

A STUDY ON DARBHANGA URBAN TRAFFIC FLOW AND METHODS FOR CONGESTION CONTROL

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Abstract:

Understanding the dynamics of urban traffic flow and assessing workable solutions for congestion management in quickly expanding cities (like Darbhanga city of Bihar) are the goals of this study. The study finds the main causes of traffic congestion, including poorly synchronized/non availability of traffic signals or non-availability of Traffic Police around the clock, road signages, limited road capacity, frequent use of private buses, and heavy traffic at intersections, by examining traffic patterns, vehicle density, and road utilization across different urban zones. These results offer a thorough summary of the operational and structural issues influencing urban mobility.

The paper illustrates how technology innovation and smart urban planning may greatly reduce traffic through data-driven analysis and case studies. Solutions are investigated, including enhanced public transit infrastructure, efficient road utilization, adaptive traffic signal systems, and rules governing private bus operations. The findings highlight how crucial it is to combine sustainable planning techniques with smart technology in order to facilitate long-term urban development, improve traffic flow, and increase urban road traffic mobility.

Keywords: Traffic Flow, Congestion, Control, Urban area.

INTRODUCTION

In Darbhanga, Bihar, a fast-urbanizing city with developing mixed transportation problems, this small study examines road traffic flow patterns and congestion avoidance strategies at the Darbhanga road. A thorough analysis study is conducted of contributing variables, including uncontrolled vehicle movement, non availability or improper signalling systems, encroachments, and insufficient road width, as Darbhanga is old city. The study also assesses efficient ways to reduce traffic, such as promoting public transportation, widening roads, optimizing and providing signal timing, and using intelligent traffic management systems. Practical suggestions are made in light of the results in order to enhance Darbhanga's traffic efficiency, provide safer transportation model, and promote sustainable urban growth of Darbhanga, with the philosophy of Safety First & Punctuality must.

In the field of Darbhanga urban intelligent and updated transportation, the judgment of traffic congestion is the main research direction. If the formation of current road congestion can be controlled in advance through the rules of traffic related information, economic losses and road traffic accidents can be avoided and reduced. Traffic system is a huge space body with complex structure. It is difficult for general methods to complete the processing of actual traffic data, and the obtained prediction results will always have a big deviation from the actual. Therefore, how to effectively find more accurate rules in the huge and complex traffic data is the main problem faced by the current intelligent transportation field. Similarly, road congestion control is also an important part of the field of intelligent transportation.

Combined with the characteristics of the current road structure, corresponding control means are provided in the research field to provide effective control decisions for the field of traffic management, so as to quickly dissipate the congested sections and avoid the continuous aggravation of traffic congestion. Therefore, this paper uses the basic theory of traffic flow and traffic control theory to complete the prediction and control of traffic congestion, which is of great contribution and significance for guiding travel and traffic control. In recent years, the continuous development of deep learning technology makes the prediction model based on neural network gradually introduced into the traffic situation prediction.

IMPORTANCE OF ROAD TRAFFIC CONGESTION CONTROL

With the rapid advancement and extensive application of wireless communication technologies, high-frequency data sharing in urban road networks has been significantly promoted. This traffic flow data can help formulate traffic control strategies to promote smooth traffic flow (*Li et al., 2019*). In the field of traffic management, designing an optimal traffic control strategy relies heavily on the accurate prediction of queue lengths before the next signal phase. This prediction helps optimize the cycle duration of traffic lights and lays a solid foundation for the operation and implementation of emerging intelligent mobility and control systems.

To accurately capture traffic flow characteristics and predict queue lengths in future periods, researchers have developed several real-time traffic flow models (*Qiu et al., 2023*), including vehicle speed models, travel delay models, and energy consumption models. These methods primarily rely on video sensors, cameras, and road detectors to collect and analyse vehicle data. However, they do not fully utilize high-dimensional spatiotemporal information to predict traffic conditions over various periods. To improve prediction methods, scholars have proposed various enhancement methods using multivariate models, including artificial neural networks, time series regression, convolutional neural networks, and autoregressive integrated moving average models.

Although these models perform well in simple cases, they often struggle to accurately capture the nonlinear spatiotemporal correlations of traffic data. To overcome these challenges, researchers have begun exploring more advanced neural network models, such as recurrent neural networks and LSTM networks (*Wang et al., 2021*). Through the application of these advanced models, future traffic signal control and management systems will be able to respond more accurately to complex and dynamic traffic environments, providing more reliable support for traffic management and control.

