Usage of Aggregated Floating Car Data for Real-Time Traffic Signal Optimization in Non-Lane-Based Heterogeneous Traffic

Master‘s Thesis of Raiza Soza

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Introduction

The many objectives for optimization of urban traffic can be comprised in the increase of network operation. Most suitably done by executing traffic management strategies, contrary to infrastructure improvements. In this regard, implementation of real-time traffic signal control has proven to generate positive results. For this, real-time data needs to be generated. In contrast to stationary detection, mobile detection offers better spatial distribution at lower costs and therefore has been studied in recent years. Nevertheless, a new data format is under study, the so called ”Spatially-aggregated FCD”. This refers to FCD data aggregated to a link level, reporting travel times on intervals as short as 30 seconds.

Objectives

The objective of the study is to assess the capability of determining traffic flow values out of spatially-aggregated travel times from FCD. For this purpose, three research questions were developed:

- What is the most appropriate method for the interrelationship of traffic parameters on urban streets?
- How can this method be applied to FCD or Bluetooth data?
- Is this representative of an accurate estimation?

Literature Review

Edie’s [Edie 1963] analysis of individual vehicle trajectories encouraged the study of the fundamental traffic parameters on a region. Later extended to represent urban networks, as so called Network Fundamental Diagrams (NFD). Which depend on the topological characteristics of the network, and the signal plans. NFDs not sensitive to changes in the cycle-length, as long as the green to cycle-length ratio is maintained, this is usually done as an adaptive-control measure.

Methodology

The methodology is divided in three steps:

NFD Generation **|** Parameter Calibration **|** Result analysis

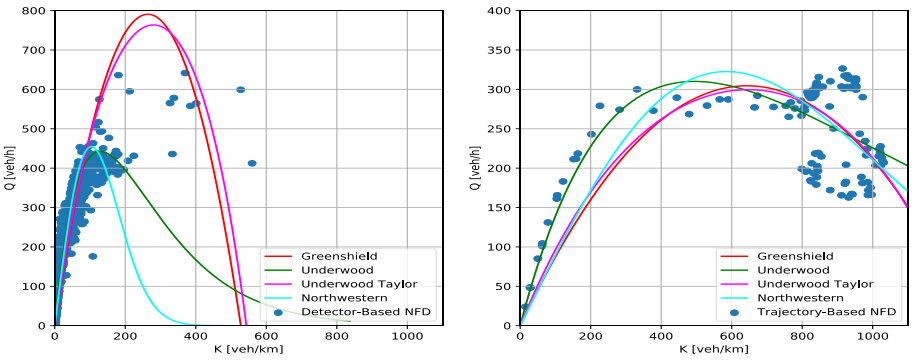
For this purpose, two network fundamental diagrams were created. The first one following the trajectory-based method with help of Virtual Probe Vehicles (VPV) in a Vissim simulation using a trapezoidal loading scheme. And the second one with the link-based method and available loop-detector data. Following this, a DBSCAN clustering algorithm was used to detect outliers on the data, and furthermore to separate congested and uncongested branches for the model fitting procedure, where four models were analyzed.

Case Study

Two study cases were studied, Case A comprises 4 intersections of a corridor in the city of Taipei, Taiwan. While case B is a series of eight corridors in the city of Ras Al-Khaimah, UAE. Travel times from FCD and Bluetooth during a week with a 30 sec interval were measured. Additionally, real-loop detector data from the same time span is available.

Results and Discussion

The initial analysis of detector data showed a 40% inactivity of loop detectors in both cases. This questions representativeness of any analysis done with this data, and exhorts to better data sources like FCD. The spatial aggregation of FCD impacts the potential for its usage on a higher level than expected. NFDs are then a useful source for determination of traffic volume values when only speed values of links are present. Following the methodology explained, two NFDs were created as seen in the next Figure.



Four models were assessed during the fitting process. Where the Underwood succeeded with a better fit of the data. Even though the generated NFDs present differences, the link-based initially considered as ground-truth can not be deemed as so due to the previously mentioned detector inactivity. Nevertheless, the maximum flow value of both differ in 100 veh/h when considering the Underwood model for both NFDs. Based on literature, FCD has a better representation of congested situations, and so the congested regime of trajectory-based NFD can be considered as more accurate than the link-based.

Model	Link -Based NFD		Trajectory-Based NFD	
	FFS v_0	$k_{\text{jam}}, k_{\text{crit}}$	FFS v_0	$k_{\text{jam}}, k_{\text{crit}}$
Greenshields	5.99	$k_{\text{jam}} = 527.8$	0.95	$k_{\text{jam}} = 1286.3$
Underwood	9.33	$k_{\text{crit}} = 128.8$	1.70	$k_{\text{crit}} = 494.7$
Northwestern	7.22	$k_{\text{crit}} = 103.8$	0.91	$k_{\text{crit}} = 584.4$
Underwood*	6.44	$k_{\text{crit}} = 340.6$	1.09	$k_{\text{crit}} = 786.6$

Conclusion

Mobile detection methods such as Bluetooth or FCD are a promising data source. In order to benefit from NFD usage their penetration rate must comply with the 2-3% minimum value. When this is met, spatially-aggregated FCD can depend on NFDs to determine values like flow and density due to their inherent capability to represent traffic throughout an urban environment. And, even though the spatial aggregation hinders direct trajectory analysis, it can benefit from simulated vehicle probe vehicle data analysis.