iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** X **Month of publication:** October 2023

DOI: https://doi.org/10.22214/ijraset.2023.56127

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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 X Oct 2023- Available at www.ijraset.com

Coimbatore Institute of Technology Campus Navigation System (Version 1.0)

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Abstract: ***A campus navigation system is a technology-driven solution designed to assist individuals in navigating through a complex campus environment, such as a university, corporate campus, or large institution. The goal of a campus navigation system is to provide users with accurate and efficient guidance to their desired destinations within the campus, whether indoors or outdoors.***
Such systems typically leverage a combination of digital maps, real-time data, and user-friendly interfaces to enhance wayfinding and improve the overall navigation experience. It provides an interactive map and search functionality to help users find buildings and locations effortlessly. Custom icons and a feedback mechanism enhance the user experience, making campus navigation more convenient for students, staff, and visitors. This project aims to create a connected and informed campus community.
Keywords: navigation, feedback, routing, campus, CNS, map, rendering

I. INTRODUCTION

College campuses are frequently visited by a large mass of people periodically during student admission, placement season, symposiums and conferences.
Every freshman on the campus finds it stressful and difficult to navigate through a new environment. A campus navigation system offers features of efficient navigation, orientation assistance, timely help during emergency evacuation and proudly boasts a technological showcase to all its users. Moreover, this Global Positioning System based map application would be useful to locate desired locations with the shortest path between the source and destination.
In an era of technological advancements, educational institutions are continually seeking innovative solutions to enhance the campus experience for students, faculty, and visitors. One prominent area that has garnered significant attention is campus navigation. Efficient navigation within a sprawling university campus can be a daunting task, particularly for newcomers. Therefore, the development of an intuitive and accessible Campus Navigation System (CNS) [7] has become a priority for educational institutions worldwide.
The CNS serves as a vital component in promoting campus connectivity, accessibility, and engagement. It aims to bridge the information gap between individuals and the physical spaces on campus, making it easier for users to locate academic buildings, administrative offices, event venues, and other essential points of interest. This system leverages modern technologies to provide users with a seamless navigation experience.
This research paper delves into the design, development, and implementation of a comprehensive Campus Navigation System tailored to the specific needs of our institution. We explore the technological stack employed in this project, which includes web-based mapping tools [11], routing algorithms, and user-friendly interfaces. Additionally, we discuss the system's potential to foster a sense of community by disseminating timely information about campus events and enabling user feedback.

II. LITERATURE SURVEY

1) *An event-driven university campus navigation system on android platform. Susovan Jana; Matangini Chattopadhyay. 2015 Applications and Innovations in Mobile Computing (AIMoC), IEEE 2015 [2]*

This paper outlines the architecture and design of this Android application, developed using the Android Software Development Kit (SDK). The application's effectiveness has been demonstrated through testing in two campuses of Jadavpur University, including the main campus and the Salt Lake campus. In essence, this research paper presents a solution to enhance campus navigation and event awareness through a user-friendly Android application integrated with Google Maps.

2) *Accurate GSM Indoor Localization. Otsason, A. Varshavsky, A. LaMarca and E. Lara, Proceedings of 7th International Conference, UbiComp, Tokyo, Japan, 2005 [12]*

This paper presents a groundbreaking GSM-based indoor localization system that outperforms previous technologies in terms of accuracy and floor identification in both large and multi-floor buildings. The research community has long aimed for precise indoor localization methods, and various solutions based on technologies like 802.11, Bluetooth, ultrasound, and infrared have been proposed. This paper introduces a novel GSM-based indoor localization system, the first of its kind, capable of achieving a median accuracy of 4 meters within a single floor in large buildings. Moreover, it can correctly identify the floor in up to 60% of cases and be within 2 floors in up to 98% of cases in tall multi-floor buildings. The system's success is attributed to the utilization of wide signal-strength fingerprints. In addition to the six strongest cells commonly used in GSM, this wide fingerprint incorporates readings from additional cells that may not be efficient for communication but contribute to localization accuracy. The paper also highlights the importance of selecting a subset of highly relevant channels from all available channels, further enhancing the accuracy of fingerprint matching for localization.

