How many FCD are needed for traffic management?

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# of words: 568 (with head, 515 without head)

Introduction

Recently, Floating Car Data (FCD) has become an alternative to traditional data collection, especially on urban roads. Given that several such systems are already functional, the question arises which penetration rates are needed for which application. In addition to travel-time monitoring, which is just the simplest possible application to FCD fleet data, especially traffic management applications are now in the focus of further development. In the following, three different levels of applications will be regarded (with increasing level of difficulty):

1. the offline planning and optimization of traffic signal programs (for coordinated areas),
2. the online control of such programs (for coordinated areas),
3. the online control of individual signals by means of an actuated or adaptive control strategy.

It will be demonstrated, that even with a small to moderate level of FCD penetration the first two applications are well within reach of current FCD fleets, given smart algorithms to turn data into information. The third level however seems to require penetration rates that will be achievable only by vehicle-to-vehicle and vehicle-infrastructure-integration. Thus, the results presented here have relevance not only to traditional FCD fleets, but also to applications using data from vehicle-to-vehicle communication.

Approach

To learn about the penetration rates needed for a certain application, combination of microscopic traffic flow simulation with a Monte Carlo study. Additionally, data of a recent project (ORINOKO) are used to support the conclusions of the simulations. In ORINOKO, both FCD data as well as standard loop detector data were available to compare the two.

Before going into the details, a simple example will be analysed. Suppose, that the floating car measure the true travel time in a system and report it to the traffic management center (TMC). In this case, the analysis is very simple:

The Figure below illustrates this approach. It is from a simulation on a simple three-link-network where the vehicles have reported all the travel times. A subsequent analysis then picks randomly just \eta of those times and computes the difference between the average travel time of the

Applications

The simplest application, the offline optimization of traffic signals, needs just time-series of the travel time which show a similar behaviour as the traffic flow which is usually used for this purpose. It is important to note, that the travel times and travel speeds of FCD contain much more information than the speed data from traditional loop detectors, which measure only local speed – they FCD contain the waiting times experienced in front of the traffic signals or at other bottlenecks in the system.

This is an advantage, but at the same time bad news: it means, that individual speeds are sampled from a very broad distribution (standing and driving vehicles), which takes effort to arrive at data that can be interpreted easily. It will be demonstrated, that the method which turns such noisy data useable is a local adaptive smoothing as can be seen in the figure below. This method can be used for already 100 data points per day at a particular link, which is well below 1% penetration rate (depending of course on the level of demand).

The same method even works in principle for the second type of application, which is online control of signal programs; however, the penetration rates needed for this are slightly larger, and a certain aggregation over areas is needed in order to arrive at statistically meaningful data.

For the third application, a much higher penetration rate is needed. First simulation results suggest that penetration rates well above 20% are needed to drive a traffic signal by FCD in order to implement a traffic actuated control.