iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** IV **Month of publication:** April 2026

DOI: https://doi.org/10.22214/ijraset.2026.80432

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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 14 Issue IV Apr 2026- Available at www.ijraset.com

Personalized Career Path Recommendation Model for Information Technology Students

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Abstract: ***The ever-growing complexities of today's career markets leave most students confused while choosing a career. Conventional counselling methods usually depend on pre-conceived notions and ignore the actual state of affairs, both regarding the market and the student's overall profile. In this paper, we present an AI-powered website that uses machine learning algorithms to offer students data-backed advice about their careers. Using various parameters such as academic record, technical expertise, personal interest and aptitude, the system uses K-Means Clustering and Random Forest algorithm to offer predictions for the right career choices. Moreover, the system offers annual career guidance in light of the current market situation. An experiment yielded an accuracy rate of 91%.***

I. INTRODUCTION

In today's age of fast-paced technological development, students have to deal with what is known as the "paradox of choice," where they are provided with enormous amounts of information yet lack a systematic approach to harnessing it. Current systems give advice that is universal in nature based on grades alone, without taking into account technical expertise and personal characteristics.

The solution to such problems, proposed by our system, will consist of creating an environment, in which, besides predicting the career path, it will provide explanations for why a certain decision was suggested. The combination of intelligent analysis and action plan creation will lead us to turning career prediction into career development.

II. RELATED WORKS

M. Z. Hossain et al. [1] have suggested an AI-driven career guidance system that uses personality information for recommending appropriate careers to students. This model is centered around the correlation between personal qualities and career roles and provides accurate career suggestions. However, it is limited in its ability to consider the changing nature of skills since it uses personality data without accounting for changes over time.

The intelligent education recommendation system proposed by Biswal A. K. et al. [2] is an attempt to develop a system that improves the effectiveness of learning by making suitable recommendations. This intelligent system takes into consideration learner information as well as academic performance to recommend learning material as well as future career options.

Zhang Y. and Zhu S. [3] studied the use of edge intelligence for analyzing students in education systems. The research emphasizes the analysis of students' behavioral data and performance at the edge level. Although there is an emphasis on better response and scalability, it still proves to be difficult to implement in regular institutional settings.

Hanafi M. F. M. et al. [4] explored the application of data mining methods in counseling systems within academia. The suggested model examines past academic records to discover trends and anticipate the performance of students in the future. The results suggest that although it aids counselors in decision-making, it does not have an interface where students can explore their careers.

Kumar S. et al. [5] developed a career recommendation system based on rule and machine learning. It matches the inputs provided by the students, such as their educational achievements and interest, with the preset career categories. However, despite its effectiveness in minimizing uncertainty in career choices, the research emphasized the requirement of increased customization to meet industry demands.

A decision support system for education based on machine learning was introduced by Al-Mansoori A. et al. [6], which helps in making decisions for career planning. It evaluates performance patterns and behavioral trends to make predictions. However, their research results indicate higher levels of decision accuracy, but there is no roadmap defined for acquiring skills.

Patel R., Shah N. [7] proposed a personalized recommendation system that changes recommendations according to the profile of users. This approach enhances recommendation accuracy by concentrating on user-oriented personalization. Nevertheless, this research does not specialize in educational environments and does not offer any particular recommendations in the domain of career guidance.

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Chen L. et al. examined the utilization of data mining to develop a personalized profile for students by analyzing their academic and behavior data. This system applies clustering and classification approaches to cluster students based on common features. Despite its solid basis for personalized systems, it fails to recommend careers. The research paper written by Singh A. et al. [9] provides an approach to skill recommendation based on recognizing knowledge gaps in students. This paper recommends skills and resources useful for learning them according to current industry requirements. Unfortunately, the focus of this research paper is limited only to skills acquisition.