3) *Indoor localization using particle filter and map-based NLOS. Jongdae Jung, Hyun Myung, 2011 IEEE International Conference on Robotics and Automation, Shanghai, China [14]*

User localization is crucial for the effective interaction of mobile robots with humans. Among the various methods utilizing radio frequency (RF) signals, time of arrival (TOA)-based localization is popular due to its ability to directly calculate target coordinates from precise range measurements. However, RF ranging-based localization faces challenges in complex indoor environments, where range measurements are affected by signal noise, blockages, and reflections. In such environments, a significant portion of range measurements becomes non-line-of-sight (NLOS), which substantially deviates from line-of-sight (LOS) distances. These NLOS measurements severely undermine the accuracy of trilateration-based localizations without compensation. To address this issue, this paper introduces a particle filter-based localization algorithm that leverages indoor map data to estimate NLOS signal paths and corrects range measurements accordingly. Experimental validations conducted in real indoor settings confirm the effectiveness of this algorithm.

4) *Long-Term Indoor Localization with Metric-Semantic Mapping. Nicky Zimmerman, Matteo Sodano, Elias Marks, Jens Behley, Cyrill Stachniss. Robotics (cs.RO); Computer Vision and Pattern Recognition (cs.CV) arXiv:2303.10959 [cs.RO], 20 March, 2023 [15]*

This paper delves into the significance of object-based maps, emphasizing their role in scene understanding. Such maps merge both geometric and semantic data about the environment, enabling autonomous robots to navigate and interact effectively with objects. The primary focus of the paper is on constructing metric-semantic maps, particularly for long-term object-based localization. The proposed approach leverages 3D object detections obtained from monocular RGB frames for two main purposes: constructing object-based maps and achieving global localization within these maps. To adapt the method to different environments, the paper introduces an efficient technique for generating 3D annotations, which refines the 3D object detection model. The authors evaluate their map construction technique in an office building and test the long-term localization approach on challenging sequences recorded within the same environment over a nine-month period. The experimental results indicate the suitability of the approach for building metric-semantic maps and demonstrate the robustness of the localization method to long-term environmental changes. Notably, both the mapping algorithm and localization pipeline can operate in real-time on an onboard computer. Additionally, the authors intend to release an open-source implementation of their approach using C++ and ROS (Robot Operating System).

5) *A Comprehensive Survey of Indoor Localization Methods. Anca Morar, Alin Moldoveanu, Irina Mocanu, Florica Moldoveanu, Ion Emilian Radoi, Victor Asavei, Alexandru Gradinaru and Alex Butean, National Library of Medicine, Sensors (Basel). 2020 May [16]*

This paper provides an extensive overview of computer vision-based indoor localization techniques, which are used to track mobile entities like people or robots within indoor environments[13]. These methods fall into two categories: those using a network of static cameras to track entities and those with cameras attached to the mobile entities themselves. The paper covers various aspects of the computer vision-based indoor localization domain, including application areas, commercial tools, existing benchmarks, and related reviews. It also offers a survey of research solutions in indoor localization, introducing a novel classification system based on factors such as the use of known environment data during configuration, sensing devices, the type of detected elements, and the localization method employed.

The authors group and discuss 70 recent and relevant image-based indoor localization methods according to this new classification, emphasizing those that provide orientation information, a critical feature for many applications, such as augmented reality.

6) *Campus Navigation System Based on Mobile Augmented Reality, Qin Yong-Xu, Liu Jia-Min, Qiu Hui, Yan Bo, Jin Chang-Xu (2014), 2013 6th International Conference on Intelligent Networks and Intelligent Systems (ICINIS), IEEE] [1]*

The methodology focuses on creating an Android app that emphasizes navigation during campus events. It involves integrating event data, offering turn-by-turn navigation, and providing real-time updates to enhance the user experience during events on the campus.

