Lane-Changing in Multilane Freeway Traffic

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ABRIDGMENT

A SERIES of analyses are presented indicating that lane-changing in multilane freeway traffic may be effectively described as a random process.

Assuming first that lane-changing may be treated as an isolated, independent event within the traffic stream, it is shown that the number of lane changes, $X_{ij}^{kt}$, between lanes $i$ and $j$ within a length of freeway $k$ and a time span $t$ may be estimated as the outcome of a simple Poisson process \( \{X_{ij}^{kt}; t > 0\} \), where

$$\text{Prob.} \{X_{ij}^{kt} = N\} = \frac{\exp\left(-\lambda_{ij}^{k} t\right)}{N!}\left(\lambda_{ij}^{k} t\right)^{N}$$

and $\lambda_{ij}^{k}$ = Avg. No. lane changes between lanes $i$ and $j$ per unit time within section $k$.

Empirical data are presented to show that the value of $\lambda_{ij}^{k}$ varies systematically with both traffic speed and traffic volume, and with proximity to entrance and exit ramps. Further, the assumption of randomness is shown to break down during medium-heavy flow periods (flows equivalent to 62 to 87 veh/min/3 lanes and at points immediately downstream from freeway entrance ramps.

It is similarly shown that the pattern of lane changes with the $k$'th section of length $L$ may be modeled as a finite Markov process \( \{X(k); L > 0\} \), where

$$\text{Prob.} \{X(k) = j \mid X(0), \ldots, X(k - 1); L\} = \text{Prob.} \{X(k) - j \mid X(k - 1); L\},$$

and

$$\text{Prob.} \{X(k) = j\} \rightarrow \text{Prob.} \text{ that a given vehicle is in lane } j \text{ as it leaves section } k.$$ A simple Markovian model based on this structure is calibrated from field data collected on a 6-lane freeway in Chicago, and extended to cover the situations of lane-changing in the vicinity of freeway entrance and exit ramps and within a complex weaving section. In each case the model effectively replicates the observed maneuver pattern.

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