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Use of Artificial Neural Network in Engineering: A Review

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Abstract: ***In the context of Artificial Neural Networks (ANNs), the use of an AI driven machine learning approach has been explored for addressing real world problems in the current scenario. For the effective functioning of ANN based models, similar datasets specific to the targeted problem are required, so that behavior resembling human general intelligence can be emulated. A comprehensive review of earlier studies related to ANNs has been presented in this paper, and conclusions have been drawn based on the evaluated literature. Within these reviewed works, significant contributions have been made using architectures such as Multi Layer Perceptron Neural Networks (MLPNNs), Convolutional Neural Networks (CNNs), and Recurrent Neural Networks (RNNs), each applied respectively to one dimensional, two dimensional and time series data for pattern recognition and learning. To ensure proper learning and adaptive behavior in ANN systems, the initial selection of an AI capable programming language has been emphasized, which must be able to process datasets intelligently before translating this behavior into artificial intelligence. As a result of these findings, clear and focused conclusions were drawn which forms the research objectives of our further technical study.***

Keywords: Multistory Building, Computational Efficiency,Optimization, Data Analysis,

I. INTRODUCTION TO NEURAL NETWORKS

From the framework of braininspired intelligence, computational models known as neural networks have been developed to mimic the structure and function of biological systems. Across layered architectures, data is processed by interconnected nodesreferred to as "neurons"and pattern recognition is achieved through experiencebased training. Within many advanced machine learning systems, the foundation is provided by these models, especially due to their capacity for capturing nonlinear and complex data relationships. Rooted in biologically inspired computing, Artificial Neural Networks (ANNs) have been categorized as a significant class of machine learning tools intended to replicate human information processing. Through multiple layersinput, hidden, and outputinformation is transmitted and transformed in ANN systems. During the training phase, weighted connections among neurons are finetuned, allowing for the learning of inputoutput mappings. As a result of this adaptive mechanism, tasks involving classification, prediction, and decisionmaking are executed by ANNs with high precision and speed. Across numerous realworld sectors, including engineering and datadriven industries, significant improvements have been demonstrated by synthetic methods such as ANNs. In contrast to traditional models, largescale and complex datasets can be effectively managed, hidden structures can be uncovered, and robust predictions can be produced through ANNbased strategies. By embedding intelligent learning mechanisms into their design, ANN models are used to construct solutions that are adaptive, responsive, and efficient in dynamic environments.

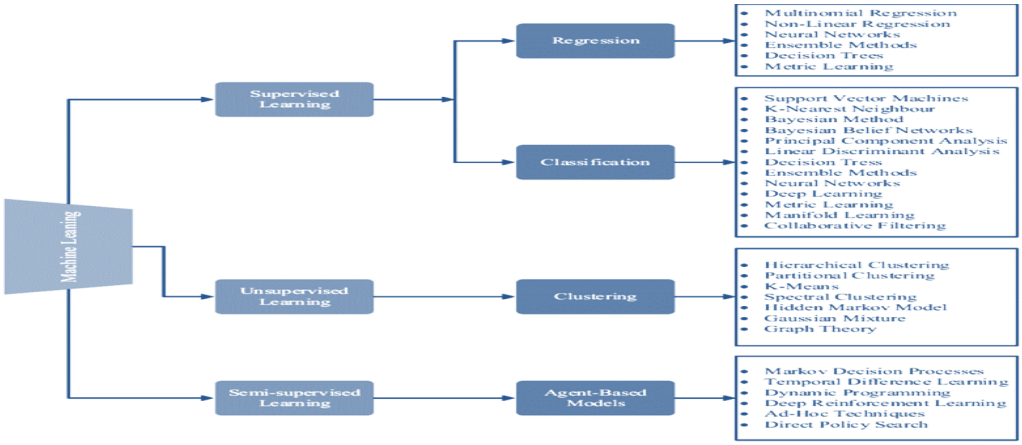


Fig. 1:Machine learning structure: A part of Artificial Neural Network

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II. LITERATURE REVIEW

The literature articles have selected for the current research study based on usage of programming language and use of Artificial Neural Network that simulate that code for machine learning. The specificreviews are:

In this paper the researcher has demonstrated that fundamental algorithms, such as sorting and hashingwhich are executed trillions of times dailybenefit from advancements in artificial intelligence. The increasing demand for computation has made the development of highly performant algorithms crucial. Despite significant progress historically, further improvements in the efficiency of these routines have remained challenging for both human experts and computational methods. The problem of discovering better sorting routines was formulated as a single player game, and a novel deep reinforcement learning agent, AlphaDev, was trained to solve this game. Small sorting algorithms, discovered from scratch by AlphaDev, were found to outperform previously established human benchmarks. These newly discovered algorithms were integrated into the LLVM standard C++ sort library, replacing existing components with reinforcement learning automated solutions. Additional results from other domains were also presented, illustrating the broad applicability and generality of this approach. Enhanced algorithm performance through AI driven discovery and successful real world integration were their conclusive outcomes. (Daniel J. Mankowitz, 2023)

In this paper the researcher has explored and applied artificial neural networks (ANN) to tackle complex problems in pavement engineering, driven by significant advancements in soft computing and data science. A state of the art review was conducted to survey recent progress in ANN applications across various stages of pavement engineering, including design, construction, inspection and monitoring, and maintenance. Literature published over the past three decades, particularly since 2013, was retrieved, resulting in the identification of 683 relevant papers, of which 143 were selected for detailed analysis. The ANN architectures primarily utilized in these studies included the multi layer perceptron neural network (MLPNN), convolutional neural network (CNN), and recurrent neural network (RNN), applied to one dimensional, two dimensional, and time series data. Notably, CNN based methods for pavement health inspection and monitoring attracted the greatest research interest, given their potential to replace human labor. Although ANN demonstrated effectiveness in pavement material design, cost analysis, defect detection, and maintenance planning, significant challenges related to data collection, parameter optimization, model transferability, and low cost data annotation were identified. The need for greater integration of multidisciplinary techniques within pavement engineering to overcome these challenges and broaden future opportunities was emphasized. Enhanced understanding of ANN applications and identification of key research gaps were their conclusive outcomes. (Xu Yang, 2021)

In this paper the researcher has addressed the challenges posed by climate change induced environmental stresses and limited agricultural land through sustainable agricultural intensification using crop diversification strategies. Dragon fruit, recognized for its nutraceutical properties, has been proposed as a viable crop for cultivation on resource poor and degraded lands. The importance of consumer acceptability and the maintenance of high quality standards for marketing and processing purposes has been emphasized. Grading and sorting techniques for dragon fruit have been developed by employing machine learning algorithms such as Convolutional Neural Networks (CNN), Artificial Neural Networks (ANN), and Support Vector Machines (SVM). A comprehensive review of existing methodologies for fruit and vegetable quality assessment was conducted to support the selection of these algorithms. Features such as shape, size, weight, color, and the presence of diseases were analyzed through the implementation of these algorithms. Raspberry Pi based functionality was applied to count the number of fruits in a bucket, and sorting operations were executed according to maturity levels. Enhanced efficiency in fruit quality assessment and improved post harvest handling through intelligent grading and sorting systems were their conclusive outcomes. (Pallavi U. Patil, 2021).

In this paper the researcher has addressed the increasing difficulty associated with developing highly efficient code due to the growing complexity of modern processors. The manual creation of such code has been acknowledged as both costly and essential, owing to the current limitations of existing compilers. An automatic code generation strategyimplemented through library generators such as ATLAS, FFTW, and SPIRALhas been explored, in which empirical search is used to identify performance optimal code characteristics tailored to each target machine. While this strategy has predominantly been applied to scientific code optimized for machine specific features, its extension to sorting routineswhose performance also depends heavily on input data characteristicswas examined in this study. Two methods for generating efficient sorting routines were proposed. In the first, the optimal "pure" sorting algorithm is chosen based on input data characteristics, with machine learning algorithms employed to compute a selection function at runtime. The second method expands on this by using genetic algorithms and a classifier system to construct hybrid sorting algorithms that adapt dynamically to input data. The results demonstrated that the sorting algorithms generated through these approaches achieved significant performance improvements over traditional implementations, such as IBM ESSL, INTEL MKL, and C++ STL. Performance enhancements of up to 26% and 62% over IBM ESSL on IBM Power 3 and Power 4 systems, respectively, were their conclusive outcomes. (Xiaoming Li, 2007)

