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AI-Powered Smart Waste Management and Complaint Redressal System Using YOLOv8

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Abstract: ***Rapid urbanization and increasing population density have significantly intensified the challenges associated with efficient waste management and environmental sustainability. Traditional waste disposal practices often lack proper segregation, monitoring, and timely response mechanisms, resulting in environmental degradation and health hazards. To address these issues, this paper presents an AI-powered smart waste management and complaint redressal system that integrates real-time object detection, data analytics, and citizen engagement into a unified platform.***

The proposed system utilizes the YOLOv8 deep learning model for real-time waste detection through webcam input and image uploads. Detected waste items are automatically classified into categories such as organic, recyclable, hazardous, and electronic waste, and are mapped to appropriate disposal bins. The system further stores detection data along with contextual information such as location, timestamp, and recyclability status, enabling structured data analysis.

The In addition to detection capabilities, the system incorporates an administrative dashboard that provides visual insights through charts and statistics, assisting authorities in understanding waste distribution patterns. A report generation module is also included to produce official documents for monitoring and decision-making. Furthermore, a complaint management feature allows citizens to report waste-related issues with images and location tracking, facilitating timely intervention by municipal authorities. The integration of artificial intelligence with data-driven decision support and user participation makes the proposed system a scalable and practical solution for modern smart cities. The results demonstrate improved efficiency in waste classification, better tracking of waste trends, and enhanced responsiveness to citizen complaints.

Keywords: Waste Management, YOLOv8, Computer Vision, Smart City, Complaint Redressal, AI, Object Detection.

I. INTRODUCTION

The Waste management has become a critical concern in modern urban environments due to rapid industrialization, population growth, and increased consumption patterns. Improper waste disposal not only leads to environmental pollution but also poses serious risks to public health and urban infrastructure. Conventional waste management systems primarily rely on manual segregation and monitoring, which are often inefficient, time-consuming, and prone to human error. Additionally, lack of real-time tracking and delayed response to waste-related issues further complicate the problem.

With the advancement of artificial intelligence and computer vision technologies, there is a growing opportunity to automate and enhance waste management processes. AI-based systems can provide accurate waste classification, reduce dependency on manual labor, and enable data-driven decision-making. In particular, object detection models such as YOLO (You Only Look Once) have shown promising results in identifying and classifying objects in real time, making them suitable for waste detection applications.

The objective of this project is to design and develop an intelligent waste management system that combines real-time detection, data analytics, and citizen interaction into a single platform. The system not only identifies waste items using a trained YOLOv8 model but also provides bin recommendations, stores detection records, and generates analytical insights. Furthermore, it bridges the communication gap between citizens and authorities by allowing users to report waste-related issues along with geolocation data. Unlike traditional systems, the proposed solution focuses on both automation and accountability. By integrating complaint redressal mechanisms and administrative tools, the system ensures that waste management is not only efficient but also responsive and transparent. This holistic approach aims to contribute towards cleaner urban environments and supports the vision of smart city development.

II. LITERATURE REVIEW

1) Paper Name - Waste Classification Using Artificial Intelligence Techniques: [1] Abood & Al-Talib (2023) presented a literature review on AI-based waste classification, emphasizing the importance of machine learning and image processing for efficient waste management. They concluded that CNNs can significantly improve the accuracy and automation of waste segregation.

2) Paper Name - Classification of Waste Materials using CNN Based on Transfer Learning [2] Poudel & Poudyal (2022) developed a CNN-based system using transfer learning (InceptionV3, ResNet, MobileNet) to classify biodegradable and non-biodegradable waste. Their approach achieved 92.5% accuracy but required expansion to handle more waste types for real-world use.

3) Paper Name - Waste Management Classification using Convolutional Neural Network [3] Hamzah et al. (2024) implemented a Faster R-CNN model for detecting recyclable materials like glass, metal, and plastic, achieving up to 97.9% accuracy. They also integrated the system into a mobile app for real-time detection and user interaction.

4) Paper Name - Waste Classification for Sustainable Development Using Image Recognition with Deep Learning Neural Network Models [4] Malik et al. (2022) worked on waste classification using deep neural networks for sustainable development. Their research focused on achieving environmental goals through automation and dataset expansion to cover multiple waste categories.

5) Paper Name - AI-Powered Waste Classification Using Convolutional Neural Networks (CNNs) [5] Yi & Kim (2024) proposed an AI-powered CNN system that uses optimized layers for fast and accurate waste recognition. They emphasized lightweight architecture suitable for low-power devices, improving accessibility and deployment feasibility.

