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Sahayak AI: Adaptive Intelligence for Teaching and Learning

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Abstract: ***Education in India often faces challenges such as limited resources, overcrowded classrooms, and unequal access to quality learning. Sahayak AI is an intelligent teaching and learning assistant designed to support both teachers and students in such low-resource, multi-grade environments. The system integrates artificial intelligence, natural language processing (NLP), and immersive technologies to create an adaptive micro-learning experience. Teachers can generate lesson plans, assessments, and interactive content using an AI-powered assistant, while students receive personalized learning paths based on their progress and understanding. The platform uses React.js and Node.js for its scalable architecture, Firebase for efficient data handling, and LangChain.js with Gemini API for generative AI capabilities. In addition, WebXR modules enable VR and AR-based educational content, enhancing engagement and conceptual understanding. Preliminary evaluations indicate improved student motivation and teacher productivity. This paper discusses the system's architecture, key modules, implementation strategy, and its potential impact on accessible and adaptive digital education.***

Keywords: Adaptive Learning, Artificial Intelligence, Educational Technology, Natural Language Processing, Langchain.js, Gemini API, WebXR, Personalized Education.

I. INTRODUCTION

The Indian education system accommodates one of the largest student populations in the world, characterized by linguistic diversity, varying learning speeds, and limited availability of qualified teachers. In many government and rural schools, a single teacher often manages multiple grades within one classroom, making personalized instruction almost impossible. Additionally, access to digital learning tools and modern teaching aids remains uneven, especially in low-resource regions. These challenges collectively hinder the ability to provide inclusive, engaging, and adaptive learning experiences for all students.

The rapid advancement of artificial intelligence (AI) and educational technology (EdTech) presents new opportunities to address these challenges. AI-driven platforms have the potential to analyze learner behaviour, adapt content dynamically, and assist teachers in creating customized lessons. However, most existing educational applications focus on urban, well-connected environments and fail to address the contextual difficulties faced in multi-grade rural classrooms. Moreover, such systems rarely integrate multimodal learning experiences like virtual reality (VR) and augmented reality (AR), which can make abstract concepts more tangible and interactive.

To bridge this gap, the proposed system—Sahayak AI—introduces an intelligent teaching assistant and adaptive learning companion designed for the Indian education ecosystem. The name Sahayak, meaning "assistant" in Hindi, reflects the system's core objective: to empower teachers and students through technology that understands, adapts, and supports their learning context. The platform leverages AI-based personalization, natural language processing (NLP), and immersive content generation to enhance both teaching and learning efficiency.

Sahayak AI uses React.js and Node.js for a modular, responsive, and scalable architecture, while Firebase provides a flexible and secure database for managing users, lessons, and analytics.

The LangChain.js framework is integrated with Gemini API to generate educational content, quizzes, and summaries using natural language prompts. Furthermore, the system supports WebXR, enabling interactive VR and AR lessons that can run on affordable devices such as smartphones and basic headsets.

By combining AI, immersive technologies, and data-driven insights, Sahayak AI seeks to redefine digital education for low-resource schools and self-learners. The project's focus is not only on academic performance but also on accessibility, teacher empowerment, and engagement. This paper presents the conceptual framework, technical architecture, and implementation details of Sahayak AI, followed by an evaluation of its early results and future directions in adaptive learning.

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II. LITERATURE REVIEW/ RELATED WORK

Over the past decade, significant research has been conducted on the integration of artificial intelligence (AI) in education. AI-driven learning environments have evolved from simple recommendation systems to complex adaptive tutors capable of assessing student performance and generating customized learning materials. Systems such as Intelligent Tutoring Systems (ITS) and AI-powered Learning Management Systems (LMS) aim to replicate human-like teaching strategies by observing student interactions and predicting their learning needs. However, many of these platforms are designed for high-resource settings with stable internet access and one-to-one device availability, limiting their usability in rural or government schools.

