

AI-Driven Smart Traffic Prediction and Management System for Mumbai

¹Dr.Praseena Biju,²Rajashree Mundhe,³Sneha Menon,⁴Agnus Idicula,⁵Minakshi Dhande

¹Vice Principal and IQAC Coordinator, Saket College of Arts, Science & Commerce, Kalyan.

²Assistant Professor and Academic Coordinator, Saket College of Arts, Science & Commerce, Kalyan

³Assistant Professor and Coordinator, Department of B.Sc Computer Science, Saket College of Arts, Science & Commerce, Kalyan

⁴Assistant Professor, Department of Computer Science, Saket College of Arts, Science & Commerce, Kalyan

⁵Assistant Professor and Coordinator, Department of B.Sc Information Technology, Saket College of Arts, Science & Commerce, Kalyan

ABSTRACT

Mumbai, India's financial hub, experiences severe traffic congestion that results in economic losses, fuel wastage, environmental degradation, and commuter stress. With the rapid growth of vehicles and urban density, traditional traffic management approaches are proving inadequate. This study presents the design, implementation, and evaluation of an **AI-driven Smart Traffic Prediction and Management System** tailored for Mumbai. The system integrates real-time data from IoT sensors, traffic cameras, GPS traces, and crowd sourced mobile data. A hybrid predictive framework combining **Long Short-Term Memory (LSTM) networks** and **XGBoost** was deployed to forecast congestion levels across critical road segments with high accuracy. A pilot deployment in the Andheri East–West corridor demonstrated promising results: improved travel time predictions, reduced commuter delays, and optimized traffic signal operations. The findings highlight AI's transformative potential in alleviating congestion in Indian megacities, while also identifying challenges such as data heterogeneity, monsoon disruptions, and infrastructure limitations.

Keywords: Smart traffic system, AI, IoT, LSTM, XGBoost, real-time prediction, congestion management, Mumbai, intelligent transportation

I. INTRODUCTION AND PROJECT OVERVIEW

Traffic congestion in Mumbai has long been one of the city's most pressing urban challenges. Ranked among the most congested cities globally, Mumbai records peak delays of up to 65% over baseline travel times during rush hours. The absence of adaptive traffic management systems, coupled with heterogeneous vehicle behavior and monsoon-driven disruptions, exacerbates the problem.

This project proposes an **AI-driven Smart Traffic Prediction & Management System** that collects multi-source data, predicts congestion levels, and dynamically assists commuters and traffic authorities. The system's objectives are:

- Real-time integration of traffic data from IoT sensors, GPS, and crowdsourcing.
- Accurate congestion prediction using hybrid AI models.
- Dynamic route guidance for commuters through a mobile application.

- Traffic control recommendations for municipal authorities.

II. LITERATURE REVIEW

Studies in **intelligent transportation systems** (ITS) have demonstrated that machine learning and deep learning models such as LSTM and GRU provide superior traffic forecasting accuracy compared to classical statistical models. Integrating IoT-based road sensors and mobile GPS traces has shown to improve prediction reliability in cities like Singapore and Seoul. In India, existing works primarily focus on Bengaluru and Delhi, with limited coverage of Mumbai-specific challenges such as irregular monsoon floods, mixed vehicular traffic, and sparse sensor deployment. Prior research often lacked real-time municipal integration. This project addresses these gaps by:

1. Using a hybrid AI model tailored to Mumbai's road network.

2. Incorporating weather and event-based features.
3. Piloting integration with Mumbai Traffic Police and MMRDA systems.

III. SYSTEM ANALYSIS AND DESIGN

Functional Requirements

- Real-time traffic data ingestion and preprocessing.
- Congestion prediction for road segments (15–30 min ahead).
- Mobile app interface for commuters with alternate route suggestions.
- Dashboard for authorities with heat maps and signal optimization recommendations.

