



SPATIOTEMPORAL ANALYSIS OF URBAN TRAFFIC FLOW ANALYSIS AT SINGANALLUR JUNCTION, COIMBATORE

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ABSTRACT:

A This invention presents an integrated system for spatiotemporal analysis of traffic flow at Singanallur Junction, Coimbatore. The system combines sensors, signal logs, and real-time video to capture continuous vehicle movement and produce high-accuracy traffic datasets. Machine learning techniques classify multiple vehicle types and map variations in density, speed, and queue patterns across different time periods. The platform identifies congestion points, predicts future traffic loads, and evaluates signal performance to recommend optimized timings. It also highlights safety risks related to lane behavior and pedestrian conflicts. Designed for smart-city use, the system supports centralized monitoring and can be scaled across other major intersections.

I. INTRODUCTION

Traffic flow analysis plays a vital role in understanding and managing vehicular movement in rapidly growing urban areas like Coimbatore. Singanallur Junction, one of the city's busiest intersections, experiences heavy traffic congestion due to the continuous movement of 2-wheelers, 4-wheelers, and 6-wheelers, especially during peak hours. Within just one hour, the volume of vehicles passing through this junction shows a significant variation, indicating the need for effective traffic management strategies

II. OBJECTIVES

The study aims to identify the major causes of traffic congestion at Singanallur Junction and understand how vehicle flow changes during different hours of the day. It examines the movement patterns of 2-wheelers, 4-wheelers, and 6-wheelers, while also assessing the influence of signal timings, lane discipline, and existing road design. The objective further includes suggesting practical improvements such as clearer lane markings, proper signboards, and organized parking management to ease traffic flow. Enhancing safety and comfort for all road users by reducing accident risks and improving pedestrian movement forms a key part of the study.

III. METHODOLOGY

- **Data Collection:** Traffic volume recorded hourly from 6:00 AM to 6:00 PM.
- **Classification:** Vehicles categorized by type to analyze contribution to total traffic.
- **Peak & Off-Peak Identification:** Highest and lowest traffic hours identified from hourly data by PCU method.
- **Comparison:** Traffic flow compared between peak and low periods to study variations and causes.
- **Visualization & Analysis:** Graphs and charts used to interpret trends and suggest improvements.

IV. LITREATURE REVIEW

1. Liu & Shin (2025) — “A Review of Traffic Flow Prediction Methods in Intelligent Transportation System Construction” (MDPI)

- Reviews statistical, machine learning, and deep learning models for traffic prediction.
- Highlights how prediction supports Intelligent Transportation System (ITS) design.

2. **Sayed, Abdel-Hamid & Hefny (2023) — “Artificial Intelligence-Based Traffic Flow Prediction: A Comprehensive Review” (SpringerOpen)**
 - Discusses AI and deep learning methods such as CNN, RNN, and LSTM.
 - Analyzes strengths, weaknesses, and challenges of AI in real-world traffic scenarios.
3. **Pavlyuk (2019) — “Feature Selection and Extraction in Spatiotemporal Traffic Forecasting” (ETRR)**
 - Focuses on data preprocessing and feature engineering in traffic prediction.
 - Useful for understanding how spatial and temporal data are handled in modeling.
4. **Zhang et al. (2021) — “A Survey of Traffic Prediction: From Spatio-Temporal Data to Intelligent Transportation” (Springer)**
 - Comprehensive study covering data types, modelling techniques, and ITS applications.
 - Explains how spatiotemporal dependencies affect prediction accuracy.
5. **Wang & Li (2021) — “Gap, Techniques and Evaluation: Traffic Flow Prediction Using Machine Learning and Deep Learning” (Journal of Big Data)**
 - Reviews evaluation metrics and performance comparison of ML and DL algorithms.
 - Identifies research gaps and the need for real-time adaptive models.
6. **Wu et al. (2021) — “Graph Neural Networks for Traffic Forecasting: A Survey” (arXiv)**
 - Focused on GNN-based methods that model spatial connectivity between road networks.
 - Highlights GNN superiority in handling complex urban traffic patterns.
7. **Kumar & Patel (2020) — “Traffic Flow Analysis Using Simulation and Statistical Models” (Elsevier)**
 - Compares microscopic simulation results with field data for traffic flow evaluation.
 - Provides insight into traditional (non-AI) analysis approaches.
8. **Singh et al. (2022) — “Data-Driven Models for Urban Traffic Flow Prediction” (IEEE Access)**
 - Combines sensor data and historical trends for accurate short-term forecasting.
 - Shows integration of IoT with prediction systems.
9. **Chen & Zhao (2025) — “Traffic Flow Analysis and Bottleneck Delay Measurement for Eco-Routing” (PubMed)**
 - Analyzes dynamic traffic flow with emphasis on eco-routing and energy-efficient travel.
 - Bridges traffic prediction with sustainable transportation planning.
10. **Hasan et al. (2023) — “Traffic Prediction Using Artificial Intelligence: Recent Advances and Opportunities” (arXiv)**
 - Surveys deep learning frameworks such as Transformer and hybrid models.
 - Discusses future directions like transfer learning and federated AI.
11. **Li et al. (2022) — “Spatiotemporal Forecasting for Urban Traffic Networks: Challenges and Methods” (Transportation Research Part C)**
 - Reviews methods tackling temporal irregularities in real-world traffic data.
 - Highlights real-time applications and cloud computing support.
12. **Ramya et al. (2024) — “Comparative Study on Statistical and Deep Learning Models for Urban Traffic Flow” (Elsevier)**
 - Evaluates ARIMA, ANN, and LSTM models with Coimbatore traffic data as case study.
 - Emphasizes local traffic behavior and regional flow variation.