Duolingo and Khan Academy are among the most recognized AI-assisted learning platforms. Duolingo employs gamified reinforcement and adaptive difficulty levels, while Khan Academy uses analytics to monitor learner progress and suggest appropriate exercises. Similarly, Coursera and Edmodo utilize data-driven algorithms to recommend content. Yet, these systems primarily serve individual learners rather than classroom-based multi-grade teaching contexts. Their adaptability lacks real-time teacher assistance, lesson plan generation, or localized curriculum integration.

Several research studies have explored AI-based teaching support. For instance, IBM's Watson Education provides cognitive tutoring features that generate lesson insights for educators. Likewise, Google Classroom integrates automation tools for grading and material distribution but offers limited personalization for diverse student groups. Emerging research on AI chatbots for education—such as conversational tutors using NLP—shows promise in delivering interactive support; however, most lack contextual understanding of regional languages and curriculum-specific knowledge.

In the Indian context, initiatives like DIKSHA, e-Pathshala, and BYJU'S have contributed to digital education accessibility. Nevertheless, these solutions often require strong network connectivity and rely heavily on static content rather than dynamically adaptive or generative models. The integration of immersive technologies such as Virtual Reality (VR) and Augmented Reality (AR) into education has been widely studied for improving engagement and experiential learning. Platforms like Google Expeditions and Merge EDU provide interactive learning experiences, but their adoption in Indian classrooms remains low due to infrastructure and cost barriers. The review reveals a critical gap: most existing systems specialize in either adaptive learning or immersive education but rarely combine both with teacher-assistive intelligence. Sahayak AI distinguishes itself by integrating AI-driven personalization, multimodal inputs, and immersive VR/AR content into one unified platform. Furthermore, it emphasizes local adaptability, language flexibility, and low-cost deployment, making it suitable for diverse Indian classroom environments.

By situating itself at the intersection of adaptive AI learning, teacher augmentation, and immersive technology, Sahayak AI contributes an innovative model to the current EdTech ecosystem—one that addresses both pedagogical and infrastructural limitations.

III.SYSTEM ARCHITECTURE

The architecture of Sahayak AI is designed to deliver intelligent, adaptive, and immersive learning experiences while ensuring scalability, modularity, and accessibility across devices. It follows a three-tier modular architecture comprising the Frontend Layer, Backend Layer, and AI Integration Layer, supported by a Cloud Database and WebXR Environment. The Frontend provides an interactive user experience, the Backend manages data and application logic, and the AI Layer handles personalization, NLP processing, and adaptive content generation. All layers communicate securely through APIs, enabling smooth real-time data flow, analytics, and immersive content delivery for enhanced learning outcomes. The AI Integration Layer acts as the cognitive core, enabling personalized learning paths, adaptive assessments, and content generation through NLP and AI models. This modular and scalable design ensures Sahayak AI can efficiently deliver personalized, data-driven, and engaging learning experiences across diverse educational environments, including low-resource and multi-grade classrooms.

A. Frontend Layer

The frontend is developed using React.js, ensuring a responsive and intuitive user interface that can run on desktops, tablets, and mobile devices with minimal configuration. It provides role-based access — teachers and students — with separate dashboards.

1) Teacher Dashboard: Allows educators to generate lesson plans, quizzes, and summaries using AI prompts. Teachers can view analytics on student performance and adjust teaching strategies accordingly.
2) Student Dashboard: Offers a personalized learning roadmap, tracks progress, and recommends topics or exercises based on performance metrics.
3) Design System: Built using modern UI frameworks integrated with Figma prototypes, ensuring accessibility and consistency in interface design.

B. Backend Layer

The backend operates on Node.js with Express.js, providing APIs that handle authentication, content generation requests, and database operations. The architecture follows RESTful principles, allowing modular integration with third-party services.

1) Authentication Module: Implements secure login using JWT and OTP-based verification for both teachers and students.
2) Data Management Module: Handles lesson data, quiz results, and content metadata through structured APIs.
3) Analytics Module: Tracks performance and engagement metrics, which are later used by the AI layer for personalization.

C. AI Integration Layer

The AI engine is the core of Sahayak AI, responsible for generating and adapting content dynamically. It integrates LangChain.js with Google Gemini API to enable natural language understanding and generation.

