I.J. Information Technology and Computer Science, **2022, 2, 54-63**
Published Online April 2022 in MECS (http://www.mecs-press.org/)
DOI: 10.5815/ijitcs.2022.02.05

Road Rush: A Review on Road Traffic Analytics Systems and A Proposed Alternative

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Received: 26 May 2019; Revised: 23 August 2021; Accepted: 28 October 2021; Published: 08 April 2022

Abstract: Road traffic congestion is a recurring occurrence causing enormous loss of valuable working hours around the world. It is impossible to eradicate such a problem overnight. Rather it could be handled intelligently with the help of modern technologies. Researchers and practitioners have introduced several algorithms, frameworks, systems to mitigate traffic congestion. This paper presents a systematic literature review on existing research and critically analyze the applications on traffic analytics systems. After designing a review protocol, each work was evaluated based on the five research questions and criteria. After critically and carefully analyzing the existing works, this paper also identified the advantages as well as the limitations of the existing approaches towards solving traffic congestion. Based on the findings, a prototype of a mobile application is proposed that can be considered as an improved alternative to the existing works. Finally, this study provides future research directions and improvement scopes in this field.

Index Terms: Road traffic congestion, road traffic analytics, smart city, real-time road traffic status, road traffic prediction, travel time prediction, route recommendation, departure time suggestion.

1. Introduction

Traffic congestion is one of the most common phenomena in urban life. In recent years it has increased at an alarming rate. People have to waste a huge amount of productive working hours being stuck in it. A study found that approximately 3.2 million business hours are lost every day due to traffic congestion and the amount of loss is worth around BDT 20,000 crore a year in Dhaka, Bangladesh [1]. Unquestionably the amount would be rocketed up if we consider the amount of loss around the globe. On the other hand, during traffic congestion, vehicles burn more fuel due to frequent stopping and starting. This higher rate of fuel consumption increases the amount of emissions released by the vehicles and contributes to another environmental phenomenon known as global warming.

As it is impossible to increase the number of roads along with the vehicle growth, so, traffic congestion cannot be eradicated all of a sudden manually. However, we can handle this unavoidable problem more efficiently by simply using technology with intelligence. If an intelligent system can show real-time traffic scenario, predict future traffic condition, estimate required travel time accurately, recommend the faster route to reach a particular destination and suggest best departure time simultaneously, then it could mitigate the sufferings. Together all these features may bring some comfort to city life.

The concept of smart city [2] is not a fiction anymore due to the recent developments in the field of data science, internet of things (IoT) and networking. Intelligent traffic analytics systems will be an integral part of the smart cities that will play an important role to diminish traffic congestion. However, to achieve this, existing works and applications need to go through further improvements. Several studies have been performed and a lot more is going on aiming at helping people by reducing the impacts of traffic jams using modern technologies. A great number of promising traffic applications have been developed to minimize traffic troubles like Google Traffic, UDOT Traffic, NZ Traffic, INRIX Traffic, Waze, Go Traffic, JamKoi and so on.

To perform further enhancements to the existing works, one needs to know what is done already, how it has been done and what are the limitations or scope of possible future works/improvements. It would be cumbersome for someone to go through the existing literature and applications, evaluate and interpret them which are aimed to eradicate traffic congestion. However, a systematic literature review (SLR) would be highly beneficial both to the researchers and practitioners where the evaluation and interpretation of all relevant available research and developments are available that are relevant to a particular research question, topic area, or phenomenon. Furthermore, due to the extensive acceptance of big data and smart city, the demand of a SLR on traffic analytic systems would be highly anticipated among the experts.

Therefore, this paper aims to fulfil the expected need of experts in the field of traffic analytic systems. As a consequence, in this paper, a systematic literature review has been performed to evaluate and interpret all available researches and systems that are relevant to traffic analytics, route recommender system. Furthermore, this paper also suggests future research directions and improvement scopes based on the SLR. Finally, this paper presents a prototype of a novel traffic analytics system that has the potential to overcome the several limitations of the existing works.

The rest of the paper is structured as follows: the research method is minutely explained in section 2, the related works are discussed in section 3, the outcome of this research and future working scopes are discussed in section 4 and finally a brief discussion on a proposed system and its features in section 5.

