Analysis of Nanostructures with Complex Shape using improved Generalized Method of Moments

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The study of light-matter interactions is of great importance to many applications ranging from optical device characterization to material design to analysis of photonic band gap (PBG) structures etc. Many nanostructures of interest possess complex geometries and topologies that are difficult to model geometrically, and even more difficult to characterize in terms of electromagnetic response; for instance, modeling of biomimetic structures (including naturally occurring PBGs) such as butterfly wings. Furthermore, topology optimization for design requires a method that has the ability to adaptively manipulate and deform the geometry in an efficient manner. The use of canonical modeling methods to meet these challenges is difficult. Some of the authors recently introduced the Generalized Method of Moments (GMM) [N. Nair and B. Shanker, Proceedings of 2011 IEEE COMCAS, 1-4] that provides an effective framework both for geometry description and manipulation of locally smooth PEC surfaces, as well as great latitude in the choice and mixing of approximation function spaces. However, the method has not been advanced to the analysis of dielectric scatterers. The goal of this work is to extend GMM to a robust integral equation solver for complex dielectric nanostructures using locally smooth surface descriptions.

Our earlier work in developing GMM for analysis of dielectric structures relied on overlapping patches, but on flat triangulations [N. Nair and B. Shanker, JOSA, 28, 328-340, 2011]. While this is effective, it is not optimal in meeting the aforementioned needs. The GMM framework we recently introduced utilizes a locally smooth surface description composed of overlapping "patches" for representation of an arbitrary smooth surface; this paradigm also provides the ability to deform the surface without a costly remeshing process. Overlapping patches are decoupled using a partition of unity, furnishing great flexibility in the choice of basis function sets, which can be arbitrary mixtures of polynomials, plane waves, RWG, etc. In the new work, we employ higher order geometry descriptions to construct accurate mapping of dielectric scatterers with complex surfaces, and develop corresponding higher order integration schemes to accurately discretize the appropriate operators. The advantages of a higher order description include (1) smooth geometry representation and (2) increased flexibility in the choice of basis set and order. At the conference, we will demonstrate application of these methods to the analysis of dielectric structures with complex surface topologies such as gyroids, Chmutov surfaces, etc., which are often used to represent biomimetic structures.