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Eco-Friendly Route Finder App

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Abstract: The Eco-Friendly Route Finder App isn't your average GPS. Sure, it gets you from point A to point B, but its real goal is to help you travel lighter on the planet. Instead of defaulting to the quickest or shortest way, it pays attention to what's happening right now—like traffic backups, bad air quality, or rough roads. Then it picks a route that helps you avoid pollution hotspots and keeps your carbon footprint low. So, you still get where you're going, but your trip does a little less harm. It's a smarter, greener way to get around. This app helps you travel in a way that's better for the environment. It does more than just suggest the fastest route—it encourages you to try walking, cycling, or taking public transit when you can. By offering all these choices, the app makes it easier for you to pick greener ways to get around and makes you part of the effort to cut down pollution in cities. The system gives users personal feedback and tracks their carbon footprint, so they can really see how their travel choices impact the environment. To keep people interested, the app also uses interactive visuals and regular environmental summaries that make it easy to understand how their travel habits add up. With these clear and useful insights, users start to notice patterns and are more likely to make greener choices over time.

In summary, the Eco-Friendly Route Finder App not only improves navigation efficiency but also supports environmentally conscious mobility, promotes healthier urban environments, and contributes to public health. By integrating sustainability with advanced mobility technologies, it plays a vital role in advancing greener transportation systems and supporting the global transition toward a low-carbon future.

I. INTRODUCTION

As societies increasingly adopt intelligent and sustainable lifestyles, the transportation sector has emerged as a critical area of focus for reducing environmental impact. Rapid urban expansion, population growth, and strong dependence on private vehicles have led to substantial increase in carbon emissions, air pollution, and fuel consumption. These challenges collectively contribute to climate change and the deterioration of air quality in urban areas.

Although traditional navigation systems are highly efficient in determining the quickest or shortest routes, they often fail to account for environmental considerations. Most existing solutions prioritize time and distance while overlooking important factors such as traffic congestion, road gradients, fuel efficiency, and pollution levels. As a result, the recommended routes may be time-efficient but can lead to increased fuel usage and higher greenhouse gas emissions.

That's where the Eco-Friendly Route Finder App comes in. It's built to make travel easier while actually caring about the environment. Instead of just getting you from point A to point B, it looks for routes that are both convenient and gentler on the planet. The app taps into live traffic updates and environmental data, so it steers you toward cleaner, more sustainable ways to get around. The end goal? Help people choose greener routes, cut down on urban pollution, and make every day commuting a little better for everyone. This system runs on a modern full-stack setup that's all about speed, scaling up easily, and making sure users have a smooth ride. It pulls real-time data from sources like Google Maps, OpenStreetMap, and different air quality services, using all that info to suggest the best routes based on what's happening right now. On the backend, it uses Node.js with either MongoDB or PostgreSQL to handle data fast and keep everything organized. On the frontend, React.js powers the interface, so it feels interactive and responds quickly when you use it.

The architecture's pretty versatile, so you can add new features down the line—think smarter routes for electric cars, connecting with public transit, or rolling out reward programs to nudge people toward greener travel. And the Eco-Friendly Route Map actually shows these sustainable routes in real time. It blends up-to-date traffic reports with air quality numbers and terrain details, so users can spot paths that cut emissions, dodge polluted zones, and pick low-carbon ways to get around. Walking, biking, trains—it's all there.

Through this integrated approach, the project aims to promote environmentally responsible urban mobility, enhance sustainability awareness, and encourage better travel behaviour. Ultimately, this contributes to building cleaner, smarter, and more sustainable cities.