To accelerate the optimization process of signal control strategies, literature (*Cai et al., 2009*) proposed an approximate dynamic programming technique combined with a reinforcement learning algorithm. This approach leverages machine learning to enhance optimization speed and efficiency, thereby overcoming the computational bottleneck associated with traditional methods in large-scale applications. Additionally, under oversaturated traffic conditions, namely traffic demand exceeds the capacity of intersections or road segments, researchers have employed the store-and-forward queuing theoretical model (*Wang et al., 2016*) to minimize traffic delays by optimizing the green time switching points in signal phases or hand signal by Traffic police and Traffic assistance.

LITERATURE REVIEW

Kashi and Akbarzadeh (2019) proposed a model based on the combination of wavelet transform and artificial neural network, in which wavelet transform is used for denoising and artificial neural network is used for predicting traffic. The results show that removal of noise can improve the accuracy of prediction obviously.

Luo et al. (2019) proposed a hybrid particle swarm optimization (PSO) algorithm combined with genetic algorithms to search the parameters of least squares support vector machines and thus predict short-term traffic flow.

Duan et al. (2021) developed a multimodal fractional Levy stable motion degradation model to predict the product technical life or remaining useful life (RUL) of equipment. The change point detection and clustering algorithm were used to identify the modes, and the validity of the prediction model was verified by an example.

Song et al. (2022) proposed a new heavy-tailed degradation model, in which the fractional Levy stable motion was taken as the diffusion term, a degradation model with power rate drift was established, and the differential iterative form of the fractional Levy stable motion degradation model was used to predict the remaining service life.

Liu et al. (2021) proposed a novel long-range-dependent (LRD) degradation model based on generalized Cauchy (GC) process. The dimensionless factor, principal component analysis (PCA) and iterative method were used to eliminate the interference of noise to the degraded data, and GC degradation model was used to predict the remaining useful life (RUL) of rolling bearings and verify the effectiveness of GC degradation model.

Saleem et al. (2022) proposed a fusion based VN intelligent traffic congestion control system (FITCCS-VN), which utilizes machine learning technology to collect traffic data and route traffic on available routes to alleviate traffic congestion in smart cities. The model improves traffic flow and reduces congestion. Atta et al. (2020) discussed the application of RFID innovative technology in traffic congestion, and proposed an intelligent system that can maintain the dynamic time of traffic signals by sensing traffic density to minimize congestion.

OBJECTIVE

- To study the Urban Traffic Flow and Congestion Control in the Darbhanga City.
- To understand the importance of Congestion Control in Darbhanga urban and sub urban areas.

RESEARCH METHODOLOGY

Traffic composition of public transport vehicles according to lane Figures 1 and 2 show the traffic percentages of buses and jeepneys according to lane for various mid-block sections and intersections surveyed in this study. In road sections with jeepney routes, the traffic composition of jeepneys is usually highest at the roadside. In road sections with bus routes, the traffic composition of buses is usually highest at the lane next to the main lane.

