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FINITE ELEMENT MODELING OF MICROSWIMMERS

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Abstract. Over the last years, we have been studying methods for fluid-structure interaction at small scales. By small we mean systems that are microscopic, such as microbia or single cells. Such systems have to surmount huge viscous effects, which make their self-propulsion to involve large displacement of appendages and/or large deformations of the body. Our objective is to build a mathematically sound discrete approximation of microswimmers, incorporating several interactions with the environment. Further, we would like to achieve a fully-parameterizable model built upon state-of-the-art open finite element libraries, so that people (or algorithms) can "play" with them and build upon them. We have started from the simpler cases of rigid bodies and articulated sets of rigid bodies embedded in Newtonian or quasi-Newtonian fluids, and recently incorporated Cosserat one-dimensional solids (flexible rods). These implementations are being carried out in the platforms FEniCS and Firedrake. In this talk we will describe the mathematical problem and adopted (ALE-based) formulation in the context of other popular alternatives, such as the immersed boundary and boundary element methods. We will also show some examples of microswimmers "in action", and some incipient attempts at making them learn to swim and feed by themselves. This work results from a collaboration with R. Ausas (Univ. de São Paulo, Brazil), C. Gebhardt (Univ. Bergen, Norway) and S. Paz (Univ. del Valle, Colombia).