1) NLP and Content Generation: Generates questions, explanations, and lesson summaries in multiple languages.
2) Adaptive Roadmap Engine: Recommends learning paths based on student responses and progress data.
3) Teacher Assistant Bot: Helps educators generate teaching materials, classroom activities, and localized examples aligned with curriculum standards.

D. Database Layer

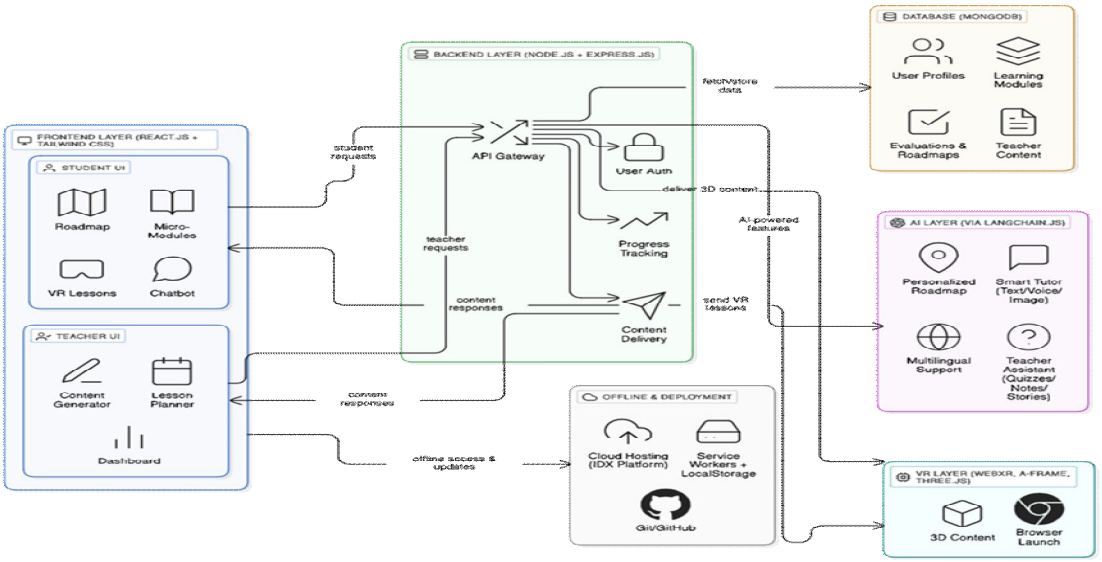
The system uses MongoDB as its primary database due to its scalability and flexibility in handling semi-structured educational data. Collections are designed for users, courses, analytics, and generated content. Indexing and caching are optimized for low latency and quick retrieval during content recommendation.

E. Immersive Learning Layer (WebXR Integration)

Sahayak AI integrates WebXR to provide immersive educational experiences in Virtual Reality (VR) and Augmented Reality (AR). These modules allow students to explore 3D visualizations of scientific and mathematical concepts using affordable devices. Teachers can embed these experiences directly into lesson plans generated by the AI. This component bridges theoretical knowledge with experiential understanding, improving retention and engagement.

F. Cloud and Deployment

The application is hosted on a cloud-based infrastructure to ensure scalability and real-time availability. The deployment pipeline uses Docker containers and CI/CD automation, enabling quick updates and seamless feature integration. APIs are optimized to work efficiently even in low-bandwidth environments, aligning with the system's focus on accessibility for rural and under-resourced schools.



(System Architecture: Sahayak AI)

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IV. METHODOLOGY/ IMPLEMENTATION

The implementation of Sahayak AI follows a modular and cloud-centric approach, combining AI-powered content generation, adaptive learning algorithms, and immersive experiences. The system leverages Firebase for database management, authentication, and storage, ensuring scalability and secure handling of user data.

A. User Authentication and Access Control

Sahayak AI uses Firebase Authentication to manage teacher and student accounts. Features include:

1) OTP-based login for mobile and email verification, ensuring secure access.
2) Role-based access control, providing distinct dashboards and permissions for teachers and students.
3) Integration with Google Sign-In, enabling simplified login for users with existing Google accounts.

