



UNIVERSITÀ DI PISA
DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE
Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

“Digital-twins for Cyber-Physical Systems”

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University of Pisa

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Short Abstract: Cyber-Physical Systems (CPSs) are complex engineered systems, where cyber and physical components are strongly interconnected. In particular, CPSs obey both a continuous-time physical plant dynamics, and a hybrid control dynamics having both a discrete-time (event-driven) and a continuous-time component. A digital-twin is a digital prototype created to gain insight into a given system. The digital-twin is useful for system analysis, monitoring in operation, prediction of future states of the assets and prediction of their impact on damage or malfunction. This course presents enabling technologies and research challenges. The added value of a digital-twin is shown using two realistic case studies from the automotive field.

Course Contents in brief:

1. Multi-model simulation as enabling technology for digital-twins of CPSs.
2. Formal models and formal verification techniques for digital-twins.
3. Human centred digital-twins: realistic interactive prototypes of user graphical interfaces
4. A tool-chain for the development and analysis of digital-twins for CPSs. The standard “Functional Mock-up Interface” for co-simulation, and the INTO-CPS tool-chain.
5. Application of the tool-chain to two case studies from autonomous driving: 1) model predictive control for trajectory following with obstacle avoidance; 2) terrestrial vehicle platooning.

Total # of hours of lecture: # 20

References:

[1] H. Feng, C. Gomes, C. Thule, K. Lausdahl, A. Iosifidis and P. G. Larsen, "Introduction to Digital Twin Engineering," 2021 Annual Modeling and Simulation Conference (ANNSIM), 2021, pp. 1-12.

[2] C. Gomes, C. Thule, D. Broman, P.G. Larsen and H. Vangheluwe, “Co-simulation: a survey”, ACM Computing Surveys (CSUR), vol. 51 (3), 1-33, 2018.

[3] P. G. Larsen, J. Fitzgerald, J. Woodcock et al., “Integrated tool chain for model-based design of Cyber-Physical Systems: The INTO-CPS project”, 2nd International Workshop on Modelling, Analysis, and Control of Complex CPS (CPS Data), 2016.

CV of the Teacher: Cinzia Bernardeschi

Cinzia Bernardeschi is associate professor at the Department of Information Engineering of the University of Pisa. Her main research activity has been carried out in the area of dependable systems and application of formal methods for specification and verification of safety-critical systems. In particular, model-checking, abstract interpretation and theorem proving. Current research is on model-based development of cyber-physical systems. This research activity aims at the development of methodologies and tools for the validation and the formal verification of cyber-physical systems, including fault/failure analysis and resilience to cyber-attacks. She is member of the ERCIM Working Group on Formal Methods for Industrial Critical Systems (FMICS) and of the IEEE SMC (Systems, Man, and Cybernetics Society) Technical Committee on Homeland Security. She has published more than 100 papers on international conferences/journals. She collaborates to the following projects: "EPI: European Processor Initiative", funded by the EU under call H2020, 2018-2021; "HiEfficient: Highly EFFICIENT and reliable electric drivetrains based on modular, intelligent and highly integrated wide band gap power electronics modules", funded by ECSEL Research and Innovation Actions (RIA), 2021-2023.

CV of the Teacher: Maurizio Palmieri

Maurizio Palmieri is a research assistant at the Department of Information engineering of the University of Pisa. He received his Ph.D. in Smart Computing, a Ph.D. program awarded by the Universities of Florence, Pisa, and Siena. His thesis was on the analysis of Cyber-Physical Systems combining techniques of co-simulation and formal reasoning. His research interests include the application of the Prototype Verification System theorem prover in co-simulation scenarios for safety analysis. He is currently working in collaboration with the INTO-CPS Association, an association that maintains a tool chain for Cyber-Physical Systems modelling, simulation and verification. He is co-chair of CoSim-CPS 2021, 5th Workshop on "Formal Cosimulation of Cyber-Physical Systems".

Room and Schedule

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Largo Lucio Lazzarino 1, Pisa*

Schedule:

14/09/2022: 9.00-13.00, 14.30-17.30

15/09/2022: 9.00-13.00, 14.30-17.30

16/09/2022: 9.00-13.00, 14.30-16.30