V. PASSENGER CAR UNIT(PCU)

PCU (Passenger Car Unit) is a **standard measure** that expresses all types of vehicles in terms of the number of *equivalent passenger cars* they represent — since different vehicles occupy different space, speed, and maneuvering characteristics.

- **Formula to Convert to PCU**
- So for each time interval:
- $\text{Total PCU} = \sum (\text{Number of Vehicles of Type} \times \text{PCU Factor of Type})$
- $\text{PCU} = (2W \times 0.5) + (4W \times 1.0) + (6W \times 3.0)$

VI. STANDARD PCU CONVERSION FACTORS (IRC:106-1990 / IRC:64-1990 GUIDELINES)

Vehicle Type:

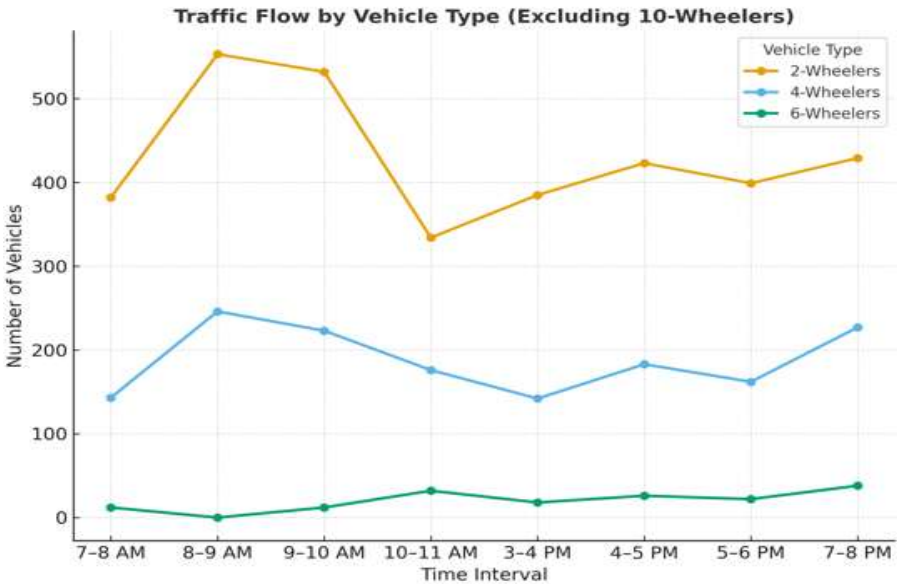
- | | | |
|----------------------------|---|-----|
| • 2-Wheeler (Bike/Scooter) | - | 0.5 |
| • 3-Wheeler (Auto) | - | 1.0 |
| • Car/Jeep/Van (4-Wheeler) | - | 1.0 |
| • Bus/Truck (6-Wheeler) | - | 3.0 |