III. PROPOSED METHODOLOGY

A. System Architecture

Personalized Career Path Recommendation Model System Architecture is constructed on a multi-tier client server structure where the students, administrative staff, and machine learning algorithm elements are synchronized via an API server. This process starts with the interaction of the student with the web-enabled frontend, which involves the submission of an all-inclusive profile that consists of details like education, skills, interest areas, and capabilities. The information is then relayed through secure communication methods such as HTTP or HTTPS to the backend for processing. At the internal level, the machine learning component employs the K-Means clustering algorithm to categorize the user into a certain domain and random forest classification to determine the ideal professional position. The profiles of all users, skills databases, and generated career pathways are safely stored in a database level made up of MySQL and MongoDB.

B. Module Description

The Personalized Career-Path Recommendation Model is structured into the following functional modules to transform traditional career guidance into a data-driven, automated process:

1) User Authentication Module

This module acts as the main security system for the platform, making sure that only legitimate students gain access to their confidential information. The module employs an encrypted username/password combination along with email-based one-time passwords (OTPs) for the verification of the user. The verification of these users is critical to avoid fraud and ensure data confidentiality.

2) User Profiling & Data Collection Module

This module is designed to collect data points that make up a profile of a student. The data points collected include information about the academic performance of the students (CGPA, courses), technical skills, hobbies/interests of the individual, and aptitude. Additionally, users can opt for the uploading of their resumes, which will be parsed through NLP to detect technical skills and work experience. Recommendation Engine for Career (AI module) Being the intelligent engine of the system, this module uses complex machine learning techniques to forecast the optimal career options for users. This is done through the use of the K-Means technique of clustering, whereby similar users' profiles are clustered into various career domains. Afterward, the Random Forest classification method is used to recommend the best career options and probabilities of success.

3) Skill Readiness Analyzer Module

The Skill Readiness Analyzer measures the readiness of a student to enter into his or her chosen profession through matching the skills already possessed with those of an actual industry. The tool determines the readiness percentage and specifies the skills gaps as well as skills strengths. Through this, it provides the rationale for recommending certain pathways to the student.

4) Career Roadmap Generator Module

The module is able to provide SMS or Email (OTP) alert to multiple users for logging into the system. Another application is providing alerts to ambulance drivers on patient location information. The module is also helpful to patients for receiving emails regarding ambulance booking confirmation.

5) Job Opportunities Integration Module

To connect education to employment opportunities, this module extracts real-time job-oriented information from publicly available databases and APIs. The module shows the user job vacancies, current trends in employment, and necessary requirements for each position on their dashboard. This module helps connect students' profiles to industry demand, adding value to their employability prospects.

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6) Real-Time Integration Module

The Real-Time Integration Module forms the core of the entire system, as it integrates all parts of the system, from frontend user interface, backend APIs, to machine learning algorithms, to one central server. The module enables the system to keep up-to-date on the current status of the user in real time and gives a feeling of synchronization in the entire dashboard.

7) Admin & System Management Module

The Admin panel gives control to the administrator that helps him/her control the career domains, update skills required, and also fine-tune the data set used to train AI models. The administrator can analyze the performance of the system, manage user profiles, and analyze overall statistics in order to keep the system up-to-date with the latest developments.

On the whole, the system will be developed as a way to eliminate any need for manual guidance in favor of using technology. This is to be deployed using cloud-based systems such as Render to ensure efficiency during periods of high traffic.

