PROGRAM of the study day of the CT Identif (SAGIP)

THURSDAY 12 MAY from 10:00 till 16:15 (Paris time)

Room R0 of the ENSAM (151 Boulevard de l'Hôpital, 75013 Paris)

VENUE - REGISTRATION – ZOOM LINK

After two years of Zoom meetings, the 12th May meeting of the CT Identif will be organized in Room R0 of the ENSAM (151 Boulevard de l'Hôpital, 75013 Paris). For the people attending in presence, it is important to register via the following link:

https://docs.google.com/spreadsheets/d/1FDieOvG2tI1ZalNQ754uisV5ihCLI3DXoez3zNyfoqc/edit?usp=sharing

For the colleagues that cannot join us in Paris, we will try to retransmit the presentations. The zoom link can be obtained by writing to the animators of the CT Identif.

TIME SCHEDULE

- 10:00-11:00 Régis Ouvrard (Université de Poitiers)
  Partial moments in system identification, a tool for initializing of output error algorithms – An application to population dynamics model estimation

- 11:00-11:45 Guillaume Mercère (Université de Poitiers)
  Noise covariance matrix estimation with subspace model identification for Kalman filtering

- 11:45-14:00 Lunch

- 14:00-14:45 Jean-François Duhé (Université de Bordeaux)
  Fractional order modelling and identification for heat transfer in lungs

- 14:45-15:30 Alain Uwadukunze (Université de Lorraine, ISL)
  Artificial Intelligence applied to aerodynamics and ballistics

- 15:30-16:15 Taleb Bou Hamdan (Université de Poitiers, Michelin)
  Tracking Distributed Parameters System Dynamics with Recursive Dynamic Mode Decomposition with control

ABSTRACTS

Partial moments in system identification, a tool for initializing of output error algorithms – An application to population dynamics model estimation

Authors: Mohamad Chhaytle, **Régis Ouvrard**, Thierry Poinot

Abstract: The mathematical tools partial moments or reinitialized partial moments can be used for the identification of continuous-time linear models, discrete-time linear models, continuous-time linear state space models, linear parameter varying models and multidimensional models based on partial differential equations. The main interest of these approaches is to provide a pre-estimation to initialize output error algorithms. To illustrate the effectiveness of these tools, an application to a bird population dynamics model is considered. A model based on a parameter-varying partial differential equation is estimated to study the global change impacts on this population. This difficult problem of parametric estimation, coupled with a poor a priori knowledge of the parameters, shows the usefulness of a pre-estimation even if it is widely biased.

Noise covariance matrix estimation with subspace model identification for Kalman filtering

Authors: Vincent Mussot, **Guillaume Mercère**, Thibault Dairay

Abstract: A problem frequently encountered in Kalman filtering is the tuning of the noise covariance matrices. Indeed, misspecifying their values can drastically reduce the performance of the Kalman filter. Unfortunately, in most practical cases, noise statistics are not known a priori. This talk will focus on a method relying on subspace model identification theory to determine them accurately. This solution is developed for linear time invariant systems with stationary random disturbances having constant covariance matrices. Convincing results have been obtained for the Extended Kalman Filter as well. The method introduced in this talk departs from most of the solutions available in the literature by the fact that it does not need any tuning parameter to be chosen by the user. After discussing theoretical results, several numerical examples are given to demonstrate the efficiency of the approach. For more details, please refer to https://onlinelibrary.wiley.com/doi/abs/10.1002/acs.3213

Fractional order modelling and identification for heat transfer in lungs

Authors: **Jean-François Duhé**, Stéphane Victor, Pierre Melchior, Youssef Abdelmounen, François Roubertie

Abstract: Cardiac surgery implies harsh conditions for the lungs, which are normally disconnected from the patient’s body during the procedure. A better understanding of lung’s heat transfer may allow to reduce potential tissue injuries. In order to analyze heat transfer for dynamic heat flows and temperature inputs, thermal two-port network formalism is used. Asymptotic behavior of the impedance elements of this model are analyzed and approximated by using fractional-order operators. The same ide ais combined with Pennes bio-heat equation

to also take into account blood's flow effect on heat transfer. A global circuit model for the lungs is proposed. On the other hand, recursive identification methods for fractional-order continuous-time systems are proposed and tested.

Artificial Intelligence applied to aerodynamics and ballistics

Authors: **Alain Uwadukunze**, Marie Albisser, Marion Gilson, Xavier Bombois

Abstract: In the frame of aerodynamics and exterior ballistics research activities, dealing mainly with aerodynamic characteristics identification from free flight data, experimental campaigns should be conducted. The trials performed correspond to the firing of architectures, such as projectiles or space probes, using propellant-based launcher. Some tools and methods to design experiments and analyse the projectile behaviour in flight already exist but can be limited due to their lack of precision or the cost of the resources needed to obtain this information. Recently, new tools were developed based on artificial intelligence and more specifically machine learning techniques in order to overcome these issues. In that respect, this presentation outlines two research projects: firstly, the predictions of experimental conditions will be presented such as the initial velocity, the pressure inside the launcher chamber or the mass of the powder, using a machine learning algorithm, the Kernel Ridge Regression. This part is based on experimental data obtained thanks to different measurement techniques deployed during the tests. A comparison between the built model's predictions and experimental data is presented to evaluate the efficiency of the method. The second part is an introduction on how machine learning and deep learning techniques can be useful within the framework of aerodynamics and optimized steering. They can be employed to analyse and predict aerodynamic characteristics, like aerodynamic coefficients or the behaviour of a projectile in flight like its stability. They can also be used to predict and optimize the physical characteristics of a projectile depending on some aerodynamic criteria such as the decrease of drag. Artificial Intelligence can also deal with optimized steering, which aim is to define different requirements based on the projectile geometry, its trajectories or actuation systems to accomplish a specific flight mission, reaching a target for example. From several projectile geometries, a database containing different aerodynamic characteristics generated from multiple sources, as semi-empirical codes or computational fluid dynamics, is created and used for AI related study.

Tracking Distributed Parameters System Dynamics with Recursive Dynamic Mode Decomposition with control

Authors: **Taleb Bou Hamdan**, Guillaume Mercère, Thibault Dairay, Patrick Coirault

Abstract: The goal of this work is to introduce a new online data driven modeling solution for tracking the dynamics of systems, the behavior of which is governed by (nonlinear) Partial Differential Equations (PDEs). In order to reach this goal, this talk introduces a recursive algorithm for online black box time varying model identification along with a recursive algorithm for reducing the order of the identified model. The resulting system model is a linear time varying low order state space representation usable, e.g., for controller design or prediction. The model reduction step relies on the recursive determination of the orthonormal basis of a specific data based proper orthogonal decomposition. The system identification procedure is initialized with the dynamic mode decomposition with control and updated recursively via the introduction of a specific recursive least square algorithm. In both steps, a

forgetting factor is used to focus on the most recent variations of the system. As case studies, a linear heat diffusion equation with a time varying diffusion parameter is first considered. The Burgers' equation, a nonlinear hyperbolic PDE, is then utilized to assess the introduced methods applicability with nonlinear systems. Identification results based on simulation show the high accuracy of this new approach.