ABSTRACT

Songchitruksa, Praprut. Ph.D., Purdue University, August 2004. Innovative Non-Crash-Based Safety Estimation: An Extreme Value Theory Approach. Major Professor: Andrew P. Tarko.

Crash-based safety analysis is set back by several shortcomings such as randomness and rarity of crash occurrences, lack of timeliness, and inconsistency in crash reporting. Safety analysis based on observable traffic characteristics more frequent than crashes is one promising alternative. Traditional approach to alternative safety analysis relies on the assumption of constant risk across locations. In addition, the current practice of collecting surrogate data often suffers from inherent subjectivity of humans involved in the task. In this research, we propose a novel application of the extreme value theory to a non-crash-based safety estimation that no longer relies on the assumption of constant risk. We evaluate the proposed method by applying to right-angle collisions at signalized intersections. The feasibility of facilitating the measurement of traffic characteristics with digital video and image processing technology is also examined.

8-hour traffic movements at selected intersections were recorded using a Purdue University mobile traffic lab. The risk of right-angle collisions was estimated using so-called post-encroachment times (PET). Two evaluated video image processing techniques were not sufficiently accurate for the purpose of our research. Post-processing of digitized video clips using a manual method was therefore selected. The Poisson and negative binomial regression analyses of short PETs and observed crash counts indicate a significant relationship between these two.

A series of negated PET observations was discretized into fixed time intervals and maximum values in each interval were treated as extremes. This approach elegantly handles dependence of extremes in comparison to an alternative approach that defines threshold excesses as extremes. A distribution of extreme values is modeled with a generalization of the generalized extreme value distribution as the r largest order statistic model. Non-stationarity of extremes and a bias-variance trade-off in choosing a suitable time interval were also considered. Calibration of the proposed model does not require historical crash data. Based on the premise that PETs being zero or less define a collision situation, safety levels can be determined from the model in terms of crash frequency and return level estimates. Evaluation of the safety estimates against historical crash counts indicates a promising relationship between these two. However, the proposed method still yield large-variance estimates as a consequence of insufficient observation period. We conducted a semi-empirical simulation experiment to examine this issue. It was found that we need a few weeks of PET observation to obtain crash frequency estimates with confidence intervals comparable to those being obtained from 3-year observed crash counts. The proposed approach can be applied to other types of locations and collisions as well. Required observation period may be shortened for other types of collisions that are more frequent than right-angle crashes.