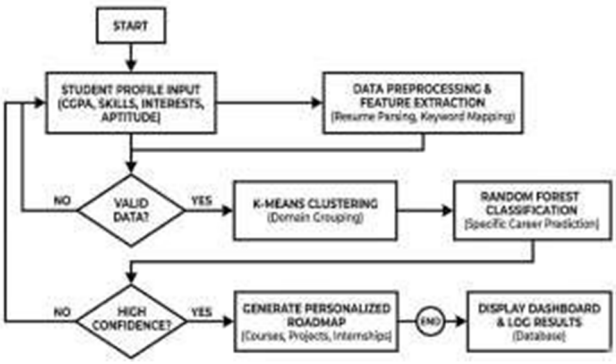


Figure 1.Module Flow

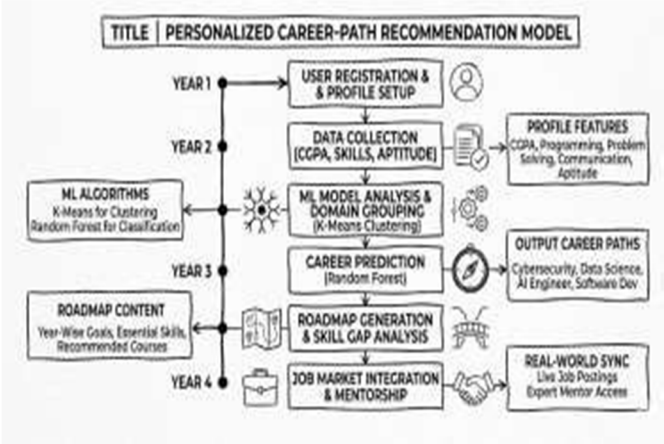


Fig 2 Architecture diagram

IV. IMPLEMENTATION

A. System Implementation and Operational Workflow

The Personalized Career Path Recommendation Model is designed in a systematic and coordinated manner, helping students make better decisions related to their career life and hence diminishing the uncertainty involved in this process. The difference between this approach and conventional career counseling approaches lies in the fact that this model transforms the entire counseling process into a digital process, whereby all processes starting from profiling to creating a career path recommendation are documented and managed through the use of servers..

Such an implementation will lead to highly accurate, dependable, and precise solutions for all parties involved. With the inclusion of machine-learning based forecasts, automated skill-gap analyses, and role-based interactive dashboards, all users, students, academic counselors, and institutional administrators will be constantly updated about the user's performance at all times. The entire process of implementation is meant to link academic success to employment opportunities in today's digital age.

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Additionally, the system is designed with scalability, adaptability, and real-time responsiveness in mind, ensuring that it can handle a large number of users while continuously improving its recommendations. By integrating dynamic data sources such as evolving industry requirements, job market trends, and user feedback, the model remains up-to-date and relevant. The modular architecture of the system allows easy integration of new features, such as advanced analytics, personalized learning pathways, and internship or job matching modules. This not only enhances the overall efficiency of the platform but also ensures that students receive holistic guidance, bridging the gap between academic learning and practical career opportunities.

1) Step 1: User Profiling and Data Collection

The whole process commences once the student is registered on the AI-driven website seeking career advice. The algorithm starts off by generating a profiling framework, where the student's academic performance (CGPA, courses education), technical capabilities, areas of interest, and aptitude are all collected. The comprehensive approach guarantees that the suggestions generated are based on a more holistic assessment of the individual instead of mere grades.

Profiling Logic :

- START
- Receive registration request and capture academic metadata
- Retrieve technical skill ratings and aptitude responses
- Calculate initial profile completeness
- STOP

2) Step 2: Resume Processing and NLP Analysis

Once the information about the profile is provided, the application gives the choice to students to upload their resumes for further processing. The backend of the algorithm uses NLP to process the resume texts, extract technical skills, certifications, and projects listed. This process is efficient in avoiding any mistakes during data entry and allows the model to include relevant terms used in the industry. Additionally, the NLP module performs keyword extraction to accurately identify skills and relevant terms from the resume. This ensures better data consistency and improves the accuracy of career recommendations.

3) Step 3: Domain Clustering and Predictive Modeling

After the profiling process, the program then calls up the basic AI components. The first step involves using K-Means Clustering, which places the learner within a cluster based on their specific field (Software Development or Data Science).

Following that, the program uses the Random Forest Classification algorithm to determine the learner's ideal occupation, along with a readiness score.

