Politecnico di Bari

DAuSy

Doctoral Research Seminars

The Doctoral program in Autonomous Systems (DAuSy) organizes a series of research seminars to disseminate its doctoral activities. Doctoral students of the PhD program will present their research activity to fellow postgraduate students and Professors.

The seminars are scheduled into three sessions on March 13th, 20th, and 27th, 2024, from 5 pm to 7 pm. Each session includes 5 presentations (20-minute time slot, Q&A included).

This event is free of charge and will be held virtually on MS Teams; however, registration is mandatory through the following links.

Registration link for March 13th, 2024:

https://events.teams.microsoft.com/event/29da33dc-d293-4af5-ae6e-f1bad0fc3ea4@5b406aab-a1f1-4f13-a7aa-dd573da3d332

Registration link for March 20th, 2024:

https://events.teams.microsoft.com/event/62e1af59-0b92-4463-86f0-f2f81064fdbb@5b406aab-a1f1-4f13-a7aa-dd573da3d332

Registration link for March 27th, 2024:

https://events.teams.microsoft.com/event/ab00d920-03fd-42db-9810-f24c3a7feaca@5b406aab-a1f1-4f13-a7aa-dd573da3d332

Organising Committee

Prof. A. Cavallo, Prof. L. Giarrè, Prof. F. Pascucci, Prof. R. Carli

DAuSy and PoliBa PhD Students will receive 1 ECTS for the attendance

PROGRAM

March 13th 2024 – Chair: Prof. L. Giarrè

Speaker	Title
Pierluigi Francesco De Paola (*Consiglio Nazionale delle Ricerche*)	A model-based approach for glucose control via physical activity
Silvia Di Girolamo (*Università di Palermo*)	Control of a Multi-Input Converter Using Dynamic Input Allocation
Matteo Sartoni (*Università di Bologna*)	Optimal Control for Fore-Active Spaceborne Radars
Paul Christian Tesso Woafo (*Università della Calabria*)	H2 and optimal LQ control strategies for energy harvesting in vehicle suspension systems
Eleonora Vitanza (*Università di Siena*)	Behavioral decision models. Markov Decision Process Models to simulate human-human, human-robot and human-environment decisions.

March 20th 2024 – Chair: Prof. A. Cavallo

Speaker	Title
Daniele Antonucci (*Università di Parma*)	Data analysis of leak detection cycles in pharmaceutical lyophilizers
Saba Askari Noghani (*Politecnico di Bari*)	Integrating Solar-Powered Electric Vehicles into V2G-Capable Smart Parking Infrastructure for Enhanced Energy Efficiency
Marco Perin (*Università di Padova*)	Meshfree Collocation for the contraction metric estimation of dynamical systems
Valeria Bonagura (*Università degli Studi Roma Tre*)	Leveraging distributed Kalman filters for anomaly detection in dynamic systems
Elisa Gaetan (*Università di Modena e Reggio Emilia*)	Modeling and Control of decision-making processes

March 27th 2024 – Chair: Prof. F. Pascucci

Speaker	Title
Shaikh Bushra (*Università dell'Aquila*)	Research trends in the security analysis of discrete event systems.
Yike Li (*Università di Cagliari*)	Safe Optimal Train Formation Control in Virtual Coupling with Control Barrier Functions
Michela Prunella (*Politecnico di Bari*)	Intelligent Systems and Digital Twins for Computational Pathology: Prediction of Disease Trajectories and Therapy Optimization and Control
Roberto Maria Scardigno (*Politecnico di Bari*)	Lightweight segmentation and classification of industrial defects
Shafqat Ali Siyyal (*Università Politecnica delle Marche*)	Cyber-Resilient CPS: A Model-Based Approach to Secure Design with software Rejuvenation

ABSTRACT

March 13th 2024 – Chair: Prof. L. Giarrè

Pierluigi Francesco De Paola (*Consiglio Nazionale delle Ricerche*)

A model-based approach for glucose control via physical activity

Despite the acknowledged role played by physical activity in delaying diabetes progression, the literature lacks mathematical models suitably describing the long-term effects of exercise on diabetes course. This talk will show a new mathematical formulation for glucose-insulin dynamics that keeps into account the effect of exercise and that can lead to a novel and original model-based approach for glucose control via precise physical activity recommendations.

