A Fluid Structure Interaction Method for Simulating the Behaviour of Fishing Nets

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ABSTRACT

Industrial fishing is carried out mainly by trawling gears, which consist of a bag-shaped net, towed by one or more boats, that captures the species that are in their path. Currently, the fishing industry faces two challenges: the improvement of its energy efficiency and the elimination of discards. The best way to face these challenges is to reduce the drag generated by the nets and improve their selectivity. Designing selective fishing gears is a very complex process, and nowadays it is mainly based on the expertise of fishermen and marine biologists, together with expensive tests in the open sea or in towing tanks. This is why computational tools have a prominent role to play in this task.

Nets are flexible structures that deform easily due to the hydrodynamic forces they are subjected to, so their accurate simulation requires taking into the account the fluid-structure interaction. In this work, a one-way cosimulation tool is developed, based on a finite element triangular structural model [1] and a novel surface porous model [2] to simulate the net behaviour in a finite volume code.

The structural model is based on a division of the net in triangular elements, each of them covering a large number of twines [1]. It is particularly well adapted to the calculation of highly deformable nets which display little resistance to opening. As for the porous surface model, it is implemented in the open source CFD libraries OpenFOAM, allowing a substantial reduction of the computation cost by not considering the detailed geometry of the net. The porous resistance coefficients are determined from experimental data using nonlinear regression.

In the cosimulation solver proposed here, the position of the porous medium representing the net is first searched among the cells that are at a prescribed distance from the triangular elements of the initial net shape. The CFD solver is run until convergence in steady state, after which the incident fluid velocity is determined in every vertex of the triangles, as well as the hydrodynamic force suffered by the net. Those data are fed into the structural solver which computes the deformation of the mesh. Using this one-way approach, the predictions are first validated against the numerical and experimental results of [3] in the case of a net sector with a free bottom entrained by a water stream. Then it is compared to our own experimental data for a fully framed net sample introduced in the test section of a wind tunnel. Finally, an attempt of two-way coupling is carried out, with a retroalimentation of the net shape into the CFD solver, requiring at each time step the searching of the cells which belong to the porous medium. The resulting model provides a computationally cheap and accurate tool for the analysis of complex fishing nets.

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