iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** VI **Month of publication:** June 2023

DOI: https://doi.org/10.22214/ijraset.2023.54235

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

Efficient Workforce Planning with a Labour Allocation System

Ashna Xavier[1], Clinz Sabu[2], H. Vishal[3], Teena George[5]
Computer Science and Engineering Department, Adi Shankara Institute Of Engineering And Technology, Kalady, Kerala, India

Abstract: ***The primary objective of this project is to develop a web-based application for the allocation of work to daily wage workers. Effective management of labour resources is crucial to the success of fieldwork. The assignment of labour to work constitutes one of the most vitally significant and successful processes in the management of labour resources. Consequently, estimating labour shortages and evaluating various labour resource allocation strategies can facilitate the allocation process. By utilising a system dynamics approach, a dynamic model is proposed for workforce allocation. The project is able to achieve this through the model that is presently provided in this study.***
Keywords: XGBoost, Machine Learning, Labour Allocation, Workforce Planning

I. INTRODUCTION

Efficient workforce planning and labour allocation are essential for any employer to operate effectively and achieve goals. A well-planned workforce ensures that the right number of employees with the necessary skills are in the right place at the right time to meet the demands of the work. A labour allocation system helps optimise the use of labour by accurately forecasting demand and allocating the necessary resources to meet that demand. However, effective workforce planning and labour allocation can be challenging, especially for employers with complex operations and a large number of employees. It requires a comprehensive understanding of the employer's goals and objectives, current and future labour needs, and the skills and capabilities of the workforce. In this project, we will create a workforce planning and labour allocation system to assist an employer in improving efficiency and meeting work demands. The system will be designed to forecast labour demand, identify and acquire necessary skills, and allocate the right number of employees to the right tasks at the right time. It will also provide tools for tracking and analysing labour utilisation and performance, allowing the organisation to make informed decisions about its workforce. To develop the system, we will use a variety of front-end technologies, such as HTML, CSS, and JavaScript, as well as frameworks like React. We will also consider the use of responsive design techniques, such as those provided by the Bootstrap framework, to ensure that the system is accessible and user-friendly on a variety of devices. This project will result in a custom-built software solution that will assist the employer in optimising the workforce and better meeting the demands of the job. This solution will not only improve the efficiency of the employer's operations, but it will also help reduce costs and increase productivity.

II. LITERATURE SURVEY

A. *Classification Based on Decision Tree Algorithm for Machine Learning. Journal of Applied Science and Technology Trends.*

B.Charbuty *et al*. [1] Decision tree classifiers are a well-known method for representing data classification. Researchers from various fields, including machine learning, pattern recognition, and statistics, have studied the problem of constructing decision trees from available data. Decision tree classifiers have been used in numerous contexts, such as medical disease analysis, text classification, smartphone user classification, image classification, and more. This paper offers a comprehensive overview of decision tree classifiers, including a review of relevant algorithms and approaches, as well as an evaluation of the datasets and results from previous studies. The authors compare and contrast the different approaches, highlighting key themes and identifying the most accurate classifiers. The paper also discusses the use of various datasets and analyses their findings.

B. *An Approach to Automatic Classification of Construction Workers by Degree of Risk.*

Y. Choi *et al*. [2] In this paper, they present a method for automatically detecting and classifying workers by their risk level in worksites where hazard areas have been identified. Our approach involves analysing worksite videos to detect hazard areas and workers and classify workers based on their risk level. In the future, we plan to expand this approach to include the ability to detect and classify workers based on various hazard area characteristics such as floor openings, aerial lifts, scaffolds, etc.

C. Dynamic modelling of human resource allocation in construction projects.

Shahin Dabirian *et al.* [3] In this study, we present a model that integrates with other methods, including optimization, to improve policy and model responses and collaborate with SD models in various fields such as cash flow analysis, site planning, and safety planning. This model allows project decision-makers to perform the necessary planning for labour allocation before implementing any practical measures and to have a clear understanding of the project's labour needs. One of the benefits of this SD model is its versatility for use in different projects, which will be explored in future research.

