AI- and IoT-Driven Traffic Management for Urban Congestion Reduction

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Objective & Research Question:

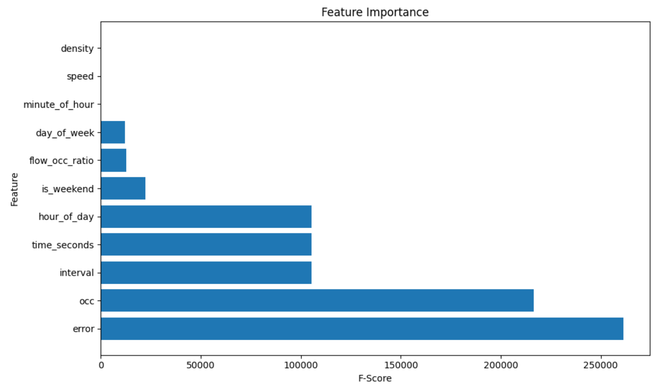
The goal of the project is to develop an Intelligent Traffic Management System (ITMS) that uses real-time IoT data and AI to optimize traffic signals and routing. It explores whether these technologies can lower congestion, fuel consumption, and emissions to promote sustainable urban transportation.

Background:

- Urban traffic congestion leads to increased travel delays, higher fuel consumption, and elevated CO_2 emissions.
- Current IoT systems in cities like Los Angeles and Singapore show promise but lack real-time adaptability.
- Integrating AI-driven predictive modeling with IoT data can provide dynamic control of traffic signals, reducing bottlenecks.
- An Intelligent Traffic Management System (ITMS) is needed to optimize flow, minimize environmental impact, and enhance public safety.

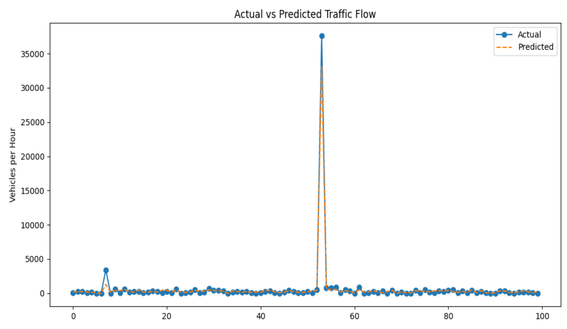
Methods:

- Data Collection: Used UTD19 dataset with real-world traffic data from 40 cities.
- Data Preprocessing: Cleaned and normalized data for training.
- Feature Engineering: Selected key features like traffic density, speed, and time of day.
- Model Development:
  - LSTM Model: Predicts future traffic congestion based on historical data.
  - RL Model: Optimizes traffic signal timings to reduce congestion.
- Evaluation: Assessed models using metrics like MAE and RMSE for LSTM and Q-table heatmap for RL.

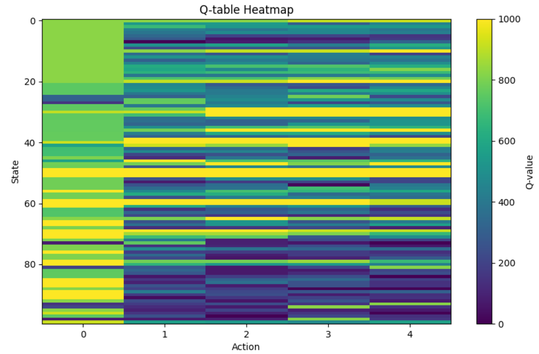


Results:

- LSTM Model:
  - Mean Absolute Error (MAE): ~102 vehicles/hour
  - Root Mean Squared Error (RMSE): ~232 vehicles/hour
  - Prediction Plot: Shows "Actual vs Predicted Traffic Flow" below.



- RL Model:
  - Q-table Heatmap: Shows “Learned state-action values for optimizing traffic signals” below.



Conclusion:

- Urban traffic congestion leads to increased travel delays, higher fuel consumption, and elevated CO_2 emissions.
- Integrating AI-driven predictive modeling with IoT data can provide dynamic control of traffic signals, reducing bottlenecks.
- An Intelligent Traffic Management System (ITMS) is needed to optimize flow, minimize environmental impact, and enhance public safety.

Future Work:

- Integrate ITMS with SUMO for real-time simulation of urban traffic scenarios.
- Expand RL model to consider multi-agent systems for multiple intersections.

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