Gaussian Process Emulators — A powerful tool for scaling the generation of cardiac digital twins

Speaker: Elias Karabelas, University of Graz

Abstract: Personalized medicine demands precise simulation models to capture individual physiologies. In particular, in the field of cardiology, cardiac digital twins (CDTs), virtual replicas of an individual's heart, have emerged as powerful tools for predicting cardiac health and guiding interventions. However, generating these models necessitates extensive computational resources due to the inherent complexity of multi-physics (electrophysiology, mechanics and fluid dynamics). In this talk we will explore the role of Gaussian Process emulators (GPEs) in addressing this challenge, particularly in surrogating hemodynamics of the heart. GPEs can efficiently approximate complex physiological simulations using a probabilistic framework. By leveraging the inherent structure and correlations in the cardiac data, GPEs can rapidly predict hemodynamic parameters, such as blood flow velocities and pressures, without necessitating exhaustive simulations. We discuss some mathematical foundations of GPEs, their advantages over deterministic models, and their potential applications. Eventually, we will also show how GPEs can be used outside of hemodynamic modeling in order to speed up segmentation of cardiac imaging data.