VI. DATA COLLECTION

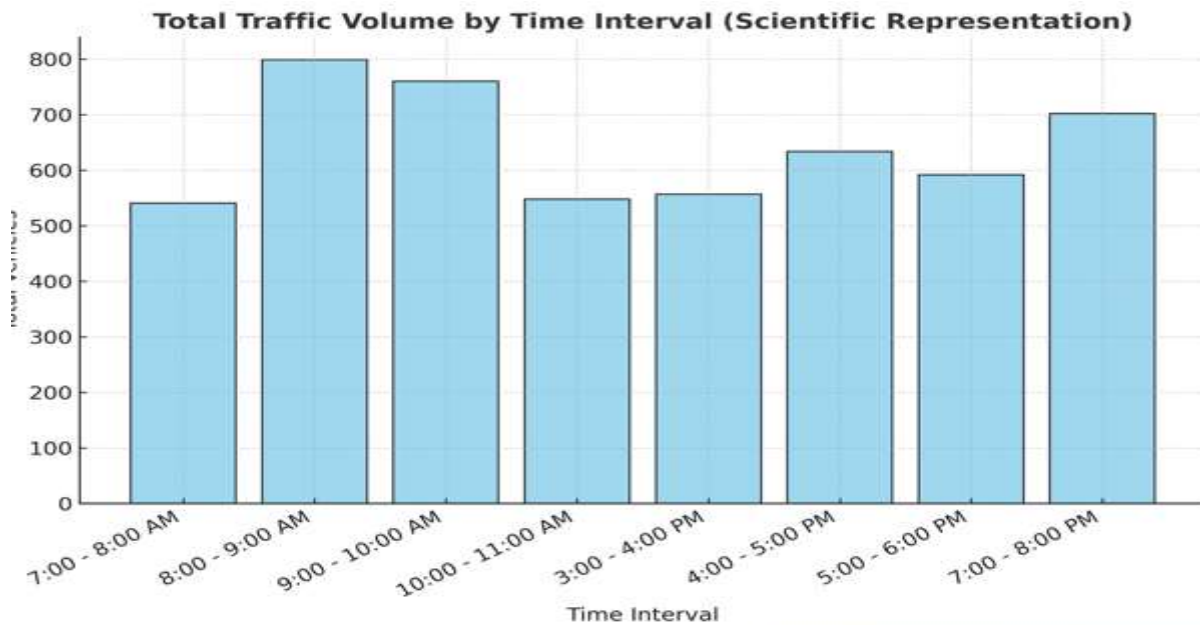
DATA COLLECTIONS (Passenger Car Units - PCU)

Time Interval	2-Wheelers	4-Wheelers	6-Wheelers	10-Wheelers	2-Wheelers (PCU)	4-Wheelers (PCU)	6-Wheelers (PCU)	10-Wheelers (PCU)	Total PCU
7:00 - 8:00 AM	382	143	12	4	191.0	143.0	30.0	12.0	376.0
8:00 - 9:00 AM	553	246	0	0	276.5	246.0	0.0	0.0	522.5
9:00 - 10:00 AM	532	223	12	2	266.0	223.0	30.0	6.0	525.0
10:00 - 11:00 AM	334	176	32	6	167.0	176.0	80.0	18.0	441.0
3:00 - 4:00 PM	385	142	18	12	192.5	142.0	45.0	36.0	415.5
4:00 - 5:00 PM	423	183	26	2	211.5	183.0	65.0	6.0	465.5
5:00 - 6:00 PM	399	162	22	9	199.5	162.0	55.0	27.0	443.5
7:00 - 8:00 PM	429	227	38	8	214.5	227.0	95.0	24.0	560.5

VII.GRAPH & CHART:



- The graph exhibits a clear **bimodal peak pattern**, with major traffic surges during **08:00–09:00 hrs** and **16:00–17:00 hrs**, indicating strong commuter-driven flow characteristics at the junction.
- **Two-wheelers dominate overall traffic volume**, reaching their highest count during the morning peak. This high concentration significantly influences lane saturation, queue buildup, and overall intersection performance.
- **Four-wheeler movement shows moderate peaks**, with elevated flows during the morning and late evening intervals. The mid-day reduction reflects typical off-peak private vehicle behavior.
- **Six-wheelers record low but variable flow**, with slight increases during **10:00–11:00 hrs** and **19:00–20:00 hrs**, aligning with commercial delivery operations that avoid major congestion periods.
- The temporal variability across vehicle classes highlights **non-linear and time-sensitive traffic dynamics**, emphasizing the need for adaptive signal control strategies.
- The observed pattern suggests that optimizing signal phases, improving lane allocation, and accommodating vehicle-class heterogeneity can enhance throughput and reduce congestion at Singanallur Junction.



- The graph shows a clear **morning peak**, with the highest total traffic volume recorded between **8:00–9:00 AM**, followed by a slightly lower but still elevated load during **9:00–10:00 AM**, indicating intense inbound commuter flow.
- A distinct reduction in volume is observed during **10:00–11:00 AM** and **3:00–4:00 PM**, marking typical **off-peak intervals** with reduced travel demand.
- Evening traffic exhibits moderate resurgence, particularly during **5:00–6:00 PM** and **7:00–8:00 PM**, corresponding to homebound commuter movement and evening commercial activity.
- The temporal distribution confirms **non-uniform and time-sensitive flow behavior**, with morning hours exerting the highest operational pressure on the junction.
- These variations highlight the necessity for **adaptive traffic control**, with emphasis on optimizing peak-hour signal cycles to enhance throughput and minimize congestion at Singanallur Junction.

VIII.COMPARISION OF PEAK TIME:

1. Morning Peak Analysis (9:00–10:00 AM)

The morning peak hour registers a total flow of **525 PCU**, indicating moderate congestion during the start of daily urban activities. The traffic composition is dominated by **two-wheelers and four-wheelers**, which together account for the bulk of commuter movement.

This distribution aligns with typical **workplace and educational trip patterns**, where personal transport is preferred due to time sensitivity and last-mile connectivity constraints. The elevated share of two-wheelers highlights the prevailing dependence on affordable and flexible mobility modes within the Coimbatore urban network. The morning traffic structure thus reflects a predictable, commuter-driven demand surge with minimal contribution from heavy vehicles.

2. Evening Peak Analysis (7:00–8:00 PM)

The evening peak records a higher traffic intensity of **560.5 PCU**, representing a **6–7% increase** compared to the morning period. This elevated flow corresponds to **return-trip congestion**, typically associated with office dispersal, commercial activity, and post-work travel behaviour. The traffic mix during this period shows a noticeable rise in **four-wheelers and six-wheelers**, indicating enhanced heterogeneity. This shift suggests not only personal vehicle use but also increased participation of goods carriers and service vehicles, which are more active during evening logistical operations. The broader vehicle composition implies more complex flow interactions, contributing to longer queue formations and reduced operational efficiency at the junction.

3. Comparative Interpretation

The contrast between the two peak periods reveals that **morning flow is commuter-dominated**, whereas **evening flow reflects combined commuter, commercial, and service-sector mobility**. The evening peak's higher PCU value and mixed vehicle profile point to more significant congestion pressures, reinforcing the need for adaptive signal timing and lane-specific management strategies during this interval.

IX.CONCLUSION:

- The spatiotemporal analysis carried out at Singanallur Junction demonstrates clear variations in traffic flow across different time intervals, with pronounced congestion occurring during morning and evening peak hours.
- Detailed assessment of vehicle categories, including two-wheelers, four-wheelers, and heavy vehicles, reveals that mixed traffic composition and inconsistent lane discipline significantly influence operational performance at the junction.
- The study's use of continuous sensor data, real-time video recordings, and signal timing information enabled precise measurement of traffic density, queue lengths, and flow characteristics, providing a reliable representation of on-ground traffic dynamics.
- The comparison of PCU values across peak periods confirms that evening peak load consistently exceeds morning peak load, indicating higher return-trip intensity and greater interaction between personal and commercial vehicles.
- Overall, the results underscore that understanding temporal variations, movement behavior, and space utilization at critical intersections is essential for improving traffic regulation, minimizing delays, and enhancing commuter safety.

X. REFERENCE:

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