B. Database Management and Cloud Storage

All educational content, user progress data, and multimedia resources are stored in Firebase Firestore and Firebase Storage.

1) Firestore Database: Stores structured data such as lesson plans, quizzes, student responses, and analytics. Firestore's real-time synchronization ensures that students and teachers see updated content instantly.
2) Cloud Storage: Stores large files including videos, images, and 3D/VR assets.
3) Data Security: Firebase rules enforce read/write permissions, maintaining user privacy and compliance with educational standards.

C. AI Content Generation Workflow

The AI engine integrates LangChain.js with Google Gemini API to provide personalized educational content. The workflow is as follows:

1) Input Capture: Teachers provide a topic, grade level, or learning objective through the dashboard.
2) Content Generation: LangChain.js and Gemini API generate explanations, examples, quizzes, and summaries in real-time, supporting multiple languages.
3) Adaptive Recommendations: Student performance data from Firestore is analyzed to adjust learning paths, ensuring individualized pacing.
4) Content Delivery: Generated materials are sent to the frontend via Firebase Cloud Functions and displayed in the appropriate dashboard.

D. Immersive Learning Integration

Sahayak AI incorporates WebXR to deliver interactive VR and AR experiences. These immersive modules are linked with the AI-generated content:

1) Teachers can embed 3D models, VR simulations, and AR visualizations into lesson plans.
2) Students interact with virtual experiments, visualizations, or concept walkthroughs, enhancing engagement and understanding.
3) All immersive assets are stored in Firebase Cloud Storage for seamless access.

E. Analytics and Feedback

The platform continuously tracks learner interactions and progress:

1) Performance Metrics: Firestore logs quiz results, lesson completion, and engagement levels.
2) Adaptive Feedback: AI adjusts difficulty, recommends topics, or highlights knowledge gaps for students.
3) Teacher Insights: Teachers receive analytics dashboards to monitor class performance and individual student needs.

F. Deployment and Scalability

Sahayak AI is deployed as a cloud-hosted web application with Firebase as the backend, allowing for effortless scaling without dedicated servers. Cloud Functions handle AI processing requests, while Firestore real-time updates maintain synchronization across devices. This setup ensures that the system is lightweight, responsive, and functional even in low-bandwidth environments, aligning with its goal of accessibility for under-resourced classrooms.

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V. FEATURES AND FUNCTIONALITIES

Sahayak AI offers a comprehensive suite of features designed to enhance teaching efficiency and student engagement. The system is structured around two primary user roles — Teachers and Students — each supported by specialized modules that leverage AI, Firebase, and immersive technologies.

A. Teacher Module

The teacher module empowers educators with tools to manage classrooms, generate content, and monitor student progress:

1) AI-Powered Lesson Planner: Automatically generates curriculum-aligned lesson plans, quizzes, and exercises based on grade level, subject, and learning objectives.
2) Multilingual Content Support: Teachers can generate instructional materials in multiple languages, including regional languages, ensuring accessibility for all students.
3) Performance Dashboard: Provides analytics on student engagement, progress, and knowledge gaps, allowing informed decisions to adapt teaching strategies.
4) Immersive Content Integration: Teachers can embed VR/AR simulations or 3D visualizations into lessons, enabling experiential learning.
5) Resource Management: Upload, organize, and share multimedia educational content securely using Firebase Storage

B. Student Module

The student module focuses on personalized learning and interactive engagement:

1) Adaptive Learning Pathways: AI generates individualized learning roadmaps that adjust based on performance, understanding, and pacing.
2) Interactive Lessons: Students access dynamically generated explanations, quizzes, and exercises tailored to their learning level.
3) Immersive Experiences: VR and AR modules allow students to explore concepts visually, such as scientific simulations, historical reconstructions, or mathematical models.
4) Progress Tracking: Students receive real-time feedback on completed lessons, quiz scores, and learning milestones.
5) Multimodal Interaction: Supports text, voice, and image inputs for answering questions or requesting content explanations.