Silvia Di Girolamo (*Università di Palermo*)

Control of a Multi-Input Converter Using Dynamic Input Allocation

The current sharing problem for interconnected power converters in DC microgrids is explained. It considers a multi-input converter (MIC), including two voltage sources connected to a common DC bus with a bulk capacitor through two parallel synchronous boost converters and an aggregated load modeled as an ideal current source connected to the DC bus. The proposed strategy achieves a fast voltage response with an optimal current distribution among the converters.

Matteo Sartoni (*Università di Bologna*)

Optimal Control for Fore-Active Spaceborne Radars

Differently from traditional radars, fore-active (FA) radars optimize the tracking performance by modulating the transmitted signal given the target estimate. In this work, we consider a novel optimal-control scheme for FA spaceborne radars to minimize the expected mean-square estimation error. Simulation results are provided for a target-tracking problem. Also, comparison between the optimal control scheme and a dynamic optimization approach shows that the former provides better performance.

Paul Christian Tesso Woafo (*Università della Calabria*)

H2 and optimal LQ control strategies for energy harvesting in vehicle suspension systems

Two multiobjective H2 and LQ state-feedback control laws are proposed with the aim of energy harvesting maximization in Regenerative Suspension Systems. Other control objectives such as ride comfort and road handling are considered with the energy harvesting objective. LQ controllers don't have the capability to include constraints in the problem formulation. In this work, a modified objective function is used in order to maximize directly the power output. Moreover, a condition on the Ride Index is added to the LQ control law allowing one to maintain the ride comfort depending on the type of road. An electromechanical regenerative vehicle suspension system is considered where the viscous damper is replaced by a linear electrical motor which is actively governed. It is shown that the LQ control law with this modified objective function is able to achieve an improvement on the amount of harvested energy with respect to the H2 control law. It is also shown that both control laws are better than the classical Viscous Regenerative damper strategy in terms of harvested energy while maintaining the other objectives at acceptable levels. Finally, simulative studies via MATLAB/ Simulink are undertaken on a quarter car model. Two different road signals are used in simulations to show the effectiveness of the work.

Eleonora Vitanza (*Università di Siena*)

Behavioral decision models. Markov Decision Process Models to simulate human-human, human-robot and human-environment decisions

The seminar will focus on describing the Markov Decision Process model of awareness, which study and simulate human decisions across different scenarios. I will also present two applications involving the human-environment interface, where exogenous data enrich the model: one addressing climate change perception, the other delving into substance addiction mechanisms. Additionally, I will discuss current and future expansions of these models.

March 20th 2024 – Chair: Prof. A. Cavallo

Daniele Antonucci (*Università di Parma*)

Data analysis of leak detection cycles in pharmaceutical lyophilizers

The freeze-drying process involves reducing pres- sure to extremely low levels within a sealed chamber to evaporate the product water. It is a vital process within the pharmaceutical industry, aimed at stabilizing, preserving, or extending the shelf life of drug products. In lyophilizers, external leaks are a major issue. Indeed, external inflows contaminate the lyophilization chamber, and may cause the disposal of the current production batch. Given that a single batch often comprises thousands of product vials, leakages from freeze-dryers pose significant challenges throughout the production chain of lyophilized drugs. This paper presents a data reduction method utilizing Principal Component Analysis (PCA), alongside a comparison of various clustering algorithms. Through proper hyperparameter optimization, K-Means Clus- tering exhibits superior performance in identifying anomalies and deterioration within historical data collected from leak test cycles. Additionally, an Health Indicator (HI) is assessed based on computed clusters to precisely identify trends where leaks exert the most substantial impact.

Saba Askari Noghani (*Politecnico di Bari*)

Integrating Solar-Powered Electric Vehicles into V2G-Capable Smart Parking Infrastructure for Enhanced Energy Efficiency

This talk introduces a novel framework for integrating solar-powered electric vehicles (SPEVs) into smart parking infrastructures, primarily focusing on optimizing energy utilization. The proposed framework relies on Model Predictive Control (MPC) to ensure efficient power flow management within smart parking infrastructures. Notably, the paper emphasizes the constraints necessary to ensure the safety and optimal performance of SPEVs and their charging requirements. Results show the effectiveness of the proposed approach, not only in preventing energy management issues but also in substantially reducing reliance on energy procurement from the grid. This integrated system contributes to a more sustainable and cost-effective energy ecosystem, representing a noteworthy advancement in electric mobility infrastructure.