2. Research Method

Systematic Literature Review is "a means of evaluating and interpreting all available research relevant to a particular research question, topic area, or phenomenon of interest" [3]. It is quite popular among researchers. In this paper, guidelines regarding SLR given by B. A. Kitchenham and S. Charters [3] were followed. At first, a review protocol was designed in order to conduct this SLR. Fig. 1 describes the review protocol.

There were eight phases in the review protocol: (i) research motivation, (ii) research question formulation, (iii) search string construction, (iv) electronic databases selection, (v) research paper collection, (vi) study selection (inclusion and exclusion), (vii) data collection and lastly (viii) data synthesis.

A. Research Motivation

Researchers are working to solve traffic congestion for many years. Significant numbers of hardware and software systems are built using different algorithms. However, the scene is almost the same for developing and underdeveloped countries. Therefore, the motivation of this research was to present the comparative efficiency of these existing works and find out improvement scopes to reduce the troubles created by traffic congestion as far as feasible.

B. Research Questions

The main questions addressed in this study were:

a) Is there any system that can show real-time road traffic condition?
b) Is there any system that can predict future road traffic condition?
c) Is there any system that can estimate the required travel time to reach a particular destination considering the various situation?
d) Is there any system that can recommend a faster route to reach a specific destination?
e) Is there any system that can suggest departure times for any time or day?
f) Is there any system that can show real-time road traffic condition, predict future road traffic condition, estimate required travel time, recommend the faster route and suggest departure time simultaneously?

C. Search Process

Some electronic databases were used to collect the research papers like IEEE Xplore Digital Library, ACM Digital Library, Google Scholar, CiteSeer, and Science Direct. Based on the research questions some search strings were formulated and used to search in these databases. Used search strings were–

1. Crowdsource based traffic analytic system
2. Real-time road traffic information
3. Live traffic information
4. Future road traffic prediction
5. Travel time prediction
6. Trip time suggestion
7. Recommendation system
8. Departure time suggestion

D. Study Inclusion and Exclusion Criteria

In this paper, mainly road traffic condition detection, prediction, route recommendation, travel time suggestion and related aspects were focused. The following criteria were considered to select research papers to accomplish this systematic literature review.

a. Inclusion Criteria:

- Papers are written in the English language.
- Papers discussing road traffic analytic systems/methods/algorithms.
- Papers discussing road traffic detecting systems/methods/algorithms.

- Papers discussing road traffic prediction systems/methods/algorithms.
- Papers discussing route recommendation systems/methods/algorithms.
- Papers discussing travel time recommendation systems/methods/algorithms.
- Papers published in the domain of traffic congestion from the year 2007 to 2019.

b. Exclusion Criteria:

- Research studies not published in the English language
- Simple articles published on websites
- Redundant studies
- Papers published before 2007
- Papers not able to answer the research questions

E. Data Collection

In this SLR, data were collected manually. Based on the previously mentioned evaluation criteria only relevant papers and systems were considered to collect data. Data related to works' features, approach, accuracy, efficiency and limitations were mainly focused here.

F. Data Synthesis

"Data synthesis involves collating and summarizing the results of the included primary studies" [4]. In this phase, a qualitative data analysis approach was used for synthesizing purposes. Data collected in the previous phase were analyzed and summarized to determine the efficiency of the existing systems.

G. Document Retrieval

Initially, 553 papers and 187 mobile applications were retrieved. 379 papers and 134 applications were rejected after going through the titles. 154 papers and 38 applications were rejected after learning the abstracts or description. However, we analyzed the remaining research papers and applications very carefully to collect the required information. Finally, 24 papers and 15 mobile-based applications were reviewed in this study.

3. Related Work

To perform a systematic literature review on existing traffic systems, each work is compared against the following evaluation criteria:

1. Real-time road traffic information
2. Road traffic prediction/identification.
3. Future travel time estimation.
4. Route recommendation for the prospective tour.
5. Departure time recommendation.

Research works, frameworks, mobile applications related to any of these contexts were gone through very carefully. Table 1 and Table 2 presents a summary of all the information collected during related work-study.

The analysis shows that most of the existing researches and systems are aiming at providing real-time traffic conditions [2, 5-17]. However, a large number of these works or systems provide traffic conditions based on historical data [5, 14, 18-25] too. Few systems provide route recommendation [6, 10, 13, 14, 26-29] also.