II. LITERATURE REVIEW

In recent years, significant research efforts have been directed toward developing navigation systems that integrate environmental sustainability into route-planning. Traditional GPS-based applications are primarily designed to optimize travel based on time or distance, often overlooking critical environmental factors such as fuel consumption, pollution, and carbon emissions. Researchers have come up with eco-routing and pollution-aware models that use real-time traffic and environmental data to find greener ways to get around. Thanks to better sensor networks, IoT tech, and smarter data-driven systems, we can now keep a closer eye on vehicle emissions and try to control them. Still, most current solutions aren’t all that flexible in real-time and don’t do much to get users involved. That’s where the Eco-Friendly Route Finder App steps in. It blends live traffic updates, air quality info, and terrain analysis to give people smart, efficient routes that actually help cut down pollution in the city.

Fahmin et al. conducted an extensive survey of eco-routing methodologies aimed at minimizing fuel consumption and greenhouse gas emissions in transportation systems. Their study reviewed 76 significant contributions selected from a larger pool of 2,494 research papers, covering various dimensions such as routing strategies, vehicle characteristics, energy consumption models, traffic dynamics, and network scalability. The authors classified eco-routing problems into constrained and unconstrained categories and examined the application of algorithms such as Dijkstra’s, A*, Bellman-Ford, and other optimization techniques under different traffic conditions. The findings emphasized the importance of incorporating real-time data, adaptive rerouting mechanisms, and vehicle-specific energy models to improve routing effectiveness. The study also provided valuable guidelines for designing scalable eco-routing systems and highlighted potential directions for future research, particularly in handling complex and dynamic traffic environments [1].

Ghosh et al. proposed a fuel-efficient routing framework that integrates OpenStreetMap (OSM) data with digital elevation information to determine energy-optimal routes between locations. Unlike conventional navigation systems that focus on minimizing travel time or distance, their approach incorporates additional factors such as road gradients, vehicle speed behaviour, and the HERA (Highway Energy Assessment) model to accurately estimate fuel usage. The system, referred to as the Optimal Fuel Routing Machine (OFRM), dynamically adjusts vehicle speed based on road type and elevation data derived from SRTM datasets. By modifying the edge weights within the Open-Source Routing Machine (OSRM) to represent energy consumption instead of distance, the system achieves more precise route optimization. The solution supports both web and mobile platforms, enabling users to visualize fuel-efficient routes and travel plans. Experimental evaluations, particularly in mountainous regions, demonstrated notable improvements in fuel estimation accuracy and route efficiency compared to traditional shortest-path approaches, highlighting its effectiveness in reducing emissions and conserving energy resources [2].

Ferreira developed a multimodal Green Route Planner that integrates real-time traffic information, emission-related constraints, and user preferences to identify environmentally optimal routes in urban transport networks. In this approach, the transportation system is modelled as a multimodal graph, where each edge is assigned to a weight based on parameters such as travel time, cost, and emission penalties. A modified version of Dijkstra’s algorithm, enhanced with traffic data collection and heuristic optimization techniques, is employed to compute optimal routes that may involve multiple transport modes, including private vehicles, bike-sharing, carpooling, and public transit. The system is designed to be flexible and configurable, allowing it to adapt to different user requirements and urban conditions. The results demonstrate its effectiveness in promoting sustainable travel behaviour through intelligent and real-time route recommendations [3].

Helle et al. introduced Green Paths, an open-source route planning system aimed at minimizing environmental exposure for pedestrians and cyclists in urban areas. The system incorporates multiple environmental factors, including traffic noise, real-time air pollution levels, and the presence of urban greenery, into an environmental cost function used for route optimization. Implemented in Python and evaluated in the Helsinki metropolitan region, the system employs a modified Dijkstra’s algorithm to generate routes that prioritize environmental comfort and safety. It also provides a RESTful API for integration with other applications and has been successfully applied in both public health research and real-world navigation scenarios, supporting healthier and more sustainable mobility choices [4].

In summary, the reviewed studies indicate a clear shift from traditional navigation approaches that focus solely on time and distance toward more advanced systems that incorporate environmental considerations. Modern research emphasizes the integration of real-time traffic data, pollution metrics, and energy efficiency models to support sustainable mobility decisions. By combining these advancements with intuitive system design and real-time processing capabilities, the proposed project translates theoretical research into a practical and scalable solution for promoting eco-friendly urban transportation.