7) *Campus Navigation Using Augmented Reality - Mayuri Tamhane, Prathamesh Sarjekar, Chirag Gupta, Prof. V M. Kharche (2018), [2018 International Journal of Scientific & Engineering Research] [3]*

The AR application overlays digital navigation information onto the real-world environment through a device's camera feed, offering users an innovative way to navigate the campus.

8) *Design and Development of Indoor Campus Navigation Application – Rabab Alayham Abbas Helmi; Harini A-P Ravichandran; Arshad Jamal; M. N. Mohammed (2022), [2022 IEEE 10th Conference on Systems, Process & Control (ICSPC), IEEE] [5]*

It includes data collection, application framework design, indoor positioning techniques, user interface development, route calculation, testing, and user feedback collection to develop an efficient and accurate indoor navigation solution.

9) *Navigation - Bräunl, T. (2023), [2023 Mobile Robot Programming. Springer, Cham] [6]*

It covers various navigation methods, principles, and technologies. It offers readers a broad understanding of navigation concepts, techniques, and their applications across different domains.

10) *Virtual Ally: Campus Navigation System using Tableau Vishakha Shelke1, Janvi Shree Shrimal,Pragati Tiwari, Pallavi Pawar (2022), [2022 International Journal of Computer Engineering in Research Trends] [4]*

The methodology focuses on utilizing Tableau to create an interactive campus navigation system. The system visualizes campus data, calculates optimal routes, and provides an intuitive user experience.

III.METHODOLOGY

The methodology for the campus navigation system involves a systematic approach to meet the navigation [10] and information needs of users within a university campus. It begins with a comprehensive analysis of user requirements and data collection, including campus maps and building layouts. The core of the system includes the development of a user-friendly interface, integrating GPS functionality for real-time tracking, implementing a robust search engine for location discovery, and devising navigation algorithms for optimal route calculations. Furthermore, event integration, user feedback mechanisms, rigorous testing, and continuous improvement through feedback analysis are pivotal components. Deployment and user training ensure widespread adoption, with ongoing maintenance, security, and scalability considerations. The methodology aims to provide a seamless and efficient campus navigation experience while staying adaptable to evolving campus dynamics and user needs.

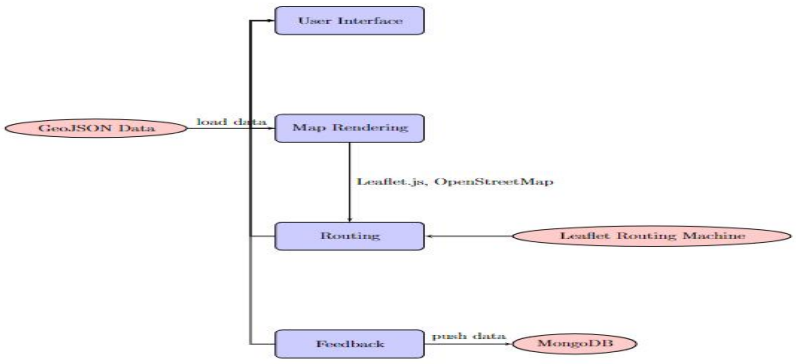

Fig. 1 System Architecture

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A. High Level Pseudocode:

// Define the CNS Modules

1) Module MapRendering

a) Initialize Map using Leaflet.js and OpenStreetMap
b) Load Campus Map Data from GeoJSON file
c) Display Map on the webpage

2) Module Routing

a) Receive User's Start and Destination Locations
b) Utilize Leaflet Routing Machine for Routing
c) Display Route and Directions on the Map

3) Module Feedback

a) Create Feedback Webpage with Input Fields
b) Fields for Feedback Type Name, Email ID, Contact Number, Message
c) Store User Feedback in MongoDB Database

// Main Application

Initialize Application:

a) Define Routes and URL Endpoints
b) Route to MapRendering Module for Campus Map
c) Route to Routing Module for Navigation
d) Route to Feedback Module for User Feedback

Start Application Server (Using Flask or Similar Framework)

IV. DESIGN COMPONENTS

1) Map Rendering Component

Leaflet.js library is used for rendering the map and displaying geographical data.

