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A Comprehensive Analysis Of The Vehicle Traffic Prediction

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ABSTRACT

The ttraffic predictions are very important as they enable to detect potential traffic jam spots. Based on the information provided from a traffic prediction system we could initiate certain traffic control methods to avoid the traffic jams. One of the most important applications of traffic control systems is the control of road network traffic. Most of the tracking methods allow capturing the position of massive numbers of moving objects. With this information, it is possible to analyze and predict the traffic density in a network which offers valuable information for traffic control, congestion prediction and prevention. The historical traffic data and real-time traffic input from the Local Transport Authority, it is possible to predict the traffic flows over regular intervals. With the help of these predictions, LTA's traffic controllers will be able to anticipate and better manage the flow of traffic to prevent the build-up of congestion.

Keywords*—Network Traffic, prediction, traffic control, traffic data, congestion, tracking methods.*

1. INTRODUCTION

Traffic congestion is one of the serious problems; almost every individual in cities faces everyday. A few reasons include increase in the number of vehicles, unplanned lanes, junctions and traffic signals, less number of roads, common roads, roads without dividers, unnecessary u-turns, long routes, narrow and ruined out roads etc. But, apart from the infrastructure limitations, due to space or economic or political constraints, the civil engineers face, in the construction of better, efficient roads and flyovers in overcoming the problems of traffic jams in urban environment, there are more risks and challenges involved in achieving balance in the traffic flow; the renovations in the existing map would create loops or new spots for traffic jams instead if care is not taken well in addressing the future possibilities of such issues. At the stage where we cannot think of changing the infrastructure of the existing road system, the best option would be to serve people by means of telemetrics[1].

Sensors or cameras or loop detectors could be used to record the traffic flow and send the information to server.

At the receiver end, either a system could be attached with user login facility to receive the information from the server whenever required or the user’s mobile could be used as the receiver. Also, with the help of a few dedicated vehicles with GPS devices attached to them, roaming round the urban environment, the server could be kept up to date with their whereabouts and hence, traffic conditions throughout the city [2]. Crowd-sourcing is an alternative where specially dedicated probe-vehicles are not made to roam around a geographical area to estimate the traffic condition. Instead, GPS devices are attached to the vehicles of the individuals who would wish to provide service and in return, they draw the benefit in finding information regarding traffic at some other locations whenever they need it [3].

The said methods will tell us the present traffic situation at a given place at particular point of time. The traffic situations may be different when the user reaches to that place and there is no guarantee that there is no traffic congestion. The traffic congestions are not constant and various according to the peak times in a city. For example, at the peak times, variation in traffic density is very high. So it would be useless in knowing about the traffic condition at present and believing that it would remain the same in future too.

This congestion depends on other environmental factors such as the climate, working conditions etc. at a given place in a city. There must be a means of forecasting the traffic congestion at certain points of time for a given place, which would help the passengers in planning their travel schedule. Many algorithms, including the Incremental Weighted Update algorithm[3] just deals with calculating the present traffic by collecting the speed profile in real-time and considering average speed profiles, incase there is delay in the reception of dataset. But now a days, researches have begun in addressing the issue. Various prediction models have been

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developed by IBM [14]. Neural networks and related concepts [13], [15] are applied in developing a prediction system.

But many prediction algorithms consider only the historical data, recorded after observation and stored in the database to predict the future. This may not provide proper predictions all the time as the situations are always not the same and traffic grows day by day in terms of number of vehicles. Although the database is updated frequently, the prediction would be more precise.

2. SYSTEM ANALYSIS

Road traffic jams continue to remain a major problem in most cities around the world, especially in developing regions resulting in massive delays, increased fuel wastage and monetary losses. Due to the poorly planned road networks, a common outcome in many developing regions is the presence of small critical areas which are common hot-spots for congestion [4]; poor traffic management around these hotspots potentially results in elongated traffic jams. Poor road traffic management is the primary reason for extended periods of traffic congestion throughout the world.

A common feature across road networks in many urban regions in the developing world is the presence of critical congestion areas; we refer to a critical congestion area as one where a network of roads converge and a large amount of traffic needs to traverse the common congestion area. As per free-flow traffic theory [17], a free flow traffic road segment can be associated with a traffic curve where the traffic exit rate is a function of the traffic density in the road segment. A free-flow road segment is known to exhibit a critical density point where any traffic input that pushes the density beyond the critical value can trigger a "spiralling effect" that results in the road segment operating at a low-capacity equilibrium point. Worse still, small traffic bursts over short time periods can potentially trigger the spiraling effect resulting in a congestion collapse.

