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Traffic Prediction Techniques: A Review

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ABSTRACT: Infrastructure of roads has failed to maintain a balance with great increase in traffic on roads. So, there is urgent need to deal with this problem of transport system. Intelligent Transport System is at the near edge now, one of the main reason being is accurate and trouble free forecasts that guarantee smooth and accurate driving and authoritative experience. In such a way, we are looking in depth of ITS for a few years and it has become a field of great growth and. Datasets are available with the application of IoT and are already under the work of existing technologies. Further, traffic is to be analysed for the betterment of traffic prediction or forecasting. This paper presents a systematic and intelligent analysis of the existing work on traffic prediction, brings to sight the changes made and presents future directions for research work.

Keywords: Traffic prediction, Traffic Dataset, IoT, Traffic flow, traffic forecasting

I. INTRODUCTION

Through ITS, we can produce information with the help of sensor nodes or through any other technology in the electronic or data form. This information is further used by the models for predictions. Analysis or prediction done can be used in variety of ways for e.g. we can predict number of vehicles, vehicle can communicate with each other, congestion can be predicted and controlled and so on. Furthermore, ITS can be used for road sign recognition, number plate detection and even in the self driving cars. Accuracy of traffic prediction generally lags behind because of various reasons such as poor infrastructure, poorly designed cities, lack of traffic capturing devices and unpredictive congestion in cities or highways.

However, the problem of poor infrastructure has been controlled by ITS. It has been made possible through usage of proper strategies while designing the models of traffic management and further enhancing them. it is even left as a challenge for most of the researchers to build an accurate model for the desired work because working on data requires more than just one's skills and sensors

To work effectively, there should be an intelligent system developed. But this system also requires credible and timely information to ensure that software can work securely and produce results within specified time. Computer systems make the interaction between human and computational devices very natural, reason being, users can get desired data in a transparent manner. The trending gadgets like mobiles, PDAs, laptops etc. make every information available anywhere at any time. By using ITS, interactive feedback loops and video games, we can analyze the traffic related behavior changes that may occur. ITS is associated with many applications and in long term it is viable to get feasible into larger frameworks in health care.

According to researchers it is suggested that usage of ITS and emergence in technology is efficient enough to aware users about the current traffic and give measures. The ITS also enable user for behavior change. Distinct elements of ITS are enhancement in decision making power and objective oriented. Thus, ITS can also be used to divert the traffic to another route which earlier just depended on how much aware the driver is. Through ITS, driver can make sensible decision and take appropriate action [4].

II. PROCCESSES INVOLVED

1. Traffic sensing- This is covered in the Perception layer where we capture the data using sensors, cameras, RFID, VIP (Video Image Processor). It is possible to even monitor the condition of roads, weather changes and other necessary information as required in the process. The technical developments evolved the improvements in the sensors which had in fact reduced their cost and made them viable to sense and store large amount of data. Table 1 summaries the various traffic sensing technologies.

Table 1: Various Traffic Sensing Technologies.

Technology	Principles	Advantages	Disadvantages
RFID (Radio-frequency identification) [5]	In RFID, radio waves are used for data to pass between electronic tag and a reader in order to track the vehicle.	*It is not costly *It causes no disturbance while sensing	*Equipped vehicles are only sensed within a range.
Infrared	In it, we use a light sensor to detect a echoed light in Infra-Red (IR) spectrum. this energy is further converted to electrical signals which detect the vehicle	*Vehicle knowledge which includes speed, position etc is determined by multiple light rays. *It can cover many lanes at a time.	*Sensitive to bad weather *High installation and maintenance costs.
Ultrasonic	Ultrasonic waves are emitted and they are reflected by a particular vehicle which detects their position.	* Multiple lanes can be sensed. * Detect vehicles with more height.	*Performance affected due to environmental factors.
Inductive loop	These are like metallic sensors which detect vehicle due to change in the magnetic field	* Very accurate data prediction *Design is very flexible Ultrasonic waves are emitted	*Many number of loops are required for covering any location *High installation and maintenance costs.
Microwave radar	Microwave frequencies are used in radar. such rays are reflected which indicates the presence of vehicles.	* Speed measured accurately * Multiple lanes operation at once	* Incapable of detecting immobile vehicles.