D. Betting on Yourself: A Decision Model for Human Resource Allocation Enriched With Self-Assessment of Soft Skills and Preferences

M. Pota *et al.* [4] This study presents a decision model designed to aid HR managers in assigning new hires to available job positions. The model measures the suitability of employee-job pairs by considering the weighted preferences of both employees and HR managers and employs AI to suggest optimal allocations that maximise departmental satisfaction. We conducted a case study at the Italian Ministry of Economy and Finance, where we customised taxonomies, adjusted suitability weights, and addressed privacy concerns through pseudonymization and anonymous statistics. Our results demonstrate the effectiveness and efficiency of our model in providing HR managers with the best allocation suggestions, ultimately reducing human effort.

E. A Decision Model for Human Resource Allocation in Project Management of Software Development

H. Y. Chiang *et al.* [5] This paper offers new insights for helping a company make decisions on human resource allocation and project evaluation under cost, project duration, and efficiency constraints. The study uses a real case and considers not only the basic factors of staff numbers and salary but also other key factors. The results indicate that these factors can help companies perform better evaluations for staff allocation in a software development project. We discuss four variants to demonstrate the feasibility of our framework. Cost-constrained project development is a core principle in a company's evaluation. Key factors such as communication and negative efficiency are important for enhancing project efficiency, which is related to project success and quality. Future research could investigate other aspects that are relevant for human resource allocation, team formation, or human resource training in software development projects. Moreover, staff type, regular employee assignment, overtime work hours, post-project maintenance, and multi-project situations are other topics of interest.

F. Human Resource Allocation Method Based on Multi-Objective Optimization

Y. Jiao *et al.* [6] This manuscript introduces a multi-objective human resource allocation model, utilising a genetic algorithm for the multistage combinatorial optimization problem, with the objective of assigning tasks to employees in an equitable manner. The fundamental concept of the resource allocation model was analysed, and a requisite network model and multi-objective mathematical model were developed. The global optimal solution can be ascertained by searching from a set of points with the intention of optimising three practical indexes for equitable grouping. Subsequently, a multi-objective optimization method based on a genetic algorithm was proposed to solve the model, and its efficacy was demonstrated through an example case. The experimental results indicated that the method can maximise the sum of the effective cumulative rate of all roles undertaking the task and possesses the advantages of lucid logic, straightforward calculation, and practical application value.

G. Solving the Team Allocation Problem in Crowdsourcing via Group Multirole Assignment

L. Liang *et al.* [7] This manuscript proposes a solution to the problem of task allocation in large-scale crowdsourcing platforms, wherein tasks are assigned to teams and a worker may belong to multiple teams, but each team is restricted to working on a limited number of tasks. The solution takes into consideration the necessity to prevent worker overload and information leakage and is predicated on the development of a composition matrix that encapsulates high-order cardinality constraints and conflicting agent constraints. The proposed solution has been validated through simulation experiments and has demonstrated its efficiency, feasibility, and practicality.

H. Extraction of Technical and Non-technical Skills for Optimal Project-Team Allocation

Bhatia, K *et al.* [8] Project portfolio management (PPM) constitutes a critical component of academia, necessitating students to possess a certain calibre of skills. In terms of skills, both technical and non-technical competencies must be considered. This study introduces a model that matches projects to teams of students based on their technical and non-technical skills. Our model employs Formal Concept Analysis (FCA) and the project-oriented stable marriage algorithm to ensure successful matching.

This model not only facilitates the determination of project requirements but also leverages students' skills in a manner that accounts for both technical and non-technical competencies.

I. An optimised prediction algorithm based on XGBoost

C. Sheng *et al.* [9] This comprehensive literature survey focuses on the accurate prediction of real estate prices and the challenges faced by traditional methods in capturing the nonlinear characteristics involved. The study introduces the XGBoost algorithm as a promising solution due to its effectiveness in representing nonlinear relationships. However, the success of XGBoost relies on parameter selection, which directly affects its learning and generalisation abilities. To address this, the research proposes the utilisation of the particle swarm optimization (PSO) algorithm for efficient and accurate parameter determination. The primary objective is to investigate the hybrid model, PSO-XGBoost, for house price prediction using a dataset from Ames, Iowa. Comparisons with four other algorithms reveal that the PSO-XGBoost model achieves the highest prediction accuracy and outperforms linear regression. The research highlights the importance of accurate real estate price prediction and showcases the superiority of the PSO-XGBoost model as well as the benefits of integrated learning algorithms over traditional approaches.