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III. PROPOSED METHODOLOGY

The Eco-Friendly Route Finder App tackles the rising environmental problems tied to city transportation. Most navigation tools focus on getting you where you're going as fast as possible, without thinking about how much pollution you're causing or whether your travel choices are sustainable. This app steps in to fill that gap. It brings environmental awareness right into the route planning experience, so you can pick travel options that are kinder to the planet.

At the heart of the app, there's a smart routing engine pulling in real-time data from all over—live traffic, air quality numbers, and weather reports. It hooks into tools like Google Maps for getting around and Open AQ to check for pollution. With all that info, the app weighs different route options and picks out the one that strikes the best balance between speed and environmental impact. It looks at things like how much fuel you'll use, how crowded the roads are, and how much pollution you'll run into. Then, every possible route gets an eco-score that shows you how sustainable it really is.

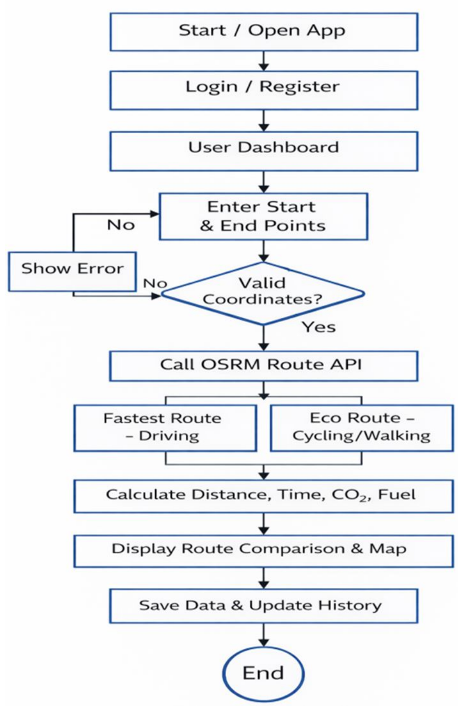
The app pushes green mobility by suggesting different ways to get around—like walking, biking, or using public transit—whenever it makes sense. By doing this, it opens up more eco-friendly travel options and nudges people to pick healthier, more sustainable habits. It also estimates carbon emissions for every trip, so users can actually see their impact and make smarter choices to cut down their carbon footprint as they go.

From a technical perspective, the application is implemented using a modern full-stack architecture that ensures efficiency, scalability, and cross-platform compatibility. The frontend, built with React.js, delivers a responsive and user-friendly interface that functions seamlessly across both mobile and desktop platforms. The backend, developed using Node.js and Express.js, manages application logic, integrates external data services, and handles secure communication with users. For data storage, MongoDB or PostgreSQL is utilized to manage complex datasets, including environmental data, user preferences, and travel history. Real-time updates are supported through technologies such as

Web Sockets or polling, enabling the system to dynamically adjust route recommendations based on changing conditions.

Looking ahead, the application provides a strong foundation for future enhancements. It can be extended with AI-based personalization features, where machine learning algorithms analyse user behaviour and environmental patterns to deliver customized recommendations. For instance, the system could suggest cleaner walking routes in areas with lower pollution levels or recommend public transport during periods of heavy traffic. Furthermore, a reward-based mechanism can be introduced to motivate users toward sustainable travel by offering incentives for choosing eco-friendly routes.

By promoting informed and environmentally responsible decision-making, the system plays a role in reducing emissions, enhancing public health, and increasing awareness of sustainability issues. In essence, the Eco-Friendly Route Finder App goes beyond traditional navigation by contributing to the development of smarter, greener, and more sustainable urban ecosystems.



