PhD course: Advanced data-driven methods for modelling and control (20 hours)

Program of the lectures

- **DAY 1 (5 hours) - MULTIVARIABLE SYSTEM IDENTIFICATION:** Limits of the input/output system representation for multivariable system identification. State-space representation of stochastic systems. Subspace-based system identification. The MOESP method and the orthogonal projection algorithm. Examples and numerical issues.
- **DAY 2 (5 hours) - ADAPTIVE AND ROBUST SYSTEM IDENTIFICATION:** (Part 1) Recursive methods for time-varying system identification. Recursive least squares (RLS) form I, II and III. The forgetting factor. The blow-up effect and some anti-burst remedies. Least mean squares (LMS). Recursive maximum likelihood (RML) and extended least squares (ELS). (Part 2) Robustness in the standard prediction error method. The instrumental variable approach.
- **DAY 3 (5 hours) - NONLINEAR SYSTEM IDENTIFICATION:** When linear system identification is not enough: nonlinearity tests. Classes of nonlinear systems: block-structured nonlinearities (example: Hammerstein-Wiener models), difference equation models, nonlinear mappings via orthogonal basis functions. Orthogonal least squares. Prediction vs simulation: a discussion. Regularization in system identification. Examples.
- **DAY 4 (5 hours) - DIRECT DATA-DRIVEN DESIGN OF FEEDBACK CONTROLLERS:** identification and control vs identification for control. The most common direct data-driven methods: iterative feedback tuning (IFT), iterative correlation-based tuning (ICbT), unfalsified control, virtual reference feedback tuning (VRFT). Comparison between direct and indirect data-driven controller design. Towards nonlinear direct data-driven control. Examples.