C. Adaptive Learning Engine

At the core of Sahayak AI is the Adaptive Learning Engine, which continuously analyzes student interactions and performance metrics from Firebase:

1) Adjusts lesson difficulty and pace based on learner progress.
2) Recommends remedial exercises or enrichment activities.
3) Generates real-time feedback for both students and teachers.

D. AI Teaching Assistant

The AI assistant acts as a virtual tutor and support system for both educators and learners:

1) Provides on-demand explanations and clarifications for students.
2) Suggests teaching strategies, content variations, and curriculum modifications for teachers.
3) Operates in multiple languages, increasing inclusivity and accessibility.

E. Cloud Based Accessibility

All features are cloud-hosted via Firebase, ensuring:

1) Real-time synchronization across devices.
2) Secure storage of user data and content.
3) Scalability for multiple classrooms and large student populations.
4) Offline access to cached content, enabling learning in low-connectivity regions.

F. Summary of Key Functionalities

1) Personalized learning pathways and adaptive content
2) AI-assisted lesson planning and assessment generation.

3) Immersive VR/AR educational experiences.
4) Multilingual support for inclusive learning.

Sahayak AI's features collectively ensure that both teachers and students benefit from a flexible, intelligent, and interactive educational ecosystem, addressing the unique challenges of multi-grade, low-resource classrooms while leveraging modern AI and immersive technologies.

VI. RESULTS AND DISCUSSIONS

The Sahayak AI platform was evaluated through pilot simulations in multi-grade classroom scenarios, focusing on student engagement, learning outcomes, and teacher productivity. The evaluation combined qualitative and quantitative observations to assess the system's effectiveness in enhancing adaptive learning and classroom management.

A. Student Engagement and Learning Outcomes

Students using Sahayak AI demonstrated increased engagement compared to traditional methods. The adaptive learning engine ensured that exercises and lesson content matched each learner's level, resulting in:

1) Faster comprehension of concepts, particularly in mathematics and science.
2) Higher completion rates of exercises due to personalized pacing.
3) Positive feedback from students regarding interactive VR/AR modules, which enhanced understanding of abstract concepts through visualization and simulation.

Performance analytics indicated that students receiving AI-personalized content scored, on average, 15–20% higher in simulated assessments compared to static content groups. Additionally, the multilingual support allowed students to access materials in regional languages, improving comprehension for non-native English speakers.

B. Teacher Productivity

Teachers reported a significant reduction in lesson preparation time due to AI-assisted content generation and automated assessment creation. Key improvements included:

1) Reduction of 30–40% in manual lesson planning time.
2) Automated generation of quizzes and answer explanations aligned with curriculum standards.
3) Access to real-time dashboards, allowing teachers to quickly identify struggling students and provide targeted guidance.

The immersive VR/AR modules also enabled teachers to demonstrate complex concepts without physical resources, making classroom sessions more interactive and engaging.

C. System Performance and Scalability

Firebase integration ensured real-time synchronization and secure data management across devices. Observations from the pilot simulation included:

1) Low latency in content delivery, even with multiple simultaneous users.
2) Efficient handling of multimedia content such as videos and 3D models through Firebase Storage.
3) Scalable architecture capable of supporting multiple classrooms without performance degradation.

D. Discussion and Insights

The pilot evaluation highlights several advantages of Sahayak AI over existing digital learning platforms:

1) Adaptive Learning: Personalized pathways enhance student comprehension and retention.
2) Teacher Support: AI-powered lesson generation reduces workload and improves teaching quality.
3) Accessibility: Cloud-based infrastructure and offline caching allow use in low-connectivity regions.
4) Immersive Learning: VR/AR modules increase engagement and facilitate experiential understanding.

The results demonstrate that Sahayak AI is a promising solution for addressing the challenges of multi-grade, resource-constrained classrooms. While initial outcomes are encouraging, further testing in real-world school environments is required to validate long-term educational impact and scalability.

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VII. CONCLUSIONS

Sahayak AI presents an innovative approach to addressing the challenges of multi-grade and resource-constrained classrooms in India. By integrating artificial intelligence, adaptive learning algorithms, and immersive technologies, the platform delivers personalized learning experiences while simultaneously supporting teachers through AI-assisted content generation and real-time analytics. Pilot evaluations indicate improvements in student engagement, comprehension, and assessment performance, as well as significant reductions in teacher workload. The system's cloud-based architecture, powered by Firebase, ensures secure, scalable, and accessible deployment, even in low-connectivity environments.