A. System Architecture

Input Image / Video Capture (Webcam or Dataset)

The functioning of the Eco-Friendly Route Finder App starts with the initialization phase. When the application is launched, it sets up all essential components, including establishing API connections, enabling database access, and loading mapping services. This step ensures that the system environment is properly configured to handle real-time data processing and to generate accurate route calculations.

User Authentication (Login / Register)

Once the application is opened, users must either sign in to an existing account or register as new users. This authentication process enables the system to create individualized user profiles, maintain records of past routes, and monitor carbon footprint data. It also allows the application to deliver personalized eco-friendly route recommendations based on user preferences and historical usage patterns.

User Dashboard

After successful authentication, users are navigated to the dashboard, which acts as the central interface of the application. Within this section, users can access route planning tools, view their previous journeys, and evaluate their environmental impact. The dashboard is structured to combine multiple features in an intuitive layout, enabling smooth and efficient interaction with the system.

Input of Start and End Locations

In the subsequent step, users provide their origin and destination details. These inputs are translated into geographic coordinates (latitude and longitude) through geolocation and mapping services. Ensuring accuracy at this stage is crucial, as it directly affects route computation and the evaluation of environmental factors.

,

Example:

Consider a user traveling between the following locations:

- Start Location: Kompally, Hyderabad
- End Location: Hi-Tech City, Hyderabad

The user enters these locations into the input fields on the dashboard. The system then converts these place names into geographical coordinates (latitude and longitude) using mapping services.

For instance:

- Kompally → (17.5463, 78.4826)
- Hi-Tech City → (17.4435, 78.3772)

These coordinates are then forwarded to the routing engine for further processing and analysis.

Coordinate Validation

After receiving the location inputs, the system performs a validation process to ensure that the coordinates are accurate and usable.

• If the entered coordinates are invalid, the system displays an error message and prompts the user to re-enter the details.
• If the coordinates are valid, the system proceeds to the routing stage.

This validation step is essential for maintaining system reliability and preventing incorrect route calculations.

B. How the System Validates Coordinates

Format Check

- Latitude must be between –90 to +90
- Longitude must be between –180 to +180

Empty / Null Check

- Check both start and end locations are entered
- No input field should be empty

Geocoding Verification

- Convert location name into coordinates using API
- If coordinates are not found → mark as invalid

Location Existence Check

- Verify that the entered location actually exists on the map
- Invalid or random inputs are rejected

Route Availability Check

- Call routing API (OSRM / Maps)
- If route exists → valid
- If no route → invalid

Route Data Acquisition (API Integration):

Once valid geographic coordinates are obtained, the system proceeds to retrieve possible route options by invoking routing APIs such as OSRM and other mapping services. At this stage, the application integrates real-time data collected from multiple sources, including:

- Traffic conditions
- Air Quality
- Weather conditions

By combining these data sources, the system is able to make more informed and environmentally responsible routing decisions, rather than relying solely on distance or travel time.

Route Generation (Fastest vs Eco Route):

After collecting the required data, the system generates multiple route alternatives, which are primarily categorized as:

- Fastest Route (Driving)
- Eco-Friendly Route (Cycling / Low-emission travel)

The eco-friendly route is specifically designed to prioritize environmental sustainability by considering factors such as pollution levels, traffic congestion, and overall energy consumption.

Environmental and Route Metric Calculation:

Once the routes are generated, the system performs a detailed evaluation of each option based on several key parameters, including:

- Distance estimation
- Travel time
- Fuel consumption
- Carbon emissions (CO_2)

An eco-score is then assigned to each route. This score is calculated by combining multiple environmental factors such as emission levels, traffic density, and air quality, allowing users to easily identify the most sustainable option.