J. Optimised XGBoost-based sparrow search algorithm for short-term load forecasting

J. Song *et al.* [10] This abstract introduces a novel approach to address the challenge of parameter selection in the XGBoost model for optimising regression effects in short-term load forecasting. The proposed method utilises the sparrow search algorithm (SSA) to optimise XGBoost by selecting similar days as the training set using the GRA algorithm. The mean absolute error from cross-validation serves as the fitness function. The SSA-XGBoost load forecasting model is constructed by optimising the covariate selection process with SSA, and the final load forecasting data is obtained by correcting the load using a compensation model. Experiments conducted on load data from a region in Zhejiang Province demonstrate the effectiveness of the SSA-XGBoost model, which achieves high accuracy compared to other models like SVM and RF optimised with SSA. The GRA algorithm ensures the reasonable selection of similar days, resulting in smaller prediction errors and a manageable number of training sets. The compensation model further enhances prediction accuracy by correcting the SSA-XGBoost load prediction data. This research provides valuable insights into optimising the XGBoost model for load forecasting, improving accuracy, and utilising clustering methods for similar day selection.

III. METHODOLOGY

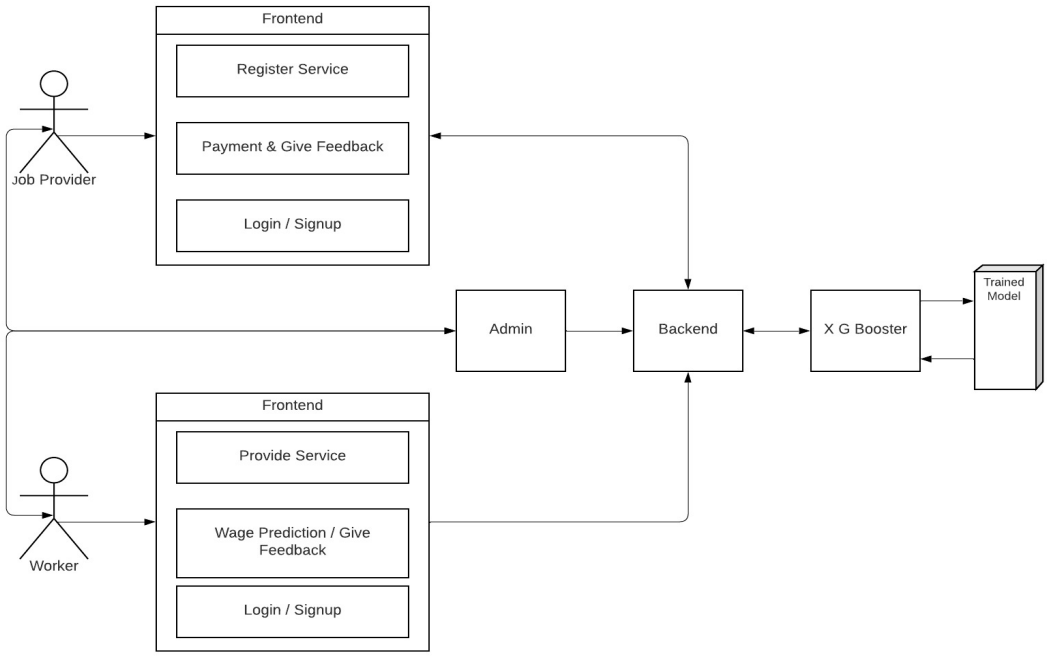


Fig 3.1 - Architecture of Proposed System

A. *Gradient Boosting*

XGBoost is built on the gradient boosting framework, which is a sequential ensemble learning technique. It combines multiple weak learners (decision trees) to create a strong learner. It builds the model in an iterative manner, where each subsequent model corrects the errors of the previous model.