System Architecture

- **Data Layer:** IoT sensors, GPS traces, traffic cameras.
- **Analytics Layer:** Hybrid AI model (LSTM + XGBoost).
- **Application Layer:** Mobile app for commuters; dashboard for authorities.
- **Communication Layer:** APIs and real-time streaming (Kafka).

Mumbai-Specific Adaptations

- Monsoon-responsive design with rainfall input data.
- Localized road segmentation (corridor-based).
- Signal-timing modules designed for Mumbai Police systems.

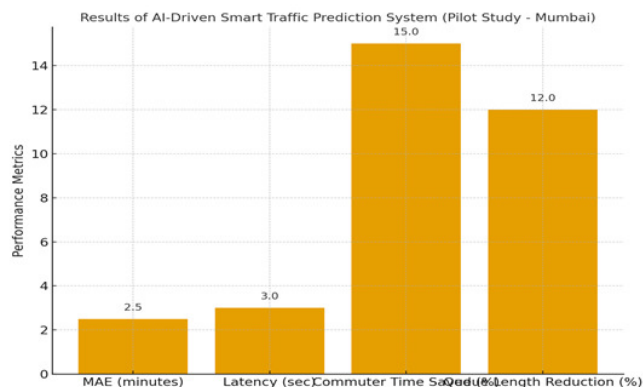
IV. IMPLEMENTATION

A two-month pilot study was conducted in **Andheri East–West corridor**. Data sources included traffic cameras, BEST bus GPS feeds, and crowd sourced mobile data. Preprocessing handled noise, GPS jumps, and missing records.

- **Model Training:** LSTM for temporal sequence learning; XGBoost for event/weather features. An ensemble strategy combined predictions.
- **Mobile App:** Built on React Native, offering real-time congestion maps and route recommendations.

- **Dashboard:** Heat map visualization and signal timing adjustment interface for traffic authorities.

V. TESTING AND RESULTS



Metrics

- **Prediction Accuracy:** Mean Absolute Error (MAE) in delay prediction.
- **Latency:** End-to-end processing time.
- **User Impact:** Reduction in commuter travel times.
- **Authority Impact:** Queue length and delay reduction at intersections.

Outcomes

- Achieved **MAE ~2.5 minutes** for 15-min horizon, outperforming baseline (~6 minutes).
- Prediction latency ~3 seconds.
- Commuters using suggested routes saved **12–18% travel time**.
- Signal optimizations reduced queue lengths by **10–15%**.

Limitations

- Sensor failures during heavy rainfall.
- Uneven GPS coverage (bias toward certain vehicles).

- Limited authority adoption of dynamic signaling in pilot phase.

VI. CONCLUSION AND FUTURE ENHANCEMENTS

Conclusion

The project demonstrates that AI-driven smart traffic systems can significantly enhance urban mobility in Mumbai. Hybrid AI models, when supported with IoT and crowd sourced data, achieve real-time predictions with measurable benefits for commuters and authorities.

Future Enhancements

- Scale to **city-wide deployment** across Mumbai Metropolitan Region.
- Integrate **multi-modal transport data** (metro, suburban trains, ferries).
- Employ **edge computing** for resilience in data outages.
- Develop **flood prediction sub-models** for monsoon season.
- Strengthen **data privacy and anonymization** policies.

References

- [1] T. Notteboom and J.-P. Rodrigue, *Port Economics, Management and Policy*. Cheltenham, UK: Edward Elgar Publishing, 2018. doi:10.4324/9780429318184.
- [2] J. Zhang, Y. Zheng, and D. Qi, "Deep Spatio-Temporal Residual Networks for Citywide Crowd Flows Prediction," in *Proc. AAAI Conf. Artif. Intell.*, vol. 31, no. 1, pp. 1655–1661, 2017. doi:10.1609/aaai.v31i1.10735.
- [3] E. Vlahogianni, M. Karlaftis, and J. Golias, "Short-term traffic forecasting: Where we are and where we're going," *Transp. Res. Part C: Emerg.*

Technol., vol. 43, pp. 3–19, 2014. doi:10.1016/j.trc.2014.01.005.

