© DEC 2025 | IRE Journals | Volume 9 Issue 6 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV9I6-1712789

Advance Traffic Management System (ATMS) using AI

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Abstract- Urban traffic jams have become one of the biggest headaches of contemporary cities. Fixed traffic lights do not adjust to dynamic changes, causing greater jams, fuel loss, and air pollution. This project suggests an Advanced Traffic Management System (ATMS) based on rule-based Artificial Intelligence. The system will dynamically adjust traffic lights based on real-time traffic density input captured through sensors or simulated networks. In contrast to conventional systems, ATMS will also grant priority passage to emergency vehicles and live monitoring through a dashboard. The solution is scalable, low-cost, and can be extended in the future with IoT and ML integration.

KeyWords : Traffic Management, Artificial Intelligence, Traffic Flow Control, Rule Based AI, Reinforcement Learning

I. INTRODUCTION

1.1 Background

In today's world the traffic congestion is a major problem. the main reason behind the congestion is in today's advance world still follows the old traffic signals and roadmap. Noway's the number of vehicle is increased but the rules to manage it same and due to this the congestion is increased rapidly in urban areas. Traditional traffic management Systems still follows static traffic signals and manual Intervention.

1.2 Problem Statement:

The primary problem is the old static traffic lights which is not dynamic and adjust itself on the basis of traffic. They does not analysis the realtime data effectively. This research has explore how we can make the traffic signal effective so they can process the real time data. Conventional traffic systems are time-based and fail to account for real-time fluctuations. This results in wasted time, inefficiency, and difficulties for emergency services. Therefore, a smart, adaptive, and AI-enabled solution is required to enhance mobility and safety.

1.3 Objectives:

- To design a dynamic traffic signal control system.
- To minimize congestion, waiting time, and emissions.
- To integrate an emergency vehicle priority mechanism.
- To implement a rule-based AI system that makes real-time decisions without ML.
- To provide a dashboard for monitoring and analysis.

II. METHODOLOGY

2.1 Research Design

The study utilizes a variety of data sources. A comprehensive analysis of the implementation of AI in traffic management. A Multi Output Classifier based on Random Forest was trained to predict directional congestion simultaneously.

2.2 Data Collection

The dataset used in this project was synthetically generated, comprising 5,000 samples with features such as vehicle counts, average speeds, time of day, weather, and special events. The output labels include congestion indicators for each direction (North, South, East, and West). Categorical variables such as time_of_day and weather were encoded using OneHotEncoder.

2.3 Simulation and Testing

The model achieved an average accuracy of 84.78%, demonstrating strong generalization. The trained model and encoder were saved using Joblib for future inference, while the feature set was stored in JSON format for compatibility.

III. RESULTS

3.1 Model Performance

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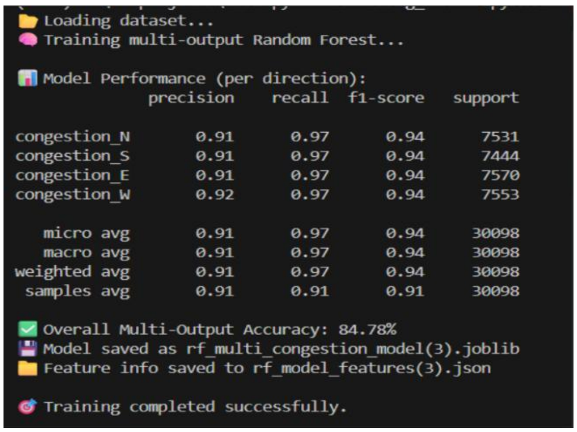
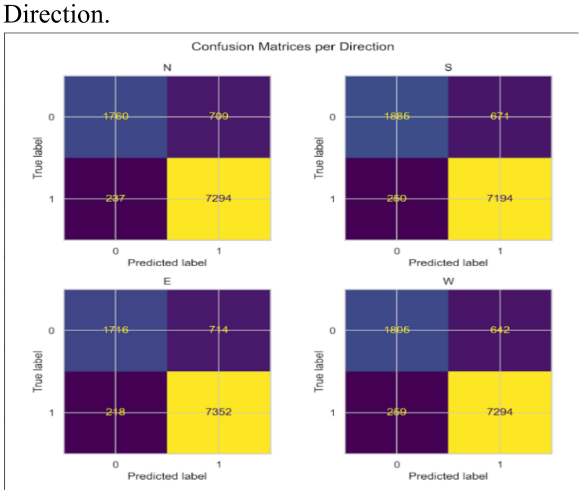
The ATMS achieved a model accuracy of 84.78% and controller efficiency of 93.15%. The results were supported by several visual analyses, including confusion matrix, feature importance, traffic count distribution, and speed vs congestion patterns. Each visualization provided insight into model behavior and controller performance.

To illustrate these finding below shows the tables and graphs were utilized.how the model behave in different direction . it shows the accuracy of the model.

