3rd INTERNATIONAL CONFERENCE ON COMPUTATIONAL AND EXPERIMENTAL SCIENCE AND ENGINEERING (ICCESEN-2016)

19-24 October 2016, ANTALYA-TURKEY

Monotonicity Recovering Methods for Postprocessing Finite Element Solutions

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Abstract

Simulation of transport phenomena based on advection-diffusion equation is very popular in many engineering applications. Non-monotonicity of the numerical solution is the typical drawback of the conventional methods of approximation, such as finite elements (FE), finite volumes, and mixed finite elements. The problem of monotonicity is particularly important in cases of highly anisotropic diffusion tensors or distorted unstructured meshes. For instance, in the nuclear waste transport simulation, the non-monotonicity results in the presence of negative concentrations which may lead to unacceptable concentration and chemistry calculations failure. Another drawback of the conventional methods is a possible violation of the discrete maximum principle, which establishes lower and upper bounds for solution.

In this talk, we suggest a least-change correction to available finite element (FE) solution. This postprocessing procedure is aimed at recovering the monotonicity and some other important properties that may not be exhibited by the FE solution. It is based on solving a monotonic regression problem with some extra constraints. One of them is a linear equality-type constraint which models the conservativity requirement. The other ones are box-type constraints, and they originate from the discrete maximum principle. The resulting postprocessing problem is a large scale convex quadratic optimization problem. We show that the postprocessed FE solution preserves the accuracy of the discrete FE approximation. We present an algorithm for solving the postprocessing problem. Its efficiency is demonstrated by the results of numerical experiments.

Keywords: *Finite element method, Convex quadratic optimization, Monotonic regression*

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