From the reviewed papers, the following common limitations were identified: • Most systems are hardware-intensive and unsuitable for low-resource environments. • They focus on limited waste categories, reducing real-world applicability. • Few systems provide real-time detection or user feedback. • Dataset imbalance and environmental variations (lighting, background) reduce model accuracy.

Several studies have explored the use of artificial intelligence and IoT in waste management systems. Traditional waste classification methods relied on manual sorting or rule-based systems, which are inefficient and prone to errors. Recent advancements have introduced machine learning and deep learning techniques for automated waste identification.

Research on Convolutional Neural Networks (CNNs) has shown promising results in image-based waste classification tasks. Models such as ResNet, MobileNet, and SSD have been applied for object detection and classification of waste materials. However, many of these approaches suffer from high computational cost and limited real-time capabilities.

The YOLO (You Only Look Once) family of models has emerged as a powerful solution for real-time object detection. Compared to traditional CNN-based detection models, YOLO performs detection in a single forward pass, making it faster and more suitable for real-time applications. The latest version, YOLOv8, offers improved accuracy, speed, and flexibility, making it ideal for practical deployment in smart systems.

In addition to detection, several systems have attempted to integrate smart bins and IoT sensors for automated waste collection. However, these systems often lack user interaction features such as complaint reporting and real-time analytics dashboards.

Existing complaint management systems are typically separate from waste detection systems and rely on manual data entry without location intelligence. This creates a gap in integrating citizen participation with automated detection.

The proposed system addresses these limitations by combining real-time AI-based waste detection, complaint redressal with geolocation tracking, and an analytics-driven admin dashboard in a single integrated platform.

III. METHODOLOGY

The proposed system is designed as a multi-module architecture integrating AI-based detection, database management, and user interaction through a web interface. The methodology consists of the following key components:

1) Data Acquisition

Waste images are obtained through two primary sources:

- ✓ Real-time webcam feed
- ✓ User-uploaded images

These inputs are processed using the YOLOv8 model for object detection.

2) Waste Detection using YOLOv8

The YOLOv8 model is employed for detecting waste objects in real-time. The model processes input frames and identifies objects based on trained classes such as plastic bottles, batteries, cans, and organic waste. The detection includes bounding boxes, class labels, and confidence scores.

3) Waste Classification and Bin Mapping

Detected objects are mapped to predefined waste categories such as:

- ✓ Organic Waste
- ✓ Plastic Waste
- ✓ E-Waste
- ✓ Medical Waste

Each category is further linked to a specific bin type (Green, Blue, Red, Yellow) to guide proper disposal.

4) Text-to-Speech Feedback

The system uses text-to-speech technology to provide audio instructions to users, enhancing accessibility and user engagement.

5) Complaint Management System

Users can submit complaints regarding waste issues by providing:

- ✓ Name and contact details
- ✓ Description of the issue
- ✓ Image evidence
- ✓ Location data (via GPS or image metadata)

The system extracts GPS coordinates from images using EXIF data and converts them into readable addresses using geolocation services.

6) Database Management

All detected waste records and complaints are stored in an SQLite database. The database maintains information such as waste type, location, timestamp, and complaint status.

7) Admin Dashboard

- ✓ The admin panel provides:
- ✓ Waste detection records
- ✓ Filtering by city and ward
- ✓ Statistical analysis (charts and trends)
- ✓ Complaint management with status updates
- ✓ Report generation in PDF format

8) Report Generation

Automated reports are generated using analytical data and exported in PDF format for municipal use.

The proposed system is designed as a modular architecture consisting of multiple interconnected components that collectively enable intelligent waste management. The methodology involves data acquisition, object detection, data storage, analytics processing, and user interaction through a web-based interface. The core component of the system is the YOLOv8 object detection model, which is used to identify waste items in real time. The model processes input from a webcam or uploaded images and generates bounding boxes along with class labels and confidence scores. Based on the detected class, each item is mapped to a predefined waste category such as organic, recyclable, hazardous, or electronic waste. Additionally, a bin recommendation system assigns the appropriate disposal bin to each detected item. To ensure efficient data handling, all detection results are stored in a structured database. Each record includes attributes such as item name, waste type, bin classification, recyclability status, city, ward, and timestamp. Location data is obtained either through browser permissions or extracted from image metadata, enabling geographical tagging of waste data. The system also incorporates an analytics module that processes stored data to generate meaningful insights. Statistical calculations are performed to determine metrics such as total detections, percentage of recyclable waste, and distribution of waste types. These insights are visualized using charts and graphs, providing an intuitive understanding of waste patterns. A report generation module is implemented to convert analytical data into PDF reports. These reports are designed for administrative use and can be shared with municipal authorities for planning and decision-making purposes. Furthermore, a complaint management system allows users to submit waste-related issues along with images and location information. Administrators can review, track, and forward these complaints to relevant authorities.

