Proposition of an establishment of a model of human machine system by hybrid dynamic system model applied to guided transport

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Abstract

Transports has known a tremendous increase during the last decade. However, this growth was not shared by all transportation system, in particular by railway system. European Union, for politic and economic reasons, wants to develop this transportation system. Today, the studies about this system are focused on technical system and new technologies integrating. But, In rail accident, feedback showed that the major causes of accidents are, in large part, the human errors (and more generally human factors). From this observation, it seems interesting to consider the human component. The aim of this paper is to propose a modelling, by hybrid dynamic system approach, of the human operator. The human component is then attached to the modelling of technical system by the same approach (hybrid dynamic system) in order to obtain a modelling of human machine system. The various hybrid dynamic system models will be summarized. In the present work, no choice has been made regarding the choice of the most relevant model to apply at the human component. The main objective is to identify the contribution of this modelling. To do that, an example will be treated at the end of this paper.

Introduction

In reference to safety the main objective of system modelling is to reduce the risk of incidents and accidents occurrence. The incidents and accidents result from three sources:

- technical failures,
- human errors,
- outside events.

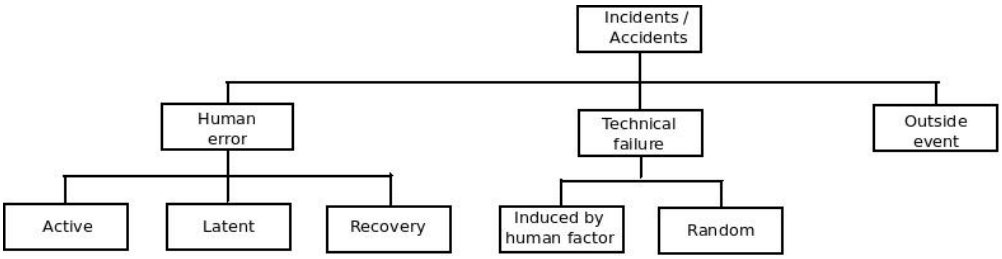

Fig.1: Generic model of causes of accidents

A Human Machine System can be defined as a complex system. This complex system is composed of a technical component and a human component and this two components communicate between them to achieve a common aim (Vanderhaegen, 2003). So, this type of system is submitted to the three factors responsible of incidents and accidents appearance. The establishment of a model for this system is necessary to limit risks. Some works have already been made, but this paper proposes a new approach by using models developed by the Hybrid Dynamic System community.

Modelling a Human Machine System

A HMS is composed by three parts:

- technical system,
- human operator,
- human machine interface.

To model a HMS, it is necessary to model each part of it.

Modelling of technical part

In (Zaytoon, 2001), modelling a technical system, in automated system, is represented by a model:

- continuous dynamic. Systems can mainly represented by differential equations,
- or discrete dynamic. Many models exist, e.g. Petri nets, Grafcet...

Moreover, the dynamic of a system is characterized by a combination of many variables:

- continuous variables. They mean a variable evolving inside a real number set,
- discrete variables. They evolve inside subsets of natural integers. E.g., they characterized a capacity of an object,
- symbolic variables. They represent the state of an element of the system which evolved inside a non structural finite set. E.g. an element can take a state opened, closed or out of order.

Most of system present an hybrid behaviour, i.e. they are submitted to continuous and discrete dynamic. The hybrid dynamic system community approach is the study of systems according to their continuous and discrete components and also by interaction which exist between these two components. To represent the continuous and discrete aspects, many formalisms were developed to model technical system and they are related in (Zaytoon, 2001).

Modelling of human operator

The problematic of modelling human operator has been starting to be treated since the 1940s. It went through three main stages (Millot, 1999):

- The first step. Modelling of perceptual component of human operator.
- The second step leans on the theories of physics:
- Theory of information. Human operator is viewed as a channel of information,
- Theory of control. The operator is viewed as an optimal pilot with limited capacity of perception,
- The third step is focused on the ability of human operator to make decisions. The operator is considered solver of problems. During this stage, the Rasmussen model appears. This model proposes three levels of behaviour (Rasmussen, 1986):
- skill-based behaviour
- rules-based behaviour
- knowledge-based behaviour

Modelling of Human-Machine system

In literature, the modelling of human-machine system are often designed in this following way. The technical part and the human part of the system are modelised with the same method. After these two parts are connected by the interaction between them.