Synchronization Flow:

- START
- WHILE profile status != "Analyzed"
- Fetches current user feature vectors and updates the preprocessing layer
- Estimates career suitability using the Random Forest classifier
- END WHILE

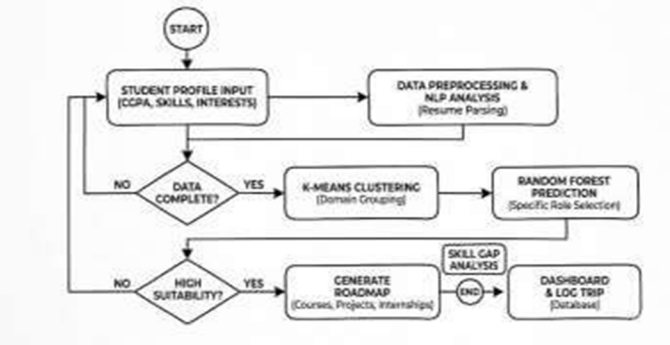


Fig 3.Real Time Tracking Synchronization

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4) Step 4: Analysis of Skill Gaps and Assessment of Readiness

Following the identification of the future career pathway, the system activates the Skill Readiness Analyzer to determine how ready a student is for such a position.

This is accomplished through the comparison of the skills possessed by a student with benchmark skills within the targeted field. Scores for readiness and skill gaps are determined accordingly. This process guarantees that students are provided with recommendations that address their weaknesses..

5) Step 5: Dynamic Roadmap Generation

On identifying the career match and gaps in skills, the system suggests an individualized career path that is organized based on years. The tool takes into account the current level in academics, the duration of courses, and the time left for learning. These include:

- Recommended technical skills to acquire.
- Relevant online courses and professional certifications.
- Specific projects and internships to be undertaken.
- A timeline for placement preparation and resume building.

6) Step 6: Notification and Dashboard Synchronization

The system makes use of a Real-Time Integration Module to maintain synchronization in all the dashboards, including the career match dashboard and analytics dashboard of the student. Rather than performing laborious tasks of updating, the system makes use of RESTful API communication to send instantaneous notifications about roadmap changes, job offers, and ways to improve skills. Moreover, users are offered a career copilot which works as an AI mentor for the user.

Synchronization Flow:

- START
- Detects event(change in student profile)
- Updates the central server
- Updates the dashboards
- Event stored in database

7) Step 7: Centralized Data Logging and Management

All information related to career counseling sessions and interaction with users is stored in a centralized database layer. The process ensures complete accountability and also helps in analyzing future performances. The stored information includes:

- Request timestamps and user profile history.
- Machine learning prediction logs and readiness scores.
- Skill gap analysis results.
- Roadmap milestones and progress tracking data.
- System activity and authentication logs.

8) Step 8: Deployment and Scalability

The solution can also be implemented in the cloud computing environment, which might comprise of services like Render and AWS, amongst others. The rationale behind implementing such a solution strategy is to guarantee that the web application is able to cope with the growing traffic due to the growing number of students.

B. Overall Implementation Perspective

Personalized Career Pathway Recommendation System forms an excellent, coherent, and integrated ecosystem of learning and planning modules utilizing both supervised and unsupervised machine learning methods. The adoption of such technology-based systems for career counseling has made the process less stressful for the students due to its seamless nature. All modules are integrated and work together towards ensuring that the advice is practical and meets the demands of the industries.

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V. RESULTS AND ANALYSIS

The Personalized Career Path Recommendation System was assessed comprehensively for its suitability in recommending effective career paths and proper professional development planning. The main assessment criteria involved the accuracy of predictions, processing speed, the efficiency of reducing the skills gap, and scalability at peak usage periods.

In contrast to the rule-based and machine learning approaches, the suggested model will be assessed using three key criteria for evaluating its performance: accuracy of prediction, processing time, and effectiveness of skill gap reduction. Accuracy-based comparison of the two methods is illustrated in Table 1

Table 1. Comparison based on Accuracy Metrics

System	Accuracy (%)
Rule-Based System	68
Basic ML Model	79
Proposed System	91

The accuracy that the suggested AI based Career Path Recommendation System will be able to attain is close to 91 percent; whereas the accuracy level attained by using a basic machine learning technique will be near to 79 percent; while the rule-based approach will get an accuracy rate of just 68 percent.

The accuracy can be calculated using the formula: Accuracy = \frac{TP + TN}{TP + TN + FP + FN}

Where TP represents correctly predicted career paths, TN represents correctly rejected domains, FP represents incorrect recommendations, and FN represents missed suitable domains.

