AI BASED TRAFFIC MANAGEMENT SYSTEM FOR SMART CITIES

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***Abstract*—Urban traffic congestion is one of the most critical challenges faced by modern cities, leading to significant economic losses, environmental pollution, and reduced quality of life. Existing traffic management systems are often inadequate in addressing dynamic traffic patterns. This project proposes an AI-based traffic management system that leverages historical traffic datasets to develop a predictive Artificial Neural Network (ANN) model. The model is designed to forecast traffic signals, thereby optimizing traffic flow, reducing congestion, and improving urban mobility. By anticipating traffic patterns, the system enables proactive traffic management strategies that reduce travel time and enhance air quality.**

***Index Terms*—AI, Traffic Management, Smart Cities, ANN, RNN, Traffic Congestion, Traffic Forecasting, Neural Networks**

I. Introduction

With the rise of urbanization, traffic congestion has become a growing concern, contributing to wasted time, increased fuel consumption, and environmental degradation. Traditional traffic management systems often fail to account for real-time and dynamic traffic conditions. To address these challenges, smart cities are integrating AI technologies for better traffic control and management.

This paper presents an AI-based traffic management system aimed at smart cities, using Artificial Neural Networks (ANNs) to predict traffic patterns and optimize signal timings. The system leverages real-time data to enhance urban mobility and reduce congestion, thus contributing to a more sustainable urban environment.

II. Problem Statement

Urban areas are increasingly burdened by traffic congestion, resulting in economic losses, fuel wastage, accident risks, driver frustration, and environmental harm. Current traffic management systems are often reactive rather than proactive, leading to inefficiencies in managing dynamic traffic conditions. This project aims to address these issues by developing an AI-based system capable of predicting traffic flow and optimizing signal timings to reduce congestion and improve travel times.

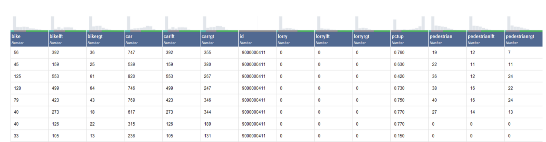
III. Objective

The primary objective of this project is to design, develop, and deploy an advanced AI-based traffic management system for smart cities. The system utilizes real-time data to predict traffic patterns, optimize traffic signal timings, identify congestion hotspots, and suggest alternative routes. Ultimately, the project aims to:

- Reduce traffic congestion.
- Improve travel times.
- Optimizing traffic managment system.
- Contribute to urban livability by leveraging AI technologies.

IV. Methodology

1) Data Collection and Preprocessing
Traffic data for the project is extracted from OpenML, consisting of over 1,000 rows and 25 columns detailing traffic patterns collected via cameras. This dataset is used to predict traffic flow and manage traffic signal timings efficiently. The data undergoes preprocessing to ensure that it is suitable for time-series forecasting.



bike	bikelft	bikergt	car	carlft	carrgt	id	lorry	lorrylft	lorryrgt	pctup	pedestrian	pedestrianlft	pedestrianrgt
Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number
56	392	36	747	392	355	9000000411	0	0	0	0.760	19	12	7
45	159	25	539	159	380	9000000411	0	0	0	0.630	22	11	11
125	553	61	820	553	267	9000000411	0	0	0	0.420	36	12	24
128	499	64	746	499	247	9000000411	0	0	0	0.730	38	16	22
79	423	43	769	423	346	9000000411	0	0	0	0.750	40	16	24
40	273	18	617	273	344	9000000411	0	0	0	0.770	27	14	13
40	126	22	315	126	189	9000000411	0	0	0	0.770	0	0	0
33	105	13	236	105	131	9000000411	0	0	0	0.150	0	0	0
21	62	0	135	62	73	9000000411	0	0	0	0.100	21	21	0

Fig. 1: Dataset for activities for traffic vehicles

2) Model Design and Implementation
A Recurrent Neural Network (RNN) model with a Rectified Linear Unit (ReLU) activation function is employed for traffic prediction. The RNN model is designed to

handle sequential data, and feedback from the model is used to optimize traffic signals dynamically. The model is structured as follows:

- 16 Input layers.
- 12 nodes in the first hidden layer.
- 10 nodes in the second hidden layer.
- Two additional hidden layers with 9 and 8 nodes.
- A final max pooling layer with 10 nodes.
- 8 output layers.
  This architecture allows the system to manage multiple traffic signals simultaneously, optimizing flow across eight lanes.