The entire system is developed using a web-based framework, ensuring accessibility and ease of use. The integration of AI, database management, and user interaction modules creates a comprehensive solution for smart waste management.

IV. RESULT AND DISCUSSION

The proposed AI-powered waste management system was successfully implemented and evaluated across multiple functional modules, including real-time waste detection, data storage, analytics dashboard, report generation, and complaint management. The system demonstrates effective integration of computer vision, data analytics, and administrative control features, providing a comprehensive solution for smart waste monitoring and urban cleanliness management.

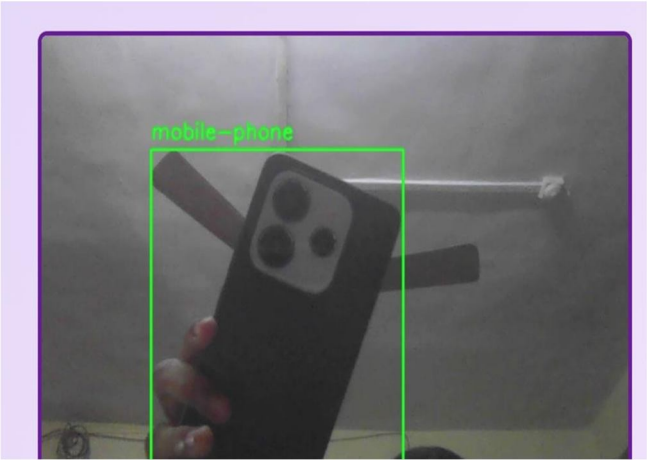

Figure 1: Detection Result

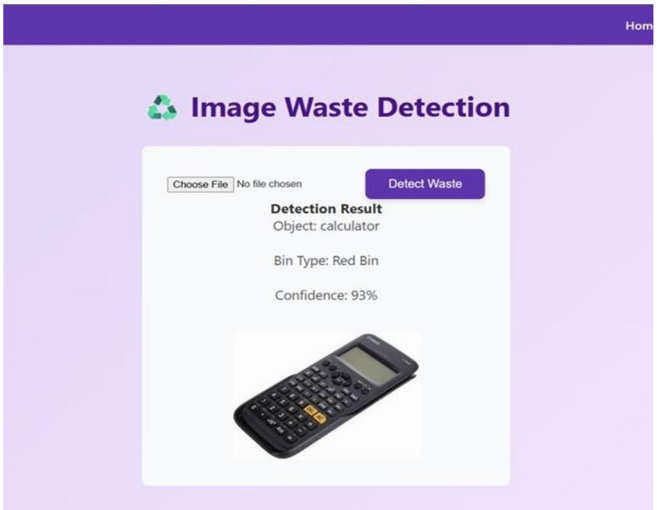

Figure 2: Detection Result

A. Real-Time Waste Detection Performance

The YOLOv8-based detection model was tested using both live webcam input and static image uploads. The system was capable of accurately identifying various waste objects such as plastic bottles, metal cans, organic waste, electronic items, and medical waste. Each detected object was automatically classified into predefined waste categories and mapped to the appropriate disposal bin (e.g., Green for organic, Blue for recyclable, Red for hazardous).

The detection pipeline was optimized to reduce redundant voice alerts using cooldown logic, ensuring a smooth user experience without repeated notifications. Additionally, bounding box filtering techniques were applied to prioritize the most prominent object in the frame, improving detection clarity in multi-object scenarios.