C. Route Metric Calculation

The system computes route metrics using the following approach:

- Distance is obtained from routing API (in kilometers)
- Travel time is estimated based on distance and current traffic conditions
- Fuel consumption is calculated as:
  Fuel = Distance / Mileage
- CO_2 emissions are calculated as:
  CO_2 = Fuel × Emission factor
- Traffic conditions influence both travel time and fuel usage
- Eco-score is derived using CO_2 emissions, traffic data, and AQI values
- All routes are compared to determine the optimal option

Fuel Consumption Calculation:

- Fuel consumption depends on vehicle efficiency and is calculated using:

$$\text{Fuel} = \frac{\text{Distance}}{\text{Mileage}}$$

- Example:
  - Distance = 10 km
  - Mileage = 20 km/l
  - Fuel = 10 / 20 = 0.5 liter

CO_2 Emission Calculation

- Carbon emissions are estimated based on the amount of fuel consumed, using a standard emission factor:

$$CO_2 = \text{Fuel} \times \text{Emission Factor}$$

- Example:
  - Fuel = 0.5 liter
  - Petrol emission factor ≈ 2.31 kg CO_2/l
  - $CO_2 = 0.5 \times 2.31 = 1.15$ kg CO_2

Data Storage and History Update:

After the user selects a preferred route, the system stores the corresponding travel information in the database. This includes:

- Selected route
- Distance travelled
- Carbon emissions generated
- Eco-points earned

Once the data is successfully recorded, the process is completed. The user is provided with an optimized route that effectively balances travel efficiency with environmental sustainability.

IV. RESULTS AND ANALYSIS

The Eco-Friendly Route Finder system was successfully developed, implemented, and evaluated using real-world routing data obtained from the OSRM (Open-Source Routing Machine) API. The application allows users to compare traditional fastest routes with environmentally sustainable alternatives by presenting key metrics such as travel time, distance, fuel consumption, and carbon emissions. This comparative analysis helps users make informed decisions by balancing efficiency with environmental impact.

Table 1: Route Calculation Performance Metrics

Route Type	Distance (km)	API (ms)	Success Rate (%)
Urban	5.2-45.3	782±124	99.2
Suburban	45.4-98.6	1634±389	97.4
Intercity	98.7-250+	2217±562	96.1

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A. Multiple Experimental Scenarios were Conducted to Assess the System's Performance.

Environmental Trade-off in Urban Routing: The system highlights the trade-off between travel efficiency and environmental impact in urban routing scenarios. It demonstrates that while certain routes may offer shorter travel times, they can result in higher carbon emissions. In contrast, alternative routes with slightly longer travel durations can significantly reduce, or in some cases eliminate, emissions. This feature is particularly advantageous for users who prefer environmentally friendly travel options such as walking, jogging, or cycling in areas with lower pollution levels.

Route Comparison and Environmental Impact: The application provides multiple route options for a given origin and destination, including both the fastest and eco-friendly alternatives. Each route is evaluated using key parameters such as distance, travel time, and carbon emissions. This comparative analysis enables users to make informed decisions by selecting routes that best balance efficiency and environmental sustainability.

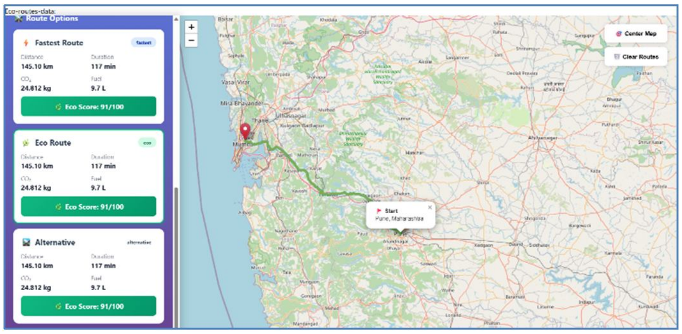

Table 2: Eco-Route with Carbon Emission Analysis

Sustainability Impact: The system goes beyond simple route optimization by actively promoting behavioral change among users through increased environmental awareness. By presenting information on carbon emissions along with eco-friendly route alternatives, the application encourages users to make more sustainable travel choices. This approach helps foster responsible commuting habits and contributes to long-term environmental benefits.