2) Routing Component

Leaflet Routing Machine is utilized for real-time routing and directions.

3) Miscellaneous Component (Feedback)

a) Used MongoDB as a NoSQL database to store data for feedback.
b) HTML/CSS/JavaScript/React.js: Develop web pages and forms for user interaction.

4) User Interaction

a) *User Interface (UI) Design:* Implement intuitive user interfaces for map interaction and feedback submission.
b) *User Feedback:* Collect user feedback for continuous improvement.

5) Data Integration

a) *GeoJSON Parsing:* Parse GeoJSON data to extract building and pathway coordinates.
b) *API Integration [17]:* Integrate Leaflet Routing Machine for routing.

6) Navigation Instructions

Turn-by-Turn Directions: Generate and display step-by-step navigation instructions based on the chosen route.

7) Search Bar

NLTK provides destination suggestions to users based on their input that aligns with the keywords in the database.

V. DATASET

A. Campus Map Data

Creation of GeoJSON file by collecting geographic data on campus buildings and other relevant features using GPS devices or geospatial software.

B. User Feedback Data

User-generated feedback submitted through the CNS interface. Feedback data is collected directly from users through the feedback webpage. The data includes fields such as feedback type (selected via radio buttons), name, phone number, date, and review, and is stored in a MongoDB database.

VI. USER INTERFACE

Creating a user interface (UI) for a campus navigation web application with three web pages – home, search, and feedback – is a key aspect of ensuring an intuitive and user-friendly experience. Here's an elaboration of the UI for each of the web pages:

A. Home Page

The home page serves as the landing page for your campus navigation application and provides users with an introduction and navigation options. The UI for the home page includes the following elements such as header, navigation tabs for search and feedback, backdrop and a footer.

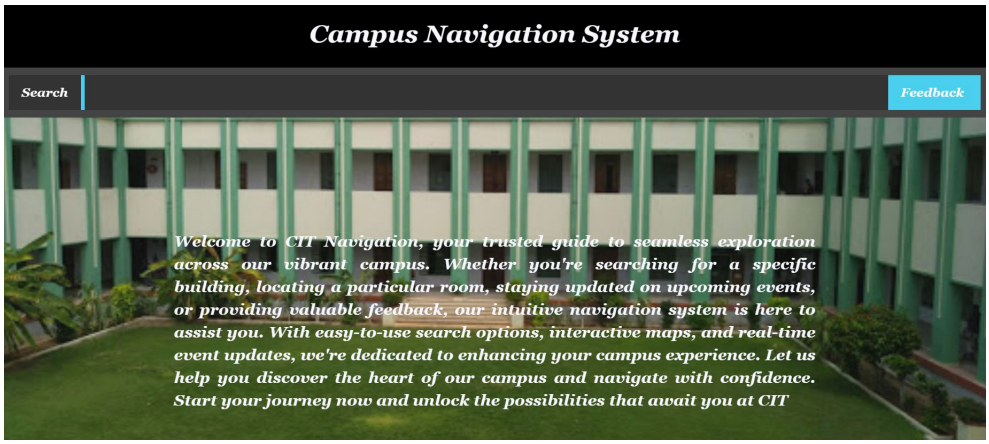

Fig. 2 Home Page

B. Search Page

The search page allows users to search for specific locations or buildings on the campus. The UI includes header, search input, search results, map integration, navigation and a back button.

