Personalizing Health in an Impersonal World: Design and Analysis for Safe Learning-Enabled Medical Systems

Abstract: Modern computing systems that interact with patients and clinicians, commonly referred to as medical cyber-physical systems (MCPS), are safety-critical embedded systems that feature tight coupling between communication and computation used to control complex, dynamic, and uncertain physical/physiological plants. Learning-enabled MCPS additionally incorporate components whose behavior is driven by “background knowledge” acquired and updated through a “learning process”. While empirical medical data is often a significant source of this background knowledge, it can also be limited, sparse, or “thin” due to small sample sizes, dataset shifts, anomalies, inter/intra-patient variability, and a limited understanding of the data generation process itself. Consequently, providing safety guarantees and predictable performance for learning-enabled MCPS in the presence of thin data is challenging. In this talk, I will present some of my recent work on techniques and tools for the design and analysis of safe learning-enabled MCPS with thin data. Specifically, in the context of learning enabled medical systems, I will present our (i) OpenICE-lite platform for medical device interoperability; (ii) techniques for addressing inter/intra-patient variability for clinical decision support; and (iii) our Verisig tool for formal verification of closed-loop learning-enabled systems. Real-world case study evaluations and implementations covering prediction of hypoxia in infants, meal detection for type I diabetes, alarm suppression in intensive care units, and detecting post-operative in-hospital stroke illustrate the utility of my group’s recent work and give light to future research challenges.

Bio: James Weimer is a Research Assistant Professor in the Department of Computer and Information Science at the University of Pennsylvania and in the Department of Biomedical and Health Informatics at the Children’s Hospital of Philadelphia. His research interests include the design and analysis of cyber-physical systems with application to medical devices/monitors, networked systems, building energy management, and security. James holds a Ph.D. degree in Electrical and Computer Engineering from Carnegie Mellon University and prior to joining Penn held a Postdoctoral Researcher position at the KTH Royal Institute of Technology. He serves as an associate editor of the ACM Transaction on Cyber-Physical Systems and has earned the best paper award and been a best paper finalist at the International Conference on Cyber-Physical Systems (ICCPS) in 2014 and 2015, respectively.

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