Shape sensitivity analysis in nano-optics

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There is a fast progress in the field of nano-fabrication. However, some production inaccuracies are inevitable. Especially in the case of nano antennae, these perturbations can amount more than 10% deviation from the initially designed structure, which can drastically affect its optical behavior.

The sensitivity of a design can be mathematically investigated using shape gradients. The behavior of the optical response in a region of interest can be modeled by introducing an objective functional. Its Eulerian derivative can then be computed by assuming a shape perturbation caused by the flow of a vectorfield.

Currently there are two approaches for computing the shape gradient. A “continuous” one is based on a mathematical derivation of the shape gradient, whose formula involves the solution of two PDEs. In the continuous approach the shape gradient is thus recovered with a post-processing on a Galerkin discretization of these PDEs. The “discrete” approach relies on a discretization with a mesh of the shape design. The Eulerian derivative of the objective functional is computed with respect to the variation of the position of the mesh nodes. We have invesitigated the formulations for both methods and tried to find out which one has better performance when finite elements setup is used for discretization.