

A Survey of Traffic State Prediction Methods on Large Urban Road Networks Using GPS and Non GPS Probe Vehicles

Prof. D. N. Rewadkar¹, Pavitra Mangesh Ratnaparakhi²

¹Department of Computer Engineering, RMD Sinhgad College of Engineering, Pune, India.

[dnrewadkar@sinhgad.edu](mailto:dnewadkar@sinhgad.edu)

²Department of Computer Engineering, RMD Sinhgad College Engineering, Pune, India.

ratnaparkhipavitra@gmail.com

ABSTRACT

The information regarding to the real time traffic is widely used for system like Intelligent Transportation System (ITS) for its applications such as vehicle direction-finding, event detection, traffic signal control, traffic monitoring etc. In addition to this, the system such as Advanced Traveler Information Systems (ATIS) as well as Advanced Traffic Management System (ATMS) also requires the current conditions of urban road traffic along with its short term evolution. Thus the main theme of this paper is about the estimation or collecting the information related to traffic state for large scale urban road networks. For estimating the traffic state of such networks, we need to have efficient and effective method in place so that overall performance will improve. There are many methods presented by different authors, however each of this method suffered from few limitations. We present the following two effective methods based on GPS probe vehicles for the traffic state estimation: 1) the curvature-correction-based method and 2) the vehicle-tracking-based method. If the vehicle has GPS equipped we take each vehicle's location using GPS otherwise the location of the non GPS vehicle getting from the network i.e. by which direction of vehicle is travelling. After the Prediction of Traffic state, we suggest the alternate route to the user. Alternate route must be least congested route, shortest Distance and Minimal Delay. For Priority Vehicles like Ambulance or Fire Brigade, Traffic signals using multistage correlation-averaging algorithm can be used to estimate traffic state.

Keywords: Traffic State Prediction, Intelligent Transportation Systems, Traveler Information Systems, GPS.

1. INTRODUCTION:

In the successful wide scale deployment of Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS) relies significantly on the capability to perform accurate prediction of the current traffic status and reliable predictions of its short-term evolution (less than one hour in the future) on the entire road network. Figure 1 showing the infrastructure of management of traffic by estimating traffic state. In this view the use of real-time Floating-Car Data (FCD), based on traces of GPS positions, is emerging as a reliable and cost-effective way to gather accurate traffic data for a wide-area road network and to improve short-term predictions of travel conditions. Unlike other traffic data collection techniques (Automated Vehicle Identification systems, video cameras, inductive loops, radar based sensors, etc.), floating cars, using GPS receiver and GSM/GPRS transmitter, act as moving sensors traveling in

a traffic stream and do not require instrumentation to be set up on the roadway. Besides increasing the understanding of individual travel behavior, floating car technique can easily provide near real time traffic performance data on any part of large networks and offers a viable way to complement fixed-point traffic sensors, such as cameras and loop detectors, involving high installation and maintenance cost.

Fixed sensors are a proven technology; they are not deployed at wide scale mostly because of its high cost. The current state-of-the-practice traffic data collection in most parts of the world is to rely on a network of road-side sensors, e.g., inductive loop detectors (ILDs), to gather information about traffic flow at fixed points on the road network [2-4]. Moreover, with fixed sensors, it is only possible to measure the spot speed, which is one inherent deficiency in comprehensive reflection of speed over the entire road link. Additionally, this type of model

is link and detector location specific, which requires careful calibration [5]. An alternative to these luxury road-side infrastructures is to employ dedicated vehicles as floating traffic probes [6-8]. The dedicated vehicle probes (PVs) are typically equipped with a GPS receiver and a dedicated communication link. A large number of vehicles should be so equipped to have enough probes. Insufficient number of probes limits the ability of generating information for large area and accuracy of results [9]. Given the trend that GPS-equipped vehicles are expected to increase in the future, the capacity and cost of dedicated communication links between in-vehicle equipment and traffic management center will still limit the sample size of PVs [5]. Moreover, since PVs are chosen from a particular category of vehicles, e.g., taxis or buses, the traffic information could be biased and not representative of the whole population [10].