In the case of mobile applications, only one system Inrix [14] fulfils the highest number of evaluation criteria (4 out of 5). INRIX does not provide departure time recommendation. Besides, inaccuracy and inflexibility of this app have been observed on several locations by the users i.e. providing inaccurate traffic status, leading to the road which is closed etc. [30-32] which questioned the real-time traffic claim by the app. Furthermore, departure alert works only for predefined locations.

This analysis also suggests some of the limitations of the existing works and future works after carefully analyzing them which indicates the enormous scope of improvements in this field. This can be useful to determine what would be the next move for someone to improve the current traffic congestion problem based on existing progress.

Table 1. Critical evaluation of research works

No	Title	Approach	Criteria					Limitations/Future Work
			1	2	3	4	5	
1.	Smart Traffic Analytics in the Semantic Web with STAR-CITY: Scenarios, System and Lessons Learned in Dublin City [5].	Used W3c semantic web stack to represent the semantics of information and deliver interference outcome.	√	√	×	×	×	Future work includes handling – –Data summarization –Flexible data integration –Advanced temporal similarity –Noisy data streams.
2.	Online Learning Solutions for Freeway Travel Time Prediction [33].	Based on the extended Kalman filter (EKF) proposed two online learning algorithms for short-term travel time predictions on freeways.	×	×	√	×	×	Limitation – –Derived predictions are short-term only
3.	Prediction, Expectation, and Surprise: Methods, Designs and Study of a Deployed Traffic Forecasting Service [18].	Data were streamed from server-based learning and reasoning systems to portable devices, based on information from the devices and other sources.	×	√	×	×	×	Ongoing research includes – –Investigating alternate machine learning modeling methods.
4.	A Constructive intelligent transportation system for urban traffic network in developing country via GPS from multiple transportation modes [19].	Collected data through cameras, sensors and GPS of various transports several processing and analyzing algorithms were adapted to predict road traffic information.	×	√	×	×	×	Future work includes - –Making the system more flexible in allowing users to interact with the control center.
5.	CrowdPlanner: A Crowd-Based Route Recommendation System [26].	Identified the best route among the candidate routes based on the evaluation of human workers through questionnaires. Question generation and suitable worker selection were also done by the system.	×	×	×	√	×	Limitation – –Fully depends on questionnaires.
6.	Evaluation of Road Traffic Congestion Using Fuzzy Techniques [34].	Evaluated road traffic status with low error margins from image processing data using manually tuned fuzzy logic and adaptive neuro-fuzzy techniques.	√	×	×	×	×	Limitation – –Road traffic evaluation is not exactly real-time.
7.	Real-time road traffic prediction with spatio-temporal correlations [20].	Predicted road traffic status collecting real-time data by loop detectors and summarizing them into 5-min volume and speed over each link.	×	√	×	×	×	–The intense arrival of signals may hamper processing. –the output may become biased.
8.	Real-time Traffic-based Routing based on Open Data and Open-Source Software [6].	Based on the Lambda Architecture, collected and stored data through web services and performed distributed processing on recent data.	√	×	×	√	×	Limitation - –Proof of concept prototype.
9.	Real Time Traffic Monitoring System Using Crowd Sourced GPS Data [21].	Real-time traffic status was monitored through cell phone GPS and then stored and processed to estimate near real-time traffic information later.	×	√	×	×	×	Limitation - –Has issues in GPS accuracy and data consumption.
10.	Event Processing and Real-time Monitoring over Streaming Traffic Data [7].	Provided real-time traffic information processing positional information of moving vehicle collected from GPS-equipped vehicles, mobile phones of the drivers, wireless networks etc. to provide.	√	×	×	×	×	Future work includes- –Managing uncertainty, aging of the system and delays of data streams. –Traffic prediction for a short-time period. –Combining online analytics with offline statistics. –Developing approximation algorithms to get traffic estimations with error guarantees.
11.	Urban Traffic Monitoring with the Help of Bus Riders [8].	Monitored bus riders' travel status through their commodity off-the-shelf (COTS) mobile phones generates a real-time traffic map.	√	×	×	×	×	Future work includes – –Deriving overall traffic of a region from the bus covered road segments. Limitation– –Real-time traffic map can be biased due to the frequent stopping of the buses at the bus stops.

