Insalate di Matematica

presents

Towards computationally efficient and accurate blood flow simulations in the entire cardiovascular system

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Abstract

In the last decades, mathematical modeling and simulation of blood flow have become of primary importance in different contexts, from basic research to clinical practice, employing different levels of model complexity and sophistication, from lumped-parameter (0D) to distributed (1D and 3D) models. A relevant contribution in this field is the global, closed-loop, multiscale mathematical model of the entire human circulation developed by Müller and Toro (2014) and recently extended (2021). Modeling blood flow in complex networks and cardiovascular models can result in computationally expensive simulations, posing the need for strategies and numerical methods to perform accurate and efficient simulations. In this contribution, I will first present the Müller-Toro global model and, in this framework, discuss the major challenges related to the 1D blood flow modeling. After that, I will focus on one of the main model components, the vascular (arterial and venous) networks, by describing both the 1D and 0D nonlinear models for blood flow. I will finally present a novel methodology we have developed to construct hybrid 1D-0D networks of vessels and to perform computationally efficient and accurate blood flow simulations in such networks. This methodology is based on high-order numerical coupling strategies and *a-priori* model selection criteria which provide the best possible trade-off between accuracy of the results and computational cost of the simulations.

Keywords:

Cardiovascular system · Blood flow · Multiscale modeling · Reduced-order models · High-order numerical schemes · Model selection criteria · Computational efficiency

"*Obvious*" *is the most dangerous word in mathematics. - Eric Temple Bell*