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Regression based neural network model for prediction of road traffic congestion : A case study of Bhubaneswar

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Abstract

The prediction of road traffic congestion is the most important and essential aspect to reduce the suffering of population of urban cities which is primarily carried by roads. The lack of a traffic congestion data unavailability and evaluation standard makes the effect of traffic congestion prediction more difficult and worsen. Traffic congestion occurs due to increase in number of vehicles on roads which reduces speed of vehicles, increases delay time, and increasing vehicular queuing in traffic. Due to traffic congestion, not only delaying time increases but also its threat to slower down the economic growth rate of our country and also have high impact on our personal growth, living condition with high level of pollution and undesirable feature of overloaded streets. Traffic congestion predicting modeling plays very

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important role so we need a innovative approach to predicting the congestion on roads. In this paper, we aim to provide a model which studies the real time environment characteristics of the road, and analyzed the data, congestion location identification, directional movement of all those locations surveyed and forecasting traffic location where traffic congestion may occur in near future.

Subject Classification: *68, 69.*

Keywords: *Traffic congestion, Regression, Model based prediction.*

1. Introduction

Road traffic congestion in India in the last 10-15 years has been a major concern. Issues arising due to acute traffic congestion influence adversely the quality of day-to-day life as well as the financial stability of the country. To mitigate the various challenges due to the traffic congestion, designing smart solutions is need of the hour such as prediction of traffic congestion level that enables identifying of traffic-issues at the earliest and thus reducing the congestion.

If we observe the traffic scenario of Bhubaneswar, capital of Odisha, we see that from all parts of Odisha population are gathered in this city for education, job, and for business etc. This increasing population is responsible for increasing vehicle population in form of two-wheelers, personal vehicles on roads which gradually leads to a congested road, slower speeds, longer delay, more fuel consumption and accidents on roads. Managing these issues and reducing the adverse impacts of traffic congestion, encourage many researchers to address this problem. Unfortunately, there is no way to handle when congestion occurs in reality. To fill this gap, we propose a predictive model in order to predict the congestion occurrences by analyzing the congestion trends.

In this paper, we have a critical study on the traffic data of the city of Bhubaneswar. We analyzed the data and developed a regression-based neural network model for an efficient prediction of traffic congestion in the city of Bhubaneswar.

By looking at the recent situation and by a recent national survey, delays caused by traffic congestion is more of a concern for peoples when they are attending any event like official, school, personal events. According to Ali et. al. [1] traffic congestion adversely affects nearly millions of price investment everyday in terms of opportunity cost and fuel consumption. Congestion has a serious threat to the lives of vehicle drivers and also serious impact on every inhabitant of the city. Due to congestion,

fuel consumption is more [2], harmful pollutants are added in the air and causes significant decline in the economic growth rate [3]. According to a laboratory study [4], pollutant which is emitted due to road congestion increases the chances of health issues like allergies and aggravates the symptoms for those who are sensitive to them. Further researches have given that traffic congestion also enhances the risk of heart attacks [5, 6]. Traffic congestion prediction provides the authorities to take right steps to avoid more congestions and remedial plan for future in the resource allocations to have a smooth road journey [7]. The traffic congestion issues in different areas of the capital city of Odisha motivated us to focus on these issues and develop a solution.

2. Related Works

Often in intelligent traffic management systems, traffic related data with missing values and outliers adversely affect the prediction of traffic congestion. Methods proposed in [12, 13] describes about Historical Imputation Methods (HIMs) which gives more than one predicted values for the missing value. In HIMs, the mean value of more than one neighboring data points received from same date and location replaces the missing value. But in [14, 15], authors have given another method that is nearest Neighbor Imputation (NIM) which takes data from the neighbouring roads. A strategy for predication of traffic congestion based on GPS trajectory data using Recurrent Neural Network (RNN) is proposed by authors in [16] where the model estimates the average speeds from existing data on road extensions with GPS trajectory data. But the RNN based model faced issues related to long-term dependencies since it could not keep the earlier data. Hence this led to the evolution of LSTM model. In [17], authors have given a temporary information improvement based LSTM model that estimates the flow of traffic on a single stretch of road and got advantages over prediction accuracy by emphasizing on the special correlation among the time and flow of traffic. Authors in [18], have developed a spatio-temporal graph convolutional network model to highlight on the temporal and spatial features in the congestion prediction. Thus there are some substantial efforts [19,20] made for the prediction of traffic intensity. But looking at the increase complexities in the city of Bhubaneswar, very little attempt has been made for the congestion prediction.

