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Comparison of two warning concepts of an intelligent Curve Warning system for motorcyclists in a simulator study

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ABSTRACT

Curve crashes are a particular matter of concern regarding motorcycle riding safety. For this reason, an intelligent Curve Warning system has been designed that gives the riders support when negotiating a curve. The system has been tested in a simulator study carried out with 20 test riders. The subjects performed three rides: one without the system (baseline) and two experimental rides using a version of the Curve Warning system, one providing the warnings by a force feedback throttle and one by a haptic glove. The effects of the two system versions were evaluated both in terms of the simulated riding performance and the subjective assessment by the riders. A descriptive analysis of the riders' reactions to the warnings shows that the warnings provided by both system versions provoke an earlier and stronger adaptation of the motorcycle dynamics to the curve than when the riders do not use the system. Riding with the Curve Warning system with the haptic glove furthermore leads to a reduction of critical curve events. The riders' subjective workload level was not affected by the system use, whereas the Curve Warning system with the force feedback throttle required an increased attention. The comparison of the riders' opinions about the system reveals a preference of the Curve Warning system with the haptic glove. The better acceptance of this system version suggests a higher potential in the enhancement of riding safety.

1. Introduction

The growing popularity of motorcycle riding is mirrored in the increasing number of motorcycles registered in the European Union. From 16 million motorcycles in 2001, the number has risen up to more than 22 million in 2008 (ACEM, 2010). At the same time, recent accident studies show that motorcycle riding safety is still a relevant matter of concern (e.g., ETSC, 2003; NHTSA, 2006; SafetyNet, 2008). Motorcycle riders are not only more at risk of suffering an accident than car drivers; they are also much more vulnerable due to their lack of protection. Compared to driving a car, riding a motorcycle implies an 18 times higher mileage-related risk of being killed in a crash, with 5126 motorcycle fatalities registered in the European accident data base CARE (Community database on road accidents) for 24 member states of the European Union in 2008 (DEKRA, 2010). While overall road fatalities have successfully been reduced in the decade from 2000 to 2009, many European countries have suffered an opposite trend in fatal motorcycle crashes (IRTAD, 2010).

The types of crashes which usually involve motorcycle riders differ from the crash configurations of other road users. The most prominent scenario is the single-vehicle motorcycle crash outside urbanized areas, where the rider runs off the road at a relatively high speed, representing up to 27% of all motorcycle crashes (Hurt et al., 1981; MAIDS, 2004; TRACE, 2008). Furthermore, these crashes are generally more severe than other motorcycle crashes, with a doubled fatality risk and an only slightly lower increase in the probability of serious injuries (Clarke et al., 2004).

Riding a motorcycle differs in many ways from driving a car, especially regarding the higher levels of motor-skills, physical coordination and balance required from the rider (Mannering and Grodsky, 1995). Therefore, the riding safety is particularly sensitive to errors committed by the rider. In almost 90% of all motorcycle crashes human error is a causal factor and in approximately 37% of the crashes the crash is provoked by a rider error, most frequently attentional failures or inadequate choice of behaviour (MAIDS, 2004). As stated by Di Stasi et al. (2009), the rider's awareness of the road situation and the corresponding judgement on

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