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In this paper the researcher has emphasized the transformative potential of optimization methodologies in the field of civil engineering. A review was conducted to explore how advanced computational techniquessuch as Design of Experiments (DOE), fuzzy logic, and Artificial Neural Networks (ANN)have been integrated to offer adaptable, efficient, and cost effective solutions for structural design, material optimization, and construction processes. These approaches have been shown to effectively manage uncertainties, thereby contributing to the development of more resilient and sustainable civil infrastructure. Through these methodologies, innovation, reliability, and progress in engineering practices have been promoted. Nonetheless, several practical challenges were acknowledged, including the complexity of integrating AI driven methods, high computational resource requirements, and concerns surrounding data privacy. The disconnect between theoretical progress and real world implementation was noted as an area requiring resolution through interdisciplinary collaboration. The necessity for efficient computational algorithms to lower processing demands and improve accessibility for smaller engineering firms was also highlighted. Broader applicability of optimization techniques and improved scalability of AI based tools in civil engineering practice were their conclusive outcomes. (AsraarAnjum, 2024)

In this paper the researcher has examined the growing importance of Artificial Neural Networks (ANNs) in addressing complex, constraint heavy problems across multiple domains, where superior performance over traditional methods has been consistently demonstrated. A systematic literature review was conducted to investigate the application of ANNs specifically within the field of civil engineering. A total of 41 relevant articles were selected from databases including Scopus, ScienceDirect, ProQuest, Google Scholar, DialNet, and SciELO. Through this review, it was determined that ANNs have been extensively utilized for the prediction of key variables in civil engineering, with applications spanning concrete property analysis, soil behavior modeling, seismic performance evaluation, hydraulic systems, real estate appraisal, and bridge structural design. Among the various models, the multilayer perceptron was identified as the most frequently employed architecture. Reported outcomes revealed an average R^2 value of 0.99, confirming the model's accuracy, robustness, and ability to manage incomplete data sets effectively. Enhanced predictive reliability and increased modeling efficiency in civil engineering problems were their conclusive outcomes.(Frank JesúsValderramaPurizaca, 2020)

In this paper the researcher has introduced a robotic multi object sorting system designed for unstructured scenes, with emphasis placed on achieving efficiency, stability, and accuracy in the sorting process. A rotating target detection model was trained using placement data of common objects, allowing the identification of object position, rotation, and category. For object surface segmentation, an optimized Mask R CNN instance segmentation model was employed, and the normal vector of the upper surface was computed to determine the object's attitude. The order of grasping was established based on the depth of the object surface. Object posture, category, and grasping sequence were fused and tested on a physical experimental platform. During experimental validation, the proposed system demonstrated a high success rate in object capture, confirming its ability to effectively sort stacked objects in complex, unstructured environments. Improved object detection precision, reliable grasp sequencing, and enhanced robotic performance in real world cluttered settings were their conclusive outcomes.(Hongyan Zhang, 2021)

In this paper the researcher has investigated the challenges associated with modeling edge level signals, which are critical in applications across traffic systems, civil engineering, and electrical engineering. These signals, which may be inherently directed (such as water flow in a pipe network) or undirected (such as pipe diameter), have traditionally been modeled through topological methods that assign orientations to edges. However, such methods have been unable to effectively handle undirected signals or to differentiate between directed and undirected edges. To overcome these limitations, several key contributions have been made: (i) the concept of orientation equivariance has been revised to support direction aware topological models, (ii) orientation invariance has been introduced to account for undirected edge signals, and (iii) a novel architectureEIGNhas been developed, incorporating direction aware graph shift operators. EIGN has been identified as the first general purpose topological Graph Neural Network (GNN) capable of accurately modeling both directed and undirected edge signals while distinguishing between them. Through comprehensive evaluations, EIGN has been shown to outperform prior models significantly, achieving improvements of up to 43.5% in RMSE for flow simulation tasks. Enhanced edge signal modeling and superior predictive accuracy in practical applications were their conclusive outcomes.(Dominik Fuchsgruber, 2024)