12.	Dynamic Time Series Prediction of Future Traffic Conditions [22].	Evaluated various input data using probabilistic techniques predictions of road traffic status are generated at multiple future times.	×	√	×	×	×	Limitation– –Uncertain incidents might be overlooked in the prediction.
13.	A Real Time Traffic Information Service for Efficient Navigation and Transport Management [9].	Integrated real-time data collected through mobile GIS application provides information regarding real-time road traffic condition.	√	×	×	×	×	–Provides real-time traffic update only.
14.	A Genetic Algorithm-based Method for Improving Quality of Travel Time Prediction Intervals [35].	Determined the number of neurons and hidden layers of the neural network models using genetic algorithm provides optimal prediction intervals for bus and freeway travel times.	×	×	√	×	×	Limitation– –The focus is only on buses and the freeway.
15.	Modeling Departure Time and Route Choice Problems in Stochastic Road Networks for Online ATIS Applications [27]	Based on traveler's preferences, suggested optimal departure time and faster route considering route length and traffic status.	×	×	×	√	√	Need to validate the model results under various congested conditions [27].
16.	A real-time personalized route recommendation system for self-drive tourists based on vehicle to vehicle communication [10].	V2VS system was adopted to gather information regarding visiting behaviors of self-drive tourists and real-time traffic status. Candidate routes were scored according to the collected information using a fuzzy set theory-based approach and the TOPSIS method. Then a genetic algorithm was applied to recommend appropriate route based on route score and restrictive conditions.	√	×	×	√	×	–Need to consider more route attributes while recommending optimal routes to fulfill more personalized requirements of users –Need to allow users to customize their self-driven plans according to their preferences. –Need to be platform-independent
17.	Large-Scale Travel Time Prediction for Urban Arterial Roads Based on Kalman Filter [36].	Based on Kalman filter using the hierarchical clustering predicted large-scale travel time.	×	×	√	×	×	–The mean absolute relative error rate of the method is 14.66% [36].
18.	Traffic Estimation And Prediction Based On Real Time Floating Car Data [23].	Used current and near-past data estimated by the presented OCTO Telematics FCD system proposed two algorithms for short-term travel speed predictions	×	√	×	×	×	–The accuracy of the presented system in estimating real-time data is about 90% only.
19.	Eco-Routing Navigation System Based on Multisource Historical and Real-Time Traffic Information [29].	Integrating historical and real-time traffic information found optimal routes considering emission factors based on traffic conditions.	×	×	×	√	×	Proposed system has errors in following contexts – –Data aggregation –Model inputs –State of traffic –Regression
20.	Efficient Traffic State Estimation for Large-Scale Urban Road Networks [37].	Proposed methods to construct an exact GIS-T digital map and estimate real-time traffic status based on data collected from GPS probe vehicles.	√	×	×	×	×	–Provides real-time traffic update only.
21.	Shared Subway Shuttle Bus Route Planning Based on Transport Data Analytics [38].	Optimized shared bus operation status based on crowdsourced shared subway shuttle bus data generated by Panda Bus Company.	×	×	×	√	×	– Limited only to Shared Bus.
22.	A resilient and distributed near real-time traffic forecasting application for Fog computing environments [39].	Proposed an architecture for a city-wide traffic modeling and prediction service based on the Fog Computing paradigm.	√	√	×	×	×	Future work: –Considering transfer-learning sceanrios.
23.	Geographical patterns of traffic congestion in growing megacities: Big data analytics from Beijing [40].	Applied several models and methods from time series analysis, cluster analysis to identify typical traffic congestion patterns in Beijing.	×	√	×	×	×	Limitation: –Data from brunch roads were excluded. –The use of K-means clustering alogirthm is sensitive to parameter settings.