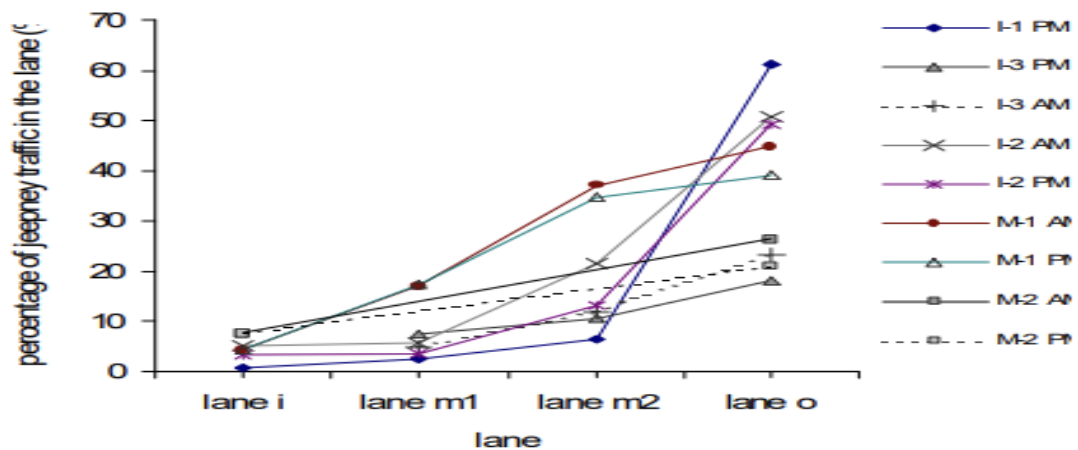


Figure 1: Traffic composition according to lane

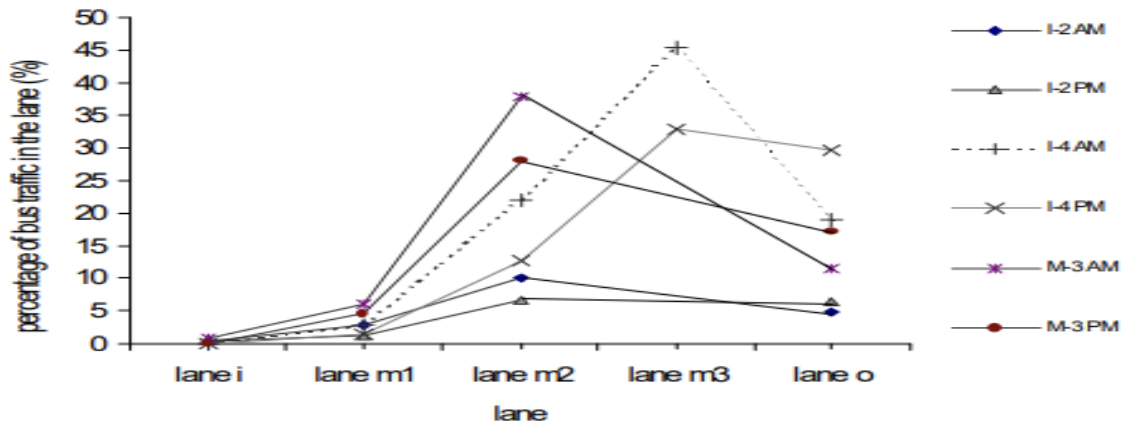


Figure 2: Traffic composition of buses according to lane

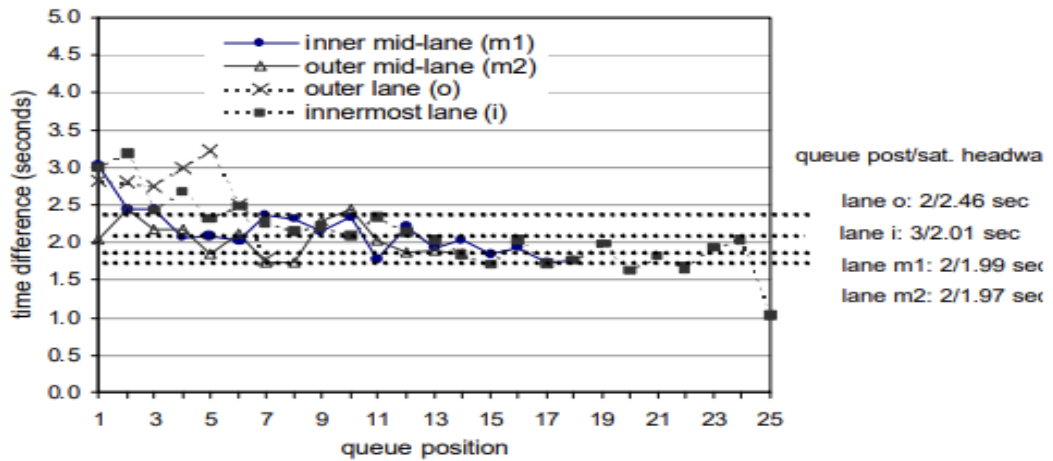


Figure 3: Headway-queue plot of intersection I-1

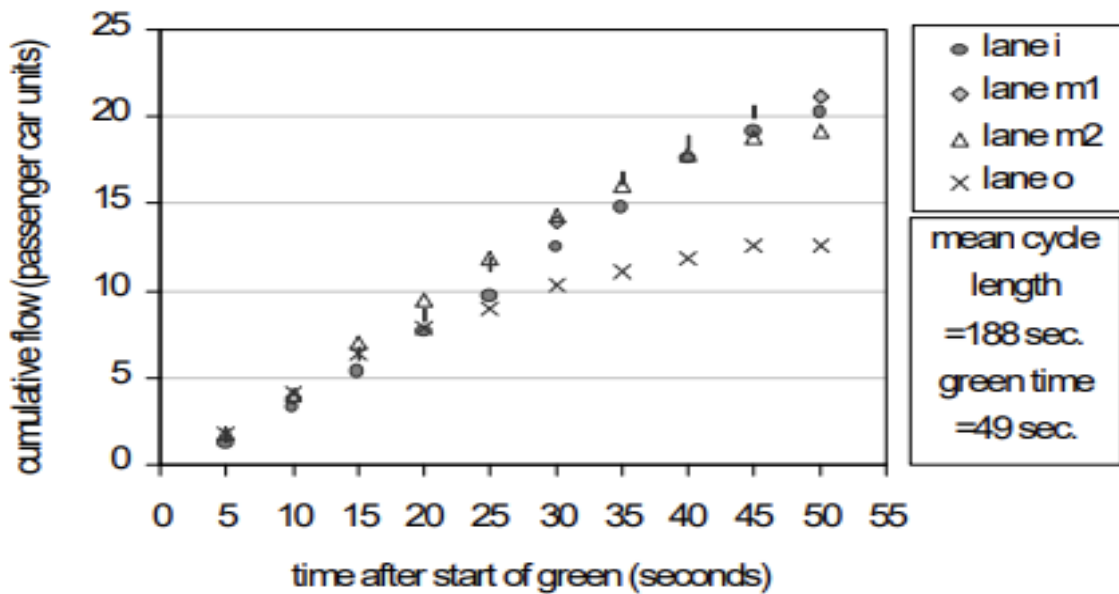


Figure 4: Cumulative curve of vehicles passing through intersection I-1

Figure 3 shows the variation of headway with queue post in intersection I-1. The higher outer lane saturation headway is influenced by the high proportion of jeepneys in the outer lane. Figure 4 shows the cumulative curve corresponding to the headway-queue plot in Figure 13 for intersection I-1. It can be understood that there is failure to fully utilize the green due to mixture of heavy right turn traffic and high jeepney ratio. Many other intersections are observed to have periods where the green times are not fully utilized.

Table1: Special factors affecting saturation flow rate

main factor	details of main factor
1. vehicle performance	1.1 slow start-up reaction of passenger cars 1.2 slow start-up reaction of trucks 1.3 slow start-up reaction of jeepneys
2. driver behavior – vehicles running in the middle of lanes	
