SOUTENANCE DE THESE

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soutiendra sa thèse de doctorat sur le sujet :

Performance shaping factor based human reliability assessment using valuation-based systems – application to railway operations

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Humans are and remain one of the critical constituents of a transportation system of systems, such as railway operations. Human error analysis in such industrial applications have gone from a person approach to more globally encompassing systems approach. However, for the railway domain, specific methods for risk assessment, particularly quantitative evaluations of contextualized human reliability are rather limited.

Regarding a critical survey on human error quantification techniques and practices, the main contribution of this thesis is a novel Human Reliability Analysis (HRA) methodology acronymed 'PRELUDE' (Performance shaping factor based human REliability assessment using vaLUation-baseD systEms). Its qualitative part uses performance shaping factors (PSFs) to characterize a safety critical context. To this end, different sources of qualitative data are used. Data from past accidents, an operational safety-oriented analysis of human functions, and PSFs from HRA methods used in other application domains. The quantitative proposition is a framework of Valuation-based System (VBS), and belief functions theory (BFT) as the underlying framework. This framework is used to build a formal model of human reliability with data from domain experts. Multiple experts are elicited on conditional elements of human reliability, and the data is combined using different combination rules, including BFT-based combination rules with considerations for conflicting opinions. To aid in the choice of appropriate combination rule, the results are compared and discussed. The combined expert data is transformed to formally build a human reliability model in VBS from conditional expert data. The VBS model, thus built, provides decision-making by allowing the calculation of the probability intervals of a human failure event given an operational context. Sensitivity analysis is used to establish a priority ranking among the PSFs giving a formal feedback for effective gains in operational safety.

Finally, a case study of a real high-speed railway accident scenario is presented to demonstrate PRELUDE's usage for a retrospective analysis. After the application of PRELUDE, on the identified scenario and contextual data it was possible to identify the most important factors (PSFs) that need to be improved (e.g. increase situational awareness, improve human system interface quality, etc.) to reduce human error likelihood. The results were also indicative of the reality i.e. the accident investigation report and expectations of experts.

To address the issue of lack of data in HRA modeling, multiple sources (empirical and expert), and different types (objective and subjective) of data are needed. Towards this objective there is a need to demonstrate the feasibility of PRELUDE with empirical data from simulator platforms, such as the ones used to train rail operators. Thus, the second part of this work proposes (1) a protocol to obtain empirical human reliability data from simulator experimentation, and (2) a transformation and data analysis methods to integrate quantitative and qualitative human performance data in the PRELUDE methodology. A European Railway Traffic Management System (ERTMS) operational simulator was employed for this task. Usage of both subjective and objective data is illustrated with the data obtained from an experimental simulator campaign carried out.

PRELUDE methodology in its current state is developed for, and applied to a case study for the railway domain. It may very well, with moderate efforts, be applied to other domains. The ability to take into account data from such different sources is conducive for a more inclusive human reliability analysis and a positive point.