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Filtering Techniques of Urban Traffic Data

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FILTERING TECHNIQUES FOR URBAN TRAFFIC DATA

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Abstract

There is evidence that the algorithms for estimating traffic flows from sensor data need to be improved before computer controlled traffic responsive urban traffic control systems can reach their full potential effectiveness. A large part of the problem appears to be that the data from traffic sensors is, in the statistical jargon, a marked point process. It is only very recently that the theoretical techniques for estimation based on point process data have reached the sophistication needed for traffic problems. In this paper, these tech-techniques are used to derive several recursive algorithms for filtering traffic sensor data and predicting urban traffic flows. These filters and predictors are then evaluated and compared using simulated traffic data.

Summary

Recent attempts to implement traffic responsive computer control of urban traffic have resulted in, at best, only marginal improvement over systems whose signal settings were based on historical data and the time of day [1].

The essential difficulty appears to be that the data from traffic sensors (normally loop detectors) are either:

1) a sequence of times $t_1, t_2, \ldots (t_i < t_{i+1})$ representing the activation times of the detector or,
2) the data in (1) together with some auxiliary observations, such as the characteristics of each pulse (e.g. duration).

In case (1) we have a random point process; in case (2) a marked point process [2]. In the urban traffic situation, neither of these point processes is a Poisson process. From this data, taken from detectors scattered throughout the network, one would like to obtain estimates of traffic volume, occupancy, queue length, stops, delay, average speed and travel time. In particular, estimates of average speed and queue length are very desirable and have been notoriously unsatisfactory in the past.

The effective estimation of most of the above parameters of the traffic flow on an urban street network requires a "good" model for the traffic dynamics. It is also important that the model reflect the interrelationship between traffic in different segments of the network. The traffic flow predictors that have been implemented treat traffic at an individual detector in isolation from the rest of the network [3]. In our case, two models of traffic flow on a network have been developed, a Markov Chain model and a discrete Variable Structure Dynamical model [6]. An important property of both models is that they allow the incorporation of feedback control of traffic light settings. It is also important that, although the models are mathematically equivalent, there are differences in the data processing required for their construction and in the form of the corresponding filters.

In both cases, the minimum mean square error filter and the linear minimum mean square error filter have been derived using recent results in the theory and application of point processes [4,5]. The filters are described and then compared with respect to:

a) The data required to actually implement the filter.
b) The difficulty in on-line operation of the filter.
c) The performance of the filter as determined numerically using simulated traffic flows.

The need to evaluate the filters with respect to (a) arises in the traffic

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context because of the difficulty and expense involved in obtaining statistical data about traffic flows. The ideal filter would require no information for its construction other than the sensor data.

With respect to (b), a very useful property of all the filters is that they are recursive. A not so useful property is that they all require relatively large amounts of computation.

The paper concludes with a discussion of techniques which might be used to reduce the computational requirements without degrading the performance of the filters.

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