Mathematical and computational framework for low Reynolds number swimmers using ALE approach

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Mathematical modelling and simulation of micro-swimmers' motion has applications in micro-robotics and potential applications in medicine. In fact, lately, micro-robots have shown their applicability in medicine [1, 2]. Micro-robots can have different propulsion mechanisms: they can be guided via external magnetic fields or move thanks to external power sources. The goal of this communication will be presenting a generic computational framework where simulation of different swimmers can be realized. These objects can be composed by elastic and rigid parts, and the propulsion technique we consider is due to the interaction between a magnetic field and magnetized parts of the swimmer. The problem is modelled following the formalism of coupled Navier-Stokes equations in moving domain and elasticity equations. Arbitrary Lagrangian Eulerian approach is used to link the Eulerian and Lagrangian formulation of the two problems. The forward motion is modelled via ODEs for the center of mass of the swimmer and for its body frame dynamics. Simulations are carried out using the FEEL++ finite element library and the related toolboxes. The ODEs are solved via a quaternion based solver, which avoids parametrization problems related to other representations of rotations (e.g. Euler angles). Some simulation results will be presented, for different kinds of swimmers. A first example will be a biologically-inspired, 2D spermatozoon-like swimmer issued from [4], which will allow the benchmarking of the results we obtained. The second swimmer we address is issued from micro-robotics [3], and it is composed of a magnetic head and an elastic tail. The work we show here is the extension of the simplified setting that was analyzed during CEMRACS 2018 [5]. The long-term purpose of this work is to investigate the dynamics and the control of the latter micro-robot close to walls or obstacles, in order to find the best strategies to guide it.

Références

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