Thesis subject:

A Systems-of-Systems approach for modeling and integrating human factors in risk analysis: Application to advanced driver assistance systems (ADAS) and railway systems.

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PhD thesis description:

In recent years, a large amount of accidents in railway transport are caused by human errors. Human error is defined as the capacity that a human operator cannot realize correctly the precise tasks in given conditions or realize additional tasks which are harmful to the functions of human-machine system. Although human factors are not taken into account in railways standards defining RAMS (Reliability, Availability, Maintainability and Safety) requirements such as EN50126 [1], the necessity of taking human errors into account in railway accidents analysis is an idea widely accepted by all the experts. The railway standards provide nevertheless a non-exhaustive list of human factors that may have an impact on RAMS parameters of systems.

In the literature, two kinds of methods have been developed in order to model human factors. The first kind is quantitative methods that appeared in the 70’s and 80’s. The methods named "the first generation" have proposed a binary model of human actions (success or failure), which are similar to the binary models defined for devices (working or failure), to quantify human errors by probabilities and to obtain a quantitative estimation of accidents risks. Then, the second kind of methods appeared. It takes into account the human, organizational and social aspects in a more detailed manner [2, 3, 4]. However, the second generation of methods suffers from its qualitative aspect, its complexity, and its non-generality.

The aim of this thesis is to propose a formal quantitative model of human factors which combines the advantages of the two above types of methods, in order to integrate it into a global model of the accident risk analysis. The human factors considered, in this project, are factors related only to the rail traffic control operators. The originality of this work lies in the fact that the identification of the risks of the global model will be done at the System-of-Systems (SoS) level (the SoS considered here is composed of human and the supervision system of rail traffic) by identifying in particular the emergent and dynamic behaviors related to human-machine cooperation. For example, as Mayer described in [5], the supervision system of rail traffic is a collaborative SoS where the cooperation between traffic supervisors, interfaces and supervision systems present several dynamic and emergent behaviors that may cause failures that are more critical and difficult to identify at SoS level compared to the failures at the systems and components levels which are identifiable thanks to an analysis of Failure Modes, Effects and Criticality Analysis (FMECA). The chosen formalism for the global model of SoS and for the model of human factors will be VBS (Valuation-Based Systems) which are valuation networks for modeling systems and their interactions as well as the propagation of uncertainties related to the occurrences of events changing the behavior of these systems. The used valuations in VBS are set theoretic valuations (imprecise probabilities or belief functions). Nowadays, there is very few works related to a risk analysis based on a SoS approach. The ambitious theme of this project aims to propose an interdisciplinary approach which not only evaluates the risk related to human factors, failures of components and subsystems, but also proposes to evaluate the risks at the SoS level which result from the different human-machine cooperation mechanisms.

The first step of the thesis is to create a model of human factors that will be implemented in several intermediate steps: the study of human factors that play an important role in the railway transport risk analysis; the determination and definition of factors that we want to integrate in our risk model; the definition of interactions between the factors and their quantification, and finally the realization of the model using VBS. The second step is to integrate the model of human factors into the global model of risk analysis which describes the accidents. The third step is to obtain the likelihood value of the occurrence of accidents and to use outward propagation to identify critical elements of SoS whose occurrence contributes significantly to the augmentation of the likelihood of the occurrence of the accidents.

The final objective of this thesis is to propose a plausible SoS model, integrating human factors, which could be used in different railway accident and advanced driver assistance scenarios. The developed models will be tested on a "Route Control Center System (RCCS)" simulator used in the Heudiasyc Laboratory and provided by ANSALDO STS and a platform for simulation of vehicle drivers (COR&GEST and MissRail) in the LAMIH laboratory.

References

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