In this paper the researcher has aimed to ensure that raisin quality meets high standards to maintain consumer satisfaction. The importance of sorting has been emphasized as a means to eliminate defective raisins, thereby allowing only high quality produce to reach the market. The limitations of manual sortingsuch as inefficiency and the potential for human errorhave been acknowledged, particularly in the inaccurate separation of defective and acceptable raisins. To overcome these challenges, automated sorting methods have been proposed to ensure consistency in features like size, color, and texture, aligning the final product with consumer expectations. In addition, proper sorting has been identified as a key factor in achieving compliance with food safety regulations.

The project has focused on the evaluation and classification of raisin quality through detailed analysis. A systematic methodology for assessing quality has been established by considering attributes such as shape, color, size, texture, and overall appearance. For this purpose, a Convolutional Neural Network (CNN) model has been implemented, utilizing a dataset comprising images of both high and low quality raisins for training. Improved accuracy in raisin classification and the potential for scalable, automated quality control were their conclusive outcomes.(Arshad Shaikh, 2024)

In this paper the researcher has examined the need for continuous advancement in sorting algorithms and their implementations to efficiently manage large scale data, particularly concerning time and memory optimization. Various adaptive sorting algorithms have been reviewed, with emphasis placed on selecting suitable approaches based on specific data set characteristics. The development of such adaptive algorithms has been facilitated by the application of Machine Learning, which enables learning from experimental data patterns. Algorithms constructed using Systems of Algorithmic Algebra and Genetic Algorithms have been analyzed to assess their effectiveness across different use cases. Pseudocode generated by Systems of Algorithmic Algebra has been designed to be translatable into high level code through an Integrated Toolkit for Program Design and Synthesis. Meanwhile, Genetic Algorithms have been utilized to optimize a fitness function aimed at producing the most efficient sorting techniques. Enhanced adaptability and improved algorithmic performance in diverse data environments were their conclusive outcomes.(SomshubraMajumdar, 2016)

In this paper the researcher has discussed the growing attention given to image processing through Artificial Neural Networks (ANNs) in Civil Engineering over the past five years. The limitations of traditional neural networkscomprising multiple interconnected neuronshave been noted, particularly their inefficiency in feature extraction from images due to intensive computational demands. To overcome these challenges, the Convolutional Neural Network (CNN) was introduced as a specialized machine learning architecture capable of handling image data effectively. Within this framework, images are processed as inputs, and varying degrees of significance are assigned to features within the images to support accurate differentiation. In the context of Civil Engineering, the application of CNNs has been met with significant success, as demonstrated by documented results across several studies. Advancements in feature recognition and improved performance in image based civil applications were their conclusive outcomes.(Alexandrina Elena Andon, 2022).

In this paper the researcher has examined the issue of cybersecurity vulnerabilities frequently present in code written by human programmers, with emerging "smart" code completion tools being evaluated for their potential in automatic bug repair. The use of large language models (LLMs), including OpenAI Codex and AI21 Jurassic J 1, has been investigated for zero shot vulnerability correction without the need for additional task specific training. The complexity of designing prompts that effectively guide LLMs in generating secure versions of vulnerable code has been explored, especially due to challenges in expressing critical semantic and syntactic cues through natural language. A large scale experimental study was conducted involving five commercially available black box LLMs, an open source model, and a locally trained model. Various security bug scenariossynthetic, handcrafted, and real worldwere used in the evaluation process. While 100% of the synthetically generated and handcrafted examples were successfully repaired, significant limitations were revealed through qualitative analysis in handling real world vulnerabilities with full functional and security correctness. Insights into the strengths and boundaries of LLM driven automated code repair were their conclusive outcomes. (Hammond Pearce, 2022).

