

**Improving the Estimation of Travel Demand for Traffic Simulation
Funded by Intelligent Transportation Systems Institute**

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Traffic Simulation is only as good as its input data. Unfortunately, it is impossible to inexpensively measure entry ramp to exit ramp flows, which would be particularly useful for testing ramp metering control strategies. Prior research supported by Mn/DOT and the Center for Transportation Studies has produced a viable method for estimating freeway Origin Destination (O-D) patterns from loop detector data (Davis 1993a,b; Davis and Kang 1994; Davis, Michalopoulos, Kwon 1994; Davis and Yu 1994).

Separate research funded by Mn/DOT and the Center for Transportation Studies and the Intelligent Transportation Systems Institute of the University of Minnesota has developed microscopic traffic simulation (Michalopoulos, Kwon, and Khang 1991; Michalopoulos and Kwon 1992; Michalopoulos 1997; Michalopoulos and Hourdakis 1999). In 1997, a laboratory environment for traffic analysis was developed where various roadway design/operational alternatives can be evaluated with state-of-the-art traffic simulators under an integrated database-simulation environment. Existing freeway simulation models with detailed traffic data collected using machine-vision and loop

detection system were evaluated, and one macroscopic and one microscopic model were selected. These models have an integrated user interface and can share basic data.

Traffic simulations of freeway sections previously directly used traffic counts (on-ramp and off-ramp) and splitting factors (the percent of traffic exiting at a particular off-ramp) to determine demand and calibrate the simulation. While traffic count data is adequate for certain applications, it is ineffective for more complex applications such as freeway/arterial corridors, or freeway networks, or even freeway sections which have major changes such as a closed off-ramp. In those cases, O-D data is required. Unfortunately, O-D data is not routinely collected.

The research presented herein further develops methods to estimate O-D demand from traffic counts for use in traffic simulation of freeway sections and corridors. The objectives of this research are twofold: First, to develop and implement a methodology for estimating origin-destination demand using available data from traffic counts. Second, to apply that method to estimate demand on specific, real-world corridors.

We went through this process twice, using different strategies. The first work, prepared as part of the Master's Thesis of Satya Muthuswamy, *Estimation Of Origin-Destination Matrices For Freeway Sections Using Detector Data*, developed an off-line method using a traffic flow model embedded in a search routine. The traffic flow model, the microscopic traffic simulator AIMSUN, is used in many traffic simulation applications in the Twin Cities. The search routine was a gradient-based optimization algorithm, MINOS. These two programs were interfaced to estimate an OD Matrix. We found that the problem posed this way is highly non-linear and non-smooth, and the optimization routine finds multiple local minima, but can not guarantee a global

minima. The system exhibited “sensitive dependence on initial conditions”. However, with a number of starting "seed" matrices, an OD matrix with a good fit in terms of reproducing traffic counts can be estimated. The dominance of the mainline counts in the OD estimation and an identifiability issue is indicated from the experiments. The quality of the estimates improves as we reduce the specification error, introduced due to the discrepancy between AIMSUN and the real world process that generates the on-ramp and off-ramp counts.

The second iteration of the research learned from the first. This work formed the basis of the Master’s Thesis of Yao Wu, *Estimation Of Origin-Destination Matrices For Freeways*. The second part examined several methods for estimating Origin-Destination (OD) matrices for freeways, using loop detector data. Least squares based methods were compared in terms of both off-line and on-line estimation. Simulated data and observed data were used for evaluating the static and recursive estimators. For off-line estimation, four fully constrained least squares methods were compared. The results showed that the variations of a constrained least squares approach produced more efficient estimates. For on-line estimation, two recursive least squares algorithms were examined. The first method extends Kalman Filtering to satisfy the natural constraints of the OD split parameters. The second was developed from sequential quadratic programming. These algorithms showed different capabilities to capture an abrupt change in the split parameters. Practical recommendations of the choice of different algorithms are given.

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