Table 2. Critical analysis of Traffic Mobile Applications

No.	Application Name	Promised Features according to Criteria					Limitations/Future Work
		1	2	3	4	5	
1.	Google Traffic [11]	√	√	√	×	×	−Does not provide traffic information for all countries [41].
2.	UDOT Traffic [42]	√	×	×	×	×	−Only works for Utah, a western U.S. state [42]. −Fails to provide accurate real time information [43-44]. −Has technical issues [45-46].
3.	NZ Traffic [12]	√	×	×	×	×	−Only works for New Zealand [12].
4.	Inrix Traffic [14]	√	√	√	√	×	−Works for limited countries [14]. −Shows inaccurate information [30-31]. −Inflexible [32].
5.	Waze [13]	√	×	√	√	×	−Does not calculate ETA considering time zone of the destination when the user is in a different time zone. [47].
6.	Darb [48]	√	×	×	×	×	−Only usable for Abu Dhabi residents [48]. −Does not show reliable information [25 49].
7.	Go Traffic [50]	√	×	√	×	×	−Fails to estimate real time information [51-52]. −Has technical issues [53-54].
8.	JamKoi Real Time Traffic [55]	√	×	×	×	×	−Fails to provide real time information [56]. −Has technical issues [57-58].
9.	Traffic Spotter - Traffic Reports [24]	√	√	×	×	×	−Forecasts driving conditions for next three hours only [24].
10.	Ma3route [59]	√	×	×	×	×	−Has technical issues [60].
11.	Route4Me Route Planner [28]	×	×	×	√	×	−Provides optimal route suggestion without considering traffic condition [61]. −Not user-friendly [62-63].
12.	Live Traffic NSW [64]	√	×	√	×	×	−Fails to provide updated information [65]. −Has technical issues [66-67].
13.	Traffic Watch [15]	√	×	×	×	×	−Does not contain for enough locations [68-69].
14.	KMOV Traffic [16]	√	×	×	×	×	
15.	Wasalny Traffic [17]	√	×	×	√	×	−Users face problem during signing up [70-72].

4. Findings & Discussion

In this paper, a systematic literature review is performed over 23 research papers and 15 mobile applications based on the evaluation criteria mentioned in section III. All these systems are aiming at the reduction of traffic troubles. Some provides real-time traffic information [2, 5-17], some provides future traffic prediction [10, 18-20, 22, 33, 35], some provides future travel time prediction [29]. Few systems [10, 26-27] provide route recommendations also. Only one system Inrix [40] fulfils most of the evaluation criteria. Our research work finds no system that provides departure time suggestions i.e. what will be the best time to avoid the traffic. So there is a scope of developing traffic analytics that can be able to provide departure time suggestions along with other features.

Based on our analysis, we provide the following scopes of improvement/ future works/ suggestions in the field of traffic analytics systems:

- Traffic analytics should be provided in real-time. However, most of the systems provide updates in near real-time. New approaches need to be developed to guarantee real-time traffic analytics.
- Systems should be smart enough to recommend the best route in real-time based on current traffic condition.
- Real-time traffic should be accompanied by road traffic prediction, estimation of travel in future, route and departure time recommendations in order to improve the present traffic congestion problem.
- Development of performance measurement criteria to compare the performance among different techniques.
- Considering the different speeds of different types of vehicles for predictions and recommendations.
- Development of the state of the art algorithms to deal with noisy data.
- Ensuring higher accuracy and reliability in case of real-time traffic conditions, predictions and recommendations. Real-time data (online analytics) should be combined with offline statistics to ensure accuracy and reliability.
- Higher flexibility should be provided to the users.
- Alternate machine learning modeling methods can be investigated for future work.

5. Proposed System & Features

Analyzing the existing works and their limitations, we have come up with a proposal of a comprehensive intelligent solution named ‘Road Rush', to mitigate traffic congestion in urban areas. This section presents the potential features and prototype of the proposed system.

‘Road Rush' is planned to be a crowdsource based traffic analytic mobile application that will be able to collect a large volume of traffic data, analyze and deliver real-time traffic insights via the internet. It will be able to generate a live traffic map from the insights and recommend the fastest route in real-time considering current traffic status. One of the most important features of the app is to predict future traffic conditions based on different traffic and weather attribute. It will also be able to estimate travel time, recommend faster routes and departure time in advance. This app will have the ability to function accordingly for several types of transportation medium like the car, bus, bicycle, motorcycle, three-wheelers etc. In fewer words, ‘Road Rush' is designed to assist users to make the right decision in advance to avoid traffic congestion in every possible way.

Initially, a sample prototype has been built which can calculate travel distance, speed and travel time. Besides, it can also search and show routes to different destinations. In addition, it can select different types of vehicles. The implementation work is still in progress. Now we are collecting data for initial analysis and predictive model building. After that, we will launch a beta version of the app to collect real-time data for building accurate models for different predictions and recommendations.

The complete system will have the following features:

- Generate live traffic map.
- Choose on road/off road option to ensure better accuracy.
- Search routes to destination.
- Choose vehicle type.
- Show the routes to user’s destination.
- Show alternate routes to user’s destination.
- Calculate required time to reach destination.