In this paper the researcher has presented Codex, a GPT based language model fine adjusted on publicly available code from GitHub, with its capabilities in generating Python code being analyzed and evaluated. A distinct production version of this model has been deployed as the engine behind GitHub Copilot. On the HumanEval benchmarkan evaluation suite created to assess functional correctness in code synthesis from docstringsa 28.8% problem solving rate was achieved by Codex, in contrast to 0% by GPT 3 and 11.4% by GPT J. Furthermore, repeated sampling from Codex was identified as a surprisingly effective method for producing accurate solutions to complex programming prompts. When this strategy was applied using 100 samples per problem, a success rate of 70.2% was observed. A detailed analysis of the model also revealed certain limitations, including difficulty in interpreting docstrings describing long sequences of operations and issues with assigning operations to appropriate variables. Considerations regarding the safety, security, and economic impacts of deploying such advanced code generation systems were their conclusive outcomes. (Mark Chen, 2021)

In this paper the researcher has explored the use of multi head attention layers, as implemented in the Transformer neural sequence model, which have been regarded as a powerful alternative to recurrent neural networks (RNNs) for transferring information across and between sequences. The training of these layers has been facilitated by their ability to be parallelized along the sequence length, making the process generally fast and efficient.

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However, during incremental inferencewhere parallelization is not applicableperformance has been hindered due to the repeated memory bandwidth demand of loading large "keys" and "values" tensors. To address this limitation, a variant known as multi query attention has been introduced, in which keys and values are shared across all attention heads to reduce tensor size and bandwidth usage. Through experimental evaluation, the models using this technique have been shown to achieve substantially faster decoding speeds with only minimal degradation in output quality. Improvements in inference efficiency and model scalability were their conclusive outcomes.(Noam Shazeer, 2019)

In this paper the researcher has examined how compiler optimizations can be automatically derived, allowing several substantial engineering challenges in the creation and maintenance of high quality compilers to be potentially avoided. To investigate the extent of this approach within the LLVM framework, a synthesizing superoptimizer named Souper was developed. During the course of its development, it was identified that Souper's intermediate representation bore strong similarities to that of Microsoft Visual C++, making its adaptation to that compiler feasible. Optimizations recommended by Souper, though manually integrated, were incorporated into production or near production releases of both compilers. Furthermore, when Souper was applied as a fully automated optimization pass, a Clang compiler binary was generated that was approximately 3MB (4.4%) smaller than the standard LLVM compiled version. Demonstrated through practical implementation and measurable performance improvements, streamlined compilation and enhanced code efficiency were their conclusive outcomes.(RaimondasSasnauskas, n.d.)

In this paper the researcher has focused on the use of Artificial Neural Networks (ANNs) as systems through which complex problemsunsolvable by traditional sequential algorithmscan be approached using example based learning. Learning mechanisms have been autonomously formulated by these networks from the datasets provided. Across various specializations in Civil Engineering, including geotechnical analysis, structural systems, and construction management, dedicated studies have been conducted using ANNs to address domain specific challenges. Through these applications, areas such as material behavior, structural identification and control, heat transfer analysis, transport infrastructure, and technological implementation in construction have been explored through neural models. Reflected in the breadth of investigations and their observed performance, varied levels of predictive accuracy and practical relevance were their conclusive outcomes.(Alexandrina Elena C. Pandelea, 2014)

III. CONCLUSION AND OUTLINE OF PROPOSED WORK

A gap in the literature regarding prior work on the current topic has been identified. The necessity for further research to address realworld problems has been emphasized. From the literature review, conclusions have been drawn that underscore the primary findings and enumerate essential outcomes:

1) The feasibility of programming languages for artificial intelligence combined with machine learning has been evaluated, with examples including Python and VBA.
2) Appropriate environments capable of executing programming language code with simulation have been determined, such as Python launcher and Google Colaboratory.
3) Programming code has been developed by studying architecture and hierarchy, followed by the implementation of learning processes inspired by human behavior, then translated into machine code.
4) Code optimization and debugging have been performed wherever possible to ensure smooth execution.
5) It has concluded that motivation plays a crucial role in the design phase of machine learning and AIbased programs. These findings represent the conclusive outcomes of the study.