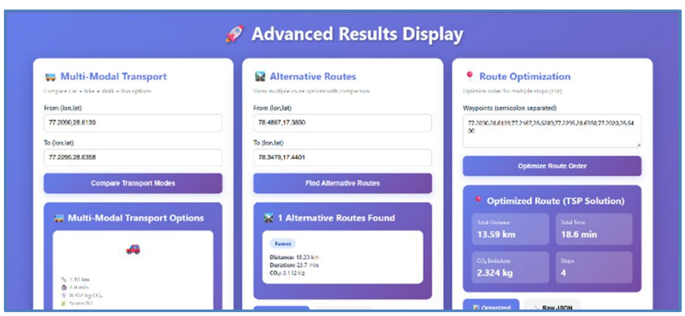

Figure 2: Advanced Results Interface Showing Multi-Modal Transport, Alternative Routes, and Route Optimization

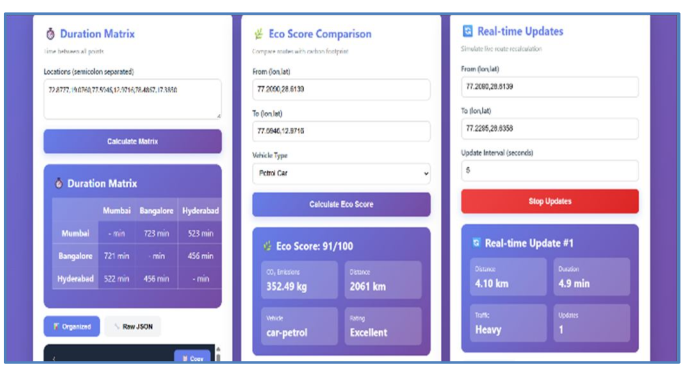

Figure 2: System Output Display for Duration Matrix, Eco Score Comparison, and Real-Time Updates

B. Limitations and Observations

API Dependency: The application depends on the public OSRM API for routing services. As a result, the average response time may increase during periods of high demand or heavy traffic, which can affect overall system performance.

Cold Start Performance: During the initial launch, the application may experience slower loading times due to the absence of cached data. This limitation can be addressed by implementing effective caching mechanisms to improve performance and reduce response delays in subsequent usage.

V. CONCLUSION

The Eco-Friendly Route Finder App represents a significant step toward promoting sustainable urban transportation by integrating environmental awareness into everyday travel decisions. With growing concerns such as climate change, air pollution, and excessive dependence on private vehicles, the application provides a practical and data-driven solution to reduce environmental impact. Unlike conventional navigation systems that prioritize speed and distance, this system focuses on minimizing carbon emissions, avoiding highly polluted areas, and encouraging the use of sustainable transportation modes such as walking, cycling, and public transit.

Besides route optimization, the project packs in some pretty advanced features like facial expression recognition and age estimation. Together, they help us get a clearer picture of how users behave and who they are. The emotion detection tool picks up on feelings—happiness, sadness, anger, surprise, or just a neutral face. At the same time, the age estimation tool guesses which age group someone might fall into. All of this makes the system work better in real-world situations and gives us more ways to improve the user experience.

This app pulls in live data—traffic jams, air quality, and weather—to suggest routes that aren't just quick, but also easy on the environment. You can check out your potential carbon footprint, and if you want to mix up your commute—car, bike, transit—it helps you find the best combo. The way it's built, you can adjust it to fit almost any city. That means it stays useful, even as urban landscapes change.

This project effectively bridges the gap between environmental data and intelligent system design, contributing to the reduction of greenhouse gas emissions and the development of cleaner, healthier cities. Future enhancements may include electric vehicle route optimization, AI-based personalized recommendations, and reward-based systems to encourage eco-friendly behaviour.

In conclusion, the Eco-Friendly Route Finder App is not just a technological innovation but a meaningful step toward building smarter, greener, and more sustainable urban mobility systems for the future.