If real-time datasets are considered along with the historical data. However, density variation metric has got a lot to do with deciding if it's really necessary to consider real-time datasets in predicting the traffic density. Accordingly, weights are defined to balance with historical and online data. In real-time, the importance to be given to the historical data during a time stamp varies with the degree of variation of traffic in the road segments. In accordance with the Weighted Density Variation algorithm which considers all these factors, the weight variables are used such that more importance is given to the historical data if the density variation is less and vice versa[5]. A dynamic window is used to overcome the errors in predicting the time required to reach a particular geographical area of interest. More the distance, more the time the vehicle takes to reach the area and the dynamic window size increases. To reach destination, the algorithm considers all the possible paths to reach the destination one at a time and calculates the traffic density along each segment towards the destination in order.

Many critical congestion areas in developing regions have poor traffic management systems that if any of these critical congestion areas hits a congestion collapse, the road network can result in a massive traffic jam for elongated time periods.

3. RELATED WORK

The problem of traffic congestion has been prevalent in both developing and developed countries. Variety of solutions have been developed in the previous decade, but most of the, developing countries suffer from an additional set of constraints hampering these predefined solutions making the problem tougher. Congestion prevention and congestion control are the two approaches to solve the traffic congestion problem. Congestion prevention focuses on reducing the number of incoming vehicles in the road traffic networks. Numerous ways have been devised by various government authorities like promoting car-pooling systems, congestion pricing or time variable toll mechanisms and car plate quotas [6].

Congestion control mechanisms include traffic engineering and monitoring. The available real-time information from deployed road sensors is leveraged and a predictive analysis is applied to propose near future traffic patterns and develop a situational solution to tackle the current traffic. Nowadays real-time traffic information is collected from various sources like traffic cameras, road sensors and even cell phone providers. Advance GPS systems mitigate this problem by finding less congested routes. Various mechanisms like variable speeding, ramp metering and lane specific signaling are applied on available real-time information to manage traffic congestion proposes the usage of histogram based density discovery scheme for road connectivity which is leveraged the focuses on global route optimal scheme to calculate best paths on its defined overlay network develops a new algorithm FlowScan, to cluster road segments instead of clustering the moving traffic to identify congested traffic routes[7].

Texas Transportation Institute (TTI) has developed several applications that are widely used in local, state and federal levels for controlling the signal timing information. McTrans project at University of Florida provides a host of applications related to road traffic management. HCS+ [11] and Traffic Network Study Tool provide signal timing optimization based on a variety of objective functions. Contram [8] is software which provides real time traffic monitoring and optimized real time traffic routes. It is currently deployed in places like Stockholm, Kent and other large cities. The Sensor Project enables efficient data collection so that traffic management can be done in a better way, by the use of sensors to collect the data. There are also applications which monitor existing real time traffic and predict traffic models which can prevent traffic congestion.

Applications like IBM Traffic prediction tool [12] and the combination of Caliper Products [6] (Transmodeller and TransCAD) are used to simulate and predict traffic models. Use of third party mediums to disseminate traffic information is being actively pursued. Danilo explores the idea of cellular networks to convey information to users of information. Akinori et al., proposes creation of well formed maps which could be used by mobile traffic information services. However, in our case, we intend to create monitoring and signaling stations which can take decisions on their own without user intervention and hence, regulate traffic.

4. DETECTING TRAFFIC CONGESTION

Vehicular traffic can be either free or congested. Traffic occurs in time and space, i.e., it is a spatiotemporal process. However, usually traffic can be measured only at some road locations (for example, via road detectors, video cameras, probe vehicle data, or phone data). For efficient traffic control and other intelligent transportation systems, the reconstruction of traffic congestion[9] is necessary at all other road locations at which traffic measurements are not available. Traffic congestion can be reconstructed in space and time.

