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Green Drive AI - Smart Traffic Management

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Abstract: *Urban areas today face major challenges such as traffic congestion, road safety violations, and increasing air pollution. Traditional traffic management systems rely on fixed signal timings and manual supervision, which are inefficient in handling dynamic traffic conditions. These limitations lead to longer waiting times, higher fuel consumption, increased carbon emissions, and unnoticed traffic violations. To address these issues, the proposed system,* ***GreenDrive AI****, introduces an intelligent, AI-powered traffic management solution. The system utilizes computer vision and deep learning techniques for real-time vehicle detection and helmet violation monitoring. OCR-based number plate recognition enables automated e-challan generation for traffic violations. A centralized dashboard provides real-time visualization of traffic flow, violation reports, and emission statistics for traffic authorities. By integrating technologies such as Python, OpenCV, deep learning models, and web-based frameworks, the system enhances decision-making and operational efficiency. GreenDrive AI aims to support eco- friendly urban mobility while functioning an assistive tool for traffic management authorities.*

Keywords: GreenDrive AI

I. INTRODUCTION

Traffic congestion, road safety violations, and rising air pollution have become serious challenges in modern urban environments. With rapid urbanization and increasing vehicle density, managing traffic efficiently has become more complex than ever before. Conventional traffic management systems mainly rely on fixed signal timings and manual monitoring, which fail to respond effectively to changing and dynamic traffic conditions. As a result, vehicles experience longer waiting times at intersections, leading to fuel wastage, increased greenhouse gas emissions, and reduced overall traffic efficiency. Additionally, violations such as riding without helmets, signal jumping, and other unsafe driving practices often go undetected due to limited manual supervision.

To overcome these challenges, there is a strong need for intelligent, automated, and data-driven traffic management solutions. In this context, the proposed project, GreenDrive AI, introduces an AI-based intelligent traffic management and emission monitoring system. The system integrates computer vision, deep learning, and real-time traffic analysis to optimize urban traffic flow and enhance road safety. It includes modules for vehicle detection, helmet detection, adaptive traffic signal control based on traffic density, and carbon emission estimation at intersections.

II. RELATED WORK

Several urban areas currently use traditional traffic management systems to control vehicle movement and monitor road conditions. These systems mainly rely on fixed traffic signals, CCTV surveillance, and manual supervision by traffic authorities. Basic features such as vehicle monitoring, signal control, and violation reporting are available, helping authorities maintain traffic discipline. However, most of these systems focus mainly on basic control and do not provide advanced analysis or intelligent insights into traffic conditions.

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Some research studies have proposed smart traffic management systems developed using technologies like computer vision, machine learning, and web- based platforms. These systems support features such as vehicle detection, traffic density estimation, and automated monitoring, making traffic management more efficient and organized. Despite these advantages, many of these systems lack real- time adaptability, predictive capabilities, and integration of multiple functionalities in a single platform.

III. LITERATURE REVIEW

1 "Real-Time Traffic Signal Control Using Artificial Intelligence" was proposed by S. B. Pradhan R.K.Gupta.
The researchers developed an intelligent traffic signal control system using artificial intelligence algorithms to manage traffic flow at busy intersections. The system analyzed vehicle density and dynamically adjusted traffic signal timings to reduce congestion. The study showed that adaptive signal control significantly reduced average waiting time and improved overall traffic movement. The authors concluded that AI-based traffic control systems can perform better than traditional fixed- timing traffic signals.

2"Automatic Helmet Detection System Using Computer Vision" was proposed by R. Silva and P. Rodrigues.''
The researchers proposed a computer vision–based system for detecting two-wheeler riders without helmets using surveillance camera images. The system used image processing techniques and deep learning models such as Convolutional Neural Networks (CNN) for object detection. Experimental results demonstrated high accuracy in identifying helmet violations in real-time traffic conditions. The proposed system helps traffic authorities improve road safety and automate law enforcement.

