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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PhD information	
Title	Recursive identification of continuous-time, non-linear and uncertain dynamic models - application to the diagnosis / prognosis of proton exchange membrane hydrogen fuel cells
Main topics regards to CSC list (3 topics at maximum)	V-5. Energie d'hydrogène et technologie de stockage d'hydrogène Energy of hydrogen and technology of hydrogen storage V-7. Pile à combustible Combustible battery

	I-17. Théorie et technique du contrôle Control theory and technique
Required skills in science and engineering	Electrical Engineering, Electrochemistry, Thermal Science, Mathematics, Numerical Analysis

Subject description (two pages maximum)

Context:

The increasing use of parameterized dynamic models in a wide range of applications (simulation, prediction, control, diagnosis, prognosis) has led to the development of new methods adapted to continuous-time dynamic models identified from input-output discrete-time signals [1-9]. These methods are based onimplicit Runge-Kutta ordinary differential equation solvers with controlled estimation error and on maximum likelihood or instrumental variable estimation techniques.

During the last years, the IREENA and LTeN laboratories of the University of Nantes have been collaborating for several years on the integration and diagnosis of hydrogen fuel cells in multi-source systems. The LTeN team is interested in the fine understanding and modeling of the multi-physics phenomena (oxydation-reduction reaction, diffusion and species transport) of the hydrogen cell. The IREENA laboratory is interested in the integration of the energy storage devices such as fuel cells in multi-source and/or propulsive systems and in the real-time identification of the parameters of gray-box-type models.

In a model-based approach to diagnosis, this combination of skills is a real asset for the search for the best model-algorithm pair fitted to the real-time diagnosis and to the prognosis of a system in situation, that is to say taking into account the actual exciting trajectory of the system and desensitization problems of the parameters.

Goals :

The main objective of the thesis is to perform a comparative synthesis of the algorithm-model couples for the diagnosis / prognosis of proton exchange membrane hydrogen fuel cells (PEMFC) used in the 300-kW Energy-Propulsion-System of fluvial shuttles usingl hybrid (hydrogen and battery) storage. The study will be structured in two distinct parts:

1. State of the art and design of recursive algorithms

The goal is to use of recursive least squares estimators or extended Kalman filters developed in an ongoing thesis, Combining efficient ordinary differential equation solvers and matrix factorization

algorithms. Particular attention will be paid to the algorithmic cost of solutions and its minimization. Whether for an extended Kalman observer or for an identification algorithm minimizing the normalized energy of the output error, we will try to make the most of the knowledge of the sensitivity functions [10] of the model. Their knowledge (simulation) can indeed be used to firstly compare the potential of a model for the diagnosis / prognosis and secondly to avoid a divergence of minimization algorithms when some parameters are momentarily desensitized. The generic character and the relevance of these estimators of physical quantities and of characteristic parameters will then be demonstrated essentially in the case of a real application.

2. Application to the diagnosis / prognosis of the hydrogen fuel cells

There is a wealth of models in the literature for the simulation of PEMFC, but very few can actually be used for real-time fuel cell diagnosis when the exciting trajectory corresponds to a real application case. An indispensable bibliographic synthesis dedicated to gray-box PEMFC models will make it possible to identify some models adapted to our diagnostic / prognosis objectives. Then we will evaluate the performances of model-algorithm pairs for a stack delivering a current corresponding to the power profile generated by a 300 kW Energy Propulsion System fluvial shuttles using hybrid (hydrogen and battery) storage.

References

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