Forward and Inverse Electromagnetic Scattering

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ABSTRACT

When electromagnetic waves impinge on an object, they are scattered by reflection, refraction and other mechanisms depending on the shape and properties of the scatterer. One the one hand, in a forward scattering problem, we are interested to compute the scattered field resulting from the interaction of a known object (the scatterer) and a known incident field. Such problems are usually well-posed and there is a great deal of theory and experience to guide numerical analysis in this area. On the other hand, electromagnetic waves are often used to try to determine properties of an inaccessible scatterer. This problem, in which the incident and resulting scattered field are known, but the scatterer, or it's electromagnetic properties, are unknown is termed an inverse scattering problem. Such problems are ill-posed and non-linear. In contrast to the forward problem, numerical methods and theory are much less well developed in this case [1].

In this talk I shall present a standard finite element method for approximating the forward problem in the frequency domain and discuss some of the issues that influence the choice of an algorithm. In particular I shall discuss edge elements and indicate how the discrete de Rahm diagram arises naturally from the need to satisfy the electromagnetic conservation laws [2].

Switching to the inverse problem, I shall present a simple algorithm for approximating the shape of a scatterer from multi-static scattering data involving only the solution of linear ill-posed problems and show some computational results using synthetic forward data [2]. I shall also briefly indicate how the same data can be used to reconstruct surface properties such as the impedance of a coated scatterer.

References

[1] D. Colton and R. Kress, *Inverse Acoustic and Electromagnetic Scattering Theory*, 2nd ed., ser. Applied Mathematical Sciences. New York: Springer-Verlag, 1998, no. 93.

[2] P. Monk, *Finite Element Methods for Maxwell's Equations*. Oxford: Oxford University Press, 2003.