3 "Intelligent Traffic Management System Using Deep Learning" was proposed by M. A. Khan and S.Lee.
The study introduced a deep learning–based traffic monitoring system that analyzes real-time traffic videos to detect vehicles and measure traffic density. The system applied object detection algorithms to classify different types of vehicles and evaluate congestion levels. Based on the traffic density, the system optimized signal timings and improved traffic flow efficiency. The research highlighted the importance of AI technologies in building smart city transportation systems. The proposed system also demonstrated improved accuracy in vehicle detection under different lighting and weather conditions.

IV. PROBLEM STATEMENT

In the current traffic management system, controlling and monitoring traffic efficiently is a major challenge due to the limitations of traditional methods. Most traffic systems rely on fixed signal timings and manual supervision, which do not provide a complete view of real-time traffic conditions, vehicle density, or road safety violations. Traffic authorities often find it difficult to manage congestion during peak hours, and violations such as helmet non-compliance frequently go lack o real- The proposed Green Drive AI – Smart Traffic Management system is an intelligent platform designed to monitor, analyze, and manage urban traffic efficiently. It connects traffic authorities and monitoring systems into a centralized platform to improve traffic flow, enhance road safety, and reduce environmental impact. The system aims to provide real-time insights, detect violations, and support adaptive traffic control.

V. PROPOSED SYSTEM OVERVIEW

The system includes a web-based dashboard and a backend integrated with AI models and a centralized database. Traffic data is collected through cameras installed at road intersections. Using computer vision and deep learning techniques, the system detects vehicles, analyzes traffic density, and identifies violations such as helmet non-compliance..

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VII SYSTEM ARCHITECTURE

The Green Drive AI – Smart Traffic Management system is an intelligent platform that connects traffic monitoring devices and authorities within a single integrated system. Its main objective is to simplify the process of monitoring, analyzing, and managing traffic conditions, ensure road safety, and support eco-friendly transportation using modern technologies and a centralized database.The system uses cameras and sensors at road intersections to collect real-time traffic data. A dashboard-based frontend provides user interaction

1. Modules

1.1 Admin Module

In this module, the administrator can securely log into the system and manage overall operations. After logging in, the admin can monitor traffic data, manage system settings, and control access permissions. The admin is responsible for overseeing traffic conditions, violation records, and emission reports. The admin can also view overall analytics, generate reports, and track traffic trends across different locations. Additionally, the admin ensures system security and smooth functioning of all modules.

1.2 Traffic Monitoring Module

Traffic authorities can securely log into the system to monitor and manage real-time traffic conditions. After logging in, they can view live traffic data, vehicle density, and violation alerts such as helmet non-compliance. The system analyzes this data to show traffic patterns and congestion levels. Authorities can monitor different intersections, view reports, and take necessary actions to improve traffic flow and road safety.

1.3 Dashboard Module

The dashboard provides a centralized interface for visualizing all system data. It displays real-time traffic flow, vehicle count, violation alerts, and carbon emission statistics. The system highlights congestion areas and important alerts, helping authorities quickly understand traffic conditions. Users can analyze trends, view graphical reports, and track overall system performance through this module.

2. Backend Architecture (ASP.NET & AI Integration)

The system uses Python and AI-based services to manage data processing, analysis, and traffic monitoring:

1. Authentication: Ensures secure login and access control for administrators and traffic authoritie.
2. Database (SQL Server): Stores traffic data, vehicle records, violation details, and emission reports
3. AI Integration (OpenCV, TensorFlow / PyTorch): Used for vehicle detection, helmet detection, traffic analysis, and pattern recognition
4. OCR Integration: Used for number plate recognition and violation tracking
5. Backend Logic (Python & .NET Core API): Handles data processing, communication between modules, and real-time traffic analysis

3. Approval and Notification Workflow

- Cameras capture real-time traffic data from road inter sections
- The system processes video data using AI models for detection and analysis
- Traffic density, vehicle count, and violations are identified
- Based on analysis, signal timings are adjusted dynamically
- If any violation (like no helmet) is detected, the system generates alerts
- Traffic data, alerts, and reports are displayed on the dashboard for authorities

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VII. IMPLEMENTATION DETAILS

The implementation of the Green Drive AI – Smart Traffic Management system consists of four main steps: Data Collection, Traffic Analysis, AI-Based Detection and Optimization, and Dashboard Visualization.