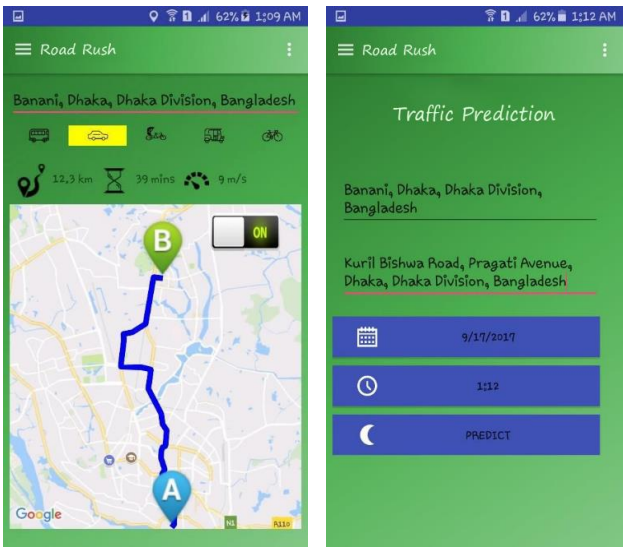

Fig.1. (a) Real team traffic data collection and insights display option; (b) Option for predicting travel time on a particular date and time.

- Calculate distance to user’s destination.
- Calculate current speed.
- Predict traffic congestion for individual date and time.
- Recommend a faster route to destination for a particular time of the day.
- Recommend the best time to start a trip on a particular day.
- Show specific incident icon for individual incidents.
- Allow user to report an incident.
- Show warning for excessive speed.

6. Conclusion

This paper presents the SLR on more than 23 articles and 15 mobile applications. The authors believe that smart traffic analytics systems will be an integral part of the Smart City in near future and this paper will help the researchers and practitioners to get acquainted themselves with the recent works at a glance. Furthermore, this paper also provides future research directions as well as improvement scopes from the perspective of a smart traffic analytics system. Finally, this paper presents the prototype of an in-progress system that will mitigate traffic congestions by addressing the limitations of the existing works and thus ease our everyday life.

References

[1] Traffic jam in Dhaka eats up 3.2m working hrs every day: WB. Retrieved from: https://goo.gl/sZzfmG.

[2] Eric Horvitz, Johnson Apacible, Raman Sarin, Lin Liao, “Prediction, Expectation, and Surprise: Methods, Designs, and Study of a Deployed Traffic Forecasting Service”, 2012.

[3] B. A. Kitchenham and S. Charters, "Guidelines for performing systematic literature reviews in software engineering," 2007.

[4] Duc-Thinh Pham, Bao An Mai Hoang, Son Nguyen Thanh, Ha Nguyen & Vu Duong, “A Constructive Intelligent Transportation System for Urban Traffic Network in Developing Countries via GPS Data from Multiple Transportation Modes”, 2015 IEEE 18th International Conference on Intelligent Transportation Systems.

[5] Freddy Lécué, Simone Tallevi-Diotallevi, Jer Hayes, Robert Tucker, Veli Bicer, Marco Sbodio, Pierpaolo Tommasi, “Smart Traffic Analytics in the Semantic Web with STAR-CITY: Scenarios, System and Lessons Learned in Dublin City”, Web Semantics: Science, Services and Agents on the World Wide Web, vol. 27–28, 2014, pp. 26-33.

[6] Diego Serrano, Teresa Baldassarre, Eleni Stroulia, “Real-time Traffic-based Routing, based on Open Data and Open-Source Software”, 2016 IEEE 3rd World Forum on Internet of Things (WF-IoT).

[7] Kostas Patroumpas and Timos Sellis, “Event Processing and Real-time Monitoring over Streaming Traffic Data”, 11th International Symposium, W2GIS 2012, pp. 116-133.

[8] Pengfei Zhou, Shiqi Jiang and Mo Li, “Urban Traffic Monitoring with the Help of Bus Riders”, 2015 IEEE 35th International Conference on Distributed Computing Systems.

[9] Milos Roganovic, Dragan Stojanovic, Bratislav Predic, “A Real-Time Traffic Information Service for Efficient Navigation and Transport Management”, AGILE 2011.

[10] Long Liu, Jin Xu, Stephen Shaoyi Liao, Huaping Chen, “A real-time personalized route recommendation system for self-drive tourists based on vehicle to vehicle communication”, Expert Systems with Applications, vol. 41, 1 June 2014, pp. 3409-3417.