3. Data Collection and Methodology

Traffic congestion prediction has two important and basic steps such as: (1) data collection and (2) model development for prediction. Both of these steps need to be executed methodically to get higher degree of accuracy. After collecting data, data processing needs to done for preparing the training and testing datasets.

3.1 *Study Area*

We have taken Bhubaneswar as our study area which is the capital of the state of Odisha. It is governed by Bhubaneswar Municipality Corporation. The city of Bhubaneswar sees rapid urbanization with both planned and unplanned way in all sides of the city such as towards Cuttack, Puri and Khurda. In the last three decades, Bhubaneswar has become the business as well as the educational hub of the state along with the best medical facilities available. As a result of which people from all corners of the state and the country as well, are coming to Bhubaneswar for their livelihood. It has a great impact on the population growth, urban environment and most importantly traffic congestion in the city. Nowadays, the traffic issue in the city has become a major concern. In Figure 1, we have given the road map of Bhubaneswar prepared using QGIS, an open-source GIS software.

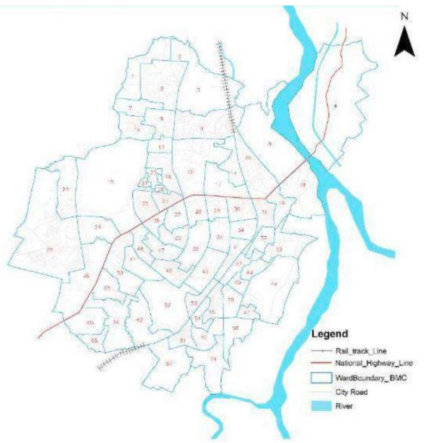


Figure 1

Road Map of Bhubaneswar

3.2 *Data Collection*

Traffic data studies are conducted to determine the traffic related attributes like number, movements and classification of road vehicles at a given location. These data can help to find out traffic volume, traffic density, traffic speed, critical flow time period, traffic volume patterns and determine the different vehicle impacts in traffic issues. By using manual count method, we have mostly collected the data like volume of traffic, count of different type of vehicles, direction to travel and vehicle occupancy. Manual count of survey method has disadvantages like time consuming, duplication of data entry and human errors, but it has lots of advantages also like scope for error correction, detailed desire information can be collected, simple to conduct, flexibility and not required much cost to perform the survey. We have collected traffic information of different road segments of a crowded road of Bhubaneswar like Janpath Road: from Vanivihar to Rupali, Rupali to Ram mandir, Ram mandir to Master canteen, Master canteen to Rajmahal, Rajmahal to Shishu Bhawan Sq. etc.

Table 1

Traffic Status from Vanivihar to Rupali Square of Janpath Road in Bhubaneswar

Vehicle Type	Vehicle Count	% Share in Congestion
Car	380	22.32
Truck/Bus	44	2.58
Auto Rikshaw	258	15.15
Moter Cycle	418	24.55
Van	25	1.46
Others	577	33.90

Table 2

Average Speed Measurement of Vehicles by using Moving Observer Test Method

Sl. No.	Number Vehicles moving against Stream (m_0)	Number of vehicles over- taken the test vehicle (m_1)	Number of vehicles over-taken by the test vehicle (m_2)
1	108	12	76
2	112	27	45
3	32	17	8
4	77	18	12

If t_1 = time required by the testing vehicle to reach the other end moving along with the traffic and t_2 = time taken while test vehicle is moving against the traffic, then the traffic flow (Q) from above Table 1 and Table 2 data can be calculated as:

$$Q = m_0 * (m_1 - m_2) \ / \ t_1 + t_2$$

and traffic average speed (V_{as}) from above table data can be calculated as:

$$V_{as} = \text{length of the road} \ / \ t_1 - (m_1 * m_2) \ / \ Q$$

Hence, traffic density (TD)can be calculated as: $TD = Q \ / \ V_{as}$

3.3 *Methodology Used*

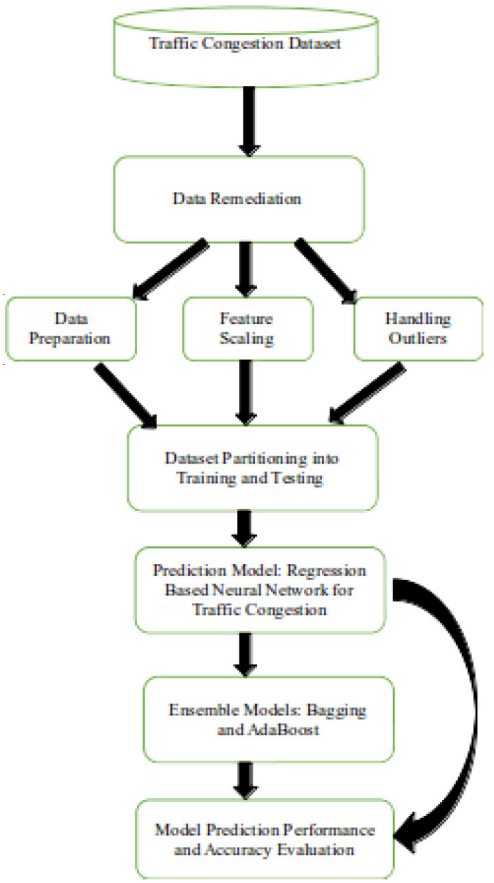


Fig. 2

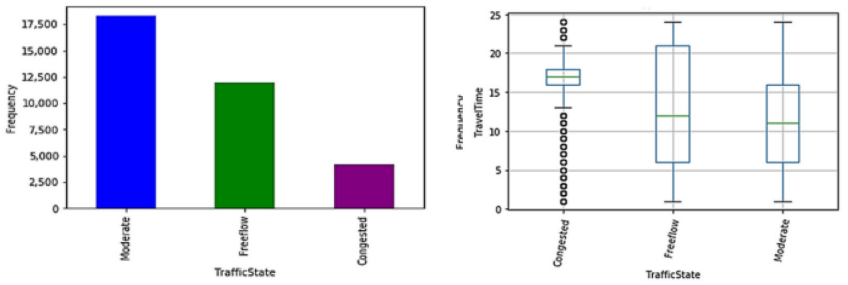
Flow Diagram of the Model for Congestion Prediction

Traffic congestion prediction is not so straight forward using models. Most common factors for traffic congestion prediction are the study area, data collection methodology, selection of predicted parameters, prediction intervals and validation procedures. Data collection for traffic congestion prediction varied from year to year. Traffic congestion level prediction is done by predicting traffic speed, flow of traffic, traffic density. We have taken eight attributes as input to our model. Our model for the prediction of congestion level based on the regression based neural network is shown in Figure 2. We have used our data set for training and testing a neural network using the neural-net library in R. We have considered a linear activation function in the keras library for our model which is based on a regression-based neural network. We consider the traffic dataset of the city of Bhubaneswar. Essentially, we are trying to predict the congestion level in the various road segments of a prominent road in the city of Bhubaneswar, based on the input attributes such as date, time, length of road, occupancy of road, direction of road, traffic volume, traffic density, speed of vehicle and traffic delay.

Our neural network model is designed using eight input attributes discussed above and a single outcome including the following attributes: (1) the graph network contains eight neurons (i.e. eight input attributes) in its input layer, (2) the graph model contains a single hidden layer with fifteen neurons, set after repeated iterations in the simulation, (3) the model contains one output layer with three neurons which signifies three levels of congestion such as free flow with little congestion, moderate congestion and highly congested, (3) trainlm is applied for training function, (4) sigmoid function is used as activation function, and (5) congestion accuracy as performance function. After several experimental verification, we got an accuracy of 89.27%, calculated from the confusion matrix that is constructed from the output levels.

4. Analysis and Discussion on Results

Figure 3 shows three traffic states known as free flow state, moderate and congested. The Figure 3a shows that the dataset is mostly in-between 75 to 125 km/h. This plot means most of dataset is distributed toward a specific speed range with most vehicles are moving with high speed, indicating there is no congestion. The Figure 3b boxplot shows the traffic state against the travel time feature. The plot is indicating that the free flow state is distributing through the travel time. The moderate flow indicates among few travels time 16:00 to 21:00 which can be a sign of congestion.



(a) Frequency Vs. Traffic State (b) Traffic Time Vs. Traffic State

Fig. 3

Experimental Results

5. Conclusion

Correct and accurate prediction of traffic congestion can provide safe traffic environments, reduce delay time spent in the congestion, cost saving and also avoid traffic accidents. So, it is most important to prevent and predict traffic congestion accurately. Our model working procedure is very simple and calculation time consumption is very less. The final result of this prediction model shows that it is not only effective to predict traffic congestion but also helps to find the different related factors associated with traffic. This paper presents a strategy for prediction of traffic congestion levels and provide basic ideas for managing related issues.

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