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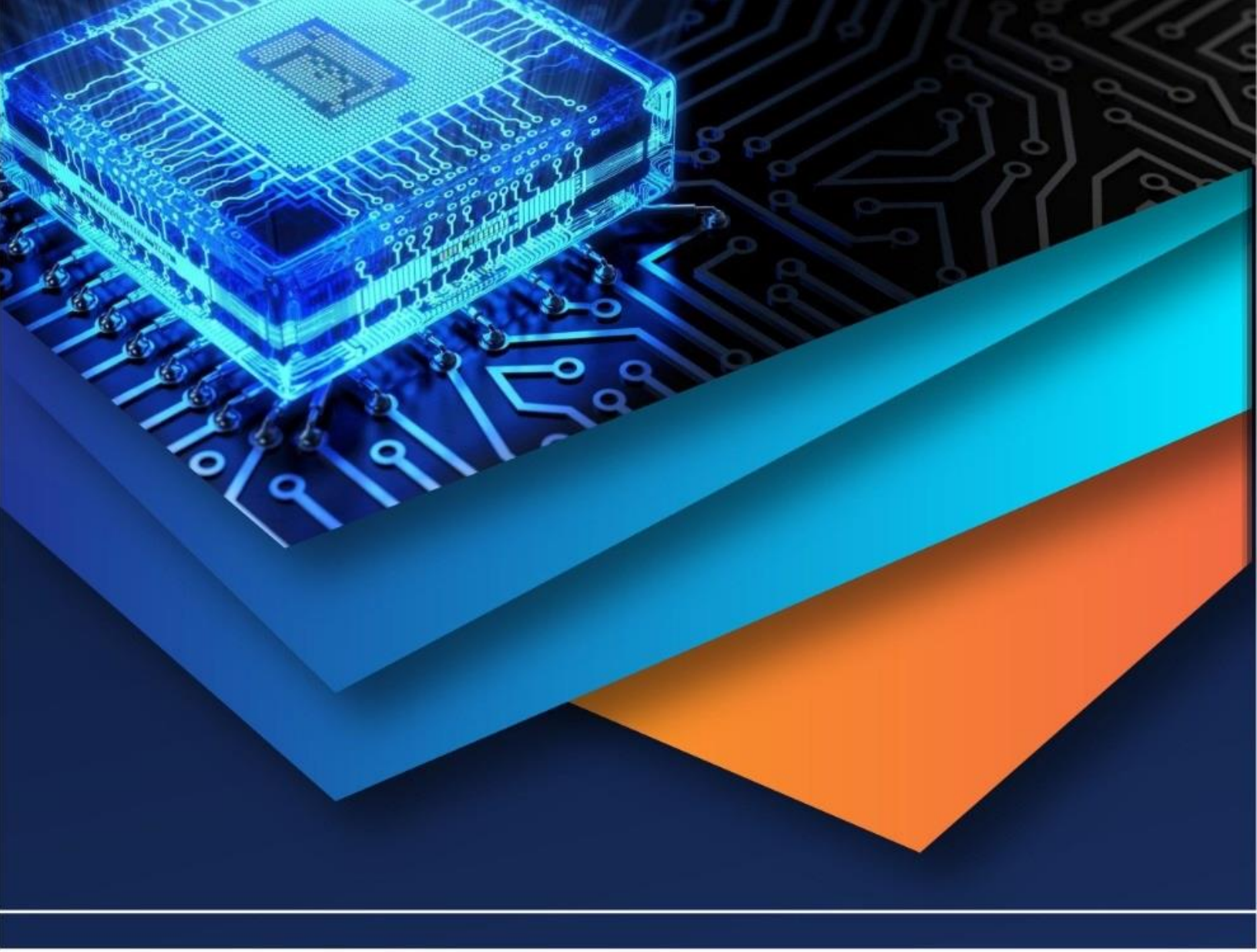

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