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# A Bayesian network based framework for real-time crash prediction on the basic freeway segments of urban expressways

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ABSTRACT

The concept of measuring the crash risk for a very short time window in near future is gaining more practicality due to the recent advancements in the fields of information systems and traffic sensor technology. Although some real-time crash prediction models have already been proposed, they are still primitive in nature and require substantial improvements to be implemented in real-life. This manuscript investigates the major shortcomings of the existing models and offers solutions to overcome them with an improved framework and modeling method. It employs random multinomial logit model to identify the most important predictors as well as the most suitable detector locations to acquire data to build such a model. Afterwards, it applies Bayesian belief net (BBN) to build the real-time crash prediction model. The model has been constructed using high resolution detector data collected from Shibuya 3 and Shinjuku 4 expressways under the jurisdiction of Tokyo Metropolitan Expressway Company Limited, Japan. It has been specifically built for the basic freeway segments and it predicts the chance of formation of a hazardous traffic condition within the next 4–9 min for a particular 250 meter long road section. The performance evaluation results reflect that at an average threshold value the model is able to successful classify 66% of the future crashes with a false alarm rate less than 20%.



## 1. Background

Road crash was conventionally believed to be a complex phenomenon involving the interaction of factors related to three major components: road geometry and environment, vehicle and human (Sabey and Staughton, 1975; Treat et al., 1977). Oh et al. (2001) introduced a fourth component, the traffic dynamics, suggesting that crashes involving safe vehicles regularly occur due to sudden formation of disrupted traffic condition even on geometrically correct roads under favorable driving condition. This contrived the opportunity to improve the shortcoming of the conventional crash prediction models that employ aggregated measures of traffic flow variables (e.g., speed limits for speed, AADT for flow, etc.) to identify hazardous locations. Since then, a small group of researchers, mainly from North America are promoting the idea of predicting crashes in real-time by using high-resolution detector data (Oh et al., 2001, 2005, 2006; Abdel-Aty et al., 2004, 2005, 2008; Abdel-Aty and Pande, 2005; Pande and Abdel-Aty, 2005, 2006a,b, 2007; Lee et al., 2003, 2006). They have advocated for developing a proactive system capable of timely spotting and evolving hazardous condition that can be countervailed with various traffic smoothing measures. Although this new concept of real-time crash prediction exhibits huge promise, being in its infancy, the available models are yet conceptual. As far as the authors of this paper are aware, none of these models have been implemented in practical scenario so far. Some of the major shortcomings of the existing models can largely be classified into three groups:

i) Location of detector: the performance of the proposed models vastly relies on the location of the detectors that are selected with respect to the crash location to fathom the risk of a future crash. Majority of the previous studies have been conducted in the USA, to be more precise, Interstate – 4 (Abdel-Aty et al., 2004, 2005; Abdel-Aty and Pande, 2005; Pande and Abdel-Aty, 2005, 2006a,b, 2007), 5 (Zheng et al., 2010), 405 (Oh et al., 2006), 880 (Oh et al., 2005). The rest took place in Gardiner Expressway of Toronto, Canada (Lee et al., 2003) and around the expressways near Utrecht region, Europe (Abdel-Aty et al., 2008). Most of these studies advocated for collecting data from both upstream and downstream of the crash location. However, the locations of the detectors varied due to high inter detector spacing. Where the study sections on I-4 have an inter detector spacing of around 0.8 kilometers, the inter detector spacing on I-5 vary between 0.6 and 3.9 kilometers. For the Utrecht region expressways (Dutch) the detector spacing is

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