B. *Regularized Learning Objective*

XGBoost introduces regularisation techniques to control the complexity of the model and prevent overfitting. It uses regularisation terms, such as L1 (Lasso) and L2 (Ridge) regularisation, on the model's weights and tree structures to penalise complex models.

C. *Decision Tree Learning*

XGBoost employs decision trees as the base learners in its ensemble. Decision trees recursively partition the feature space to make predictions. XGBoost allows the use of both shallow and deep decision trees to capture different levels of feature interactions and patterns.

D. *Gradient-Based Optimization*

XGBoost optimises the objective function by computing gradients and using them to update the model parameters. It uses the second-order approximation of the objective function (Newton's method) to improve optimization efficiency. It also incorporates a learning rate (eta) to control the step size of each parameter update.

E. *Tree Pruning*

XGBoost applies tree pruning techniques to remove or collapse tree branches that do not contribute significantly to improving the model's performance. Pruning reduces the complexity of the tree ensemble and prevents overfitting.

F. *Column Subsampling*

XGBoost supports column subsampling, also known as feature subsampling or column sampling. It randomly selects a subset of features at each split during tree construction. This technique helps prevent overfitting and improves model generalisation.

G. *Handling Missing Values*

XGBoost has built-in handling of missing values in the input data. It uses a technique called 'Sparsity-aware Split Finding' to efficiently handle missing values during the tree construction process.

H. *Parallelization*

XGBoost utilises parallel processing and multi-threading to speed up computation. It can take advantage of multiple cores on a machine and parallelize the training and prediction process, making it highly scalable and efficient.

IV. IMPLEMENTATION

A. *Tech Stack*

1) *Front-end Technologies:* HTML, CSS: These fundamental web technologies will be used to create the user interface (UI) of the system.
2) *JavaScript Libraries:* jQuery: A fast and feature-rich JavaScript library that simplifies HTML document traversal, event handling, and AJAX interactions. jQuery can help enhance the user experience and handle client-side operations.
3) *Back-end Technologies:* Django: A high-level Python web framework that follows the model-view-controller (MVC) architectural pattern. Django provides a robust set of tools, including an ORM, routing, authentication, and more, to build scalable and maintainable web applications.
4) *Database:* MySQL: An open-source relational database management system. Django has excellent support for MySQL and provides seamless integration for data storage and retrieval.
5) *Authentication and Authorization:* Django's built-in authentication system: Django offers a comprehensive authentication system out of the box, which can handle user registration, login, and password management. It also provides mechanisms for implementing role-based access control (RBAC) and permissions.

6) *Version Control:* Git: A distributed version control system that allows you to track changes to your codebase, collaborate with other developers, and manage different versions of your software.

B. Data Gathering

Relevant data on daily wage workers was discovered and acquired, including state, district, work type, year, month, gender, and associated average salaries. To create a comprehensive dataset, many data sources were used, including government records, industry databases, and surveys.

C. Data Preparation

To deal with missing numbers, outliers, and discrepancies, data cleaning was undertaken. To ensure compliance with the XGBoost algorithm, numerical data was normalised or standardised. One-hot encoding or label encoding techniques were used to encode categorical information such as state, district, work type, and gender.

D. Model Development

The XGBoost algorithm, a sophisticated gradient-boosting machine learning system, was used to forecast average earnings. To analyse the model's performance, the dataset was divided into training and testing sets.

The XGBoost model was trained using the training set by optimising hyperparameters such as learning rate, number of estimators, and maximum tree depth. The model's performance was assessed using relevant assessment criteria, such as mean squared error or mean absolute error.

E. Django Compatibility

A Django project was established, together with the requisite Django apps, models, and views. The user interface for the labour allocation system was created and constructed, using forms and views to capture the essential input parameters such as State, District, Work type, Year, Month, and Gender. The trained XGBoost model was implemented into the Django app to forecast wages depending on user inputs.