Marco Perin (*Università di Padova*)

Meshfree Collocation for the contraction metric estimation of dynamical systems

Contraction Theory is a powerful tool that provides computationally friendly ways to study the robustness of nonlinear systems. Indeed, a system that is contracting, express well-behaved trajectories and great convergence properties. I studied the method of Meshfree Collocation to approximate a metric WRT which a nonlinear autonomous system is contracting. This, thanks to some recent results, implies exponential stability of said system, that could represent, for example, a closed loop system.

Valeria Bonagura (*Università degli Studi Roma Tre*)

Leveraging distributed Kalman filters for anomaly detection in dynamic systems

In industrial control systems, monitoring and detecting anomalies is crucial as they signal critical events like faults or cyberattacks. This seminar delves into employing the Interlaced Kalman Filter (IKF) for distributed model-based anomaly detection. However, ensuring synchronization among agents is paramount in distributed state estimation. Hence, we will tackle this challenge by analyzing the Multirate-IKF, which ensures consistency.

Elisa Gaetan (*Università di Modena e Reggio Emilia*)

Modeling and Control of decision-making processes

Nowadays, different multi-agent systems or networks have become prevalent. These frameworks involve agents engaging in interactions, influencing one another's behaviors, decisions, or opinions. Moving beyond the modeling of decision-making processes, we investigate how to control decisions by manipulating the external environment, or by the potential influence of a super-agent immune to external influences. We introduce several everyday-life examples, to prove the applicability of our framework.

March 27th 2024 – Chair: Prof. F. Pascucci

Bushra Shaikh (*Università dell'Aquila*)

Research trends in the security analysis of discrete event systems.

With the increasing use of communication network in cyber physical systems (CPS), security has become a crucial problem. In many applications, CPS are modelled as discrete event systems (DES), where the system evolution take place in discrete states, through discrete events. Hence, it is important to identify classification strategies and research trends in the security analysis of DES and learn about the gaps and challenges for potential future research directions.

Yike Li (*Università di Cagliari*)

Safe Optimal Train Formation Control in Virtual Coupling with Control Barrier Functions

This research focuses on the optimal train motion control during the Virtual Coupling (VC) convoy formation where the following train (simply called the follower) needs to timely catch up with the velocity of the leading train (simply called the leader) while strictly adhering to the spacing principle that is undergoing change. We employ the Control Barrier Functions (CBFs) and Control Lyapunov Functions (CLFs) to demonstrate the control objectives within the formation progress, construct a safety control scheme composed of two controllers for the follower to achieve the coupling goals safely and apply Quadratic Programming (QP) framework to fast compute the optimal constrained control input for the follower's motion control. The effectiveness of the proposed control method is demonstrated through numerical simulations of different types of convoy formation cases.

Michela Prunella (*Politecnico di Bari*)

Intelligent Systems and Digital Twins for Computational Pathology: Prediction of Disease Trajectories and Therapy Optimization and Control

In the realm of precision oncology, computational imaging for biological systems modeling is allowing the before-treatment prediction of the therapy outcome. To develop complete intelligent workflows that exploit deep learning for histological image segmentation and pathomics for quantitative feature extraction aims to calibrate a personalized mechanistic model, thus is expected to drive from one-fits-all models to an improved simulation and control of cancer trajectories.

Roberto Maria Scardigno (*Politecnico di Bari*)

Lightweight segmentation and classification of industrial defects

In the field of industrial defect recognition, unsupervised deep learning systems strive to identify defects automatically and accurately without the need for extensive data collection to train the system. Although various networks can already achieve this, the presented work proposes a further advancement: the ability to recognize the type of defect with a very limited number of samples, while keeping both the size of the network and the size of the training set limited.

Shafqat Ali Siyyal (*Università Politecnica delle Marche*)

Cyber-Resilient CPS: A Model-Based Approach to Secure Design with software Rejuvenation

This research explores the application of software rejuvenation, a well-established practice in software engineering for averting potential failures, as a preventive measure to enhance the security of cyber-physical systems (CPSs) against cyber-attacks. The primary objective involves periodically refreshing the control system by substituting the potentially compromised controller with a trusted copy of the control software before any attack-induced damage becomes irreversible. This proactive approach aims to fortify the system against attacks without the need for specific attack detection algorithms. Despite advancements, challenges persist in implementing software rejuvenation in real-world scenarios, especially in the presence of persistent attacks, where periodic rejuvenation may adversely affect the performance of highly dynamic reference tracking systems. In response to these limitations, this research proposes the integration of software rejuvenation with irregularities detection mechanisms inspired by fault detection methods. This combination is designed to optimally and robustly secure CPSs from a control-theoretic perspective, addressing the challenges posed by dynamic environments and persistent threats.