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Cellular Traction as an Optimal Control Problem

Force Traction Microscopy is the determination of the stress exerted by a cell on a planar deformable substrate on the basis of pointwise measured displacement. This classical inverse problem in biophysics is typically addressed inverting the displacement field using the Green functions of linear elasticity, under suitable regularizing conditions.

An alternative method formulates an adjoint problem for the direct two-dimensional plain stress operator by minimization of a convenient functional. The resulting coupled systems of elliptic partial dfferential equations (the forward and the adjoint problem) can then be solved by a finite element method. One advantage of such an approach is that can be extended to three dimensional case, including inhomogeneity and anisotropy and even finite displacements of the material.

This work deals with the rigorous statement of the inverse problem Some results of well posedness for the linear case are first given, using standard techniques. The theory is then extended to the less trivial case of pointwise observations with boundary control in 2D and 3D. The model is numerically approximated in 2D and a critical discussion of the results is addressed. Early results of the major biophysical problem of pointiwise observations with boundary control will be shown.

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