As mentioned in section 2.1, the most relevant and most complete model for a system seems to be hybrid dynamic modelling. A study of literature shows little work on the human part model-ling with HDS models. But this type of model is a tool which allows combine continuous and discrete aspect. It seems interesting to transpose this modelling at the human operator. Indeed, human operators seem to have continuous behaviours or tasks (e.g. supervising) and discrete behaviours and tasks (e.g. press a button).

Some objectives of modelling human operator

The main objective is upgrading performances of modelling human operator and, with extension, of human machine system. In term, this modelling could take into account:

- behaviours and actions doing by the operator that not appear in actually model,
- modelling the dynamic conditions of transition of behaviour that not take into account by actually model (Delépine, 2007).

Treatment of an example with an hybrid dynamic system model

The example chosen is the opening and closing door of a guided transport system. The functioning of this system is described in the two tables.

Tab.1: Technical part of functioning of opening and closing doors

Opening doors	Closing doors
1. Spread out step 2. Unbolting door 3. Opening door	1. Closing alarm 2. Closing door 3. Closing step 4. Inflation of joints

Tab.2: Human part of functioning of opening and closing doors

Opening door	Closing door
1. Press the button 2. Check the side of opening door (platform)	1. Check that doors are cleared 2. Turn the key 3. Check that doors are closed 4. Release key

This example (figure 1) uses Hybrid Petri nets. The continuous is represented by double circle and discrete by simple circle. With this type of modelling, we observe the interaction between human operator and the technical system. The continuous tasks, notably supervising tasks, appear in this modelling unlike classical modelling with Petri nets.

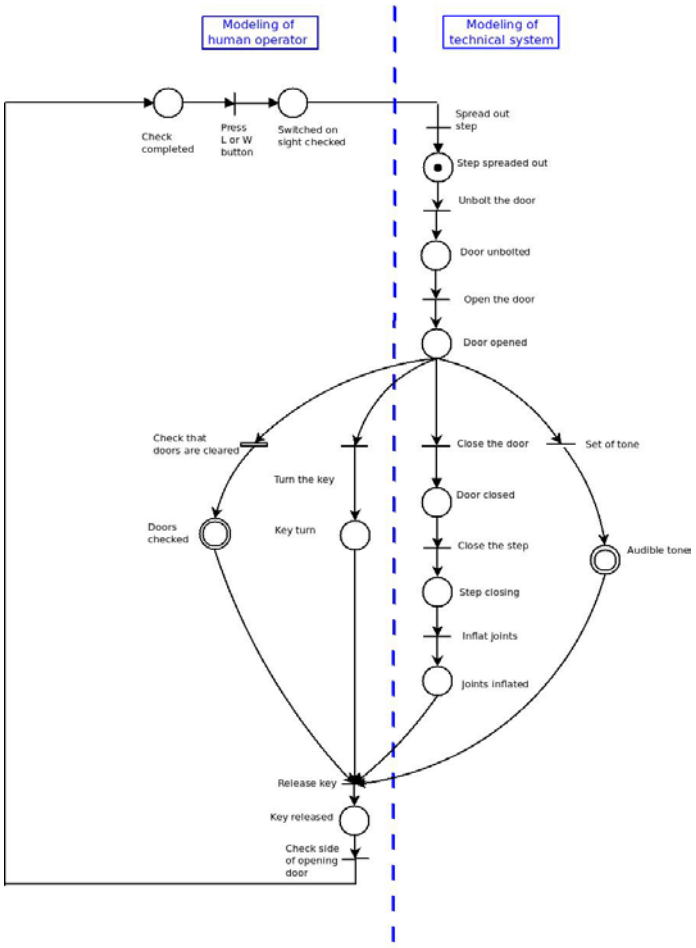

Fig.2: Modelling of human machine system with hybrid Petri nets

Conclusion

This paper proposes some tracks to model the human component with hybrid dynamic system models. This proposed approach seems promising. Indeed, some tasks appear during use of hybrid dynamic system models applied to human operator unlike “classical” modelling. Nevertheless, it is a prospecting work, so it is necessary to do complementary works, notably identify another hybrid dynamic system models for the human component to judge the more pertinent model. It seems judicious to do a study to identify continuous and discrete states, behaviours, tasks...

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