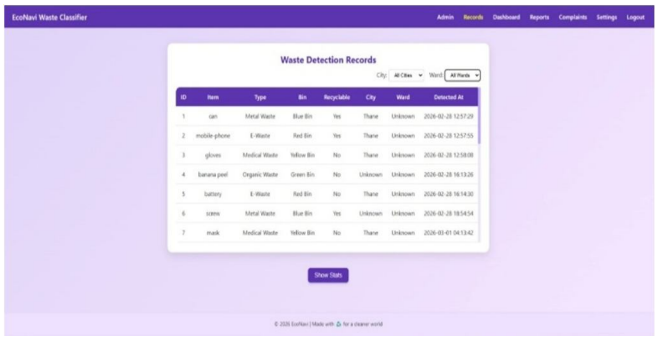

Figure 3: Records

B. Waste Detection Records and Data Storage

All detection results were successfully stored in a structured database system, capturing essential attributes such as detected item, waste type, bin recommendation, recyclability status, city, ward, and timestamp. The system ensures persistent logging of detection events, enabling long-term analysis and monitoring.

The records interface provides dynamic filtering capabilities based on city and ward selection. This feature allows administrators to isolate specific geographical areas and analyze localized waste patterns efficiently. The scrollable table interface enhances usability for large datasets while maintaining performance.

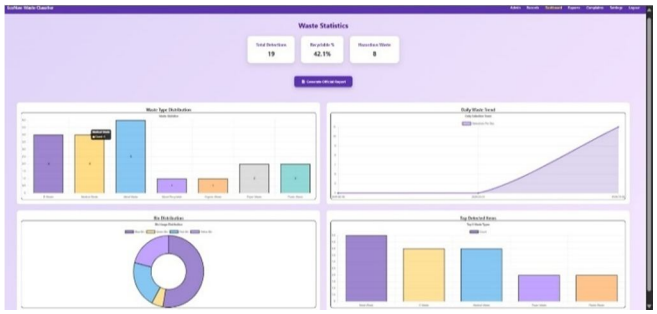

Figure 4: Dashboard

C. Analytics Dashboard and Data Visualization

The analytics dashboard presents processed data in the form of intuitive visualizations, enabling better understanding of waste distribution trends. Key performance indicators (KPIs) such as total detections, recyclable percentage, and hazardous waste count are displayed prominently.

Graphical components include:

- ✓ Bar Charts for waste type distribution
- ✓ Line Graphs for daily detection trends
- ✓ Doughnut Charts for bin usage distribution
- ✓ Top Items Analysis for frequently detected waste types

These visualizations assist authorities in identifying high-waste zones, understanding disposal behavior, and making informed decisions for waste management strategies. The system dynamically updates charts based on selected filters, ensuring real-time analytical insights.

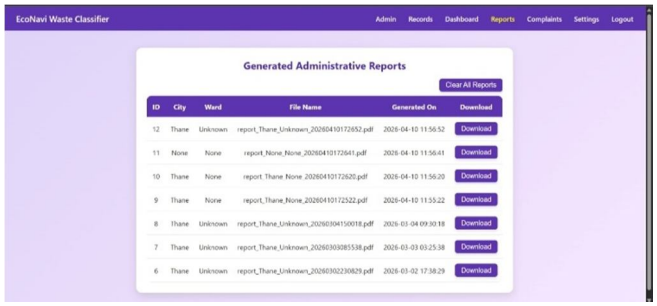

Figure 5: Generated Reports

D. Automated Report Generation System

The system includes an automated report generation feature that converts filtered waste data into structured PDF reports. These reports summarize key statistics and trends, making them suitable for submission to municipal authorities or higher administrative bodies.

Each report contains:

- ✓ Selected city/ward information
- ✓ Waste statistics summary
- ✓ Graphical representations
- ✓ Timestamp of report generation

The reports are stored within the system and can be accessed or downloaded later through the reports module. This functionality reduces manual effort and ensures standardized documentation for waste management operations.