F. Validation and Testing

The labour allocation system was thoroughly tested to guarantee its usefulness, correctness, and resilience. Test cases and scenarios were created to evaluate the accuracy of wage forecasts using various combinations of input parameters. The system's performance was evaluated against real-world data by comparing anticipated average pay to actual wages.

G. System Analysis

The testing and validation phase's data were analysed and interpreted. The pay projections' accuracy and reliability were evaluated using criteria such as mean squared error and mean absolute error. User comments and system reaction times were used to assess the system's usability, performance, and scalability.

V. RESULTS AND DISCUSSION

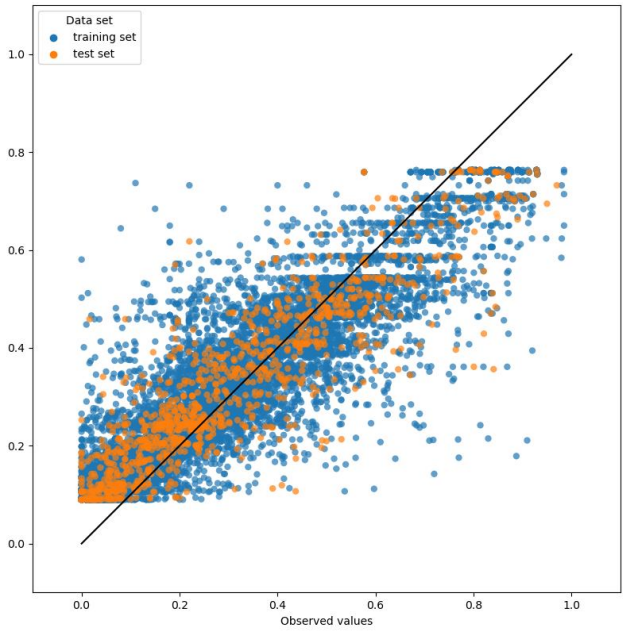
This project has developed an Efficient Workforce Planning with a Labour Allocation System for daily wage workers, which has achieved remarkable outcomes in enhancing the process of labour allocation and improving the accuracy of wage prediction for various kinds of daily wage work. The implementation of the project, using Django Python and the XGBoost algorithm, has demonstrated its effectiveness in facilitating workforce planning and decision-making processes for both work providers and workers.

A. Enhanced Labour Allocation Efficiency

The system has successfully increased the efficiency of labour allocation for daily wage workers. Work providers can easily create comprehensive profiles and post job opportunities, reaching a large pool of workers with diverse skill sets. This streamlined process enables prompt and effective matching of available workers with job requirements, minimising time gaps in filling vacancies and reducing idle time for workers.

B. Accurate Wage Prediction

The integration of the XGBoost algorithm for wage prediction has yielded highly accurate results. By analysing historical data and relevant parameters, including location, work type, and temporal factors, the system generates precise estimates of average wages for specific jobs. This information empowers workers to make informed decisions regarding job acceptance, considering the potential earnings. The accuracy of wage predictions contributes to equitable compensation and heightened job satisfaction among workers.



C. User-Friendly Interface

The web-based platform developed as part of this project offers a user-friendly interface, ensuring a seamless and intuitive user experience for both work providers and workers. The registration and profile creation process is straightforward, granting users swift access to the system's functionalities. Job posting and application procedures are streamlined, enhancing the efficiency of labour allocation while minimising administrative overhead.

D. Secure Payment Processing

A key emphasis of this project was on secure payment processing. The integrated payment system ensures a reliable and trustworthy mechanism for facilitating financial transactions between work providers and workers. This feature guarantees timely and accurate compensation for workers, cultivating trust and fostering positive relationships among stakeholders.

E. Scalability and Adaptability

The developed system has been meticulously designed with scalability and adaptability in mind. It can effortlessly accommodate a diverse range of daily wage occupations, enabling work providers to post job opportunities across various industries. Moreover, the system can be easily customised to incorporate additional parameters or enhance the accuracy of wage predictions as new data becomes available, ensuring its ongoing relevance and utility.