[11] Google Traffic Description. Retrieved from: https://goo.gl/3nUzxS.

[12] NZ Traffic. Retrieved from: https://goo.gl/HYX9zU.

[13] 31. Waze. Retrieved from: https://goo.gl/DAz4AS.

[14] 22. Inrix Traffic. Retrieved from: https://goo.gl/m6m2CL.

[15] 36. Traffic Watch. Retrieved from: https://goo.gl/EPLEVC.

[16] Kmov Traffic. Retrieved from: https://goo.gl/6JuuP3.

[17] Wasalny Traffic. Retrieved from: https://goo.gl/k1khZc.

[18] Eric Horvitz, Johnson Apacible, Raman Sarin, Lin Liao, “Prediction, Expectation, and Surprise: Methods, Designs, and Study of a Deployed Traffic Forecasting Service”, 2012.

[19] Duc-Thinh Pham, Bao An Mai Hoang, Son Nguyen Thanh, Ha Nguyen & Vu Duong, “A Constructive Intelligent Transportation System for Urban Traffic Network in Developing Countries via GPS Data from Multiple Transportation Modes”, 2015 IEEE 18th International Conference on Intelligent Transportation Systems.

[20] Wanli Min, Laura Wynter, “Real-time road traffic prediction with spatio-temporal correlations”, Transportation Research Part C: Emerging Technologies, vol. 19, Issue 4, Aug. 2011, pp. 606-616.

[21] MD. Al Amin, MD. Rofi Uddin, “Real Time Traffic Monitoring System Using Crowd Sourced GPS Data”, BRAC University, pp. 5-61.

[22] Oliver B. Downs, Craig H. Chapman, Alec Barker, “DYNAMIC TIME SERIES PREDICTION OF FUTURE TRAFFIC CONDITIONS”, US Patent, Patent NO: US 8,065,073 B2, 2011.

[23] Corrado de Fabritiis, Roberto Ragona, Gaetano Valenti, “Traffic Estimation And Prediction Based On Real Time Floating Car Data”, 2008 11th International IEEE Conference on Intelligent Transportation Systems.

[24] Traffic Reports. Retrieved from: https://goo.gl/bfndDU.

[25] Darrb user review. Retrieved from: https://goo.gl/QcfjzD.

[26] Han Su, Kai Zheng, Jiamin Huang, Hoyoung Jeung, Lei Chen, Xiaofang Zhou, “CrowdPlanner: A Crowd-Based Route Recommendation System”, 2014 IEEE 30th International Conference on Data Engineering, pp. 1144-1155.

[27] Bi Yu CHEN, William H.K. LAM, Mei Lam TAM, “Modeling Departure Time and Route Choice Problems in Stochastic Road Networks for Online ATIS Applications”, Journal of the Eastern Asia Society for Transportation Studies, Vol. 8, 2010, pp 1796-1805.

[28] Route4Me Route Planner. Retrieved from: https://goo.gl/cxTcpQ.

[29] Kanok Boriboonsomsin, Matthew J. Barth, Weihua Zhu and Alexander Vu, “Eco-Routing Navigation System Based on Multisource Historical and Real-Time Traffic Information”, IEEE Transactions on Intelligent Transportation Systems, Vol. 13, Issue: 4, 2012, pp. 1694 – 1704.

[30] Inrix Traffic user review. Retrieved from: https://goo.gl/1e629E.

[31] Inrix Traffic user review. Retrieved from: https://goo.gl/N5oZMm.