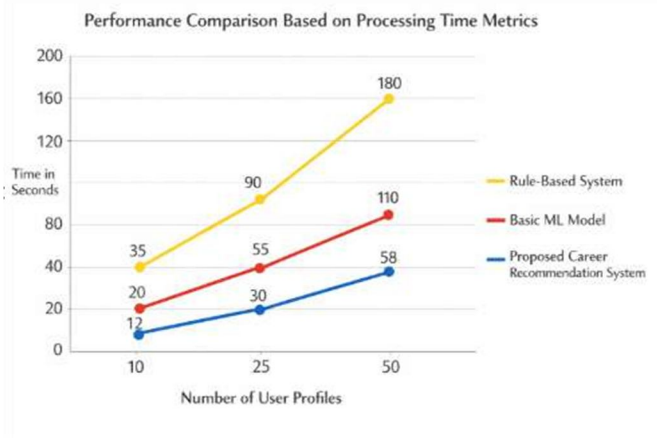


Fig. 6. Performance comparison based on accuracy metrics

The proposed system when compared with the rule-based and basic ML approaches based on processing time as a performance criterion is analyzed in Table 2.

Table 2. Comparison based on Processing Time Metrics

Number of User Profiles	Proposed System (sec)	Basic ML (sec)	Rule-Based (sec)
10 Profiles	12	20	35
25 Profiles	30	55	90
50 Profiles	58	110	180

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Time taken for evaluation of recommendations generation for 10 user profiles is 12 seconds and 58 seconds for 50 user profiles using the suggested system, while the time taken by the basic ML algorithm and the rule-based system is much more. The time saved in the evaluation process using the proposed system is about 45 percent and 68 percent, respectively.

Processing efficiency is enhanced due to the use of clustering, which narrows the search space and performs classification based on domain groups instead of evaluating all career categories.

Skill Gap Reduction Efficiency is the third evaluation metric examined, which quantifies how efficiently the system discovers skill gaps and generates roadmaps to reduce the gap.

Table 3. Comparison based on Skill Gap Reduction Metrics

System	Average Skill Gap Reduction (%)
Rule-Based System	22
Basic ML Model	31
Proposed System	40

The skill gap reduction achieved by the proposed model is close to 40% on an average basis after implementing the roadmap in a simulation environment. The rule-based model and the basic machine learning model have shown significantly lower reductions compared to the proposed model.

This improvement is made possible by the implementation of a system that involves the analysis of resumes, skill comparison, and roadmap generation based on timelines rather than making static recommendations.

Skill\ Gap\ Reduction\% = \frac{Initial\ Skill\ Gap - Remaining\ Skill\ Gap}{Initial\ Skill\ Gap} \times 100

The better performance of the proposed system can be attributed to the fact that the implementation involved a combination of different analysis tools such as clustering, probabilistic classification, extraction of features from resumes, and roadmap generation. As compared to rule-based and standard machine learning systems, the proposed system makes recommendations after going through several stages of analysis.

VI. CONCLUSION AND FUTURE WORK

In the proposed AI-Based Career Path Recommendation System, the system efficiently suggests career paths based on academic results, technical skills, preferences, aptitude test responses, and resume review. It is important to note that not only does this system help determine the right career domains by applying clustering and classification techniques, but it also provides structured career paths that will enable the student to realize their career dreams. By combining skill-gap assessment and market fit, the recommendations provided are realistic and relevant to the industry, hence fulfilling the true objective of career counseling. The K-means clustering algorithm and random forest classification algorithm used in the recommended career path system complement each other very well and offer supplementary functionalities like readiness scores, personalized dashboards, and career path timelines. Therefore, the AI-based career path recommendation system provides a reliable and intelligent solution for students, which eliminates the need for generic advice and enables them to make informed career choices. Future improvements on the AI Based Career Path Recommendation System include the integration of APIs for real-time updates on new technology and trends in job markets. Other features may involve personality assessment, adaptive feedback loops, and deep learning algorithms. The system may also be enhanced through mentoring services, mobile applications, and scalable cloud hosting services to ensure user convenience