F. Potential Impact

Efficient Workforce Planning with a Labour Allocation System has the potential to exert a significant impact on the daily wage labour market. By optimising the labour allocation process, reducing information asymmetry, and providing accurate wage predictions, the system empowers work providers and workers to make well-informed decisions. This leads to improved job matching, heightened worker satisfaction, and increased overall productivity, thereby benefiting the broader economy.

In conclusion, the results obtained from this project demonstrate the effectiveness and value of the developed system in optimising workforce planning and labour allocation for daily wage workers. The integration of Django Python and the XGBoost algorithm, alongside a user-friendly interface and secure payment processing, has yielded a robust platform that enhances efficiency, transparency, and decision-making capabilities for all stakeholders involved. The project's outcomes possess the considerable potential to revolutionise the daily wage labour market, ultimately fostering a more productive and equitable labour ecosystem. These findings contribute to the advancement of workforce planning methodologies and offer significant implications for labour market optimization.

Algorithm	XGBoost	Random Forest	Logistic Regression	SVM
Interoperability	Moderate	Low	High	Low
Handling Missing Data	Yes	Yes	No	No
Feature Importance	Yes	Yes	No	No
Scalability	Excellent	Good	Good	Moderate
Model Training Speed	Fast	Moderate	Fast	Slow
Ensemble Learning	Yes	Yes	No	No
Handling Large Data	Yes	Yes	No	No
Robust to Outliers	No	Yes	Yes	Yes
Hyperparameter Tuning	Required	Required	Minimal	Moderate

VI. CONCLUSION

A labour allocation system can be a useful tool for efficiently planning and managing a workforce. It can help organisations match the right employees to the right tasks, optimise the use of available resources, and improve overall productivity.

A labour allocation system can be a valuable tool for improving the efficiency and productivity of a workforce. By matching the right employees to the right tasks and optimising the use of available resources, organisations can achieve significant benefits and drive business success.

Some key benefits of using a labour allocation system include improved efficiency, enhanced productivity, better resource utilisation, and improved communication and coordination. These benefits can help organisations save time and resources, and improve overall efficiency and effectiveness.

It is important to note that the success of a labour allocation system depends on its implementation and use within an organisation. It is crucial to carefully consider the specific needs and goals of the organisation and to select a labour allocation system that is tailored to these needs. Additionally, it is important to provide proper training and support to employees to ensure that they are able to effectively use the system and achieve the desired results.

VII. FUTURE SCOPE & IMPROVEMENTS.

Efficient workforce planning is a critical aspect of businesses that rely on daily-wage workers. The labour allocation system for daily wage workers is an excellent project that could be further enhanced by integrating AI and machine learning. The labour allocation system could become more efficient and accurate with the incorporation of AI and machine learning algorithms. The system could learn from past data and make better predictions about future labour requirements. It could also optimise labour allocation based on factors such as worker skills, availability, and performance. This could lead to cost savings and improved productivity. Another area of improvement for the labour allocation system is predictive analytics. The system could be improved by incorporating more advanced predictive analytics. For instance, the system could predict labour requirements based on historical data, upcoming events, and other factors. This could help managers to plan labour allocation more effectively and reduce the risk of over or under-allocation. Predictive analytics could also help managers to identify trends and patterns that could be used to improve the system over time.

In addition to AI and predictive analytics, incorporating additional data sources such as weather and traffic patterns could improve the system's accuracy. For example, if the system knows that there will be a significant traffic jam in a particular area, it could allocate more workers to that area to ensure that work is completed on time. Similarly, if the weather is expected to be particularly bad, the system could adjust labour allocation accordingly.

A mobile app could also be developed to allow workers to view their schedules, accept or decline work requests, and communicate with managers. This could improve worker engagement and make the labour allocation process more efficient. The app could also be used to collect data on worker performance and other metrics that could be used to improve the system over time. Finally, real-time monitoring capabilities could be incorporated into the system. For example, if a worker calls in sick, the system could automatically allocate a replacement worker to the job. This could reduce the risk of delays and ensure that work is completed on time. Real-time monitoring could also be used to track worker performance and identify areas for improvement. In conclusion, the labour allocation system for daily wage workers could be significantly enhanced by incorporating AI and predictive analytics, additional data sources, a mobile app, and real-time monitoring capabilities. These improvements could lead to cost savings, improved productivity, and better worker engagement. By embracing these technological advancements, businesses can optimise their labour allocation system, resulting in better outcomes for both workers and management.