The feasibility of using artificial intelligence to explore AIbased machine learning programming for automatic simulation of problem solving has been set as the primary objective of this study. The aim is to obtain solutions with simplicity, which will serve as the central focus for the forthcoming proposed work.

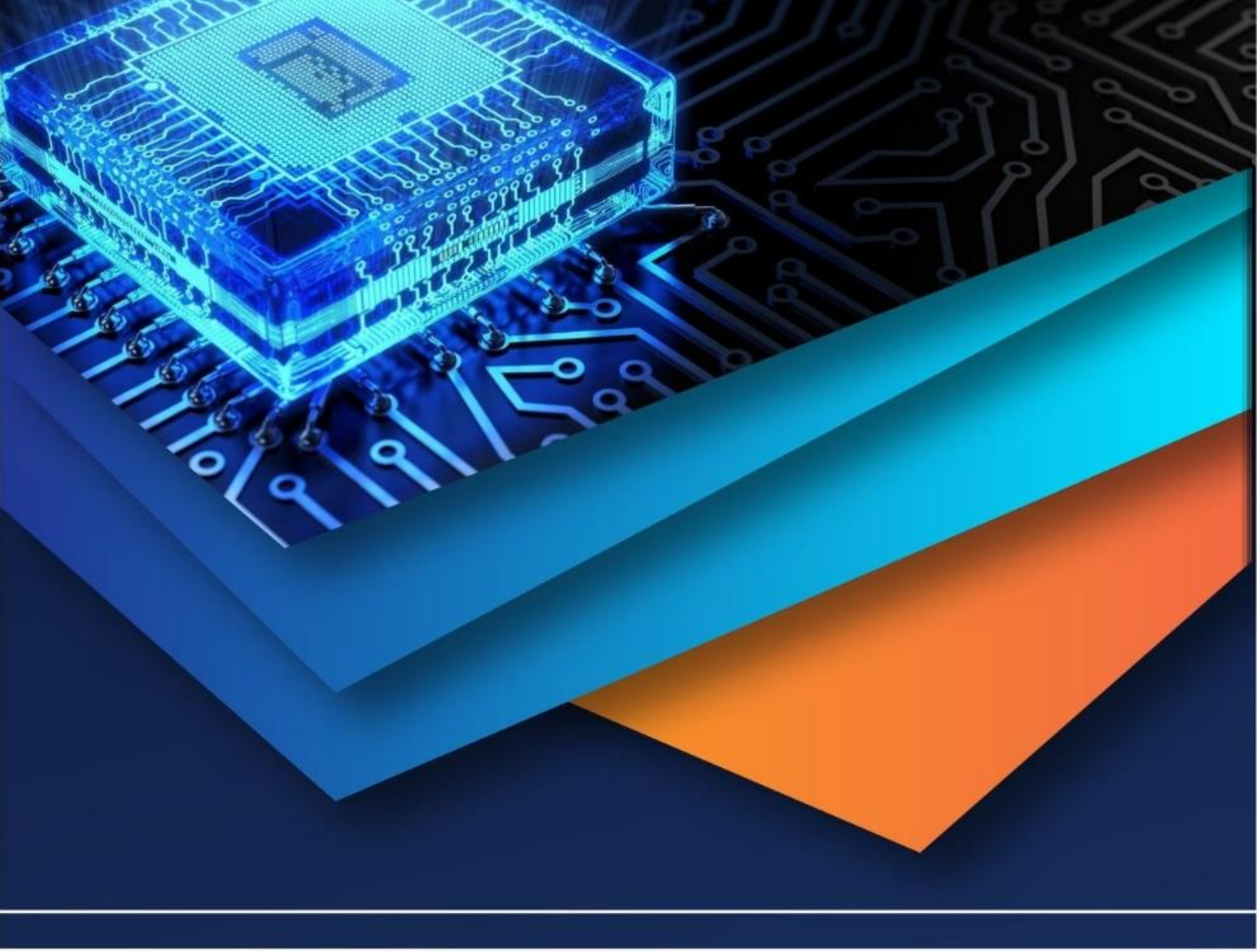
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