PhD Position at the CRAN (2021-2024)
PhD advisors : Benoît Marx and Jean-Christophe Ponsart
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Title : Fault diagnosis and fault tolerant control of LPV systems

Administrative description

Faculty :	Université de Lorraine
Laboratory :	CRAN Centre de Recherche en Automatique de Nancy (site web)
PhD advisros :	Benoît Marx (site web) - Jean-Christophe Ponsart
Date of beginning :	October 2021
Duration of the PhD :	3 years
Funding :	Doctoral grant of the University of Lorraine
Salary :	approx. 1500 euros / month
Candidate's profile :	M.Sc in Automatic control or applied mathematics
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Mots-clefs
Fault diagnosis, fault tolerant control and nonlinear systems.

Context
Fault diagnosis and fault tolerant control (FTC) are key issues. Indeed, fault diagnosis allows to detect, locate and possibly quantify one or more malfunctions in a process. The fault tolerant control relies on the results provided by the diagnosis to ensure a certain level of performance despite the occurrence of fault(s) [1]. While these tools have been developed in the linear framework for several decades, the current challenge remains their extension to the nonlinear framework, which is necessary for an accurate description of complex processes. In this perspective, the use of linear parameter varying systems (LPV) [3, 9], or polytopic or TS systems [12] is an interesting and generic tool for representing a large class of nonlinear systems by a structure close to the linear case or defined by a set of linear submodels [6, 13]. This representation facilitates the performance analysis and the synthesis of control, observation and diagnostic modules using, for example, optimization under linear matrix inequality constraints (LMI).

Expected researches
The cause and nature of the faults affecting the process to be diagnosed and/or controlled have a significant influence on the diagnosis or FTC techniques to be used. According to [11], faults can be caused - among other things - by accidental or malicious corruptions of measures taking the form of unknown entries replacing the transmitted data or by transmission defects (missing data, saturations [2], dead zones, etc). From the modeling point of view, two main classes of faults can be distinguished : additive and parametric. Among the latter, a particular care should be taken with input saturations that prevent the calculated control input from being applied to the system [14]. Several works have already been done in this direction [2], but some obstacles still remain (restrictive assumptions, pessimism of the results, etc.) and limit their applications. A more accurate description of the saturation phenomena in a polytopic form should make it possible to remove some of these locks.
Constraints on state variables should also be included to take into account the validity domain of the polytopic rewriting of the original nonlinear model [10].
In the context of diagnosis and tolerance to additive faults, an interesting research direction would be to avoid the exclusive use of observer-based structures. Indeed, the observer is synthesized by minimizing the fault influence on the estimation error, and then the residue generator is constructed to be as sensitive

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as possible to faults, precisely from this estimation error. It would therefore be interesting to consider alternative structures for the diagnostic modules based on the available input and output signals of the system. Among the possible structures, the use of coprime factorization should be considered for the diagnosis and FTC of nonlinear systems. This technique was used in the linear framework for diagnosis [5] and for FTC [15], but its extension to the non-linear framework remains open.

To summarize, after a preliminary bibliographical work, the following pathes could be explored by the PhD student :
- polytopic modelling of transmission faults phenomena, such as saturation and/or dead zones, allowing them to be taken into account in the system model, and may be allowing the estimation of their parameters [2] ;
- Observer-based diagnosis for nonlinear systems based on polytopic / LPV models [8, 7] ;
- the extension of the coprime factorization-based diagnosis to nonlinear systems represented by polytopic models / LPV
- the extension of the obtained results to descritor polytopic LPV models [4, 8].

Références

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How to apply ?

Please send the documents listed above to the following e-mail addresses :
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as soon as possible and before the 1^{rd} **of April 2021**.

- A detailed CV including your university curriculum and a description of your professional and internship experiences.
- A Masters degree or equivalent degree certificat (this equivalence should be validated by the graduate school in the case of foreign testamurs).
- Copies of testamurs and diploma supplements, as well as grades and rankings from the candidate.
- Dissertations and/or internship reports and/or publications from the candidate.
- Letters of recommendation from the scientist(s) who supervised the Master ?s thesis or internship.
- Any item which demonstrates the candidate ?s value and ability to prepare a PhD in automatic control.
- A scan of your passport (for non-EU) or identity card.

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