iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** VII **Month of publication:** July 2024

DOI: https://doi.org/10.22214/ijraset.2024.63499

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VII July 2024- Available at www.ijraset.com

Road Sense: Intelligent Road Monitoring System

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Abstract: This project proposes a system for detecting traffic signals, lane layouts, and speed bumps in road infrastructure using video footage through machine learning. Lane detection is performed through region of interest selection and edge detection. Lane lines are extracted based on specific characteristics. A deep learning model is trained to detect lane boundaries and road curvature. The system provides real-time alerts and recommendations to enhance road safety and driving experiences.
Keywords: YOLO v8, Object Detection, Lane Detection, Autonomous Vehicles, TensorFlow, Python

I. INTRODUCTION

Our advanced system combines computer vision and machine learning to enhance road. Safety and traffic management. By accurately detecting traffic signals, lane layouts, and curves, speed bumps in real-time, our solution aims to improve driver awareness and optimize traffic flow.

Our objective is to develop a robust real-time system for identifying and classifying various traffic signals. Through image preprocessing and color segmentation, we isolate signal regions based on their distinct colors.

Advanced algorithms, including blob detection, distinguish signals from other objects. We extract essential features like shape, size, position, and color to characterize the traffic signals.

Machine learning techniques, such as pattern recognition and deep learning, classify these features accurately, determining the specific signal type.

In addition, our system includes advanced lane detection. By defining a region of interest (ROI) and utilizing Canny edge detection, we identify lane markings with high contrast against the road surface. This enables us to extract lane lines for improved driver assistance and lane-keeping functionality.

II. PROPOSED METHODOLOGY

A. Image Extraction and Preprocessing

The project proposes a system for detection of traffic and road signals, lane and curve layouts for roads. It involves image or frames acquisition from video footage captured using cameras. This is followed by the image preprocessing to enhance resolution of the image and reduce noise.

B. Feature Extraction and Segmentation

Color segmentation is done to isolate regions containing the colors of the traffic signals by setting appropriate threshold values for hue, saturation, and value (HSV). Relevant features are then extracted from blobs to characterize the traffic signal. These features may include shape, size, position, and color information. A machine learning model is employed to classify the extracted features and determine the type of traffic signal. This is done using deep learning- based approaches of YOLO v8.

For lane detection, region of interest is defined to focus only on the road area. Typically, this region is a trapezoidal shape representing the area in front of the vehicle where lanes are expected to be present. Canny edge detection is applied to detect edges within the ROI. This helps identify lane markings that exhibit significant contrast with the road surface.

For speed bump detection, filtering the detected objects to focus on potential speed bumps based on their size, shape, and location within the frame. We use a classifier to distinguish speed bumps from other objects in the ROI. We are determining the precise location and dimensions of the detected speed bump.

C. Awareness Alerts

Based on the interpretations obtained from the algorithms, alerts and suggestions are provided to the driver and actions are recommended based on the potential problems.

III. ARCHITECTURAL DESIGN AND BLOCK DIAGRAM

This diagram signifies the main steps that are executed during the system run.

