Research Grants for PhD students from the China Scholarship Council

Supervisor:

Name: Frédéric KRATZ

Status: Full Professor

E-mail: frederic.kratz@insa-cvl.fr

Co-Supervisor:

Name: Yunhui HOU

Status: Assistant Professor

E-mail: yunhui.hou@insa-cvl.fr

Description of the research work proposed for a PhD:

Title: Imperfect maintenance integration to model-based prognostics considering uncertainties on effect of maintenance actions and initial states.

Keywords: imperfect maintenance, model-based prognostic, epistemic uncertainty, optimisation

Subject:

In order to assure the system performance continuously, maintenance actions are (pre-) programmed according to different constraints or determined according to system condition. Each maintenance action is integrated within the discrete event model by means of a variable associated to the intervention on a certain component's damaging model [1]. The cost, time to repair (delay) and effect of maintenance action are uncertain. There are three types of maintenance actions grouped according to its effect: perfect maintenance, minimal maintenance and imperfect maintenance. Imperfect maintenance presents either positive or negative effect on the operated component which often materialized by probability distributions [2, 3]. However, the probability distributions present only the aleatory uncertainties due to natural randomness; the epistemic uncertainties caused by insufficient information are not discussed. Uncertainties are characterized as epistemic, if the modeller sees a possibility to reduce them by gathering more data or by refining models [4, 5, 6]. The objective of this thesis is to build a model-based prognostic model with maintenance decision and uncertain imperfect actions integrated in order to satisfy continuously system performance criteria and other constraints.

In this thesis, firstly we need to integrate pre-scheduled uncertain imperfect maintenance effect into a model-based prognostic process. The epistemic uncertainties on the cost, delay and effect of maintenance actions should be considered using uncertainty theory such as belief functions. The final model will be a hybrid (continuous and discrete events included) linear uncertain

system. It is possible to evaluate the effect of the maintenance scheduling strategy at the end of a certain period. Secondly, the maintenance is programmed dynamically based on the current system conditions with constraints, i.e. cost, availability, etc. Given a continuous system performance objective, this problematic can be identified as a reachable set problem [7]. With the maintenance actions as well as initial system states modelled by uncertainty models, the final effect of maintenance scheduling strategy is estimated. Finally, the parameters of maintenance strategies (considered as part of initial system condition or configuration) satisfying both system availability objectives and maintenance constraints can be identified while inversing the process.

- Contribution of this study

Model-based prognostic model is widely considered more precise when historical information is not sufficient especially on the early stage of usage. The notation of imperfect maintenance action is more approach to the reality. The first contribution of this study is to integrate imperfect maintenance action to model-based prognostic. Secondly, using this model maintenance strategies can be evaluated and selected while stochastic and epistemic uncertainties on initial states and maintenance action performance are taken into account. Finally the results of this study will improve the performance of PHM (Prognostics and Health Management) tools by providing more realistic conditions.

- Perspectives

Further study will focus on the following subjects: integration and improvement of condition-based maintenance scheduling algorithms with imperfect maintenance and model-based prognostics tools; sensibility analysis of initial system condition and maintenance policy parameter; application of human factor model on imperfect maintenance action with model-based and data driven prognostic.

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