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Traffic Flow on a Freeway Network

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4.1 Introduction

Traffic congestion is an unpleasant fact of modern life. Although difficult to quantify precisely, congestion must cost Californians millions of dollars per day. Since further extensive construction of freeways is unlikely, information technology is being increasingly looked to for amelioration by providing information allowing more efficient use of existing freeways. Statistics plays a major role in such efforts.

A large interdisciplinary team of faculty, postdocs, graduate students, and undergraduates at the University of California, Berkeley, has been working on a host of problems of this kind. Researchers come from Computer Science, Electrical Engineering, Statistics, and Transportation Engineering.

This chapter gives an overview of some of our activities, focusing on gathering statistics on traffic flow over the network of freeways in Los Angeles and on the prediction of travel times over this network. The chapter is organized as follows: The freeway system of Los Angeles is equipped with a densely deployed array of sensors, loop detectors, which we describe in the next section. Information from these sensors is captured in real time, displayed, and archived by the Freeway Performance Measurement System, as described in a Section 4.3. In Section 4.4 we describe briefly our attempts to globally model the evolution of the fascinating spatial-temporal field of traffic flow. Ultimately, however, rather than trying to fit and update

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such comprehensive models, we found it preferable to use simpler, direct methods. These are described in Section 4.5 for the purpose of predicting the particular functional of interest, travel time. Section 4.6 contains final remarks.

4.2 Loop Detectors

Inductive loop detectors are the basic sensors monitoring the state of a freeway. A detector consists of a wire buried beneath the roadway. An alternating current generates an electromagnetic field, resulting in a change of inductance when an engine passes by on the surface. Such loops are located fairly densely on many freeway systems, with loops in each lane located in banks every half mile or so. Figure 4.1 shows a set of double loop recorders. Data from loops is usually sampled at rates ranging from 30 seconds to five minutes.

The fundamental variables that can be deduced from loops are flow (the number of vehicles per second) and occupancy (the percentage of time that vehicles are over the loops). The latter is essentially the density of vehicles. With assumptions about average vehicle length, these measurements can be converted to average velocity:

\[ v(t) = g(t) \times \frac{c(t)}{o(t) \times T}. \]  

(4.1)

Here \( c(t) \) is the flow, \( o(t) \) is the occupancy, and \( g(t) \) is the effective vehicle length during a time period of duration \( T \). The effective vehicle length depends upon the mix of traffic (trucks and cars) and thus upon the lane and the time of day an also on the electronics of an individual loop. If loops...