Educational Software Package for Electromagnetic Scattering from Simple Two and Three Dimensional Canonical and Non-Canonical Objects

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Abstract This paper presents a software package designed as an educational tool for the purpose of visualizing the physical phenomena of electromagnetic scattering from some canonical and non-canonical objects. The package is constructed to provide solutions for dielectric and conductive materials wherever appropriate, and it calculates and displays the near and far fields due to an excitation from a line source or a plane wave.

Introduction

In electromagnetic education, the fundamentals of electromagnetic scattering theory are usually taught through solutions of scattering from some canonical objects due to excitations by incident plane, cylindrical, or spherical waves. These solutions are in general available in closed mathematical forms that in many cases are hard to visualize and difficult to extract from them the physical characteristics of the scattering process. Therefore, it is important to have such canonical solutions programmed and arranged in an easy to use tool for the purpose of visualizing the physical phenomena of scattering from these objects. Thus, the availability of programs that solve these types of canonical problems on the widely available personal computers and workstations provides students with a better understanding of electromagnetic scattering theories. Furthermore, such tools can be used as benchmarks for a wide range of researchers who are developing numerical electromagnetic techniques, and they would be able to have immediate access to solutions to a variety of test cases to verify their techniques. With these needs in mind, a software package has been developed to calculate and display the scattering from two and three-dimensional canonical objects based on exact boundary value solutions. In addition to canonical objects this package also includes some simple non-canonical objects where the presented scattering parameters are based on approximations. Many configurations are considered in this package; thin strip, circular cylinder, capped wedge, truncated cone, line source above a ground plane, sphere, triangular and circular flat plates, and ellipsoid. The package is constructed to provide solutions for both dielectric and conductive materials wherever appropriate. It calculates the far and near field components due to an excitation from a line source or a plane wave [1-4]. In the two-dimensional problems the TE and TM cases are treated separately.
Description of The Program

The software package is programmed using Matlab, and provides a user-friendly graphical user interface. Each object is programmed in a separate module and the package can easily be extended to include new objects. Near field calculations take some time but far field calculations are fast enough to get results instantaneously. Therefore, the user interface is designed such that some parameters can be changed by use of sliders and the change in the response of respective parameters can be observed in near real time. The following geometries are included in the package:

**Thin strip**: Scattering from a thin strip is calculated due to an incident plane wave based on the approximate solution given in [1].

Figure 1. A snapshot of the “Thin Strip” module.

Figure 2. A snapshot of the “Capped Wedge” module.
The plane wave can be TE or TM polarized. Monostatic RCS and bistatic RCS can be calculated and displayed either in polar or Cartesian coordinates. A snapshot of this module is shown in Fig. 1.

**Line source above a ground plane:** Scattered field from a line source located above a ground plane, is calculated based on the closed form solution given in [1]. The scattered field can be displayed either in polar or Cartesian coordinates.

**Capped Wedge:** Scattering from a capped wedge is calculated based on the exact closed form solution given in [2]. The excitation can be either due to an incident plane wave or a line source. The wedge material can be dielectric or conductor. Near field distribution can be displayed as well as the far field can be plotted. A snapshot of this module is shown in Fig. 2.

**Circular cylinder:** Scattering from a circular cylinder is calculated based on the closed form solution given in [1]. The excitation can be either due to an incident plane wave or a line source. The plane wave can be TE or TM polarized. The cylinder material can be dielectric or conductor. Near field distribution can be displayed as well as the far field can be plotted. A snapshot of this module is shown in Fig. 3.

**Truncated cone:** Scattering from a truncated cone is calculated due to an incident plane wave based on the approximation given in [3]. The RCS can be plotted as viewed from the large or the small end of the cone.

**Triangular flat plate:** Scattering from a triangular flat plate is calculated due to an incident plane wave based on the approximate solution given in [3]. Backscattered RCS can be calculated and displayed in Cartesian coordinates.

![Figure 3. A snapshot of the “Circular Cylinder” module.](image-url)
Circular flat plate: Scattering from a circular flat plate is calculated due to an incident plane wave based on the approximate solution given in [3]. Backscattered RCS can be calculated and displayed in Cartesian coordinates.

Ellipsoid: Scattering from an ellipsoid is calculated due to an incident plane wave based on the approximate solution given in [3]. Backscattered RCS can be calculated and displayed in Cartesian coordinates.

Sphere: Scattering from a sphere is calculated due to an incident plane wave based on the exact closed form solution given in [4]. The sphere material can be dielectric or conductor. Co-polarized and cross-polarized radar cross-sections can be plotted and saved to a file. A snapshot of the module is shown in Fig. 4.

Conclusions

A graphical user interface has been developed for scattering from two and three-dimensional objects with high computational efficiency and adaptability, in addition to its ease of use. The provided user interface is characterized by a considerably fast computational time, thus the user can interactively observe, in near real time, the effect of changing any of the physical or electrical parameters on the resulting far field patterns and parameters.

References