3. driver behavior – vehicles changing lanes	3.1 merging 3.2 diverging
4. public transport operation	4.1 effect of jeepneys 4.2 effect of trucks

Analysis of the Road Traffic Environment

Collection of air quality data

A total of 9 signalized/traffic police intersections and 13 mid-block road sections were surveyed in July and August of 2025 to collect roadside concentration of suspended particulate matter (SPM) and nitrogen dioxide (NO2) using portable pollution monitoring equipment. Meteorological and physical data were also obtained.

Roadside pollutant concentration and traffic volume

Figure 5 shows the plot of the SPM concentration as a function of the hourly traffic volume per lane. Initial results show a direct proportional relationship between traffic volume and roadside pollutant concentration.

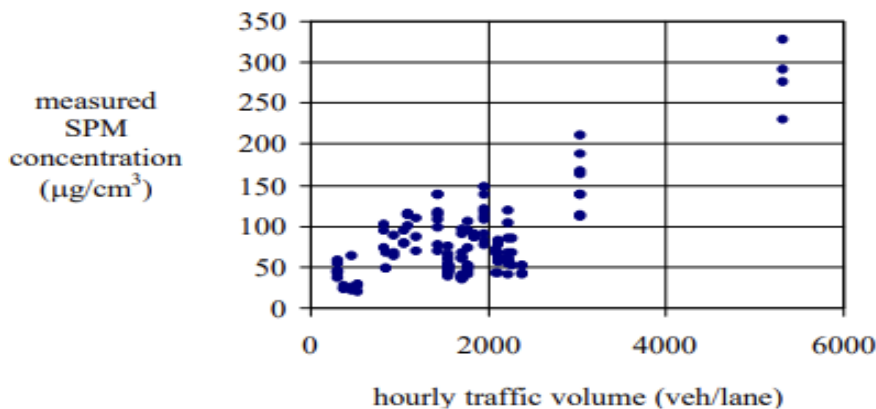


Figure 5: Variation of suspended particulate matter concentration with hourly traffic volume

Roadside pollutant emission concentration model

The pollutant emission mass concentration is modelled as a multiple linear regression of traffic volumes of various vehicle types, meteorological information and road geometry.

