Extension of a Fast Method for 2D Steady Free Surface Flow to Stretched Surface Grids

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ABSTRACT

Steady free surface flows are often encountered in the field of maritime engineering. The most common application is the ship hull resistance problem. CFD methods to simulate these flows can be divided in two categories: capturing and fitting methods. Capturing methods track the free surface and need to reconstruct its position to apply the interface conditions. In fitting methods –the focus of this research– the mesh conforms to the free surface. As there is a large density difference between water and air, the air phase can be neglected, making the free surface a domain boundary. The free surface position then has to be determined iteratively, alternating between two steps: first the flow field is calculated, and subsequently the free surface position is updated by deforming the mesh.

On the one hand, a fitting method for steady problems should converge in a low number of iterations. On the other hand, it should be flexible enough to be implemented and used with a flow solver of choice. There is usually a trade-off between these two properties. Most methods use a time-stepping mechanism, but due to the long physical times before transient phenomena disappear, these are quite slow [1]. The method by van Brummelen [2] is truly steady and therefore converges quickly, but relies on a dedicated coupled solver as a complex boundary condition needs to be applied at the free surface.

The new method seeks to be both fast and compatible with any moving mesh flow solver. During the step in which the flowfield is calculated, a free-slip wall boundary condition is used at the free surface. The new free surface position is calculated using a surrogate model of the flow solver in quasi-Newton iterations. This surrogate model is based on a perturbation analysis and is improved each iteration using a least-squares technique. The surrogate can be constructed in several ways; here a technique based on convolution is outlined, which can be used for 2D flows with stretched free surface grids. The capabilities of the method are demonstrated by simulating the flow over a bottom object, for which experiments have been done by Cahouet [3].

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