An Improved Re-distancing Algorithm for the Level-Set Method

Artur F. Sucena*, Alexandre M. Afonso*, Manuel A. Alves* and Fernando T. Pinho*

* Faculdade de Engenharia da Universidade do Porto, Porto, Portugal.
E-mail: asucena@fe.up.pt, aafonso@fe.up.pt, fpinho@fe.up.pt, mmalves@fe.up.pt

ABSTRACT

This work presents a new numerical method to preserve the definition of the distance function of the level-set method, with a particular interest for the solution of highly elastic flows of viscoelastic fluids. In the Level-Set method [1], the interface between phases is represented by a closed curve using the so-called level-set function which takes positive or negative values inside and outside the curve, respectively. This function is governed by a Hamilton-Jacobi differential equation, which is solved numerically and makes it easier to track changing topologies. However, the Level-Set method does not guarantee mass conservation and overcoming this drawback requires the use of locally refined meshes or special reconstruction methods for the interface and re-distancing of the signed distance function.

In this work we present a new re-distancing method. Unlike some previous partial differential equations based re-distancing methods, which calculate the value of the Level-Set function on each iteration on the basis of the deviation between each point and its neighbours, the proposed method disregards the value of the Level-Set function prior to the correction, using it only on the points adjacent to the interface and then it recalculates the function on the remaining domain. In this way, the method reaches stability in a finite number of cycles, which is proportional to the size of the mesh, without the need of a tolerance value to finish the iterative process. This allows it to be more computationally efficient while also improving precision. Several numerical simulations were performed using the new method to test its accuracy, namely the bubble transport in a bended channel and in a contraction/expansion channel are presented in order to validate the method. These test-cases were also investigated for different surface tension values, using both Newtonian and viscoelastic fluids, described by the Oldroyd-B model.

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