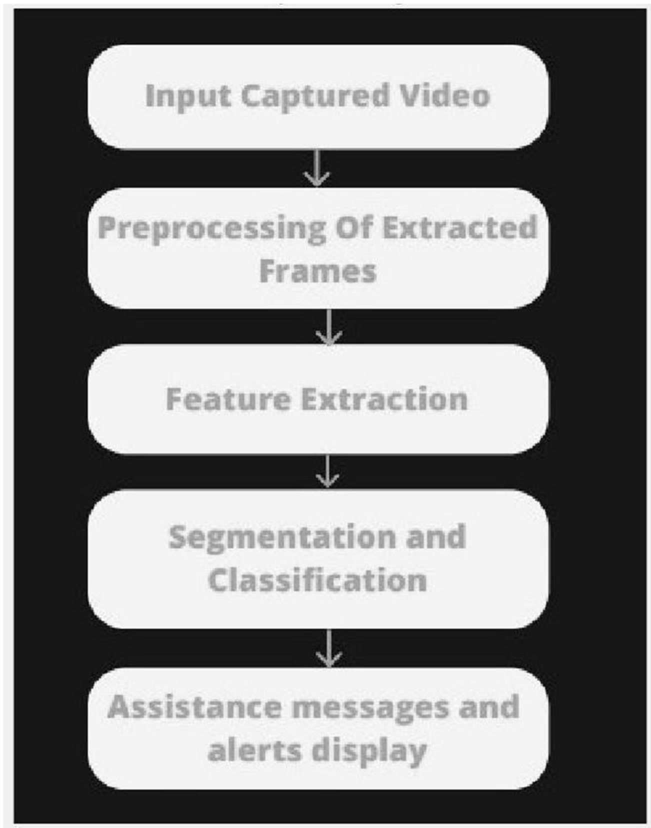


Fig – I

The below diagram shows the detailed working of the algorithms for producing successful alerts as output.

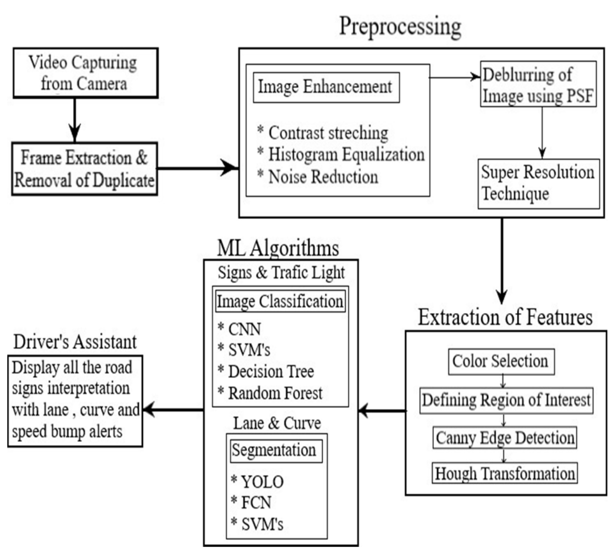


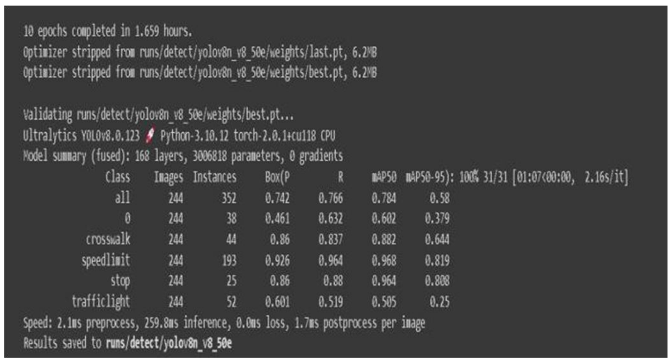
Fig – II

IV. ADVANTAGES OF THE NOVEL SOLUTION

1) Deep learning models handle complex scenarios such as lane changes, merging lanes, and intersections more effectively. They can capture the contextual information from the surroundings, such as the presence of other vehicles and road geometry, to make accurate predictions for different road layouts.

2) They achieve high accuracy in lane detection from diverse labelled-datasets and powerful architectures like convolutional neural networks (CNNs). The model can learn intricate lane patterns and generalizations that are difficult to achieve with handcrafted rules and heuristics.
3) ML algorithms like YOLO for image classification and object detection to find traffic lights and signals help analyzing large amounts of data in real-time for various traffic scenarios, weather conditions, and lighting variations without manual intervention.
4) Machine learning models extract relevant features and patterns from the data, making them more robust to noise and variations in the appearance of traffic signals and can be continuously adapt to evolving designs.
5) ML models allow integration of new features into current design to improve efficiency and can be easily deployed on different systems.

