A thin shell approach to the registration of implicit surfaces

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In different imaging scenarios, such as the acquisition of medical and biological data, several images of the same object are taken over time with the purpose of observing changes in it. However, the environment in which the acquisition is performed can never be perfectly controlled, so one can not assume that these images will correspond point by point, so a direct comparison of their values is not possible. Usually finding some alignment, in the form of a deformation of the domain on which these objects 'live', is needed. This problem is usually known as registration, and requires defining which kind of deformations are desirable. Sometimes, variational models from continuum mechanics can be succesfully applied as a selection principle for preferred deformations.

In this talk, we introduce a model for registration in which the two objects to be aligned are two dimensional surfaces embedded in $\mathbb{R}^3$, which are represented as level sets of real functions defined on some domain. In our approach, these level sets are seen as elastic shells, the desired deformations then corresponding to equilibirum configurations of these shells under the action of a force that tries to force one surface onto the other. These are then considered to be embedded in a soft elastic material, in order to prevent self-intersections. Specifically, we consider an energy funcional that combines a forcing term, shell terms penalizing expansion, compression, and bending of the surfaces, and a elastic volume term.

We will discuss the formulation of such a model, pointing out its similarities and differences with respect to the corresponding physical theories, briefly consider its discretization, and show some numerical results. We will also hint, time permitting, at a way to modify this model in such a way that existence of solutions is ensured.