Data Collection and Input

Traffic data is collected using cameras installed at intersections. The system captures real-time video input and extracts relevant information such as vehicle count and movement. All data is validated and stored securely in the database for further processing.

Traffic Analysis and Processing (AI Model)

The system uses AI and computer vision models to analyze video data. It performs vehicle detection, helmet detection, and traffic density estimation. The system identifies traffic patterns and detects violations automatically, enabling intelligent decision-making.

SYSTEM AECHITECTURE

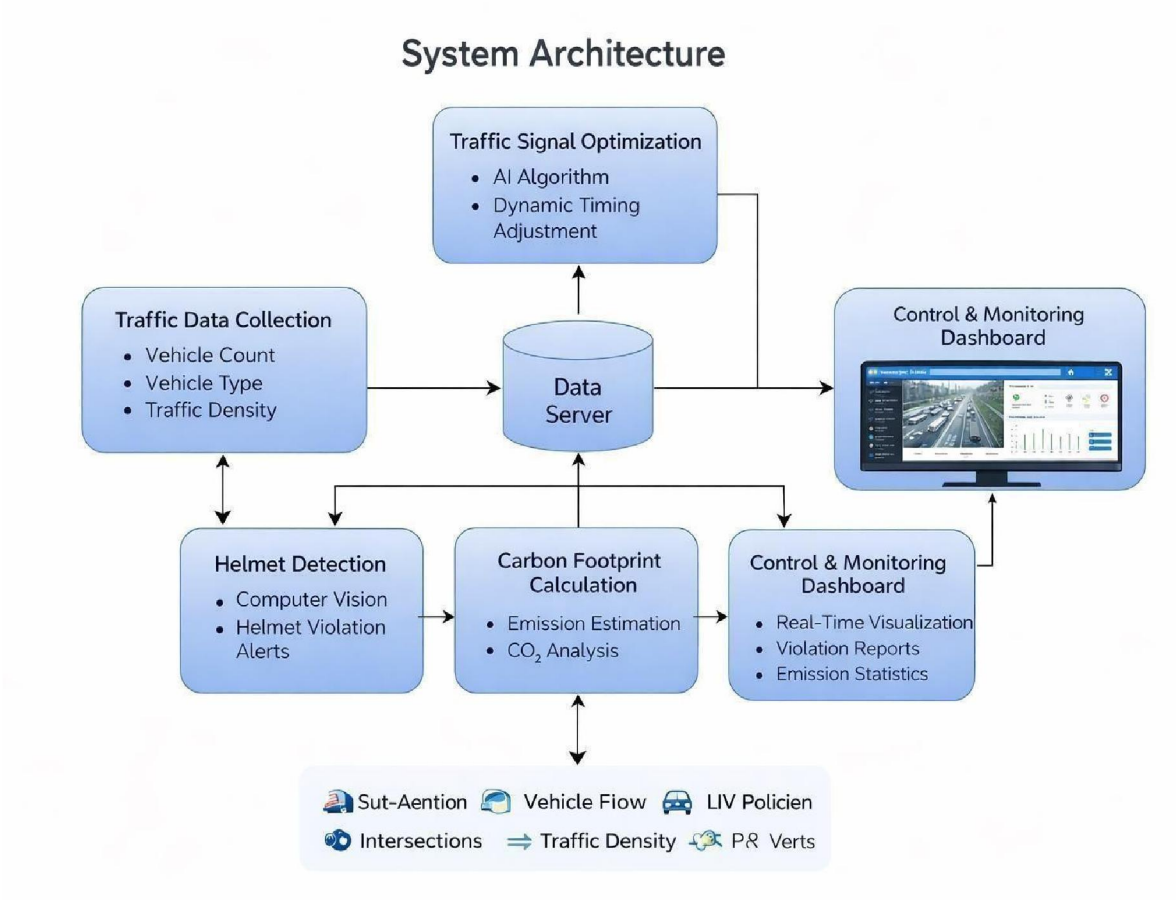

Figure 1: System architecture

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VIII. PROPOSED SYSTEM

System Architecture:

System Architecture is shown in Figure 1.