V. MODEL TRAINING AND ACCURACY



```
10 epochs completed in 1.659 hours.
Optimizer stripped from runs/detect/yolov8n_v8_50e/weights/last.pt, 6.2MB
Optimizer stripped from runs/detect/yolov8n_v8_50e/weights/best.pt, 6.2MB

Validating runs/detect/yolov8n_v8_50e/weights/best.pt...
Ultralytics YOLOv8.0.123 🚀 Python-3.10.12 torch-2.0.1+cu118 CPU
Model summary (fused): 168 layers, 3006818 parameters, 0 gradients
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100% 31/31 [01:07<00:00,  2.16s/it]
                   all        244        352      0.742      0.766      0.784       0.58
                     0        244         38      0.461      0.632      0.602      0.379
             crosswalk        244         44       0.86      0.837      0.882      0.644
            speedlimit        244        193      0.926      0.964      0.968      0.819
                  stop        244         25       0.86       0.88      0.964      0.808
          trafficlight        244         52      0.601      0.519      0.505       0.25
Speed: 2.1ms preprocess, 259.8ms inference, 0.0ms loss, 1.7ms postprocess per image
Results saved to runs/detect/yolov8n_v8_50e
```

Fig. 1. Model Training

Fig 2-Accuracy , Precision and Recall for Model

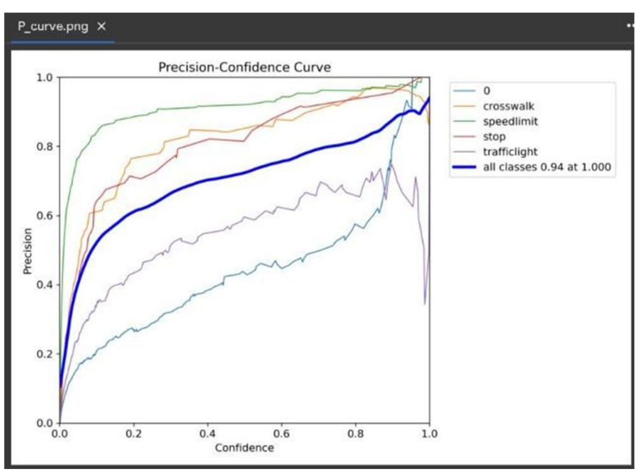


Fig 3 - Detailed graphs of the model training

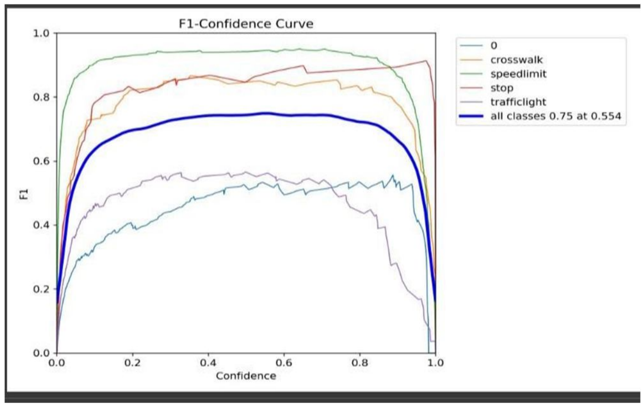


Fig 4 - F1- Confidence Curve

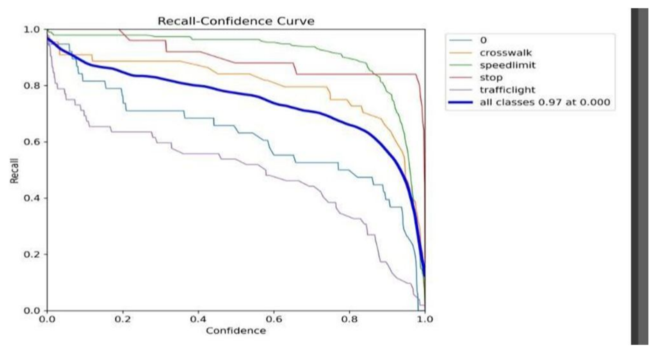


Fig 5- Recall Confidence Curve

VI. WORKING OF THE SYSTEM

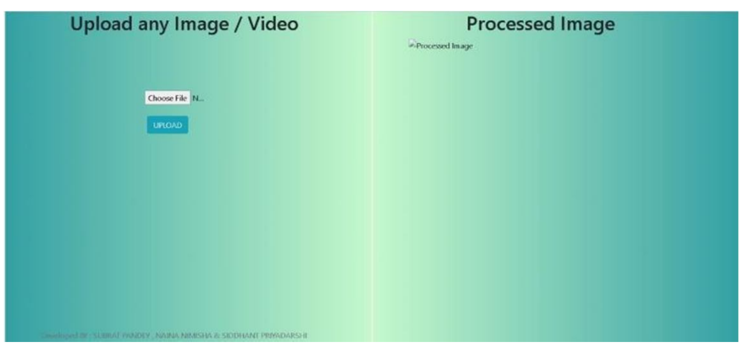


Fig 6 – User Interface of the System

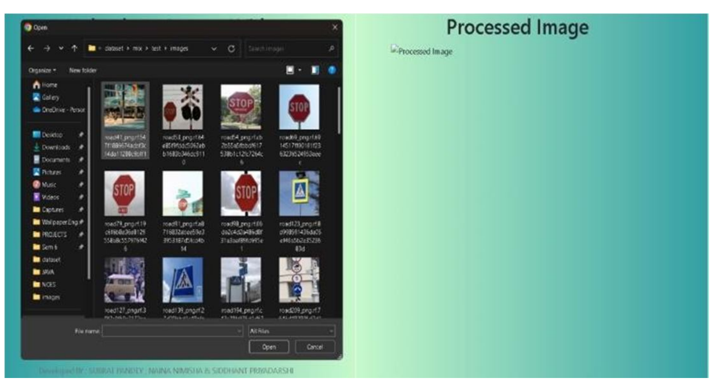


Fig 7- Pop up window to select input file

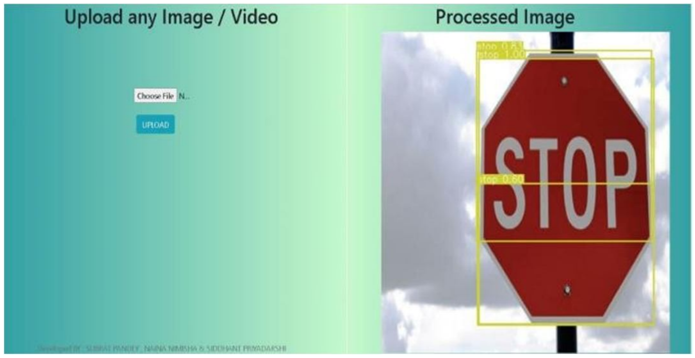


Fig 8 – Stop Sign detected after processing

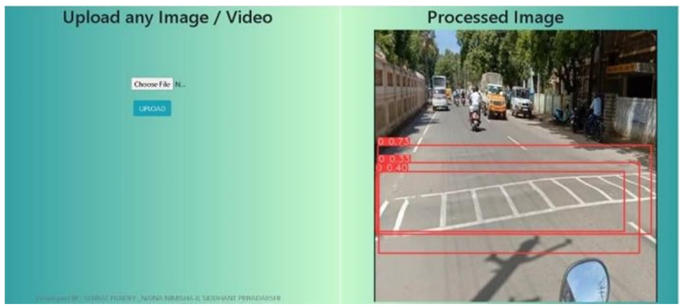


Fig 9 – Speed Bump detection being carried out

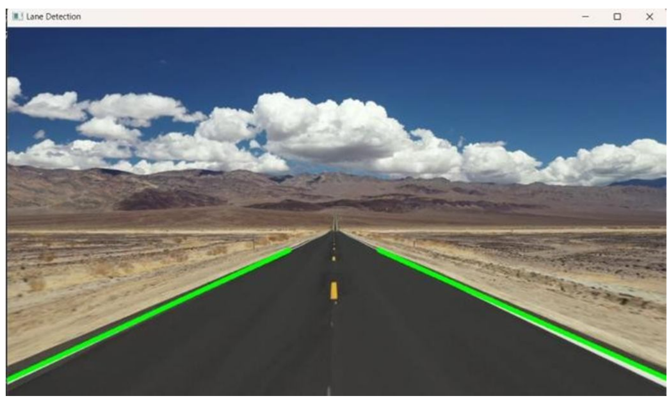


Fig 10 – Road Lanes detection and marking real-time

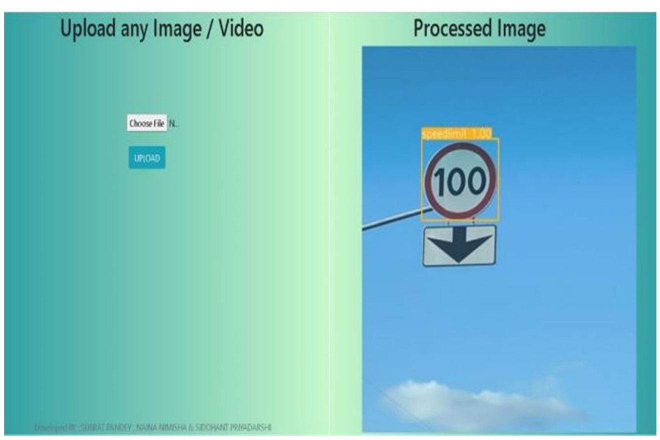


Fig 11 – Speed Limit detection and alert is sent

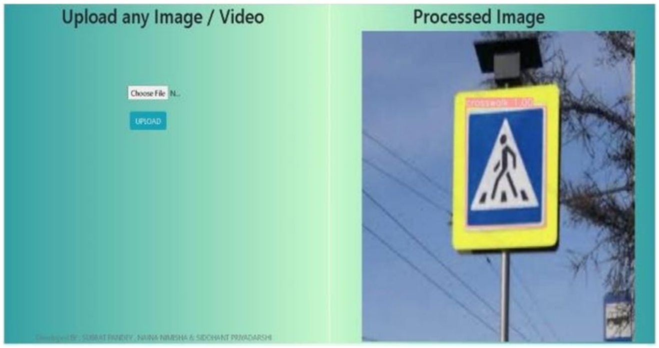


Fig 12 – Another Road Sign being detected after processing

VII. CONCLUSION

In conclusion, our road monitoring system offers significant advantages in improving road safety, traffic management, and lane detection. Its ability to provide real-time data, enhance safety, optimize traffic flow, and inform decision- making processes makes it a valuable tool for transportation authorities and road users alike.

The research findings have demonstrated the system's ability to accurately collect and analyze data to optimize traffic management strategies, detect curve layouts on the road, determining lanes and provide timely warnings to drivers about potential risks and avoid congestion on roads.

While this research is promising the benefits of this system, there may be challenges in terms of implementation, cost, and data management. Further studies and developments to include more features and develop a more interactive interface for user while maintaining the accuracy are essential to refine the system for releasing a prototype.

VIII. ACKNOWLEDGMENT

We would like to express our sincere gratitude to all individuals and organizations involved in this project. First to our guide Dr. Anusha Preetham for her insightful feedback and guidance during the research process. Secondly, to Prof. Mahanthesha U for encouraging the projects involving Digital Image Processing. Lastly, to our Artificial and Machine Learning Dept. for having a conducive environment to promote projects and research.

