Shape Optimization of Micro-Magnetic Locomotors

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Locomotion at the micro-scale is important in biology and in industrial applications such as targeted drug delivery and micro-fluidics. We present results on the optimal shape of a rigid body locomoting in 3-D Stokes flow. The actuation consists of applying a fixed moment and constraining the body to only move along the moment axis; this models the effect of an external magnetic torque on an object made of magnetically susceptible material. The shape of the object is parametrized by a 3-D centerline with a given cross-sectional shape. No a priori assumption is made on the centerline. Thus, we pose an infinite dimensional optimization problem and solve it with Boundary Integral and Variational methods. Sensitivities of the cost and constraints are computed variationally via shape differential calculus and a boundary integral formulation yields the boundary stresses. The optimization method can be considered as a sequential quadratic programming (SQP) approach. We report examples of locomotor shapes with and without different fixed payload/cargo shapes.

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