Urban road traffic is a non-linear, non-stationary, and uncertain process; its uncertainty increases rapidly when making short-term traffic flow prediction. The state-of-the-art in traffic flow prediction is reviewed here, including Time-Series, Artificial Neural Network, Ada-Boost, and Support Vector Machine based algorithms. Some of the methods proposed are:

a. A novel prediction method is proposed for short-term traffic flow prediction. The time interval between vehicles is treated as a stochastic variable and described with the Marked Point Process in the ARCH (AutoRegressive Conditional Heteroskedasticity) framework. Different point processes may generate a corresponding ACD (Autoregressive Conditional Duration) model for the prediction of time intervals between vehicles in the traffic's flow. A particle filter is applied with measured vehicle speed data for traffic flow speed and density prediction.

b. Another method for the prediction of the traffic congestion is to estimate the amount of traffic on the link at any given point of time. A common method is to place sensors on the road and count the number of times they are actuated by the passing wheels of a vehicle[9][10]. This approach suffers from four main problems: **i.** It is expensive to deploy, as the sensors need to be partially embedded in the tarmac, **ii.** The sensors on the road are prone to theft, **iii.** Sensors need to be placed at multiple entry and exit points on the road, to maintain accurate counts, and iv. Even on a single stretch of road, the sensors need to be placed at regular intervals so as to estimate the density on different segments of the road.

The detection mechanism is divided into two parts:

i. Day Time Congestion Detection: During the daytime, the underlying intuition is that when there is no traffic on the road, it appears gray in color irrespective of the natural day light[16]. When the road is filled with traffic, the amount of visible gray (empty road) in the picture reduces because of the majority of vehicles attributing a varied level of non gray color.

ii. Night Time Congestion Detection: Night time congestion detection is a harder problem because of multiple extraneous factors. Absence of light eliminates typical vehicle feature estimation techniques. The next contender for vehicle identification becomes headlight counting, which suffers from light reflection/refraction and alternate light sources such as billboards and traffic signal lamps.

c. Most of the prediction algorithms consider only the historical data, recorded after observation and stored in the database to predict the future. This may not provide proper predictions all the time as the situations are always not the same and traffic grows day by day in terms of number of vehicles. Although the database is updated frequently, the prediction would be more precise if real-time datasets are considered along with the historical data. However, density variation metric has got a lot to do with deciding if it is really necessary to consider real-time datasets in predicting the traffic density.

Accordingly, weights are defined to balance with historical and online data. In real-time, the importance to be given to the historical data during a time stamp varies with the degree of variation of traffic in the road segments. In accordance with the Weighted Density Variation algorithm which considers all these factors, the weight variables are used such that more importance is given to the historical data if the density variation[17] is less and vice versa. A dynamic window is used to overcome the errors in predicting the time required to reach a particular geographical area of interest. More the distance, more the time the vehicle takes to reach the area and the dynamic window size increases. To reach destination, the algorithm considers all the possible paths to reach the destination one at a time and calculates the traffic density along each segment towards the destination in order.

This approach considers both real-time or online datasets and stored density and density variation information along different road segments, recorded at various time stamps (historical data) in predicting the traffic in future at a given geographical area of interest. It uses the dynamic window concept to reduce the error incurred in estimating the travel time. It calculates weights based on the average of the weights at different time stamps, calculated relative to the ranks assigned to the road segments, based on their density variations. The algorithm predicts the traffic condition at a given road segment by considering all the segments to reach the area of interest, one by one towards the destination, calculating traffic density at each point with probabilities of number of vehicles through other road segments in the neighborhood which would add the number in predicting the density too.

5. CONCLUSION

Road traffic congestion is a central problem in most developing regions. Most urban areas have poorly managed traffic networks with several traffic hot-spots or potential congestion areas. In this paper, we study the problem of road traffic congestion in high congestion hot-spots in developing regions. We first present a simple image processing algorithm to estimate traffic density at a hot-spot using CCTV camera feeds. Based on analysis of traffic images from live traffic feeds, we show evidence of congestion collapse which last for elongated time periods. Based on the free-flow traffic curve behavior of links, critical road segments when exposed to short bursts in traffic can result in the specific segments operating at low-capacity levels for long time periods.

To partially alleviate this problem for small congestion areas such as traffic hot-spots, we develop a local de-congestion protocol that controls the flow of traffic into near-congested regions, thereby preventing collapse caused by short bursts of traffic. Our hope is that localized de-congestion mechanisms are potentially easier to deploy in real-world settings and can enhance the traffic flow at critical hot-spots in road traffic networks. We believe that this represents only a first step in the development of low-cost, deployable strategies for alleviating congestion in developing regions.

The future work lies towards deploying a real time proof of concept to analyze instantaneous traffic density. The paper discussed a means to detect and curb congestion in a localized setting. Although, the solution is feasible to affect local congestion, it is still not able to curb the congestion extending for miles due to the localized focus of the approach. The analysis can thus be improved with multiple sequential cameras along a highway which in addition to localized congestion control analyzes the congestion buildup from the starting point to the ending point. With the aggregate image data, the congestion control strategy can make global decisions and affect congestion control on a reasonably sized scale.

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