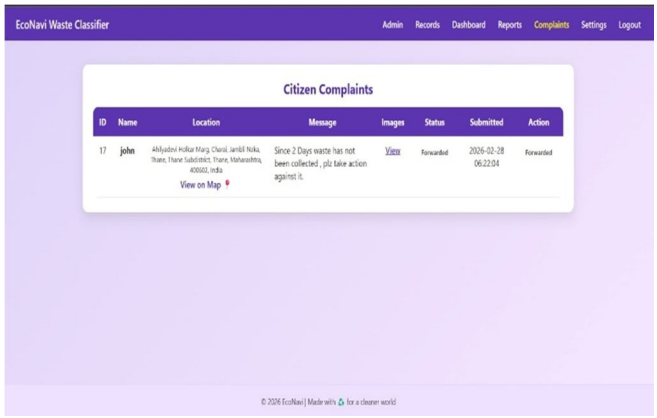

Figure 6: Citizen Complaints

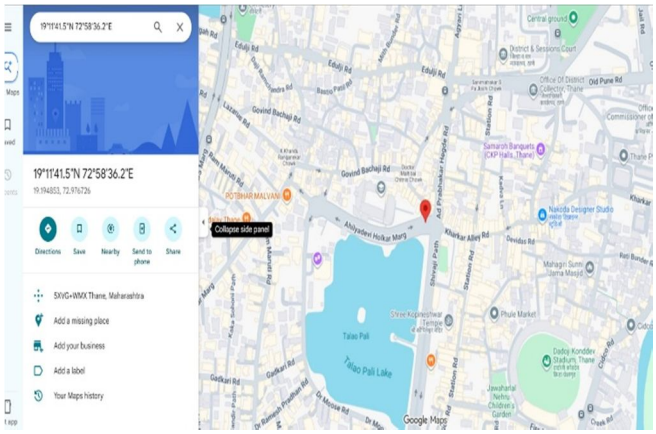

Figure 7: Location On Map

E. Complaint Management and Geo-Tracking System

The complaint management module allows citizens to report waste-related issues through the user interface. Each complaint includes user details, message description, uploaded images, and location data. The system extracts location either from browser permissions or image metadata (EXIF), ensuring accurate geo-tagging.

Administrators can:

- ✓ View complaints in a structured table
- ✓ Access uploaded images through modal previews
- ✓ Track complaint locations via integrated Google Maps
- ✓ Forward complaints to relevant municipal authorities

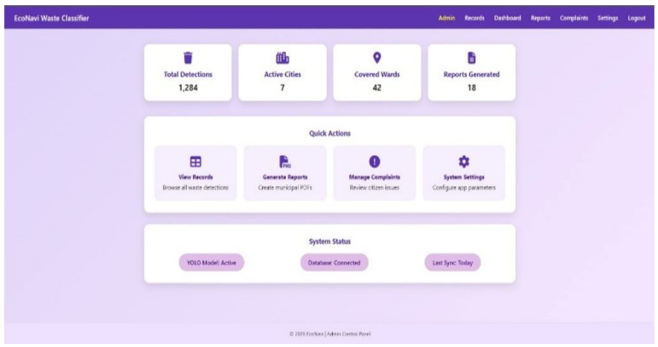

Figure 8: Admin Page

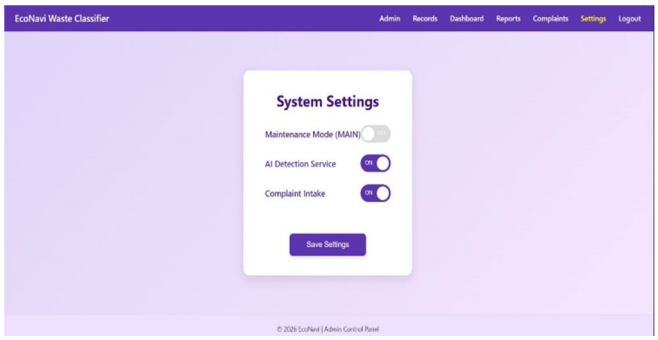

Figure 9: System Settings

F. Administrative Control Panel and System Settings

The system includes a centralized admin dashboard that provides an overview of platform activity and quick access to all modules. Key metrics such as total detections, active cities, covered wards, and reports generated are displayed for monitoring purposes.

Additionally, the settings module allows administrators to control system behavior through toggle-based configurations such as:

- ✓ AI Detection Service Enable/Disable
- ✓ Complaint Intake Control
- ✓ Maintenance Mode Activation

These controls ensure flexibility in system operation and simulate real-world deployment scenarios where services may need to be temporarily managed or restricted.

V. CONCLUSION

This The proposed AI-powered smart waste management and complaint redressal system successfully demonstrates the potential of integrating artificial intelligence with real-world environmental applications. By combining real-time object detection, structured data management, analytics, and user interaction, the system provides a comprehensive approach to addressing modern waste management challenges.

The implementation of the YOLOv8 model enables accurate and efficient waste classification, reducing dependency on manual segregation and minimizing human error. The storage of detection data along with location and time information allows for detailed analysis of waste patterns, which can be utilized for improving waste collection strategies and resource allocation.