Our proposed system will function in the following steps:

Step 1: Traffic Data Collection

Cameras installed at road intersections capture real-time traffic data such as vehicle count, vehicle type, and traffic density.

Step 2: Data Storage

The collected data is sent to a centralized data server where it is stored and managed for further processing.

Step 3: Data Processing and Analysis

The system processes the data using AI and computer vision techniques to detect vehicles, analyze traffic density, and identify patterns.

Step 4: Helmet Detection

The system uses computer vision models to detect whether two-wheeler riders are wearing helmets and generates violation alerts if not.

Step 5: Traffic Signal Optimization

Based on real-time traffic density, AI algorithms dynamically adjust traffic signal timings to reduce congestion and waiting time.

Step 6: Carbon Footprint Calculation

The system estimates CO_2 emissions based on vehicle density and idle time to identify high pollution zones.

Step 7: Dashboard and Monitoring

All processed data, including traffic flow, violations, and emission statistics, is displayed on a centralized dashboard for traffic authorities.

IX. ANALYSIS OF PROPOSED SYSTEM

1. Enhanced Efficiency and Real-Time Insights:

The Green Drive AI system improves traffic monitoring efficiency by providing real-time data analysis and visualization. It reduces manual effort and enables faster response to traffic conditions.

2. Intelligent Analysis and Automation:

The system uses AI and computer vision to automatically detect vehicles, analyze traffic density, and identify helmet violations. This ensures accurate and fast decision-making without manual intervention.

3. Secure and Centralized Control:

The platform provides centralized control for traffic authorities with secure access. All traffic data, violation records, and reports are stored and managed efficiently.

4. Improved Decision-Making and Transparency:

The system provides clear insights through dashboards, reports, and alerts. Authorities can monitor traffic conditions, identify congestion areas, and take timely actions, improving overall traffic management.

1. MODULES

The proposed AI-Based Student Performance Tracker is divided into four main modules: Student, Teacher, Admin, and Notification. Each module is designed to handle specific functionalities and ensure smooth operation of the system.

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X. MODULES

The proposed Green Drive AI – Smart Traffic Management system is divided into the following main modules:

1. Traffic Data Collection Module

This module captures real-time traffic data using cameras. It collects vehicle count, vehicle type, and traffic density for analysis.

2. Traffic Signal Optimization Module

This module dynamically adjusts signal timings based on real-time traffic conditions to reduce congestion and improve traffic flow.

3. Helmet Detection Module

This module detects riders without helmets using computer vision and generates violation alerts automatically.

4. Carbon Footprint Calculation Module

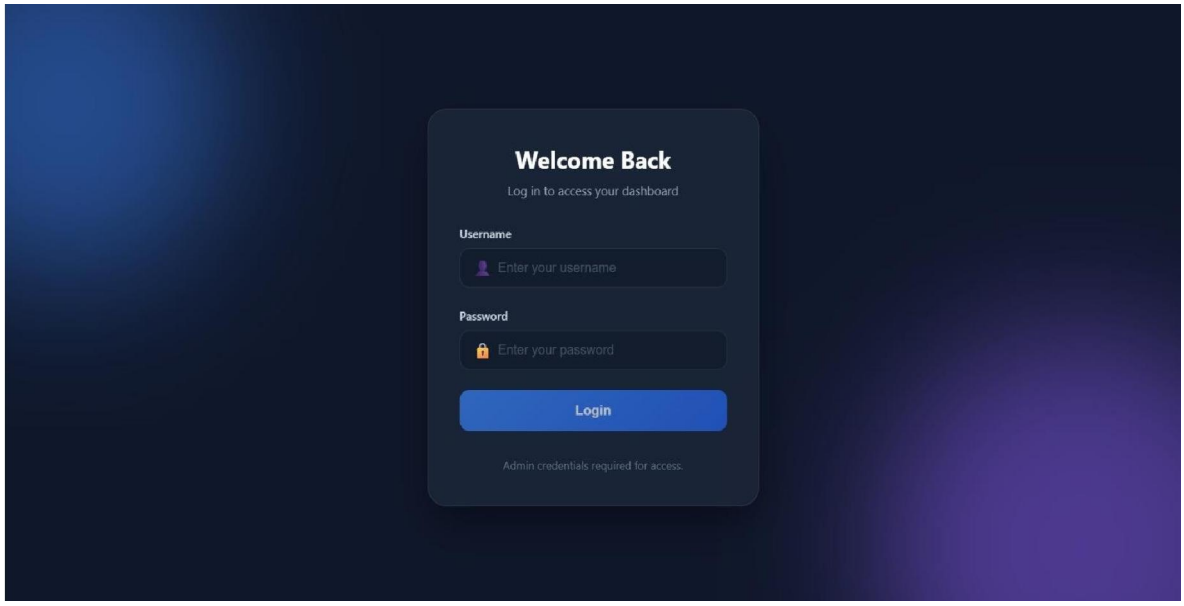
This module estimates CO_2 emissions based on traffic density and idle time, helping identify high pollution areas.