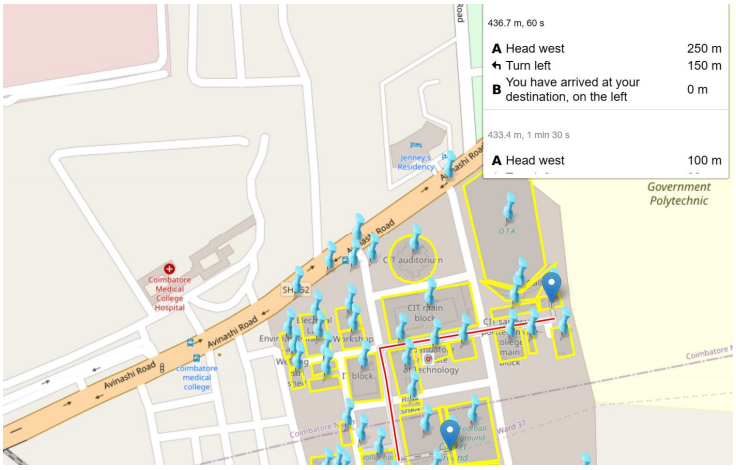

Fig. 3 Navigation

C. Feedback Page

The feedback page is where users can submit their feedback about the application or report issues. The UI includes the following fields:

1) *Name:* Text input for the user's name.
2) *Email:* Text input for the user's email address.
3) *Contact Number:* Text input for the user's contact number (optional).
4) *Message:* A larger text area for the user to enter their feedback or message.
5) *Send Button:* A button to submit the feedback.
6) *Cancel Button:* A button to cancel or clear the form

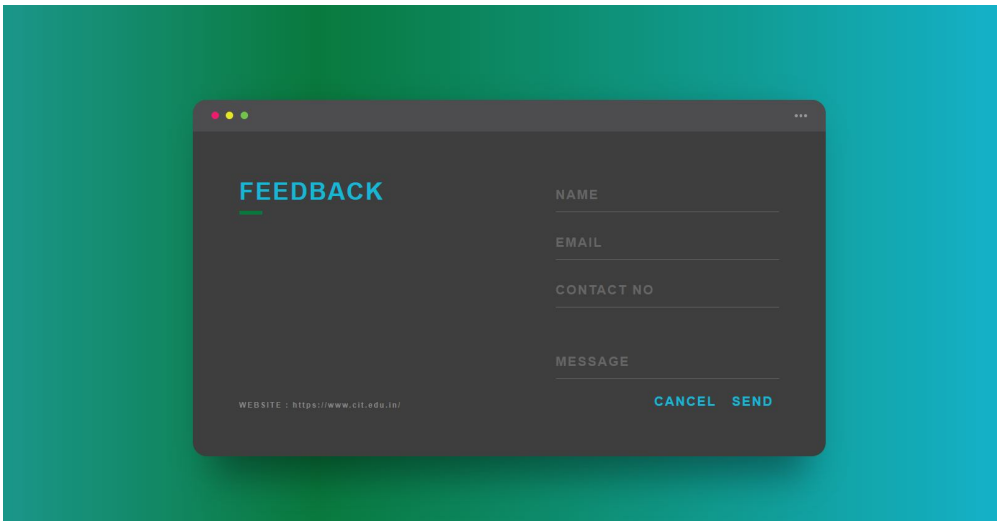

Fig. 4 Feedback Page

VII. APPLICATIONS

A campus navigation system has a wide range of practical applications that benefit various stakeholders within a campus environment.

Key applications include:

1) Efficient Navigation for Users
2) Orientation Assistance for Visitors and Conference Attendees
3) Reduces Stress on Navigating Through an Unfamiliar Campus
4) Inclusivity and Accessibility
5) Timely Navigation During Emergencies
6) Convenient during Campus Events
7) Technological Showcase of a Modern Institution

VIII. CONCLUSION

In conclusion, the Campus Navigation System presented in this project offers an innovative [8] and practical solution to the common challenges faced within university campuses. By leveraging GPS technology and a user-friendly web application, this system empowers students, faculty, staff, and visitors to navigate the complex and ever-evolving campus environments with ease and efficiency. It addresses the critical need for a reliable and real-time mapping tool that not only helps users find specific buildings, departments, and facilities but also keeps them informed about campus events and activities. Through extensive testing and deployment, the system has proven its effectiveness and adaptability. This Campus Navigation System not only reduces frustration and confusion but also sets the stage for a smarter, technology-driven future for university campuses. As technology continues to advance, this project serves as a valuable foundation for further enhancements and innovations in the realm of campus navigation and beyond, ultimately enhancing the overall campus experience for all its users.

