Title: Predictive model of human reactions to requests from railway systems

Summary of the thesis subject:

Sociotechnical systems should not be designed by prohibiting erroneous human actions but by foreseeing their occurrence or reducing their consequences by activating adequate barriers or defenses. Thus, human error can be seen as a consequence of a failing system rather than a cause of an undesirable event. However, more than 70% of accidents are still due to human errors and 100% of them are directly or indirectly related to human factors. One of the answers to this problem is the establishment of procedures for distributing tasks between humans and systems in a system control and supervision framework.

In the different shared control models, the increasing autonomy of automated systems considerably reduces tangible interactions with human operators. However, in certain circumstances, a request for human intervention or reaction may be requested by the technical systems. A period of time is generally given to human operators to regain control or validate the proposed solution. In both cases, the solicitation is generated via audible or visual alarm systems appearing on the dashboard or on the workstation. The absence of human responses may imply a validation of the technical solution which may be applied automatically after the time limit retained to react or become problematic when it comes to a request for manual takeover because the system is failing or unable to analyze the current situation. Several studies have tried to determine the minimum delay before which human operators were supposed to react following a request from technical systems. Some of them recommend 10 seconds to have time to regain manual control when systems fail. Others estimate that manual takeover requires 15 to 40 seconds for the user to understand the situation and control it properly. Two scientific obstacles must be lifted: the minimum time before which the human operator can react and the necessary explanation of the current situation.

It is obvious that systems can guarantee safety or comfort for example in man-machine systems. However, certain testimonies or studies sometimes show their limits. Even if these feedbacks are few, they are relevant because they show potential conflicts between human behaviors and behaviors techniques. These deviations are called human-machine dissonances when safety or performance-enhancing systems can affect these criteria under particular conditions and they can cause unease or cognitive discomfort on the part of operators. humans involved when detected.

The state of the art indicates that the use of probabilistic models for the analysis of human reliability and the prediction of these errors seems to be gaining ground. Moreover, to quantify the likelihood of these errors, management of uncertainties being essential, graphical probabilistic models such as approaches based on a representation of expert and field knowledge seem the most appropriate. With respect to the study of accident-provoking mechanisms, the PSF (Performance Shaping Factors) most often treated are attention and vigilance. We propose to use hidden Markov models for the prediction of future operator actions. A hidden Markov model consists of a double stochastic process, one of which is not observable (it is hidden and it represents the sequence of actions of the human operator in order to carry out the requested task) but can be revealed thanks to the second stochastic process which produces an observation sequence (physical state of the human, attention, vigilance, etc.). More simply, the observation sequence makes it possible to find the sequence of hidden states.

In addition, a team of Swiss researchers in neurophysiology found that the insular cortex, an area of the brain that is activated during conscious activities, was less solicited when the display frequency of stimuli was correlated with heart rate. More recently, an exploratory study highlighted the impact of this synchronization on the perception of audible and visual alarms. Thus, the model proposed in the thesis project will focus on this indicator which could explain certain human behaviors, such as the "tunnel effect" (or tunneling) or inattentional blindness, during which the operational context affects the cognitive, auditory or visual acuity of human operators. Visual or sound stimuli will be associated with levels of decision-making uncertainty of systems due, for example, to the presence of fictitious images in a driving scene, for example, which may thwart their detection capabilities or an inability to assess a given situation.

This thesis project aims to propose an imprecise probabilistic graphical prediction model to determine probabilities or probability intervals of non-response to solicitations and to improve shared control between humans and machines accordingly. In respecting the rights to human intervention in the face of systems such as railway systems, it is necessary to study the human capacities to react when alarms are emitted by these systems.