Mechanical Engineering

Ph.D. Dissertation Defense

Self-Optimizing Smart Control Engineering Enabled by Digital Twins

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Schedule

Date: 04/26/2022
Time: 02:30 pm- 04:30 am/pm
Location: Remote
Zoom Link:
https://ucmerced.zoom.us/j/89675861326?pwd=eGdIVXZNeEJvaEZ5VUJ4a2huL21CQT09

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Biography

Jairo Viola is a Ph.D. candidate in Mechanical Engineering at the University of California, Merced, and works at the Mechatronics, Embedded Systems, and Automation Lab (MESALab). He has a bachelor's and master's degrees in Electronic Engineering from Pontifical Bolivarian University, Colombia. His research topics include Control Engineering, Artificial Intelligence, Digital Twin, Self-Optimizing Control, Machine Learning, Big Data, Edge Computing, and Applied Fractional Order Calculus.

Abstract

There are two critical questions in control engineering: how optimal and robust is a system? However, Digital Transformation, Industry 4.0, and the advent of breaking technologies like Artificial Intelligence, Deep Learning, Big Data Analytics, Edge Computing etc., contribute to increased system health knowledge, sensing capabilities, and automation of performance assessment metrics. For this reason, two new questions emerge: how smart and how developmental a control system is? Therefore, a new frontier in control engineering appears, and this dissertation defines it as Smart Control Engineering (SCE), supported by three breaking technologies Digital Twin (DT), Industrial Artificial Intelligence (IAI) and Self Optimizing Control (SOC). Thus, Smart Control Engineering transforms classic control systems into smart systems. It means systems that are aware of their capabilities and limitations (cognizant), able to learn from past experience to improve their future performance (reflective), supported by a substantial body of knowledge (knowledge-rich), handling high-level instructions based on vague human commands (taskable), and always adhering to social and legal norms (ethical). This thesis tries to establish the foundations of the Smart Control Engineering framework and its combination with Digital Twin, Industrial Artificial Intelligence, and Self Optimizing Control to develop smart control systems. A set of smart and developmental controllers supported by Digital Twin are developed using real-time zeroth-order optimization algorithms to enable smartness on real systems. Likewise, enabling capabilities resulting from breaking technologies like smart controller design, Control Performance Assessment, or parallel Intelligence and controls are integrated into the SCE framework, powered by real-time data analytics provided by IAI methods. The embedded implementation of smart controllers with enabling capabilities is performed and demonstrated for single-input and multi-input control systems using Edge Computing devices. Obtained results show that Smart Control Engineering is a new and effective framework that can systematically improve performance, reliability, and robustness under varying internal and external conditions.

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