A LOCAL TIME STEPPING SOLVER FOR 1D BLOOD FLOW: APPLICATION TO THE ADAN MODEL

LUCAS O. MÜLLER, PABLO J. BLANCO, SANSUKE M. WATANABE, AND RAÚL A. FEIJÓO

ABSTRACT. We present a finite volume solver for one-dimensional blood flow simulations in networks of elastic and viscoelastic vessels, featuring high-order space-time accuracy and local time stepping (LTS). The solver is built on: (i) a high-order finite-volume type numerical scheme [3, 5]; (ii) a high-order treatment of the numerical solution at internal vertexes of the network, often called junctions [6, 7]; (iii) an accurate LTS strategy [4]. After verifying the accuracy of the proposed methodology by empirical convergence tests, we apply the LTS scheme to the Anatomically Detailed Arterial Network model (ADAN) [1, 2]. Such model comprises 2142 arterial vessels, reaching an unprecedented level of detail in the anatomical description of the human arterial vasculature, with vessel lengths ranging from less than a millimeter up to tens of centimeters. We examine the gain in execution time with respect to standard global time stepping for serial and parallel versions of the solver when applied to two model settings, corresponding to purely elastic and to elastic/viscoelastic vessels. Moreover, we illustrate the effect of using a simple p-adaptivity approach and discuss the advantages and implications of using high-order schemes for one-dimensional blood flow solutions in complex networks. The proposed methodology can be extended to any other hyperbolic system for which network applications are relevant.

Keywords: blood flow; explicit schemes; local time stepping; high-order schemes; finite volume schemes.

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National Laboratory for Scientific Computing, Petrópolis, Brazil and Institute of Science and Technology in Medicine Assisted by Scientific Computing, INCT-MACC, Petrópolis, Brazil
E-mail address: lmuller@lncc.br

National Laboratory for Scientific Computing, Petrópolis, Brazil and Institute of Science and Technology in Medicine Assisted by Scientific Computing, INCT-MACC, Petrópolis, Brazil

Federal Rural University of Pernambuco, Garanhuns, Brazil and Institute of Science and Technology in Medicine Assisted by Scientific Computing, INCT-MACC, Petrópolis, Brazil

National Laboratory for Scientific Computing, Petrópolis, Brazil and Institute of Science and Technology in Medicine Assisted by Scientific Computing, INCT-MACC, Petrópolis, Brazil