2. Communication and Processing of Data Fetched- This module consists of wireless communication of data through various technologies such as Bluetooth, Zig Bee, Wi-Fi etc.

These techniques are tabulated in Table 2.

Further, data is processed under various steps which are data consistency processing, data standardization, data verification, data validation etc comparison of which is discussed in the next section. More steps can be added according to the need of the community.

3 Applications of Traffic Management- Data thus collected and processes in the network layer is then passed to application layer through cloud or fog platform thus enabling its use in the various applications of traffic management field such as traffic monitoring, traffic control, detection of jams, peak busy hours detection and solutions to it etc.

Many of these applications are covered in the Literature Survey latter.

Table 2: Various Wireless Data Communication Technologies.

Technique	Standard	Range	Feature
Zig-Bee	IEEE 802.15.4	<75 m	Low power consumption, low latency, Multiple protocol availability.
Bluetooth	IEEE 802.15.1	Class 1: 100 m Class 2: 15–20 m Class 3: 1 m	Low power version available.
Wi-Fi[16]	IEEE 802.11a; 802.11b/g/n	<100 m	High speed and expandable.
GSM	-	Dependent on service provider	Large coverage, large capacity and high quality of transmitted data.
Wi-Max	IEEE 802.16	<10 km	High speed and large coverage area.

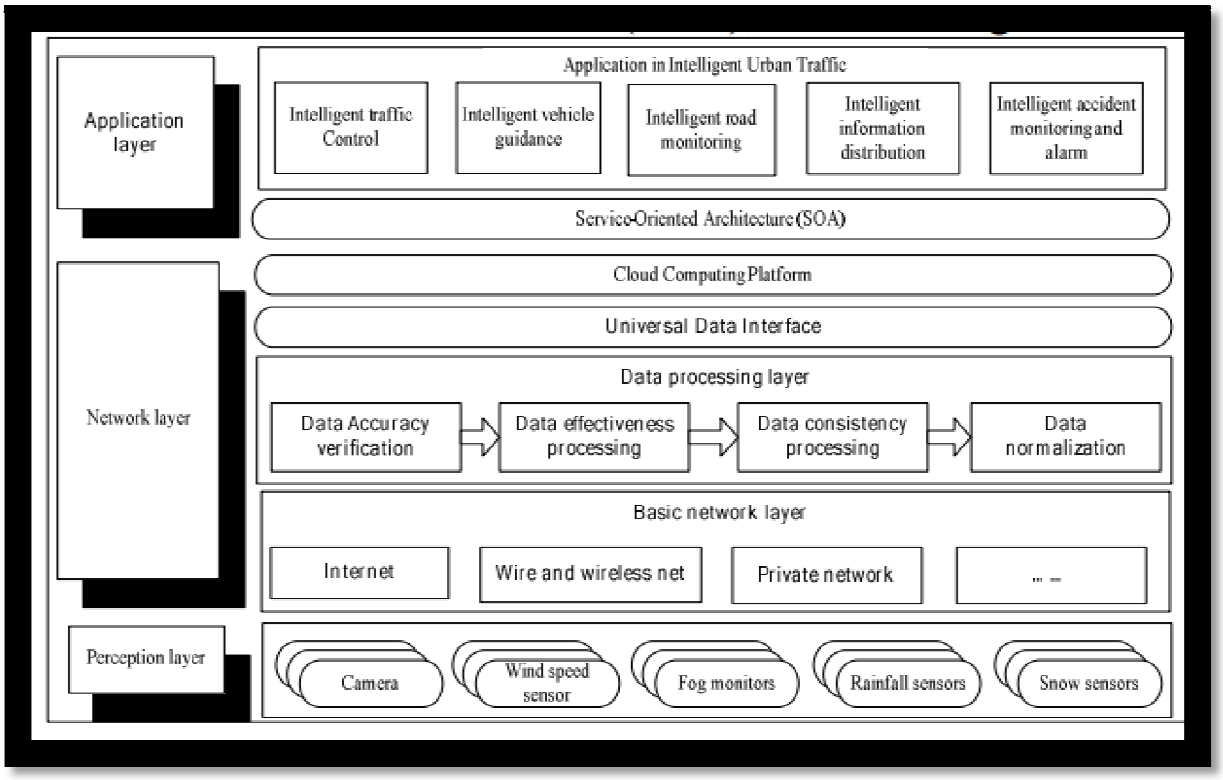

Fig. 1. Structure of the intelligent urban traffic management system [3].

