Ph.D. in Information Technology: Thesis Defenses

July 2nd, 2020

Online by Microsoft Teams – at 15.00

Marta ZANIOLO – XXXII Cycle

“Feature Representation Learning in complex water decision making problems”

Advisor: Prof. **Andrea Castelletti**

Abstract:

The success of a control policy highly relies by its feature representation, i.e., the information set it is conditioned upon.

In real world control problems, defining an appropriate feature representation is a complex task, given the coexistence of multiple interacting processes whose relevance for the control task is often unclear. In this thesis, we address the control problem of water resources systems, where a dam release policy is designed accounting for multiple water demands.

Currently, the control rules of most water reservoirs are conditioned upon basic information systems comprising reservoir storage and time index, however, the value of a more informative feature representation is generally undisputed.

We capitalize on recent advances in monitoring and forecasting water availability to develop novel feature representation learning strategies to enhance water systems resilience towards their crucial vulnerabilities, including droughts, critical phases in reservoir development (i.e., construction and filling), and multisectoral conflicts. Additionally, in multi-purpose systems, different control targets might be heterogeneous in their dynamics and vulnerabilities, and likely benefit from a tailored feature representation that varies across different objectives tradeoffs.

We revise current literature on feature representation learning, and propose a taxonomy comprising a priori, a posteriori, and online approaches. For each approach, we propose novel contributions targeting the control problem of multipurpose water systems.

A common thread of the outcomes generated in this collection of works is that learning an appropriate policy information set is an asset to improve water system performance, especially by targeting its most critical failures. Specifically, by mitigating the damages associated with hydrological extremes (e.g., drought emergencies), critical stages reservoir development (i.e., construction and filling), and social tensions deriving from conflicts between different users and their demands.

Marco LAURICELLA – XXXII Cycle

"Set Membership identification and filtering of linear systems with guaranteed accuracy"

Advisor: Prof. **Lorenzo FAGIANO**

Abstract:

This work addresses the problems of model identification and output filtering for linear time-invariant systems affected by measurement noise, under an unknown but bounded uncertainty framework. The objective is twofold: identify one-step-ahead models providing guaranteed accuracy, in terms of worst-case simulation error bounds, and obtain a filtered version of the unknown system output providing tight and minimal filtering accuracy bounds.

New theoretical results are derived under the Set Membership identification framework, allowing one to use a finite set of data to estimate the unknown measurement noise bound, together with the system order and decay rate. Moreover, guaranteed simulation error bounds for an infinite future simulation horizon are derived, and their properties and convergence conditions are analyzed, improving over existing results pertaining to finite simulation horizon only. These bounds and the estimated decay rate are the basis of a new theoretical finding that allows one to guarantee the asymptotic stability of the identified models, providing a method to include this structural property in the proposed identification approaches. These results are then used to derive a novel data-driven direct filtering approach, allowing one to compute tight guaranteed uncertainty intervals for the system output. Such filtering method is able to achieve good filtering accuracy, quantified in terms of average filtering error, and to attain optimality, in a worst-case error sense.

The performance and the validity of the presented identification and filtering approaches are illustrated on a numerical example, and on an experimental case study, concerning the forecasting of non-residential buildings energy consumption.

PhD Committee

Prof. **Simone Formentin**, DEIB

Prof. **Andrea Garulli,** Universita' di Siena

Prof. **Patrick Reed,** Cornell University