5. Control & Monitoring Dashboard Module

This module provides real-time visualization of traffic data, violation reports, and emission statistics for better decision-making.

RESULTS

Admin Dashboard



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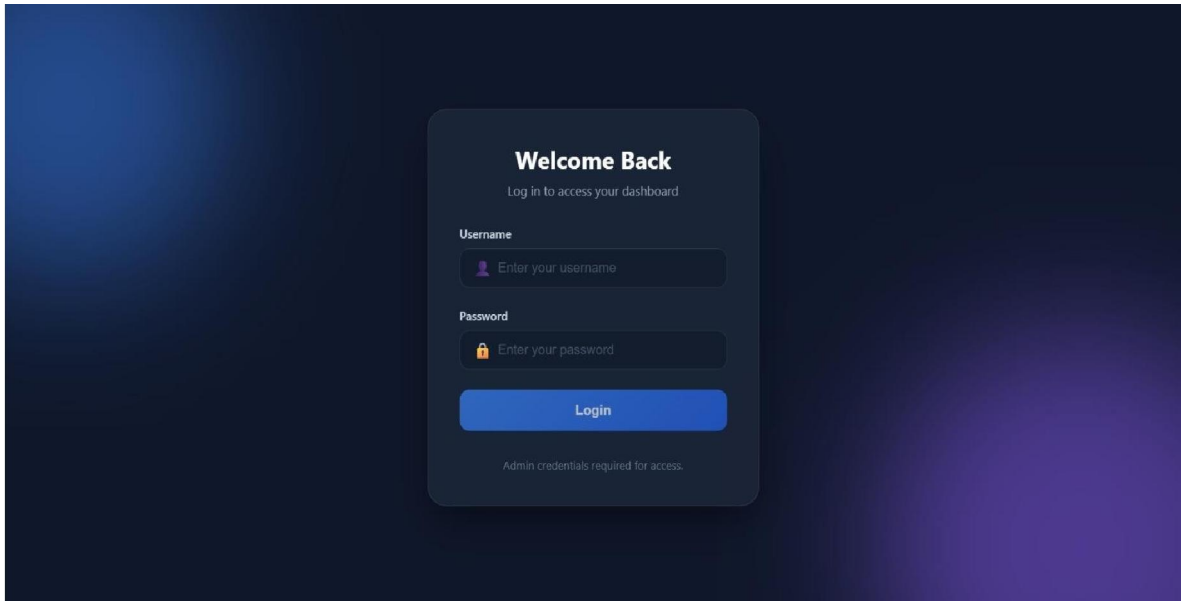
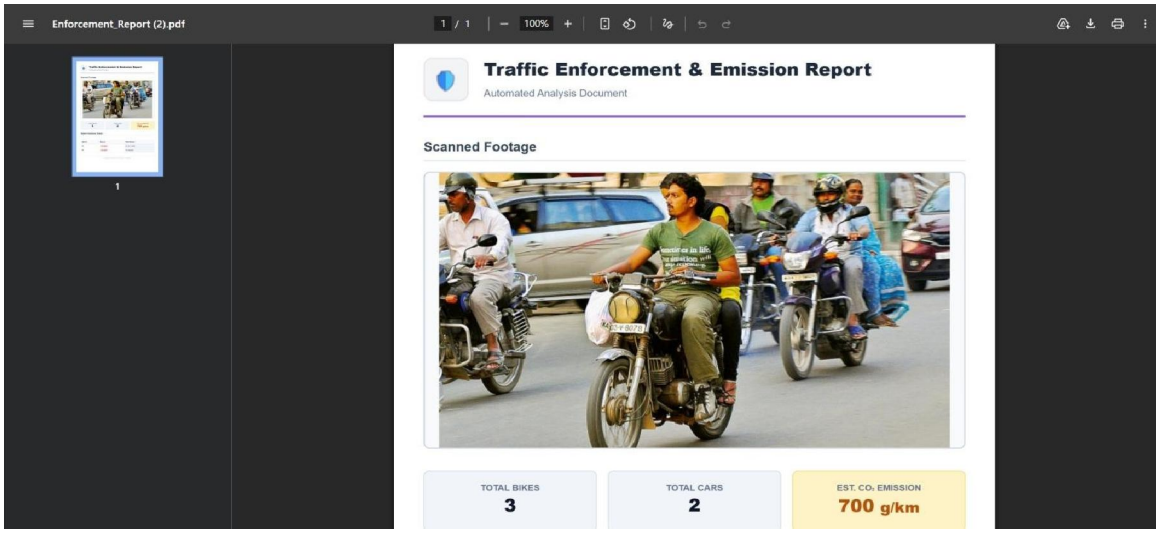
AQI Dashboard:



