

Surrogate modeling and control of medical digital twins

Luis Fonseca

University of Florida

The vision of personalized medicine is to identify interventions that maintain or restore a person's health based on their individual biology. Medical digital twins, computational models that integrate a wide range of health-related data about a person and can be dynamically updated, are a key technology that can help guide medical decisions. Such medical digital twin models can be high-dimensional, multi-scale, and stochastic. To be practical for healthcare applications, they often need to be simplified into low-dimensional surrogate models that can be used for the optimal design of interventions. Here, we introduce surrogate modeling algorithms for optimal control applications. As a use case, we focus on agent-based models (ABMs), a common model type in biomedicine for which there are no readily available optimal control algorithms. By deriving surrogate models based on systems of ordinary differential equations, we show how optimal control methods can be employed to compute effective interventions, which can then be lifted back to a given ABM. The relevance of the methods introduced here extends beyond medical digital twins to other complex dynamical systems.

In Special Session 49 on Bifurcations at the Mathematical Congress of the Americas 2025.