In advance of the mobile communication technology, mobile phones are increasingly utilized for collecting traffic data. This approach avoids installation and maintenance costs, either in vehicles or along roads. In addition, using mobile phones as traffic probes overcomes the coverage limitation in road-side sensors and insufficient probes in dedicated PVs. In this paper, we propose an algorithm for route estimation as per traffic on roads. This algorithm provides less traffic convenient route from source to destination to the driver before or after he leaves from the source. The concept presented is based on the base stations which receive precise coordinates of the GPS vehicles which might be utilized in personal computers for process. Each base station receives coordinates of every GPS vehicle. With every base station we are attaching server and a database which will be updated continuously by real time traffic data through GPS Simulator. For priority vehicles, Algorithm provides least congested as well as minimal delay (because of traffic signals) path from source to destination. It will be helpful to save the lives. Traffic of those Vehicles who don't have GPS mounted on it (i.e. Minimum Configuration Vehicles) can be measured through network. The algorithm used for measuring non GPS Probe vehicles is multiscale correlation-averaging algorithm which is novel approach to measure gross Traffic on Indian Roads, Because it is a fact that Many Indian vehicles are Less configured. In Survey, It has been seen that only 40% of Indian vehicles are Highly Configured. Other vehicles are minimum configured so we must consider those vehicles in gross traffic. The contribution of this paper lies in the following aspects.

1) a systematic and efficient solution to realize the traffic state estimation for large-scale urban road

networks based on GPS probe vehicles as well as non GPS vehicles through network .

2) The proposed methods are expected to obtain large number of real traffic data in a real large-scale urban road network and obtain specific performance indices.

3) Based on the large-scale GPS probe data, this system will measures the spatiotemporal coverage of the GPS sampling points for a large-scale urban road network.

4) System will acquire plenty of ground truths of the link average speeds to evaluate the accuracy of the estimation methods at the speed level.

However, traffic estimation on arterials is more challenging than on freeways due to the following facts [7, 14, and 17]: 1) arterials have lower traffic volume; 2) arterials have more variability in speeds; and 3) arterials are controlled by traffic signals at intersections. For study purposed we have studied the VANET routing mobility models those are presented in [18].

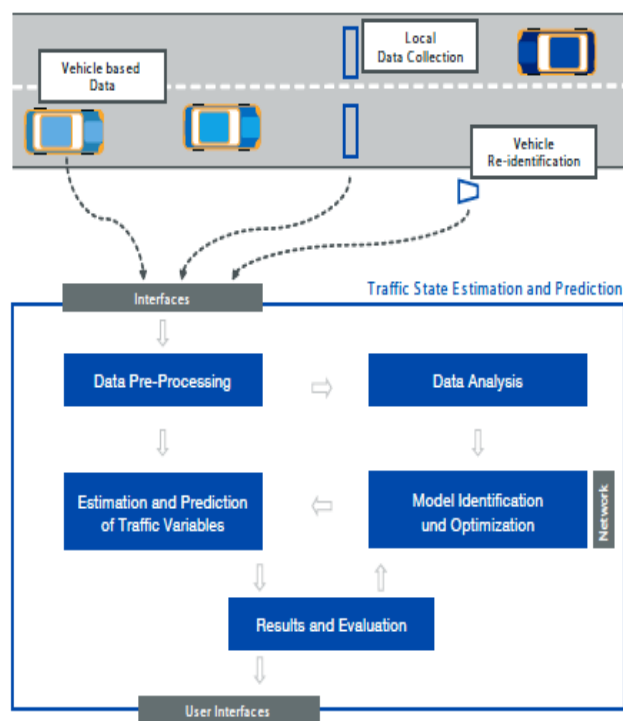


Figure 1: Example of traffic state estimation and prediction system.