Traffic Report:



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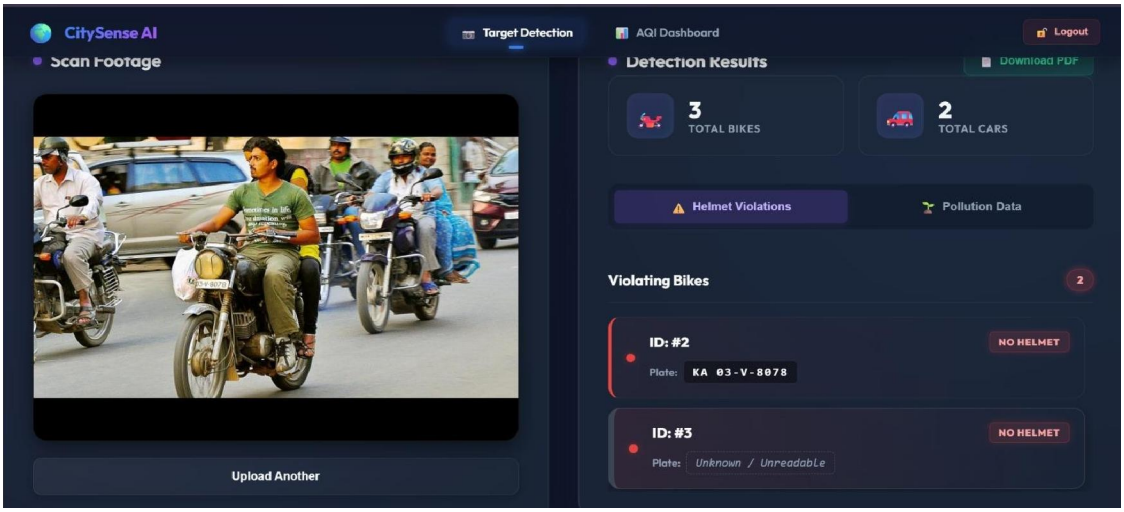
Target Detection:



IX. CONCLUSION

The Green Drive AI – Smart Traffic Management system demonstrates how modern technologies can improve traffic management by making monitoring faster, smarter, and more efficient. The system automates the process of traffic analysis, vehicle detection, violation monitoring, and signal control, reducing manual effort and minimizing errors associated with traditional traffic systems. It provides authorities with a centralized platform to manage real-time traffic data effectively and support better decision-making.The integration of Artificial Intelligence and computer vision techniques helps in analyzing traffic flow, detecting vehicles, identifying helmet violations, and optimizing signal timings based on real-time traffic density. Technologies such as Python for AI processing, .NET Core for backend operations, and SQL Server for database management ensure that the system is efficient, scalable, and capable of handling real-world traffic conditions.

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