Development and implementation of intelligent techniques for the detection (and classification) of abnormal conditions in safety-critical systems

INTRODUCTION

In the operation and control of safety-critical (e.g., civil, aerospace, chemical, nuclear) systems and plants, operators are typically required to promptly identify their abnormal conditions and the corresponding causes, considering the time evolution of continuously monitored signals (e.g., temperatures, pressures, mass flow rates, etc.). Such activity is of paramount importance, because it allows to timely detect behavior deviations that could lead to severe accidental sequences. However, the task is often quite challenging, given the large number of monitored signals in the "Industry 4.0" era and the complex relationships among them.

To aid the operators, various computational frameworks for anomaly detection and fault diagnosis have been engineered, commonly based on (data-driven) statistical techniques and artificial intelligence methods (which do not require detailed a-priori physical knowledge of the very complex systems or components under analysis).

Within this framework, the present thesis aims at developing and implementing methods for abnormal condition detection (and possibly diagnostics) of safety-critical systems and plants. In particular, statistical techniques for functional outlier detection (e.g., Gaussian Mixture Models-GMMs, Isolation Forest-IF, unsupervised clustering, …) and artificial intelligence methods (such as Auto Associative Kernel Regression-AAKR, Artificial Neural Networks-ANNs and/or Deep Learning-DL algorithms) will be possibly considered. Applications to synthetic data sets, as well as to (time-varying) data (transients) coming from realistic simulators of safety-critical systems (from the aerospace and *nuclear* research domains), are foreseen.

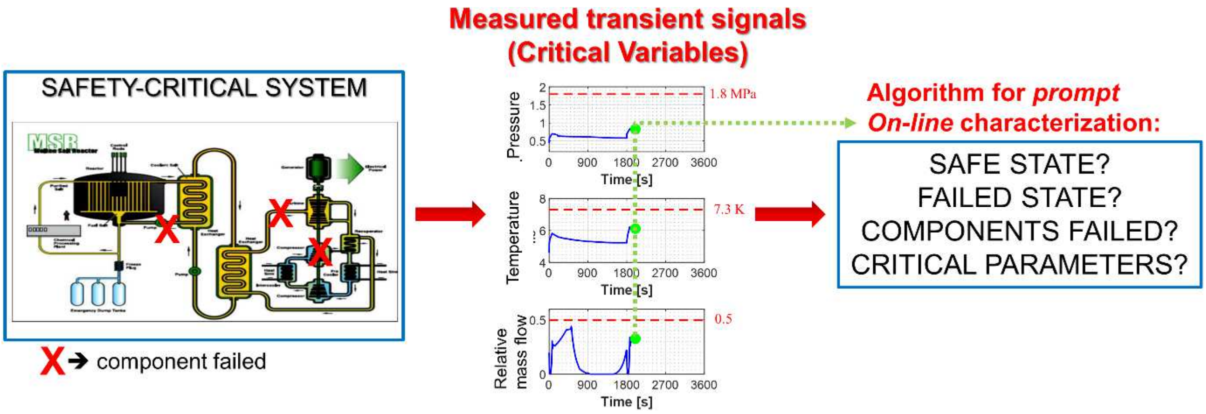

Figure 1: Conceptual sketch of the thesis project.

OBJECTIVE OF THE RESEARCH

Methodology/ies investigation, development and pilot case(s) examination, with software implementation of the method(s) explored.

WORK PHASES

- Literature review and analysis of the possible solution methods;
- Selection of the most promising solution method(s);
- Development of the selected solution method(s);

- Application to synthetic and realistic case studies;
- Analysis of the results obtained (including comparison of the performance of the techniques considered).

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THESIS DURATION

It can be discussed, and it depends also on the “confidence” of the student with the topic. However, a work period of *at least 6 months* is strongly recommended.