This challenge of traffic estimation is overcome by many methods which are presented recently for the same. In this paper we are presenting the discussion over such methods along with their advantages and disadvantages for future road map of research. Below in section II we will present different methods for collect real-time traffic information, later in section III we will present the different methods for estimating the traffic state in urban

road networks. Finally conclusion is derived based on review of all methods.

2. Literature Survey:

On some large-scale field-testing results of a real-time freeway network traffic observation tool that has recently been developed to enable a number of real-time traffic observation tasks is described in [1]. That paper first introduces the related network traffic flow model and the approaches employed to traffic state prediction, and event alarm. The field testing of the tool for these observation tasks in the A3 throughway of 100 km between Naples and Salerno in southern Italy is then reported in some detail.

□ in [2] authors presented an information-fusion-based way to the prediction of urban traffic states. The approach can fuse online data from dissident loop detectors and global positioning system (GPS)-equipped probe vehicles to more precisely and absolutely obtain traffic state estimation than using either of them alone. In this approach, three parts of the algorithms are developed for fusion computing and the data processing of loop detectors and GPS probe vehicles. First, a fusion algorithm, which integrates the merged Kalman filter and evidence theory (ET), is proposed to arrange a vigorous, plausible, and extensible fusion platform for the fusion of multi sensor data. After that, a novel algorithm based on the traffic wave theory is employed to estimate the link mean speed using single-loop detectors buried at the end of links. With the GPS data, a series of technologies are merged with the geographic information systems for transportation (GIS-T) map to calculate another link mean speed.

These two velocities are taken as the inputs of the proposed fusion platform. Finally, tests on the accuracy, resistance, robustness, and operation speed by real-world traffic data demonstrate that the proposed approach can well be used in urban traffic applications on a large scale.

In [3] author presented the results of a before-and-after probe-vehicle-based outfitted comparison of optimized time-of-day (i.e., before control) and SCATS (i.e., after control) traffic control system performance. The spotlight of this operational analysis is the typical operating performance during the weekday peak, weekday off-peak, and weekend travel periods. Travel time data were gathered using Global-Positioning-System (GPS)-equipped test vehicles. The results showed that both systems provided good performance, whereas neither the before time-of-day or after SCATS is clearly dominant, except on Cumberland Parkway, where SCATS control reliability

provides equivalent or superior performance to that of the time-of-day control.

In the [4] they self-diagnosing intelligent highway surveillance system and design effective resolutions for both daytime and nighttime traffic observation. For daytime observation, vehicles are detected via background modeling. For nighttime videos, headlights of vehicles need to be located and paired for vehicle detection. An algorithm based on likelihood computation is developed to pair the headlights of vehicles at night. Moreover, to balance between the robustness and plenty of acquired information, the proposed system adapts diverse strategies under different traffic conditions. Performing tracking would be preferred when traffic is smooth. However, under congestion conditions, it is better to obtain traffic parameters by estimation. They exploit a time-varying adaptive system state transition matrix in Kalman filter for better prediction in a traffic observation scene when performing tracking. Also propose a mechanism for estimating the traffic flow parameter via regression analysis.

In [5], authors discussed a new real-time urban observing system. The system uses the Localizing and Handling Network Event Systems (LoCHNESs) platform developed by Telecom Italia for the real-time assessment of urban dynamics based on the anonymous monitoring of mobile cellular networks.

In addition, data are complemented based on the instantaneous positioning of buses and taxis to provide information about urban mobility in real time, ranging from traffic conditions to the movements of pedestrians throughout the city. This system was revealed at the Tenth International Architecture Exhibition of the Venice Biennale. It marks the unprecedented monitoring of a large urban area, which covered most of the city of Rome, in real time using a variety of sensing systems and will hopefully open the way to a new paradigm of understanding and optimizing urban dynamics.