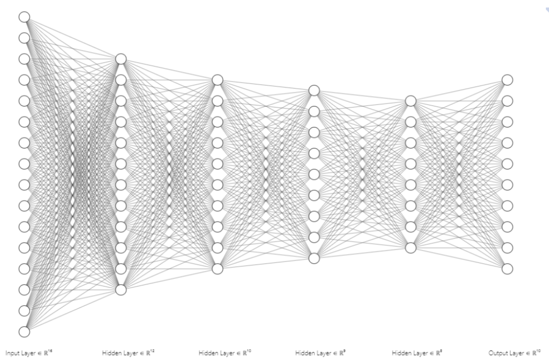


Fig. 2: Recurrent Neural Net Model

3) Simulation
   The system is simulated using PyGame, where various types of vehicles are generated based on the dataset. The simulation includes managing eight traffic signals, each reacting to real-time traffic patterns. Traffic signals are optimized using a feedback-based mechanism called "Road Rage," which increases linearly as vehicles wait. The feedback is inversely proportional to the Road Rage value, encouraging quick signal changes in high-congestion areas.

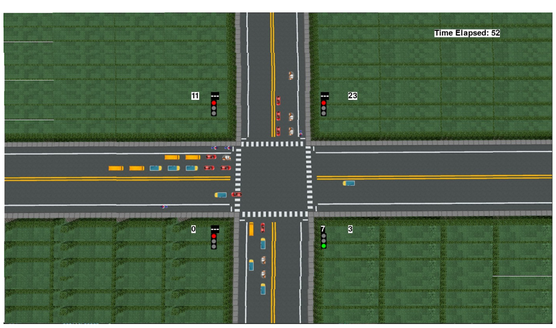


Fig. 3: Virtual Simulation using Pygame

4) Traffic Signal Optimization
   The system uses NEAT (NeuroEvolution of Augmenting Topologies) combined with RNN to optimize traffic signals. NEAT allows the RNN to evolve and adapt to changing traffic patterns over time, ensuring better traffic management in real-world scenarios.

V. Evaluation and Testing

The performance of the AI-based traffic management system is evaluated based on its ability to:

- Reduce road congestion.
- Improve travel times.
- Improving in decresing road rage value and trained upto 100 times
- Accurately predict traffic patterns. Real-time testing was conducted through the PyGame simulation, demonstrating significant improvements in traffic flow, reduced wait times, and optimized signal management.

VI. Results and Analysis

The AI-based system successfully predicted traffic flow and adjusted signal timings in real-time. The RNN model showed high accuracy in forecasting traffic patterns, leading to a reduction in congestion across simulated traffic lanes. Furthermore, the feedback system effectively mitigated the Road Rage issue, ensuring smooth traffic movement. Key statistics from the dataset analysis include:

- Mean values for vehicles (cars, bikes, pedestrians).
- Variance and median values reflecting traffic density. These values were instrumental in training the model to predict and optimize traffic patterns efficiently.

VII. Conclusion

The AI-based traffic management system developed in this project offers a robust solution to urban traffic congestion. By leveraging AI, historical data, and real-time monitoring, the system enhances traffic signal efficiency and reduces congestion, travel time, and pollution. Future work could involve deploying this system in a real-world scenario, integrating additional data sources like GPS, and scaling the model for larger cities.

References

[1] OpenML Dataset for traffic data.
[2] PyGame and NEAT documentation for simulation and optimization.