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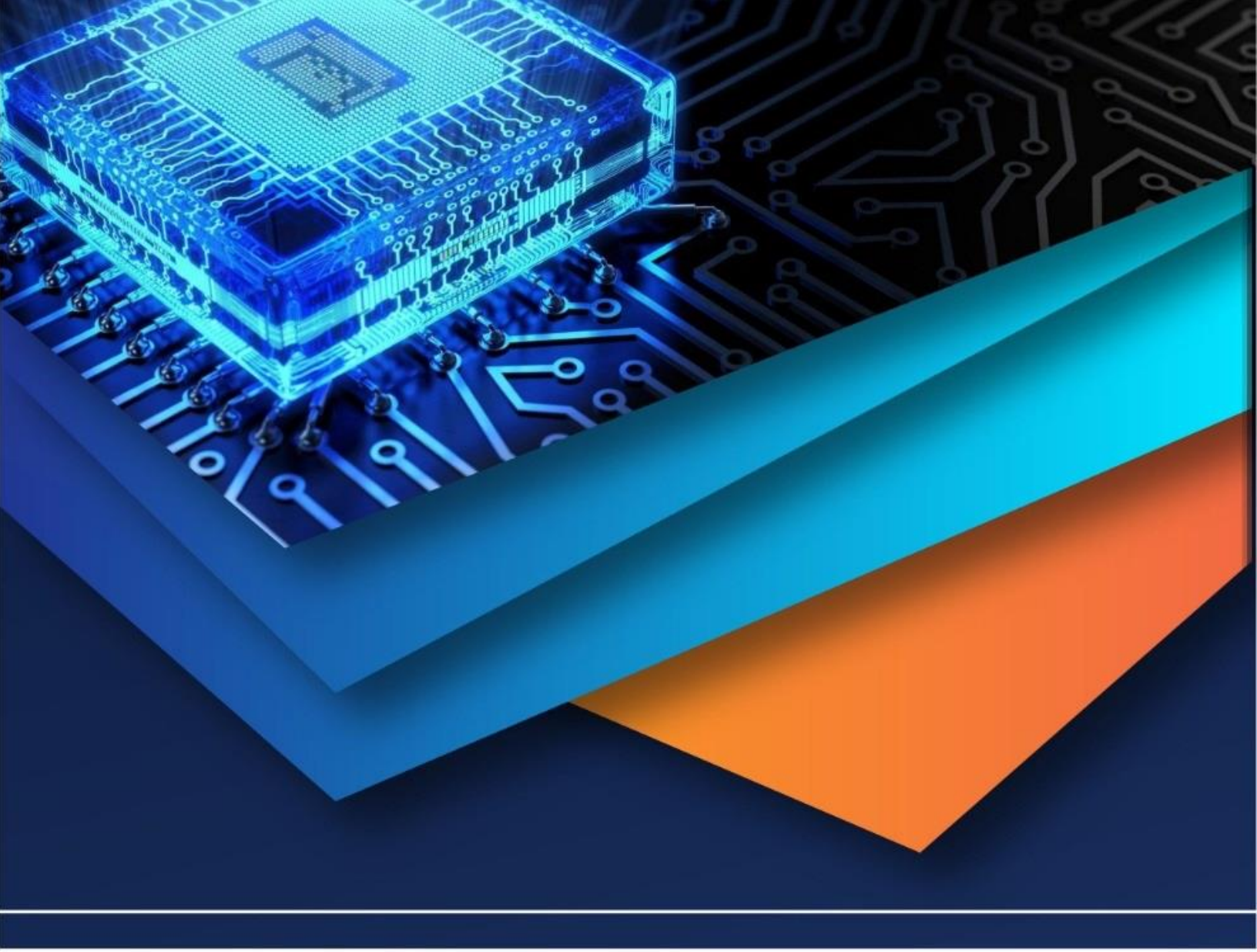
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