In [6] authors described a system for measuring the state of a road network in real time. That appears to be the first cost-effective, scalable system that provides real-time measurements of vehicle count and individual vehicle travel times in the links of a road network. The system requires deployment of wireless magnetic sensors at locations that demarcate each link. The deployment is flexible in the way links are defined. A link may span several intersections and not all lanes in a link may be sensed. Deployment can be incremental. The system is based on anonymous matching of vehicle magnetic signatures recorded by sensors at the ends of a link

3. Review of Traffic State Estimation Methods

In [8], the three analyses methods included to support in the process of understanding the GPS/GIS methodology are the following: segment lengths, sampling rates, and central tendency. The segment length investigation examines the effect of using different highway segment lengths and shows that relatively short segments (0.2–0.5 miles long) are needed to perceive localized traffic effects. These traffic disturbances become noticeable only when segment lengths are at most half the length of the associated disturbance. This means that traditional link-based segments, which are typically longer than 0.5 miles, are not sufficient to characterize localized effects properly. The sampling rate analysis addresses the cause of collecting GPS data at different sampling periods and shows that for a segment to have GPS data associated with it, the GPS sampling period should be smaller than half the shortest travel time associated with the segment. The analysis also demonstrates a tradeoff between sampling rates and segment speed reliability, and emphasizes the need for even shorter GPS sampling periods (1–2 s) in order to minimize errors in the computation of segment speeds. The central tendency analysis evaluates harmonic mean speeds and median speeds and shows that median speeds are more robust estimators of central tendency than harmonic mean speeds.

In [9] some probe vehicles cannot provide correct positions but can provide location-specific information on when and where they are located at the segment or cell level. These topological position (TP) data with segment- or cell-level accuracy cannot offer the distance component that is necessary for traffic speed estimation. However, considering the wide availability of TP data in the existing telecommunications network, there is still hope and benefits to make use of the data for traffic state estimation. An algorithm is proposed using low-resolution positioning data. They implement proposed method is capable of fusing low-resolution positioning data with other data sources, leading to more accurate and reliable speed estimation of relatively low bias. In addition, this method shows sturdy robustness and error tolerance and can reveal the magnitude of the estimation error, which is helpful for travel time prediction and traffic control.

In [10] author presented approach for real-time traffic state estimation on urban road with signalized intersection is presented. The conventional discretization of kinematic wave model for freeway based on demand and supply concept is modified in order to be capable of describing traffic state on urban road with signalized intersection and to better prediction of traffic speed. The

novel filter, namely Unscented Kalman filter (UKF), is used as a improvement algorithm to make the estimate to be consistent with observed traffic data. Numerical tests show superiority of the modified model over the conventional model on speed estimation and the improvement in flow estimation when combining the model with UKF.

In [11], the traffic supply is estimated by the ideal carrying capacity, and the traffic demand is evaluated by vehicle traffic intensity considering tenant travel characteristics. In this way, the network carrying capacity and traffic intensity are compared by equities unit. By introducing the intensity/capacity ratio, the matching degree among traffic demand and supply is determined, and the traffic state is identified based on average vehicle speed.

In [12], author presented the development of a laboratory designed to discover GPS and other emerging traffic and traffic-related data for traffic monitoring and control. It also presents results to illustrate the scope of traffic information that can be provided by GPS-based data, using the city of Stockholm as a case study. The preliminary analysis shows that network coverage, especially during peak weekday hours, is adequate. Further investigation is needed to validate the data, and increase its value through fusion with corresponding data from other sources.

In [13], a kernel-based density estimation method is utilized to extract the congestion spots in urban areas based on collected position samples with time-stamp from floating car data. A probabilistic framework is developed to model the traffic data with generalized Gaussian density and then to find optimized weights of kernels in an approximation function, centered at points-of-interest by minimizing the Cramervon Mises distance between localized cumulative distributions of mixture of Dirac distributions of position samples and Gaussian mixtures of points-of-interest in a pre-defined time window. The approximation density function by optimized kernels' weights can be used to estimate the mobile vehicles density in a specific time and space. Modeling the traffic data to extract the required parameters improves the performance significantly. The proposed method is applied to real measurements and can be implemented in real time in traffic management systems.