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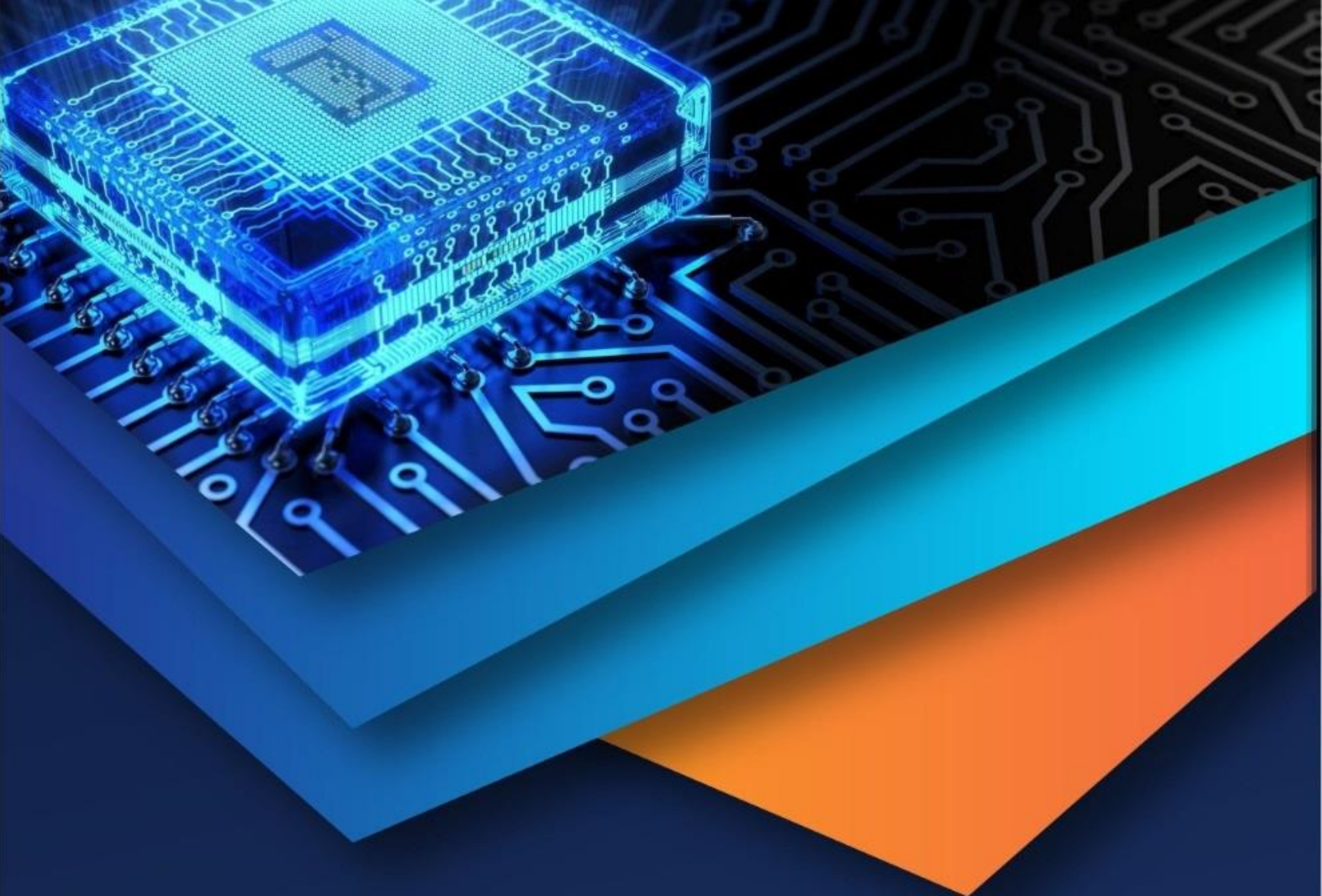

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