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Reliability analysis of roadway departure risk using stochastic processes

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ABSTRACT

The work presented here aims to develop a warning device to prevent roadway departure while cornering. Given the random variability arising from the driver, the vehicle and the infrastructure at the entrance of the curve, a probabilistic strategy is adopted to assess the roadway departure risk. Random variables and processes are introduced in a specifically developed vehicle dynamics model. The driver's behaviours are deduced from real traffic measurements. Structural reliability methods are employed to compute a roadway departure risk index, used to take the decision of an alarm triggering. Particular care is brought to the reduction of the computational cost. Refinements made on the standard reliability methods to handle with the model non-linearities and the stochastic dimension are presented.

1. Introduction

Single vehicle roadway departure (SVRD) accidents are responsible for 30% of casualties in the 2008 French road safety figures. This kind of accidents occurs mainly on secondary roads during cornering. The French national project SARI aims to develop a SVRD warning system in order to equip dangerous turns. This preventive system must be capable of targeted alarms (i.e. related with the curve entrance conditions) in order to warn drivers of risky situations. It is made up of specific pavement integrated measurement devices disposed at the entrance of the curve, and of flashing lights mounted on the regulatory curve road signs. The subject of this paper is the development of a methodology in order to compute a roadway departure risk index used as a decision support tool for the alarm triggering.

At the entrance of the curve, a random variability exists simultaneously in the physical characteristics of the car, the actions of the driver and the road infrastructure. In order to obtain realistic results, a probabilistic approach is chosen to reflect this variability. Little work is available in the literature concerning combined probabilistic analysis and vehicle dynamics studies. It mostly deals with suspensions analysis under uncertain characteristics and loading [8,28], but the impact on the vehicle trajectory is not considered. Collision avoidance studies [13,6] present some common aspects with SVRD, but they are generally based on simple vehicle models since they imply interactions with several vehicles. This is not possible for roadway departure studies where the dynamic solicitations may be high.

SVRD prevention systems are currently an active field of research [30,6,16,19,1,20] as a natural evolution of the electronic stability control (ESC) systems. Compared to these studies, the originality of the method presented here relies on two major points. First, SVRD prevention systems are generally based on forward looking camera and/or GPS, thus requiring specific car embedded equipment. This is an obstacle for a mass implementation of the system. On the contrary, the risk assessment process proposed here is based on pavement integrated measurement devices at the entrance of the curve so that no

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