Human Factors Issues Associated with Automation Interventions in Safety-critical Situations during a Lane-change

Husam Muslim[1] & Makoto Itoh[2]
[1]Graduate School of Systems and Information Engineering,
[2]Faculty of Engineering, Information and Systems,
University of Tsukuba, Ibaraki, Japan

Abstract

In order to improve road traffic safety, increasingly sophisticated and robust collision avoidance systems are being developed. However, the effectiveness of these systems is highly dependent on how human drivers interact with the system. Even though the system may work perfectly, a crash may occur if a driver does not fully understand the functionalities and limitations of the system. A driving experiment was designed to evaluate how drivers' understanding of the system and its authority impact on human-automation interactions and safety in critical conditions. Two groups of 24 drivers each had to avoid several impending hazards, while each group received a different type of assistance for avoiding collisions during a lane change: a haptic feedback force through the steering wheel or an automatic steering control. The haptic system provides a steering force feedback to avoid hazardous lane change, and the automatic system provides a semi-autonomous driving action to prevent hazardous lane change. Both systems were examined in three conditions: i) hazards within system design to help the drivers build their model of the system and evaluate system effectiveness, ii) hazards outside system design to explore the effects of automation intervention on drivers' perception of risk, and iii) combined hazards to evaluate the effects of control authority on the innate ability of the drivers to regain the control and recover the critical situation.

The different assistance systems were applied to different hazards, resulting in significant differences in drivers reactions and behavior. Collision data showed that both systems were equally efficient when drivers expectations, system capabilities, and the hazard encountered were in line (within system design). More collisions were observed when both systems reached functional limits that were misunderstood by the drivers (outside system design). However, the impact of these limitations varied, depending on the driver's ability to retake the control, and recover the critical situation (combined hazards). The overall drivers subjective post-hazard assessments were significantly affected by the smoothness of control authority transfer, and the types of critical conditions. This indicates the necessity of adaptive automation that can strike a balance between the processing abilities of the human and the system, and hazardous contexts encountered. The study has demonstrated, for the first time how the way control is handed over between the human and system plays a significant role in realizing safe and cooperative work environment. Although the current study is based on a relatively large sample size, further studies to assess the long-term effects of the driver-automation interaction on driver performance and safety are necessary. In real world driving, these types of support systems might not be activated very often; therefore, once the system is activated, it may lead to some surprises.