Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

Supervisor information	
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Polytech name	POLYTECH GRENOBLE
University name	UNIVERSITY GRENOBLE ALPES
Country	France

PhD information	
Title	Reliability and safety analysis of manufacturing systems modeled by timed event graphs: a machine learning approach

Main topics regards to CSC list (3 topics at maximum)	I-8.Techniques of simulation and application VI-2. Prevention of serious engineering breakdowns and system safety
Required skills in science and engineering	good knowledge in: programming, reliability and safety engineering, manufacturing systems

Subject description (two pages maximum)

The PhD thesis aims to develop methods and tools for the fault diagnosis and reliability analysis of manufacturing systems modeled by timed event graphs with machine learning approaches.

In the first part of the PhD project, we will develop a methodology for modeling manufacturing systems as timed event graphs in Matlab/Simulink. We will take into account time shift failures. A manufacturing system is a network of machines and transportation elements that are used together for the transformation of some material resources. In this PhD thesis, we will model a manufacturing system as a Timed Event Graph (TEG). Timed event graphs are a special class of timed Petri nets. The first objective of this PhD thesis is to develop a Matlab/Simulink toolbox, which will allow to model and simulate a TEG. Our research team hold some expertise in Simulink toolbox development [1,2]. The modeling methodology must take into account some uncertainties in delay operation times. Consequently, operation times will be defined as time intervals and the toolbox will propose some time shift failure injection blocks. The Matlab simulation of a production system defined by our toolbox will allow to generate a collection of observations collected sequentially in time, called a time series.

In the second part of the PhD project, we will develop a methodology for the detection and localization of time shift failures in manufacturing systems modelled as timed event graphs. Current approaches for fault diagnosis in TEG use a Max-Plus algebra (a special subclass of idempotent–invertible dioïds) [3,4,5]. Indeed, timed event graphs can be easily modeled as (max,+)-linear systems. The second objective of this PhD thesis is to propose a new approach based on artificial intelligence like machine learning for the detection and localization of time shift failures. We will use the results of the first part of the PhD thesis to generate a set of simulations of a manufacturing system with and without time shift failures. This set of simulations will help us to train our machine learning model. As a result, we will hold a classifier which will allow to identify a time shift failure from a time series generated from the measures of sensors monitoring a production line over time.

In the last part of the PhD project, we will study some metrics to analyze the reliability of manufacturing systems modeled as timed event graphs and we will propose a safety analysis of these systems.

Expected results:
− Development of a Matlab/Simulink toolbox for timed event graph with time shift fault injection.
− Development of a methodology detection and localization of time shift failures in timed event graphs based on machine learning techniques.
− Proposal of a reliability and safety analysis method for timed event graphs.

References
[1] Eric Gascard, Zineb Simeu-Abazi, Joseph Younes, "Exploitation of Built in test for diagnosis by using Dynamic Fault Trees: Implementation in Matlab Simulink". 20th European Safety & Reliability Conference (ESREL 2011). CRC Press, pp. 436-444, September 2011.

[2] Zineb Simeu-Abazi, Maria Di Mascolo, Eric Gascard, "Queuing network-based methodology for designing and assessing performance of centralized maintenance workshops". Journal of Manufacturing Technology Management, Volume 25(4), pp. 510-527, April 2014.

[3] Gernot Schullerus, Volker Krebs, "A method for estimating the holding times in timed event graphs". Proceedings. of the Sixth International IEEE Workshop on Discrete Event Systems, 2002, pp. 209-216.

[4] Alexandre Sahuguède, Euriell Le Corronc, Yannick Pencolé, "Design of indicators for the detection of time shift failures in (max,+)-linear systems". IFAC-PapersOnLine, 2017, Vol. 50, No 1, pp. 6813-6818.

[5] Euriell Le Corronc, Alexandre Sahuguède, Yannick Pencolé, Claire Paya, "Localization of time shift failures in (max,+)-linear systems". IFAC-PapersOnLine, 2018, Vol. 51, No. 7, pp. 186-191.

Main supervisor: Dr Zineb Simeu, Assistant Professor in Automation and Industrial Engineering
Co-supervisor: Dr Eric Gascard, Assistant Professor in Computer-Science