III. OBJECTIVE OF THE PAPER

The main focus of this paper is to study the existing techniques, models used till date for traffic prediction and summarise them. Results of the summary can be used by researchers to continue their research work further with ease.

IV. LITERATURE SURVEY

To tackle the requirements of systematic review, background analysis is conducted. The background analysis present the existing techniques that are comprehensively used to predict on road traffic.

Most of the work done earlier focussed on data of expressways whereas analysis on proper urban roads' data was missing. Spatial and Temporal correlations are paid attention which was a gap in the literature mentioned in the paper. Traffic prediction on 5 minutes basis in done but author tried to fine tune it to 15 minutes. Multivariate spatial-temporal autoregressive (MSTAR) model has been introduced for the purpose but there is need to include data regarding weather and roadwork [1].

A special model called Seasonal ARIMA has been adopted which outperformed many techniques such as ARIMA, random walk, linear regression. This paper dealt with prediction of short term traffic such as for one hour i.e. for three days data was fed to train the model and it was validated with next day 24 hour traffic analysis. Maximum likelihood method is used as an estimation method using R software. But this technique is only useful in the case when data supply is limited [2].

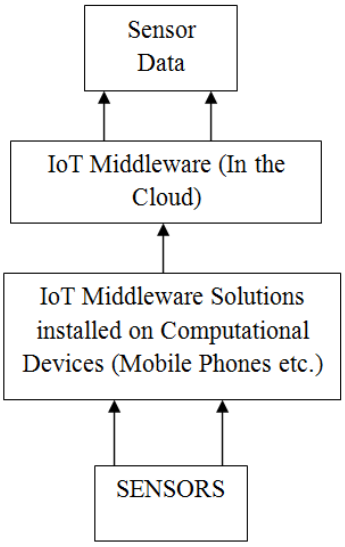

Fig. 2. Internet of Things(IOT).

In this paper, Urban Traffic Management System is based on Cloud Computing and IoT. The paper made a profound research on the data observing in light of Internet of things, estimation and the shrewd displaying segments what's more, learning coordinating segment. Mass estimation was acknowledged by the utilization of the distributed computing stage. The framework generally understands the shrewd observing what's more, administration of urban traffic and understands the reason for keen dig of urban traffic [3].

Improved method for short term traffic prediction has been put forward by Xiyu Pang. It uses improved version for kNN algorithm i.e. Three layer K-nearest Neighbor non-parametric regression algorithm. Similarity in shapes between current and earlier data paves way to better traffic analysis. Still author recommends the need to improve the accuracy because data size increases exponentially everyday and short term prediction does not work in real time world [4].

Intersections of roads forming '+' junction is studies in Nigeria for many traffic jams using Fuzzy Logic Based System and vehicles are made intelligent with use of embedded sensors and microchips. Real time simulation is done in JAVA [5].

Wireless Sensor Networks(WSN) form the basis for the urban traffic management system in order to avoid any type of congestion and thus get assured of the route to follow like in the case for emergency vehicles. Various traffic management and routing schemes are available such as RFID based methods, greedy approach, GPS based vehicle tracking etc and these have been reviewed efficiently in the paper [6].

Single multilayer perceptron has been used over the real data of Poland. Density of vehicles has been predicted on the intersections of the city with the help of this model. Many dependencies found and the problems such as curse of dimensionality, over fitting, error rates were solved easily. Since the available data was used, so the cost of the model is also negligible [7].

Now, traffic management detail can be broadly classified into 4 types-ATIS, APTS, ATMS and EMS. It has been shown how ITS plays a major role in developing nations and is in early stages in developing countries like Brazil, India etc. Subsequently, various ITS engineering models have been discussed under the umbrella of the previously defined four branches. Target is definitely to audit such models by carefully examining each of them carefully. This will further find out loopholes in the system and directs us to the future scope of various systems [8].

Trending technology IoT (Internet of things) will be of great benefit is combined with the traffic or transportation system because of the various advantages it offers such low costs, larger scalability, low upgradation costs and easy to use feature. It is based on wireless technology that focuses on making the model more intelligent by automation of tracking, managing and processing. Further, many heterogeneous and decentralised devices can be connected to extract benefits. Active radio-frequency identification(RFID) has been introduced for tracking purposes. Framework which involves simulation model with NetLogo is using this technology for its sole purpose [9].