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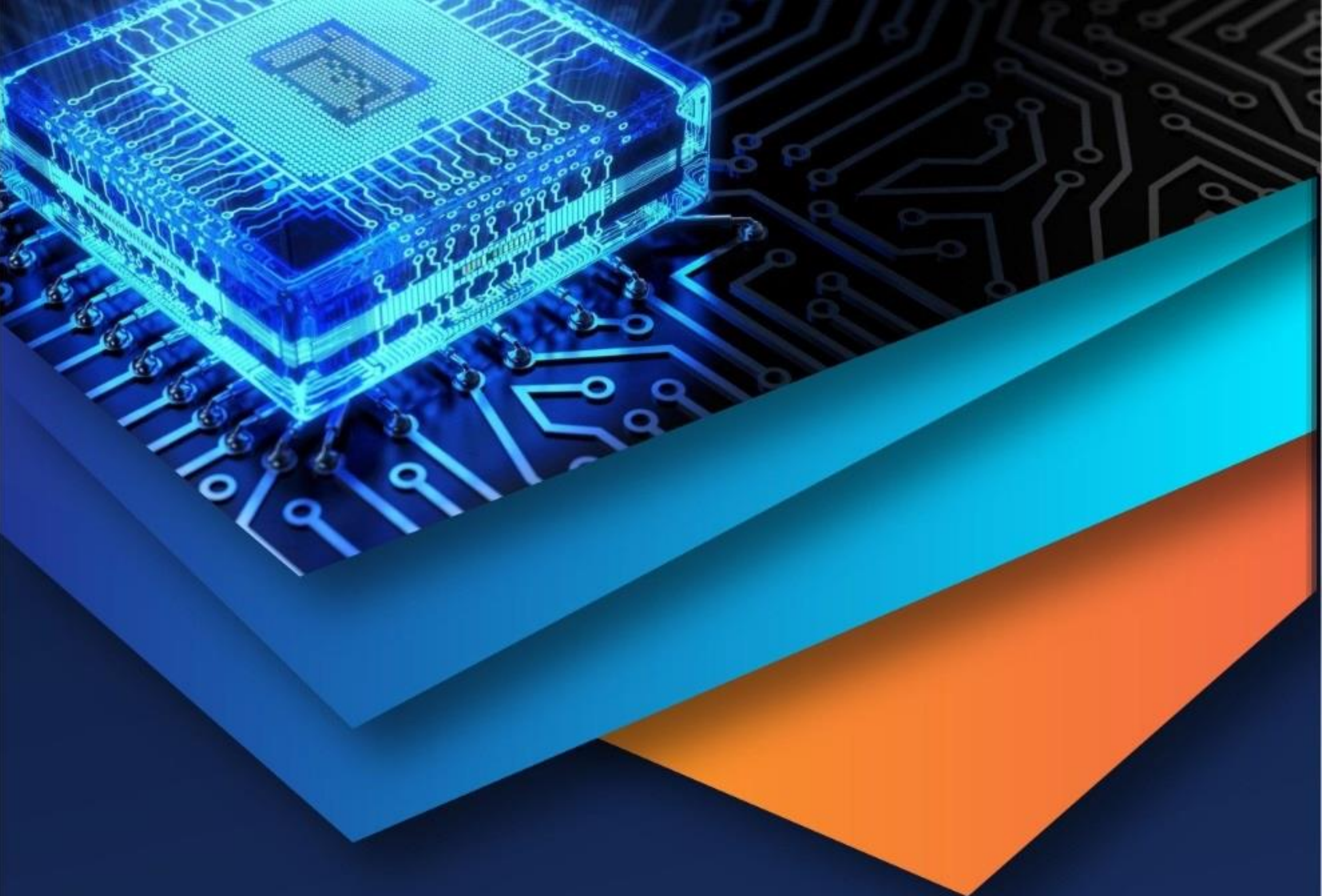

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