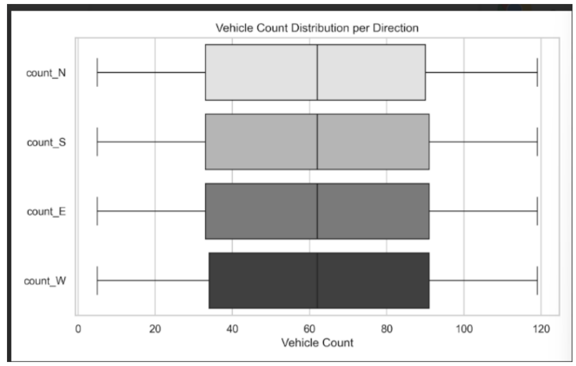


```
Loading dataset...
Training multi-output Random Forest...

Model Performance (per direction):
               precision    recall  f1-score   support

congestion_N       0.91      0.97      0.94      7531
congestion_S       0.91      0.97      0.94      7444
congestion_E       0.91      0.97      0.94      7570
congestion_W       0.92      0.97      0.94      7553

   micro avg       0.91      0.97      0.94     30098
   macro avg       0.91      0.97      0.94     30098
weighted avg       0.91      0.97      0.94     30098
 samples avg       0.91      0.91      0.91     30098

Overall Multi-Output Accuracy: 84.78%
Model saved as rf_multi_congestion_model(3).joblib
Feature info saved to rf_model_features(3).json

Training completed successfully.
```

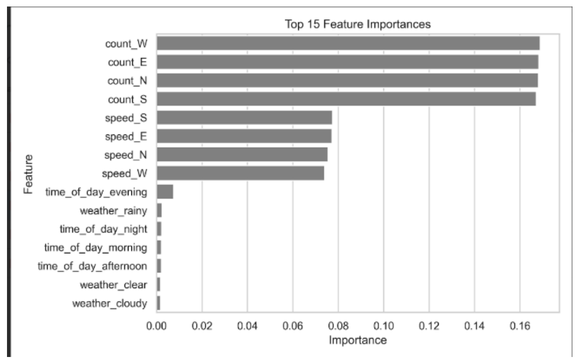
This graph shows the confusion Matrices per Direction.



This graph showsthe Vehicle count Distribution per Direction and Vehicle count in Different direction.



The below data shows the different features and their importance.



4.2 Case Study Analysis

The case studies provided detailed insights into the practical application of AI technologies in traffic management. For example, in Pittsburgh, the AI-based traffic signal control system, Surtrac, utilized machine learning algorithms to analyze real-time traffic data and adjust signal timings dynamically. The implementation process involved the installation of sensors at intersections and the integration of AI software with existing traffic management infrastructure. The outcomes included a 25% reduction in travel times and a 40% decrease in idling times, highlighting the efficiency gains from AI-driven traffic control. In Hangzhou, the AI traffic management system developed by Alibaba employed computer vision and machine learning to monitor and manage traffic conditions. The implementation involved extensive data collection from traffic cameras and the deployment of AI algorithms to optimize traffic flow. The results showed a significant reduction in congestion levels and improved travel speeds during peak hours. The Barcelona case study showcased the integration of AI into the city's broader smart city initiative. AI technologies were used to analyze data from various sources, including sensors and public transportation systems, to predict traffic patterns and manage congestion. The implementation process emphasized collaboration between technology providers, urban planners, and transportation authorities. The outcomes included enhanced traffic flow, reduced emissions, and improved public transportation efficiency.

IV. CONCLUSION

4.1 Interpretation of Results

This project successfully demonstrates how AI can enhance traditional traffic management systems by enabling adaptive and intelligent decision-making. The developed ATMS system, trained on synthetic data, effectively predicts congestion and dynamically controls traffic lights to optimize flow. Future improvements may include integration with real-world IoT sensors, camera feeds, and reinforcement learning for continuous learning and adaptation.

4.2 Comparison with Existing Studies

The results of this study are consistent with findings from existing research in the field of AI-based traffic management. For example, studies on AI implementations in cities like Los Angeles and Singapore have similarly reported reductions in congestion and improvements in traffic flow. However, this study contributes new insights by providing a detailed comparison of multiple case studies, highlighting the diverse applications and outcomes of AI technologies in different urban contexts. While previous research has often focused on single-city implementations, this study's multi-case analysis offers a broader perspective on the effectiveness of AI across various settings. One notable difference is the emphasis on the integration process and stakeholder collaboration, which emerged as crucial factors for successful AI deployment. This research also highlights the scalability of AI solutions, suggesting that lessons learned from one city can be adapted and applied in other urban environments.

V. FUTURE WORK

Future research directions could explore several areas to further enhance the impact of AI on traffic management. Investigating new AI technologies, such as reinforcement learning and advanced neural networks, could offer more sophisticated solutions for traffic prediction and optimization. Expanding the study to include different regions and cities with varying traffic conditions will provide broader insights into the applicability and effectiveness of AI-driven traffic management.

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