$$y = \alpha_0 + \sum_i \alpha_i V_i + \sum_j \beta_j W_j$$

where y = pollutant emission mass concentration (mg/m3)

ai, bj = parameters

V_i = traffic volume of vehicle type i (v eh/hr)
 W_j = meteorological information, road geometry

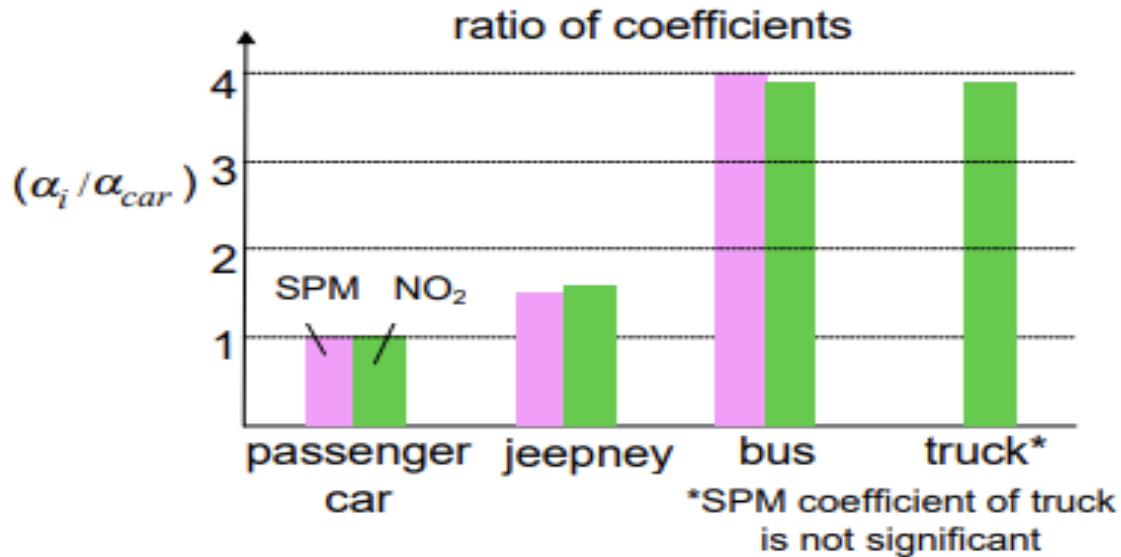


Figure 6: Ratio of the coefficients of the regression model

FINDINGS & CONCLUSION

This study examined the urban traffic environment by measuring roadside Suspended Particulate Matter (SPM) concentrations and analysing the characteristics of jeepney engines. Key factors related to driver behaviour and vehicle performance were considered to enhance the microsimulation software, leading to a more stable simulation system. While the car-following and other driver behaviour models remained unchanged, the study successfully calibrated vehicle parameters, roadway geometry, and other operational traffic characteristics to reflect local conditions.

The factors affecting saturation flow rate such as vehicle performance, driver behaviour and public transport operation were confirmed by traffic flow analysis and traffic flow simulation experiments using the Paramics microscopic traffic simulation software. The impacts of driver behaviour, vehicle performance and the physical environment or traffic policies on traffic flow and the environment are quantified in terms of changes in simulation output values of traffic flow parameters and SPM emission levels.

To further support, traffic flow patterns, vehicle composition, and stop-and-go behavior common in congested urban corridors. Emission factors were estimated based on both observed engine conditions and manufacturer specifications, with a particular focus on older, poorly maintained vehicles that contribute disproportionately to air pollution. The integration of these empirical data into the simulation framework enhanced the model's capability to reflect real-world traffic scenarios more accurately.

SCOPE FOR FUTURE RESEARCH

Further Studies There is a need to for more accurate calculation of the saturation flow rate from the microsimulation system through the counting of heavy vehicles to express saturation flowrate in passenger car units. Aside from the basic traffic characteristics such as headway, speed and volume, there is a need to compute the major indicator of level of service of signalized intersections, that is, the intersection delay. This will be another good indicator of various countermeasures or changes in vehicle performance, driver behaviour and traffic operations.

A more detailed tracking of vehicle movements (time-space) to more accurately estimate vehicle emissions based on different running modes is necessary in future studies. Of course, the automation of

pollution counting would be very much helpful in calculation of vehicle emissions. After establishing the simulation system for intersection-level analysis, future studies would include expansion to a road network, even a sub-network, in order to analyse overall and areawide traffic and environmental impacts of various changes in vehicle performance, driver behaviour, traffic operations, physical environment and other transport countermeasures.

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