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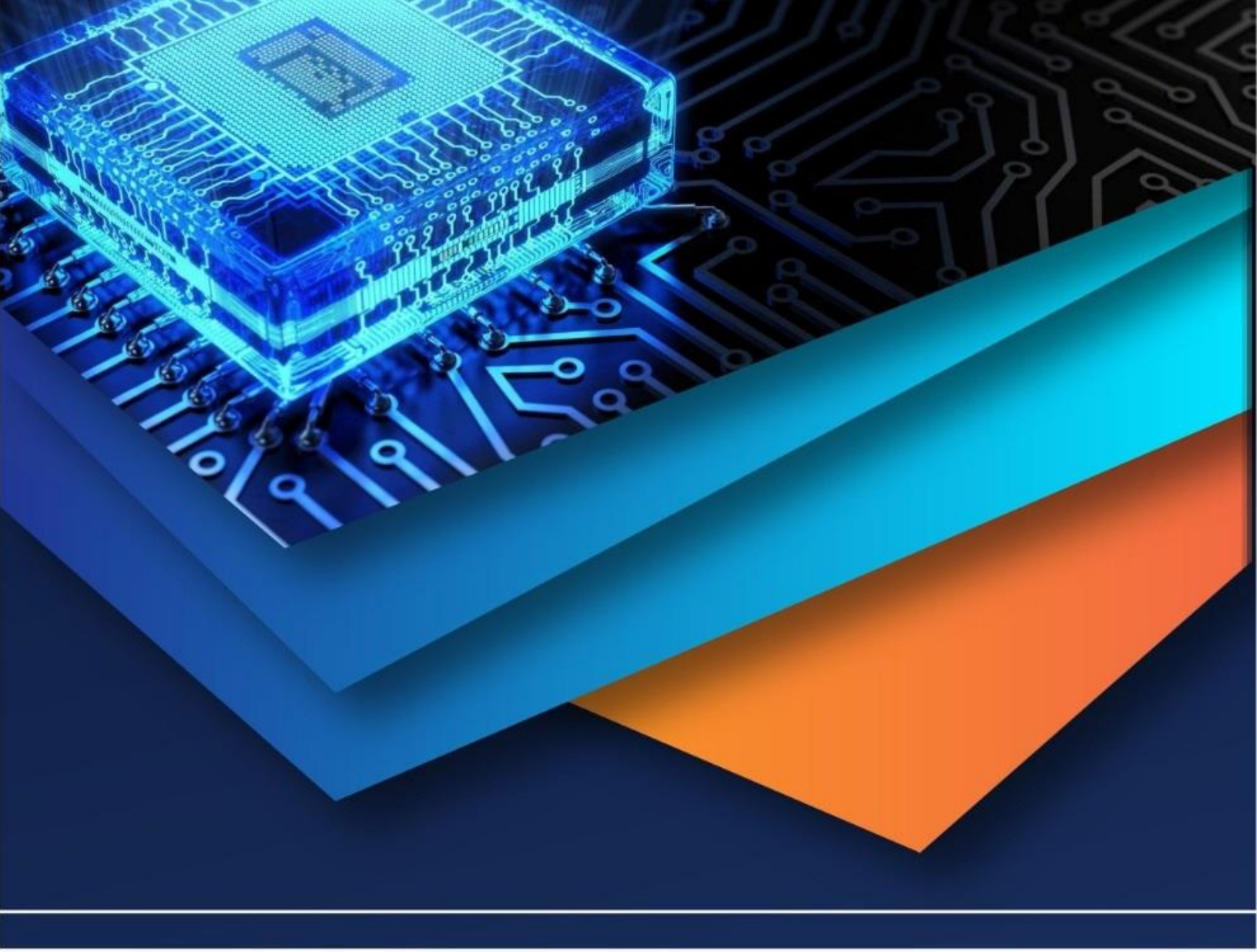

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