4. System Architecture

The basic concept used in this paper is to provide a least-congested route to the driver when he starts from the source or ongoing router.

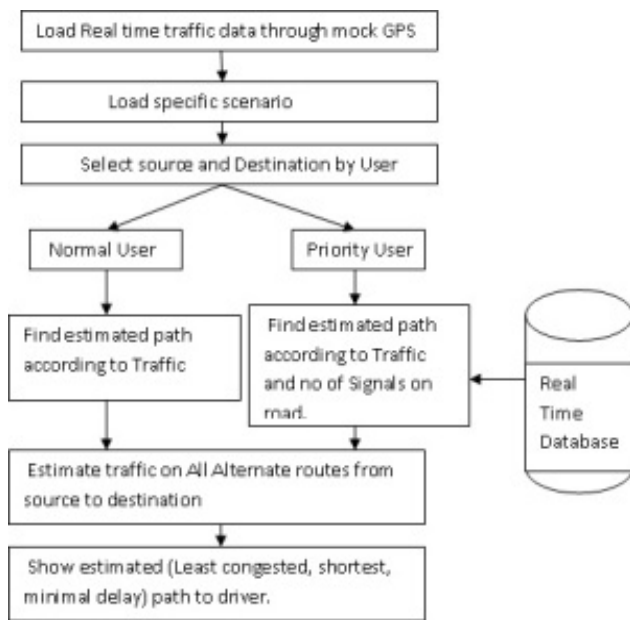


Figure 2: System Architecture

In this paper we are aiming to present and extend the existing method & the concept of relevance feedback methods which is not dynamic. We will use dynamic method both implicit and explicit feedback method along with traffic state estimation. This method makes this approach more efficient, robust as well as reliable. In real time applications such as medical, banking etc we need to have automatic image annotation by using the appropriate input keywords as well as the concept of relevance feedback to satisfy the end user needs. Hence we further extended the methods using road side sensors. This improves the performance of proposed system in terms of efficiency and robustness.

The solution includes the following two parts: 1) digital map design and assessment of algorithm 2) traffic state estimation. The first part was used in digital maps for accuracy and to reduce further improved systematic errors, and map data structures assessment system to work more efficiently reconstructed. second part has been implemented in three stages Transformation of co-ordinates algorithm: 1) coordination (Location based distance formula) 2) map-matching algorithm; The first step in the assessment algorithm and 3), a fast transforming method from the GPS coordinates to the geographic information system (GIS) coordinates is applied to satisfy the real-time requirement of the system. In the second step, an improved map-matching method, which combines the track information of the probe vehicles, is proposed to reduce the matching errors. In the last step, we will use the following two typical estimation methods in detail: 1) the curve-fitting

based method and 2) the vehicle-tracking-based method.3) multistage correlation –averaging algorithm. Here as our contribution we will use road side sensors to track vehicles. So it makes system dynamic as well as it gives more accuracy to system because easy to install and cost-sensitive options allowing you to get up and running quickly.

Benefits:

- 1) Working on Real time traffic data
- 2) Consideration of High as well as low configuration Vehicles.
- 3) Priority vehicles' time constraint considered through traffic signals.
- 4) Less costly and easy to install.
- 5) Use of low power resources.

5. CONCLUSION

In this paper we have discussed the different methods for traffic state prediction along with their advantages and disadvantages. This study will absolutely helpful for further research over the same area. Traffic stage estimation has two essential things to do: first is the real time data gathering and second is based collected information prediction of traffic efficiently. We will further like to estimate the performance study of these methods with comparative analysis.

The estimation of traffic is very helpful for the systems like traffic management in large cities. As implementation point of view, GPS-equipped taxis can be viewed as persistent sensors and the large-scale digital traces produced permit us to have a unique view of the underlying dynamics of a city's road network.

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