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PROPOSITION DE SUJET DE THESE

Intitulé : Active control methods applied to reacting systems

Référence : **TIS-DTIS-2026-40**
(à rappeler dans toute correspondance)

Début de la thèse : 0/10/2026	Date limite de candidature : 01/05/2026

Mots clés

Nonlinear control ; Model Predictive Control

Profil et compétences recherchées

The PhD candidate should have an excellent Master's degree (or comparable) in Control Engineering, or a closely related field. The ideal candidate will have:

- A strong background in control theory. Experience in nonlinear or model predictive control would be appreciated.
- Demonstrable experience of the use of Matlab/Simulink (other software competences are an asset)
- Good communication and writing skills in English are required, as well as the ability to work independently

Présentation du projet doctoral, contexte et objectif

Combustion is a ubiquitous form of energy conversion in modern society, but is a phenomenon that is still difficult to model, control and measure precisely due to the highly dynamic environment around the flame. Two major types of instabilities typically arise in such systems and jeopardize performance: (i) thermoacoustic instabilities, which result from the coupling between unsteady heat release and the natural acoustic modes of the combustion chamber, and (ii) hydrodynamic instabilities, caused by flow perturbations that can lead to local flame extinction or reignition. Both phenomena may interact, giving rise to complex, nonlinear, and multi-scale unsteadiness.

Traditional passive controls, like geometric changes or damping liners, often fail to stabilize combustion instabilities due to the complex, nonlinear, and time-varying dynamics of reactive flows. In contrast, modern active control strategies use responsive actuators (e.g., fuel modulation, plasma) and sensors (e.g., pressure probes, chemiluminescence detectors). When paired with automatic control methods, these technologies offer new stabilization pathways. Additionally, recent modeling advances, such as the digital twin framework, provide powerful tools to characterize these phenomena using experimental and numerical data.

The objective of this thesis is to develop and evaluate active, robust control strategies for suppressing instabilities in combustion systems. A particularly promising approach is Model Predictive Control (MPC)—an optimization-based control method that uses a dynamic model of the system to predict its future evolution and determine an optimal control sequence that respects physical and operational constraints (e.g., actuator limits, safety margins). Recent developments on *machine learning* (ML) and *reinforcement learning* (RL) are also of interest, as they might also benefit from digital twins and be directly coupled to MPC – lightening, for instance, its implementation in embedded systems.

Collaborations envisagées

Collaboration with CentraleSupélec et le Conservatoire des Arts et Métiers de Paris (CNAM) within the ANR project REACT[2]

Laboratoire d'accueil à l'ONERA
Département : Traitement de l'information et Systèmes
Lieu (centre ONERA) : Toulouse
Contact : Sérgio WAITMAN
Tél. : +33 5 62 25 25 32 Email : sergio.waitman@onera.fr

Directeur de thèse
Nom : Alex DOS REIS DE SOUZA
Laboratoire : DTIS/ONERA
Tél. : +33 5 62 25 26 14
Email : alex.dos_reis_de_souza@onera.fr

Pour plus d'informations : https://www.onera.fr/rejoindre-onera/la-formation-par-la-recherche