[32] Inrix Traffic user review. Retrieved from: https://goo.gl/5w3xB9.
[33] J. W. C. van Lint, "Online Learning Solutions for Freeway Travel Time Prediction", IEEE Transactions on Intelligent Transportation Systems, vol. 9, March 2008, pp. 38 – 47.
[34] Panita Pongpaibool, Poj Tangamchit, Kanokchai Noodwong, "Evaluation of Road Traffic Congestion Using Fuzzy Techniques", TENCON 2007 - 2007 IEEE Region 10 Conference.
[35] Abbas Khosravi, Ehsan Mazloumi, Saeid Nahavandi, Doug Creighton, J. W. C. Van Lint, "A Genetic Algorithm-based Method for Improving Quality of Travel Time Prediction Intervals", Transportation Research Part C: Emerging Technologies, Vo. 19, Issue 6, December 2011, pp. 1364-1376.
[36] Tongyu Zhu, Xueping Kong, Weifeng Lv, "Large-Scale Travel Time Prediction for Urban Arterial Roads Based on Kalman Filter", 2009 International Conference on Computational Intelligence and Software Engineering.
[37] Qing-Jie Kong, Qiankun Zhao, Chao Wei, Yuncai Liu, "Efficient Traffic State Estimation for Large-Scale Urban Road Networks", IEEE Transactions on Intelligent Transportation Systems, Vol. 14, Issue: 1, March 2013, pp. 398 – 407.
[38] Kong, Xiangjie, et al. "Shared subway shuttle bus route planning based on transport data analytics." IEEE Transactions on Automation Science and Engineering 99 (2018): 1-14.
[39] Pérez, Juan Luis, et al. "A resilient and distributed near real-time traffic forecasting application for Fog computing environments." Future Generation Computer Systems 87 (2018): 198-212.
[40] Zhao, Pengjun, and Haoyu Hu. "Geographical patterns of traffic congestion in growing megacities: Big data analytics from Beijing." Cities 92 (2019): 164-174
[41] Google Traffic. Retrieved from https://goo.gl/fMWd8x.
[42] UDOT Traffic. Retrieved from: https://goo.gl/EeeAEy.
[43] UDOT User Review. Retrieved from: https://goo.gl/aaNkvi.
[44] UDOT User Review. Retrieved from: https://goo.gl/VKdjJN.
[45] UDOT User Review. Retrieved from: https://goo.gl/R7jaeD.
[46] UDOT User Review. Retrieved from: https://goo.gl/UmzEeV.
[47] Waze user review. Retrieved from: https://goo.gl/sdBeZh.
[48] Darb. Retrieved from: https://goo.gl/zCm3Ak.
[49] Darb use review. Retrieved from: https://goo.gl/tdEssV.
[50] GO Traffic. Retrieved from: https://goo.gl/5Veozt.
[51] Go Traffic user review. Retrieved from: https://goo.gl/puFVKF.
[52] Go Traffic user review. Retrieved from: https://goo.gl/4h9ztW.
[53] Go Traffic user review. Retrieved from: https://goo.gl/6yxpQx.
[54] Go Traffic user review. Retrieved from: https://goo.gl/fjnQh2.
[55] JamKoi Real Time Traffic. Retrieved from: https://goo.gl/m3WBsX.
[56] JamKoi Real Time Traffic user review. Retrieved from: https://goo.gl/DfnMrr.
[57] JamKoi Real Time Traffic user review. Retrieved from: https://goo.gl/JMtGfg.
[58] JamKoi Real Time Traffic user review. Retrieved from: https://goo.gl/f8KyZK.
[59] Ma3route. Retrieved from: https://goo.gl/dnXSR2.
[60] Ma3route user review. Retrieved from: https://goo.gl/JvFzhw.
[61] Route4Me Route Planner description. Retrieved from: https://youtu.be/vSi5wzeRQlg.
[62] Route4Me Route Planner user review. Retrieved from: https://goo.gl/xgd34C.
[63] Route4Me Route Planner user review. Retrieved from: https://goo.gl/FjyWDn.
[64] Live Traffic NSW. Retrieved from: https://goo.gl/UETBHh.
[65] Live Traffic NSW user review. Retrieved from: https://goo.gl/j76fXR.
[66] Live Traffic NSW user review. Retrieved from: https://goo.gl/vjhcxp.
[67] Live Traffic NSW user review. Retrieved from: https://goo.gl/6PQdyz
[68] Traffic Watch user review. Retrieved from: https://goo.gl/4RdkJs.
[69] Traffic Watch user review. Retrieved from: https://goo.gl/fJDeuc.
[70] Wasalny Traffic user review. Retrieved from: https://goo.gl/EDzfG3.
[71] Wasalny Traffic user review. Retrieved from: https://goo.gl/g7mvcb.
[72] Wasalny Traffic user review. Retrieved from: https://goo.gl/wo2vze.

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How to cite this paper: Kaniz Fatema Fomy, Ashik Mahmud, Musabbir Islam and Shamsur Rahim, "Road Rush: A Review on Road Traffic Analytics Systems and A Proposed Alternative", International Journal of Information Technology and Computer Science(IJITCS), Vol.14, No.2, pp.54-63, 2022. DOI: 10.5815/ijitcs.2022.02.05