Image processing techniques have been combined with computer vision to extract the maximum out of them. Two models which are of low cost have been discussed *i.e.* with and without the support of hardware. It provides us an excellent system which can help in reducing traffic congestion, detect the vehicles density and gradually defines the waiting time for each user. In addition, it can auto -detect the condition of road and advice the vehicle to make the change in the path accordingly. Time is definitely saved and the low cost model adds to its advantage. Being a low cost model only single server has been deployed. efficiency can be further enhanced by applying machine learning model and solar cells can be used to increase its efficiency in terms of power consumption [10].

This paper deals with the problem of traffic maintenance as faced by the public. So this problem was worked out on through IoT framework and is genuinely known as Intelligent Transport Framework. vehicle terminal provided the server the necessary traffic data which was treated on by the algorithm and the necessary routes were provided to the passengers. Thus, many of the passengers benefitted from the proposed model and the city traffic was handled well [11]. IEEE802.11ah protocol which has not been standardized yet is used for IoT devices to communicate amongst themselves. Transceiver has been proposed which utilises all the subcarriers for the long range communication which is helpful even in case of emergency situations [12].

Project for smart cities is discussed through user scenarios which collaborates IoT and Cloud together to form ClouT. The architecture discussed serves as a base to manage large amount of data of modern cities. It is still in process and is not fully developed yet [13-14].

Not only in the case of transportation field, but also the health ministry aims at disease detection at earlier stages to provide better medical facilities to patients. IoT (servers at hospital) has been used for the purpose to go beyond just face to face interactions [15].

In this paper, author justifies use of IoT in smart homes and uses Wi-Fi for communication. Power consumption for Wi-Fi has been an issue which is solved in this paper. because Wi-Fi is more secure than other techniques available [16].

Selective sensing in Context Aware Mobile Sensor Data Engine used with IoT is proved useful through three use case scenarios. The only disadvantage faced is no privacy preserving rules which can be improved further [17].

Till now only IoT has been discussed but no one pointed out the issue of portability. in this paper, author deals with ECG Android App so that patients can also view their healthcare which seems interesting research. Better microcontrollers can be deployed for better accuracy and increase in prediction results [18].

Pallavi Vaish also dealt with similar idea of abnormality detection in kidneys through smart phones via App. detection is based on Viola Jones Algorithm which is proceeded by SVM with an accuracy of 90% [22].

Various data mining techniques have been discussed in the paper such as SVM, Bayesian, kNN and so on. Each of them has been reviewed, merits and demerits of each of the model have been listed. It can be observed as very thorough review of the techniques hence useful for future research [19].

Combination of KNN, C4.5, SVM And Naive Bayes Classifier has been used over UCI datasets for better prediction and accuracy of the classification purpose. It was observed that results of the collaborated model proved better than individual ones [20].

Besides them, need to find spatial and temporal patterns in traffic was found which was handled by Muhammad Tayyab Asif. He proposed unsupervised methods such as k-means clustering, self organizing maps(SOM) on real time data and proved SVR outraged all the other predicting models[23].

SVR [24], Neural Networks [25], Bayesian networks [31] have been used wisely in different papers under different circumstances for different datasets. Other than these, hybrid models [27] played their roles in prediction too.

As observed from the above models, Traffic management with the implication of sensors is complex and required accuracy. Techniques devised so far still requires further enhancements for increasing accuracy of prediction. Next section presents gap in literature and summarised version of the literature survey.

V. RESEARCH GAP

Analysis of literature indicates that dataset used is offline and is not derived with the application of IoT. Sensor data utilization within traffic related application is the prime cause of interest. Accurate prediction related to traffic to drivers involved along with direction sensing is missing in existing literature. Advanced application framework construction for traffic prediction is the solution for the problem.