The inclusion of an analytics dashboard enhances decision-making by presenting data in a visual and interpretable format. Additionally, the automated report generation feature simplifies documentation processes and supports communication with higher authorities. The complaint management module further strengthens the system by enabling direct citizen participation, ensuring that waste-related issues are reported and addressed promptly.

Overall, the system provides a scalable and practical solution for smart cities aiming to improve waste management efficiency and environmental sustainability. Future enhancements may include integration with IoT devices, deployment on mobile platforms, and expansion of the detection model to cover a wider range of waste categories. The project highlights the importance of combining technology with user-centric design to create impactful and sustainable solutions.

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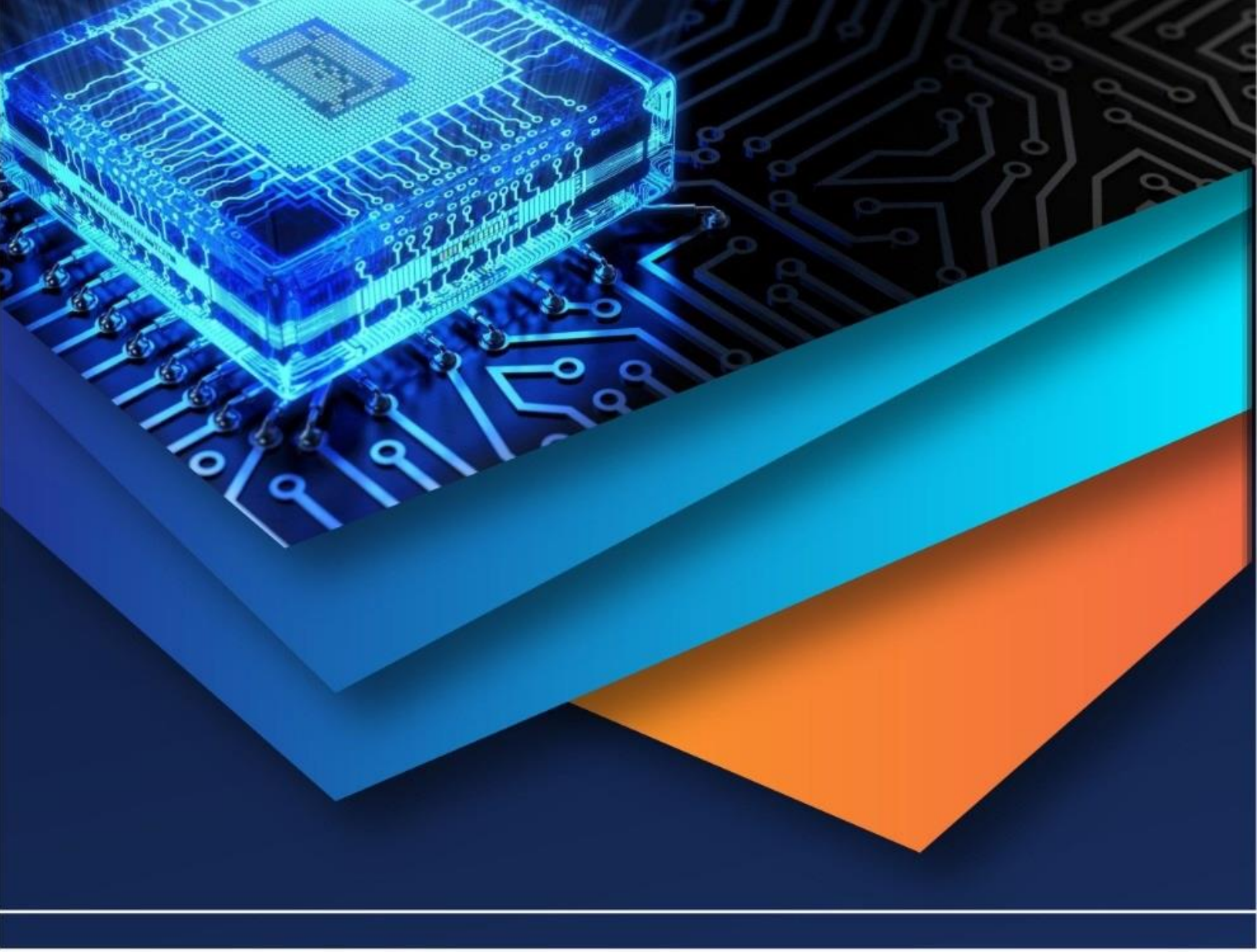

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