Capacity Estimation in Freeway Weaving Areas for Traffic Management and Operations

Principal Investigator: Dr. Eil Kwon, Advanced Traffic Systems Program Director

Intelligent Transportation Systems Institute
Center for Transportation Studies
University of Minnesota • Twin Cities
P: 612-626-1077 • F: 612-625-6381
E-mail: kwonx001@umn.edu

Why This Research is Needed

In increasingly crowded urban freeway systems, some of the worst congestion problems occur at "Type-A weaving sections," where an entrance ramp is closely followed by an exit ramp. Even the most basic weaving sections are difficult for traffic managers to monitor and control because these areas involve complex vehicle interactions as vehicles merge into and out of the traffic stream. For successful planning, it is critically important to understand exactly how traffic behaves in a weaving section, and to be able to estimate a given section's capacity in real time.

Research Objective

To illuminate design and operational issues related to freeway weaving sections through analysis of drivers' weaving behavior and development of an online model for estimating weaving section capacity.

Methodology

First, the major weaving areas in the Twin Cities' freeway network were identified and classified depending on the length and geometric configuration of weaving areas. Next, a group of six weaving sites containing short ramp-weave sections were selected for detailed analysis and a database was developed with the loop-detector data collected from those sites.

In particular, data on the speed of weaving flows were collected for two days from one of the short ramp-weave sections using a video recorder mounted on a 44-foot mast, which was assembled and installed on a special trailer by the engineers at the Minnesota Department of Transportation. The video recorder was connected to a prototype video detection system developed at the University of Minnesota, which was able to measure the speed of individual vehicles changing lanes in the sample weaving area. Based on analysis of the collected data, characteristics of drivers' weaving behavior were identified, along with a set of factors affecting the weaving capacity.

The video-based mobile data-gathering system in operation

An online estimation model for weaving capacity (maximum possible weaving volume through time) was developed and tested with the data collected from the sample weaving section.

Research Results

The field observations and the analysis of the traffic data collected from a sample weaving section indicate that the freeway-to-ramp and ramp-to-freeway vehicles first merge and travel together at the beginning portion of the auxiliary lane before splitting to mainline and exit ramp. It was further observed that the length of the shared portion of the auxiliary lane, termed the "effective weaving zone," varied depending on the overall length of the auxiliary lane and the volume of weaving traffic.

The merge-split behavior and the resulting brief period of mixed flow in the auxiliary lane indicates that the maximum possible weaving volume in a simple ramp-weave section is equal to the maximum through volume that the auxiliary lane can handle. This observation was supported with the estimated weaving volume data from three weaving sites using a Kalman filter analysis.

Based on these findings, an online procedure was developed to estimate the maximum possible weaving volume for a given ramp-weave area through time using the volume and occupancy measurements from the loop detectors.

Research Impacts

The major findings from this research regarding limits on maximum capacity for weaving sections and the length of auxiliary lanes will significantly affect the design process for weaving sections. The online capacity model developed in this project will help develop efficient operational strategies for entrance and exit ramps.

What's Next

Building on the information gathered to date, further study of traffic behavior in weaving sections is planned. In particular, online estimation techniques will be extended to cover more complex types of weaving sections.

Related Publications

Journal of the Transportation Research Board 1727, 2000

IEEE Trans. on Intelligent Transportation Systems, March 2001