VI. COMPARISON TABLE

The comparison of various techniques that can be used to predict traffic is listed as under:-

Title	Technique	Datasets	Parameters	Merit	Demerit
Road Traffic Prediction with Spatio-Temporal Correlations [1]	multivariate spatial-temporal autoregressive (MSTAR) model	Road network which consists of 502 Links	Accuracy, Mean, Deviation	Traffic prediction for larger time intervals.	Lack of use of weather, roadwork situation data
Short-term traffic flow prediction using seasonal ARIMA model with limited input data [2]	SARIMA (Seasonal ARIMA)	Rajiv Gandhi road in Chennai, India	MAPE	Serves as a boon where data is inefficient	Invalid for large datasets.
Intelligent Urban Traffic Management System Based on Cloud Computing and Internet of Things[3]	Three layers of IoT architecture were combined with SOA	---------	Accuracy, Effectiveness	Specific applications were realized such as intelligent traffic control, intelligent vehicle guidance, intelligent accident monitoring etc.	No real time data is involved here
A Short-Term Traffic Flow Forecasting Method Based on a Three-Layer K-Nearest Neighbor Non-Parametric Regression Algorithm [4]	Three-Layer K-Nearest Neighbor Non-Parametric Regression Algorithm	--------	Performance and Accuracy	Better Accuracy	Not suitable for large datasets

Title	Technique	Datasets	Parameters	Merit	Demerit
Design And Simulation Of An Intelligent Traffic Control System [5]	fuzzy logic based system	Chartered Institute of Traffic and Logistic in Nigeria	Waiting Time, Moving Time	Lesser Waiting Time And Better Accuracy	--------
A Survey on Urban Traffic Management System Using Wireless Sensor Networks [6]	WSN(Wireless Sensor Networks)	--------	---------	Better Congestion Control, Lesser Average Waiting Time, Priority to emergency vehicles	Number of accidents and traffic violations yet to be included.
Road traffic predictions across major city intersections using multilayer perceptrons [7]	Single multilayer perceptron	Real data of Poland	RMSE, MAPE, MAE	Reduced the curse of dimensionality,	Poor prediction in some cases
Intelligent Traffic Information System Based on Integration of Internet of Things and Agent Technology [9]	RFID and NetLogo	Real-time data collected from the distributed online simulations	--------	Better efficiency and accuracy of the system.	Need for better security and privacy of users
Intelligent Traffic Management System for Cross Section of Roads Using Computer Vision [10]	Object-oriented software design is used along with hardware components	--------	Running time, Waiting time	Reduces the waiting time and increases running time of traffic lights.	Machine learning algorithms missing, Need for low powered capturing devices which operate on solar energy
Research of Intelligent Transportation System Based on the Internet of Things Frame [11]	GPS is involved	Three modules under one dataset with respect to vehicles and stations	Accuracy	Better resource utilisation	Analysis of model on huge datasets is missing
A Consumer Transceiver for Long-Range IoT Communications in Emergency Environments [12]	IEEE 802.11ah Wi-Fi protocol, Time Domain Least Square(TDLS)	--------	Packet Error Rate(PER), MSE	Increased range of service	Execution Time is substantially high
The advantages of IoT and Cloud applied to Smart Cities[13]	ClouT architecture which is combination of cloud and IoT is discussed	--------	-------	Sensorisation , Actuatorisation layer along with IoT have been added in CIaaS layer to extract data out of API's	CSaaS layer is still not completely defined.
Smart Disease Surveillance Based on Internet of Things (IoT) [15]	IoT in the field of health care	Central Health Ministry	Prediction accuracy	Fast prediction of patterns of disease, help to take measures on time	Inadequate data managers, low budget, lack of technical advisory group
Optimising Power Consumption of Wi-Fi inbuilt IoT Devices[16]	Reduce power consumption of Wi-Fi enabled devices	--------	Power consumption of various processors	Wi-Fi is better than other technologies in terms of range and security	No parameters enhancements are suggested
Energy-Efficient Location and Activity-Aware On-Demand Mobile Distributed Sensing Platform for Sensing as a Service in IoT Clouds [17]	C-MOSDEN platform	Context, activity and location aware module(Both real world and simulated lab - based data were focused on)	Energy, Storage, Communication	Sensors energy is conserved and increases lifetime of network	No focus on privacy preservation technique.
Internet of Things: Remote Patient Monitoring Using Web Services and Cloud Computing[18]	Android app is framed which takes data from IOIO-OTG board. Binary file is uploaded on cloud and processed using MATLAB	Bio-medical data like temperature, pulse, blood pressure etc.	Portability of binary data	Uniform service to patients, feasible, inexpensive	Overhead due to authentication of users. Micro-controller of higher configuration can be used.

