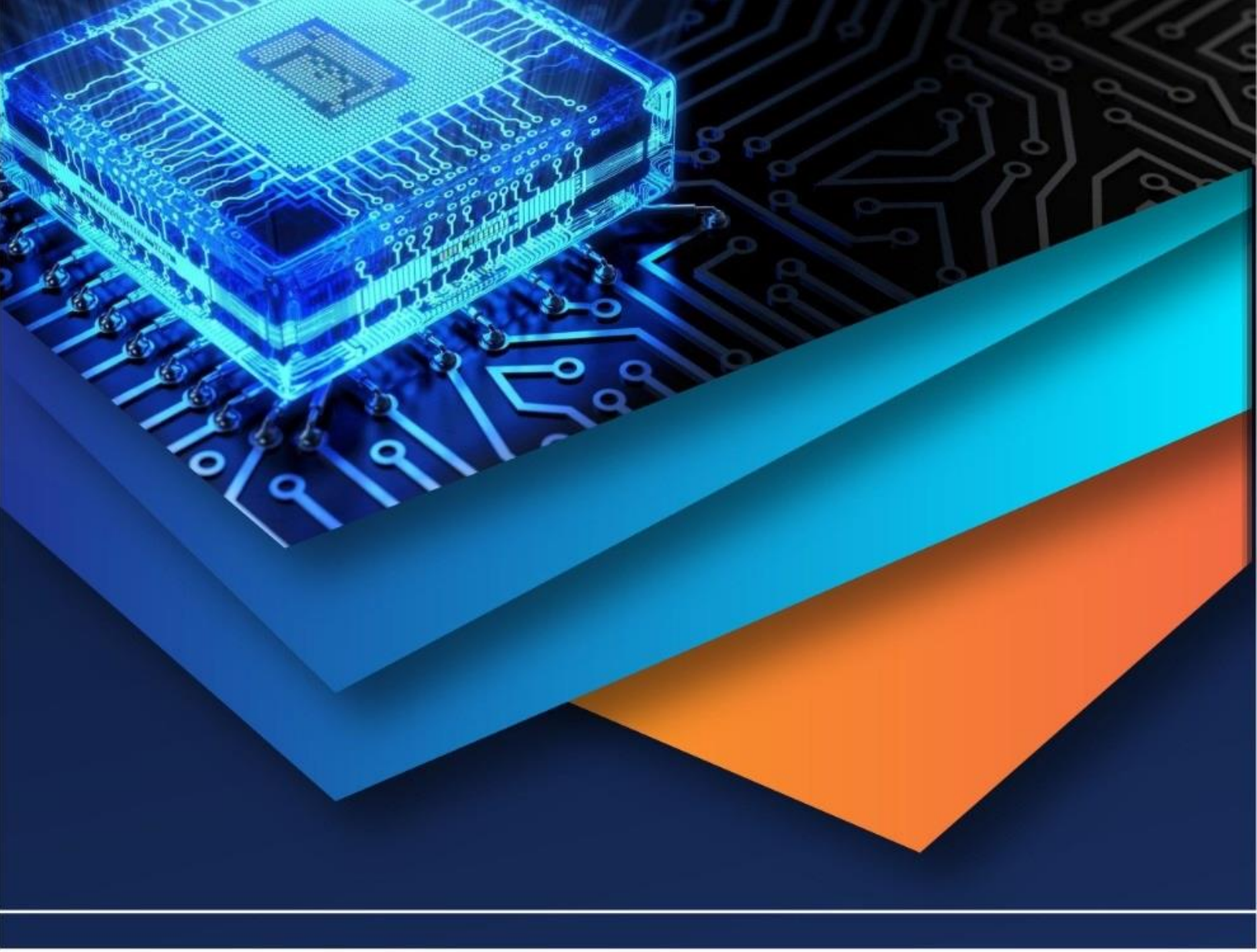

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