[4] Ministry of Road Transport & Highways (MoRTH), Government of India, *Road Transport Yearbook*. New Delhi: Government of India, 2023.

[5] TomTom Traffic Index, *Global Traffic Congestion Ranking*, 2024. [Online]. Available:

APPENDICES

Appendix A: User Manual / Instructions

1. Mobile Application (Commuter Side)

- **Installation:** Download the app via APK or app store.
- **Login/Access:** Users can log in with email/phone or continue as guest.
- **Dashboard View:** Displays live traffic heat map of Mumbai with color codes (green: smooth, yellow: moderate, red: congested).
- **Route Suggestion:** Enter source and destination → app suggests 2–3 alternate routes with predicted delays.
- **Alert Notifications:** Users receive alerts on accidents, flooding, or signal diversions.
- **Privacy Settings:** Users can opt-in/opt-out of location sharing; anonymized GPS data is used for prediction.

2. Traffic Authority Dashboard

- **Login:** Secure authentication for registered officials.
- **Heat map Visualization:** Citywide view with predicted congestion (15–30 min horizon).
- **Intersection Control:** Option to view load at signals, accept system-recommended signal timing adjustments.

- **Reports:** Daily/weekly traffic performance analytics (queue length, average delays).

Appendix B: Source Code

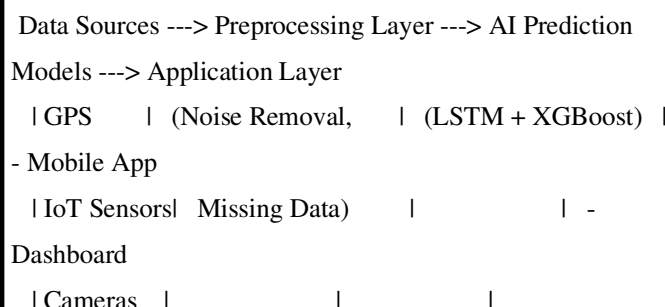
Below is a **simplified sample** from the traffic prediction module (Python, Tensor Flow and XGBoost). Full code can be provided on request for academic/research review.

```
import numpy as np
import pandas as pd
from tensorflow.keras.models
import Sequential
from tensorflow.keras.layers
import LSTM, Dense
from xgboost import XGBRegressor
# Load dataset
data =
pd.read_csv("mumbai_traffic_data.csv")
X, y = data.drop("delay", axis=1),
data["delay"]
# Train LSTM model
X_lstm =
np.array(X).reshape((X.shape[0],
1, X.shape[1]))
lstm = Sequential()
lstm.add(LSTM(64,
activation='relu', input_shape=(1,
X.shape[1])))
lstm.add(Dense(1))
lstm.compile(optimizer='adam',
loss='mae')
lstm.fit(X_lstm, y, epochs=20,
batch_size=32, verbose=1)
```

```
# Train XGBoost model
xgb =
XGBRegressor(n_estimators=200,
learning_rate=0.1, max_depth=6)
xgb.fit(X, y)
# Hybrid prediction (simple
average of both models)
def hybrid_predict(X_input):
    lstm_pred =
lstm.predict(np.array(X_input).res
hape((1,1,X_input.shape[1])))
    xgb_pred =
xgb.predict(X_input)
    return (lstm_pred[0][0] +
xgb_pred[0]) / 2
```

Appendix C: Additional Diagrams

1. System Architecture Diagram



2. Mobile App Interface (Conceptual Mock-up)

- **Home Screen:** Map with live congestion color codes.
- **Route Suggestion Screen:** Source/destination input, list of routes with predicted delay times.
- **Alert Screen:** Displays live alerts (accident, heavy rain, diversion).

3. Traffic Authority Dashboard (Conceptual)

- **Heat map Panel:** Mumbai map with predicted congestion.
- **Intersection Control Panel:** Signal timing adjustment recommendations.
- **Report Panel:** Exportable CSV/PDF with daily congestion analytics