Short-, Medium- and Long-term Road Traffic Prediction with Spatio-Temporal Correlations

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Road traffic prediction, for the short and medium term, is a field whose importance is growing for three main reasons: i. with more and more vehicles equipeed with sensor tags, as well as recent advances in vehicle tracking through cell phone signals, the increasing availability of real-time traffic data has motivated research into more sophisticated traffic prediction methods to be developed; ii. Advanced Traffic Management Systems now have access to this weath of information, and provide guidance to traffic controlers in real-time; iii. end-users now have a wealth of devices available to them to provide traffic information, from desktop computers to wireless phones. In all these examples, there is an emphasis on the development of algorithms to compute reliable estimates of traffic speeds and volumes into the future, both the short and medium term.

Long-term traffic prediction has existed for several decades. A favored approach to long-term traffic prediction is through the use of equilibrium modeling, while traffic simulation presents an alternate approach. In both cases, the traffic predicted tends to be either peak-hour traffic, or daily volumes. Recent advances in data availability and application development have skewed the emphasis on traffic prediction research towards the finer time-scales. Short-term prediction implies forecasting road traffic several minutes to several hours into the future. Medium-term predictions provide assessments of traffic from several hours to a few days into the future. These time frames have in common the heavy reliance on large volumes of historical data, such as that which is obtained by storing real-time data feeds of traffic sensor data.

While numerous techniques have been developed in the past several decades for time-series prediction, the application to road traffic prediction requires, in general, additional work. In particular, the spatial-temporal relationship of road traffic is critical to prediction. Some work already exists to handle this need, to extend time-series models to account for spatial correlation, both in the transportation and in the regional science literature. However, the majority of the models suffer from some drawbacks.

The fundamental observation that we make use of in developing our new model is that the traffic condition at a link is affected by the immediate past traffic conditions of some number of its neighboring links in a somewhat complex manner. In general, a time lag function defines how traffic flows are related in the temporal dimension. In parallel, the spatial structure defines which neighboring links have an effect on the traffic characteristics of other links, as a function of road type, speed, etc. These properties have been incorporated in recent work on spatio-temporal time series models.

However, what is not included in such recent work is the fact that the nature of the dependence itself depends upon the variable being predicted. This is not true in all applications: in regional science, for instance, spatial correlations are fixed and static, in many cases. On the other hand, in short- and medium-term road traffic prediction, the degree and the nature of spatial interaction varies with the

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speed and volume of traffic on the roadway. It is this more complex relation that we seek to adress and model in our new approach. At the same time, the computability of the model in of importance.

This paper therefore presents a new method that provides a complete description of the most important interactions in a road network while maintaining the estimatability of the model. It improves upon existing methods proposed in the area.

References

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