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

THURSDAY 23 November 2023 from 10:00 till 17:00 (Paris time)

Salle structure, Hall 3 - 1er étage (escalier de gauche, 1ère salle à droite), Labo PIMM UMR

ENSAM (151 Boulevard de l'Hôpital, 75013 Paris)

VENUE - REGISTRATION – ZOOM LINK

The 23rd November meeting of the CT Identif will be organized in Salle structure (Hall 3 - 1er étage (escalier de gauche, 1ère salle à droite, Labo PIMM UMR) 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://evento.renater.fr/survey/reunion-ct-identif-23-11-2023-f8dgrl3g

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

TIME SCHEDULE

- 10:00-11:00 Mathieu Pouliquen (Université de Caen)
  Some elements on system identification from binary measurements of the output

- 11:00-11:45 Kévin Colin (KTH, Stockholm, Sweden)
  Optimal time invariant experiment design approaches for regret minimization in linear quadratic adaptive control.

- 11:45-14:00 Lunch

- 14:00-14:30 Information on ICFDA 2024 and SYSID 2027

- 14:30-15:30 Luigi Vanfretti (Rensselaer Polytechnic Institute, Troy, NY, USA)
  Using Probing Input Signals for Enhanced Power Grid Monitoring and Control

- 15:30-16:15 Abderrahmane Adel (Université de Bordeaux)
  Time-domain system identification using fractional models from non-zero initial conditions - Application to the identification of Lithium-Ion Batteries

- 16 :15-17:00 Visit of PIMM laboratory at ENSAM

ABSTRACTS

Some elements on system identification from binary measurements of the output

Author: **Mathieu Pouliquen**

Abstract: This talk deals with systems identification using binary-valued measurements. This identification context can occur for an economical reason (a low resolution sensor is less expensive than a high resolution sensor), for a technical reason related to the system to be identified (there is no high-resolution sensor available) or for a technical reason related to the implementation environment (only few binary data can be transmitted). Traditional identification methods cannot be successfully applied with such quantization constraints. In the past few years, a substantial effort has been devoted to the problem of identifying a system with binary-valued measurements. The objective here is to introduce you to some identification algorithms dedicated to this particular context.

Optimal time invariant experiment design approaches for regret minimization in linear quadratic adaptive control

Authors: **Kévin Colin**, Håkan Hjalmarsson, Xavier Bombois

Abstract: In this talk, we consider the problem of model-based linear quadratic adaptive controller where the dynamics are learned every time new data are measured. In order to guarantee fast decrease of the model uncertainties, an external excitation must be added. The external excitation is designed such that an optimal trade-off between exploration and exploitation is reached. This problem is vastly studied in both adaptive control and reinforcement learning research communities. The trade-off is often expressed as a function of both the exploration and exploitation control costs, called (cumulative) regret. The optimal trade-off is then obtained by minimizing the regret. Nowadays, the focus has been towards linear quadratic adaptive problems. It has been recently proven that the regret can be upper- and/or lower-bounded by $O(\sqrt{t})$ in both the finite-time and the asymptotic regime by considering an additive white noise external excitation on the control effort, with a time-varying variance decaying as $O(1/\sqrt{t})$. However, from an abstract theoretical study inspired from experiment design, we show in the first part of the talk that the $O(1/\sqrt{t})$ excitation might not be the optimal exploration choice since another one, which concentrates all the excitation at the beginning of the experiment, minimizes the regret. This strategy referred as immediate exploration is nevertheless not implementable as it depends on the true system dynamics. Therefore, in the second part of the talk, we develop a new exploration design for regret minimization which (i) does not enforce the $O(1/\sqrt{t})$ structure of the external excitation and (ii) does not require the knowledge of the true system dynamics. The main approach is to divide the experiment horizon into intervals of sufficient duration and approximately reformulate the regret minimization problem into a time invariant optimal experiment design problem on each interval. By considering the external excitation as a white noise filtered with finite impulse response filter for which the filter changes from one interval to another, we show that we can reformulate the regret minimization all the intervals problem into a convex semi-definite programming. Simulation results show that all the exploration effort is focused on the first intervals, which approximates the immediate exploration. We also show that it can beat the $O(1/\sqrt{t})$ exploration strategy, comforting the theoretical results from the first part. However, this approach requires large computational power which prevents its real-life implementation. Consequently, in the third part of the talk, we show that the computational power required

for the novel strategy can be highly reduced based on several theoretical results. Using dual theory, the main result shows that many decision variables of the semi-definite programming can be removed.

Using Probing Input Signals for Enhanced Power Grid Monitoring and Control

Authors: **Luigi Vanfretti**, Sjoerd Boersma, Marcello de Castro, Xavier Bombois, Juan-Carlos Gonzalez-Torres, Abdelkrim Benchaib

Abstract: Power grids are undergoing major transformations across the globe due to the integration of renewable resources and changes in electricity demand (e.g. electric vehicles, massive data centers, etc.). This poses tremendous challenges to maintain adequate dynamic performance in the grid, which needs to be assisted with advanced monitoring tools and means to enhance existing controls. System identification techniques are incredibly valuable for such applications. These techniques can be used for system-level oscillatory monitoring, plant-level dynamic performance monitoring and control design. This talk describes how the prediction error identification techniques developed by the system identification community can be used for such purposes and applied to power systems. The talk will introduce a framework for designing a multisine probing signal that, when applied in the control inputs of either power electronics-based devices (e.g. HVDC) or conventional synchronous machines, is able to provide a damping estimation with user specified (low) variance. The employed framework is demonstrated through simulations of Modelica-based nonlinear power system models of varying complexity. Finally, as the next step to bring such techniques into practice, we demonstrate recent work on prototyping of probing experiments, where power system models designed with Modelica are exported via the FMI standard for deployment in real-time simulators. The portability of the studied model allows not only for off-line design of the identification technique, but also enables testing in the real-time simulator environment for probing signal design optimization before field experiments are conducted. The contents of this presentation are based on work supported by the SuperGrid Institute, Lyon, France; and Dominion Energy Virginia, Richmond, Virginia.

Time-domain system identification using fractional models from non-zero initial conditions - Application to the identification of Lithium-Ion Batteries

Authors: **Abderrahmane Adel**, Rachid Malti, Olivier Briat

Abstract: Electrochemical Impedance Spectroscopy (EIS) serves as a valuable tool for characterizing the electrochemical behavior of Lithium-ion batteries. However, its requirement for the battery to reach a relaxed state results in significant time consumption during data acquisition across various State-Of-Charge (SOC) levels, typically involving approximately one hour of time relaxation per SOC level. To expedite measurement procedures, this study introduces a time-domain system identification approach utilizing non-zero initial conditions within a fractional-order equivalent circuit model (FO-ECM). Two distinct methodologies are explored: the first employs a two-stage iterative algorithm that estimates the system's free response and forced response in separate stages, utilizing past initialization and input/output signals, respectively. The second method relies on an output error model, simultaneously estimating the initial conditions through Historical Battery Behavior and the model parameters. These techniques are applied to identify a Li-ion battery FO-ECM using experimental data.