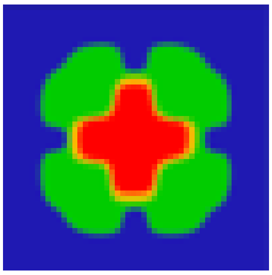

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Numerical (micro)aquarium using the deal.II library

Tuesday, July 24, 2018 11:40 AM (10 minutes)

During the last 8 years the mathLab laboratory at SISSA has analysed the swimming mechanisms of micro-organisms (unicellular beings as protists, algae or bacteria) both from a theoretical and an experimental point view. In this work we present a way to derive an accurate and reliable numerical setting for the resolution of general swimming mechanism. Such a framework can be seen as a numerical microscope.

A general swimming motion (both for micro than macro organism) can be seen as a Fluid Structure Interaction problem.
Given the characteristic length-scale of the problem (100 microns at most) the fluid part of the problem is well described by the Stokes equations (in particular we use the Boundary Integral Equations for the Stokes system). For what concerns the structural part of the system the typical swimming mechanisms (flagellar movements, body deformations) involve large domain deformations which pose severe mesh quality problems to finite element or finite volume solvers, and make Boundary Element Method an ideal discretisation strategy for these FSI problems, requiring only the discretisation of the domain boundaries.

We present a series of tools that allows the resolution of swimming problem starting from the analysis of an experimental video. In particular we isolate the shape changes of the swimmer and we use this informations as input data to recover the rigid movements of the overall organism. We use an OpenSource 3D modelling tool (Blender) to generate the computational mesh and we use an efficient MPI parallel solver (based on deal.II) for Stokes problems exploiting a collocation Boundary Element Method. The BEMStokes library, released under LGPL license, solve both 2D and 3D problem and it is rigorously tested using continuous integration over more than 120 different test cases.

The resulting softwares constitutes what we call a “numerical aquarium” since it allows for an efficient and reliable study of complex swimming organisms complementing the analysis that can be obtained through a real microscope.

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