Title	Technique	Datasets	Parameters	Merit	Demerit
Data Mining for the Internet of Things: Literature Review and Challenges[19]	Review of various data mining techniques and its applications is performed	--------	3 views of data mining--> knowledge, technique, application view.	Big data, data mining are hot topics to discover deep.	Parameter optimization is not considered
Combining KNN Algorithm and Other Classifiers [20]	KNN, C4.5, SVM And Naive Bayes Classifier(KNC)	20 UCI Datasets	Accuracy for classification	Higher accuracy	Execution time not considered
Internet of things: Vision, applications and research challenges[21]	Review of IoT along with the challenges is discussed.	--------	-------	IoT applications are described ensuring its efficient use in future work	No parameter enhancement mechanism is considered
Smartphone Based Automatic Abnormality Detection of Kidney in Ultrasound Images[22]	Viola Jones algorithm, SVM, Genetic algorithm	Ultrasound images from ultrasound scanner	Prediction accuracy	Benefits rural people, can be used for emergency	Only cyst and kidney stone is considered
Spatial and Temporal Patterns in Large-Scale Traffic Speed Prediction[23]	Unsupervised methods(k-means, self organising maps, principal component analysis) to find out global trends	Road network from Outram park to Changi in Singapore.	Prediction accuracy MSE	Spatial and temporal trends found which was not possible through use of SVM	Need to incorporate these found patterns into route guiding algorithms
Improving Traffic Prediction with Tweet Semantics[24]	Correlation analysis between traffic measurements and number of tweets. Later optimisation framework was used.	Traffic and data from Twitter>> San Francisco Bay area of California	MAPE and RMSE	Prediction better in comparison to auto-correlation model	Spam data presence, no work on heterogeneous traffic.
Road Traffic Parameters Prediction In Urban Traffic Management Systems Using Neural Networks[25]	Neural Networks	-------	Accuracy	Only for short term prediction	Better prediction model is needed for long term prediction of traffic
Smart video surveillance system for vehicle Detection and traffic flow control[26]	Image Processing-->Background Subtraction using Threshhold Adjusting process	Video Database	False Rejection Rate(FRR), False Acceptance Rate(FAR), Total Success Rate(TSR)	Prediction accuracy is increased by the use of video surveillance	Cameras not for night vision, situations to suspect danger not covered.
Utilizing Real-World Transportation Data for Accurate Traffic Prediction[27]	H-ARIMA+(Hybrid model of HAM and ARIMA)	Los Angeles County Transport Network	MAPE and RMSE	Short term and Long term prediction accuracy better than ARIMA, ES, NNet	Data from each sensor is studied individually. need for spatial correlations between sensors
A Comprehensive Review on Traffic Prediction for Intelligent Transport System[28]	Review of techniques used in ITS is considered like NN, SVM, Bayesian etc	PeMS, TMC,MIDAS, Bing data, twitter Data.	RMSE, MAPE, MRE, VAPE, EC etc	Techniques are given that can be enhanced in future work for prediction accuracy	Lack of use of deep learning techniques, datasets excluded parameters such as humidity, holidays etc.
An Aggregation Approach to Short-Term Traffic Flow Prediction[29]	Integration of MA, ES and ARIMA using NN	National Highway 107, Guangzhou, Guangdong, China	RMSE, PAE and MAPE	Accuracy is high	Situation involving multiple detectors is missing
Traffic big data prediction and visualization using Fast Incremental Model Trees-Drift Detection (FIMT-DD)[30]	FIMT	Department of transport UK	Prediction accuracy through MAE, RMSE and SMAPE	Accuracy is high and visualization of traffic presented for better understanding	Means square error can be further reduced.
Traffic Flow Forecasting Using a Spatio-temporal Bayesian Network Predictor[31]	Bayesian Network	--------	Accuracy through MMSE	Prediction accuracy is improved since pre-processing reduces the impact of error	No real time dataset is considered

CONCLUSION

Traffic prediction using the application of fog computing is critical that can be used to monitor time critical applications such as preventing road accidents. The relevant information is required to be transferred to the source so that user who can be a driver can take appropriate action regarding route towards the destination is the prime objective of this study. Dataset derived from sensor will be used to construct real time traffic prediction framework. Accuracy will be the key parameter that could be enhanced by the application of proposed methodology.

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