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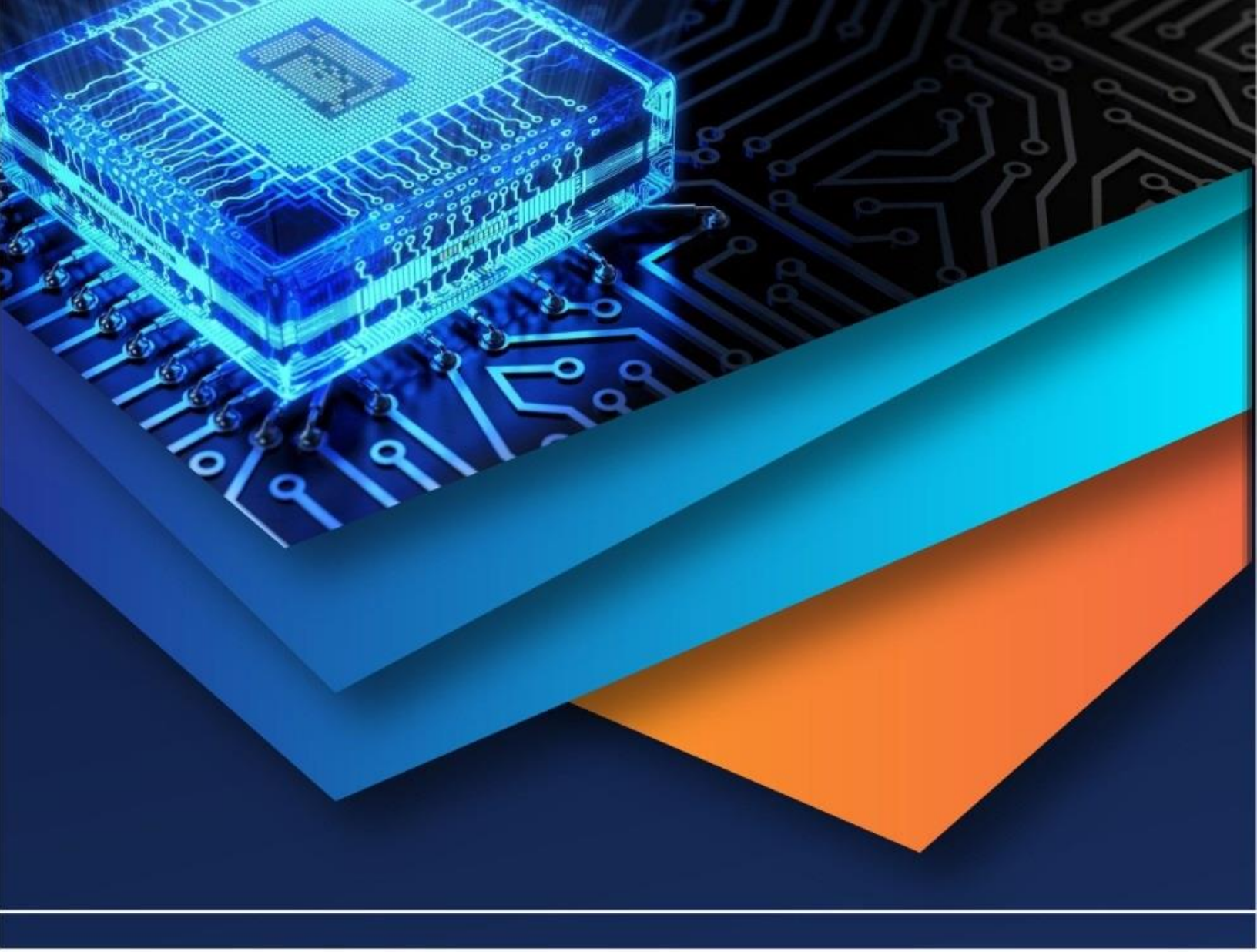

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