A Systematic Method for Producing Simulated Scattered Field Data From Known Structures

R. S. Ritter[1], M. A. Fiddy[2]

[1]Olivet Nazarene University, Bourbonnais, IL, USA
[2]University of North Carolina - Charlotte, Charlotte, NC, USA

Abstract

Introduction
One of the greatest challenges in developing algorithms for imaging from scattered fields is the lack of suitable scattered field data from known targets to use for testing new imaging algorithms. This is especially true for methods that involve the diffraction tomography approach as illustrated in Figure 1.

It would be ideal to develop a structured way to virtually model various known targets to produce simulated scattered field data for use in working with imaging algorithms utilizing a finite element application such as COMSOL Multiphysics® software.

COMSOL Application
The task of 2-dimensional target modeling and image data generation from scattered fields is not a trivial one. The problem lies in that there is no general solution for analytically determining scattered fields for an arbitrary target. This means that the analytical solution would have to be derived each time for a new target. A common numerical solution to this type of problem or modeling is to use the technique of Finite Element Analysis [1] [2]. The basic model setup for this procedure is much like the general model shown in Figure 1, with the exception that there is an artificial boundary that defines the extent that the iterative calculations are performed for since this is a finite method as shown in Figure 2.

In this research, this method is implemented using the commercially available finite element software COMSOL Multiphysics. This software allows the user to create the target graphically, modify and/or sweep virtually any and all parameters, then applies the finite element process to the model and returns both a graphical and numerical solution for the total field in the defined space. The only challenge then is to process the data into a format that can be used by imaging algorithms in MATLAB®, which can easily be done in a commercially available spreadsheet such as Microsoft® Excel.

Results
In order to verify the validity of this modeling process, the data obtained from the COMSOL® model is compared to measured data obtained from the Institut Fresnel [3] website for a range of targets. These data were similarly processed using the same algorithms described in [4]. To

demonstrate that the data from the COMSOL® modeling process is valid, the two images for each target, one from the measured data, and one from the simulated data respectively are shown to be comparable in appearance. The target definitions, and outputs from both data sets is presented in Figure 3.

Conclusion
In this paper, a fundamental challenge to developing imaging algorithms was identified in that there are a limited amount of data to test these algorithms. A structured method to produce simulated scattered field data for known targets is proposed using the finite element method utilized through the commercially available software package of COMSOL Multiphysics. In this paper it is demonstrated how these models can be constructed and the pertinent data gathered to use for algorithm evaluation.

Reference

[1] Jin, J, The Finite Element Method in Electromagnetics, IEEE Press, New York, 2002.

[2] Silvester P and Ferrari R, Finite Elements for Electrical Engineers, Cabridge University Press, New York, 1996.

[3] Christelle Ayraud, Jean-Michel Geffrin, Pierre Sabouroux, Kamal Belkebir and Marc Saillard, "Laboratory controlled data for validating inversion algorithms", Institut Fresnel, UMR-CNR 6133, France.

[4] U Shahid, "Signal Processing Based Method for Solving Inverse Scattering Problems", PhD Thesis, UNCC, Charlotte, 2009.

Figures used in the abstract

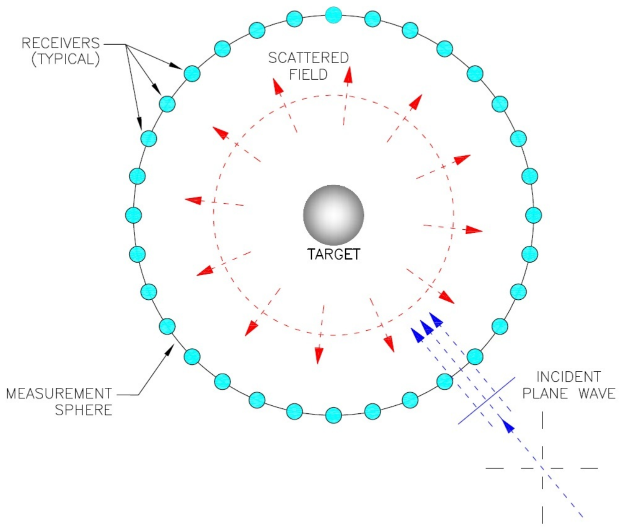

Figure 1: Typical experiment setup for diffraction tomography

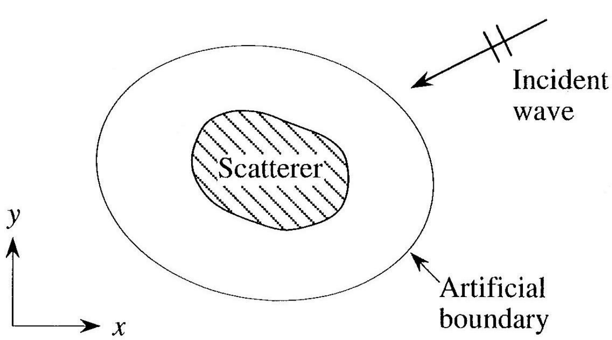

Figure 2: General 2D finite element scattering model

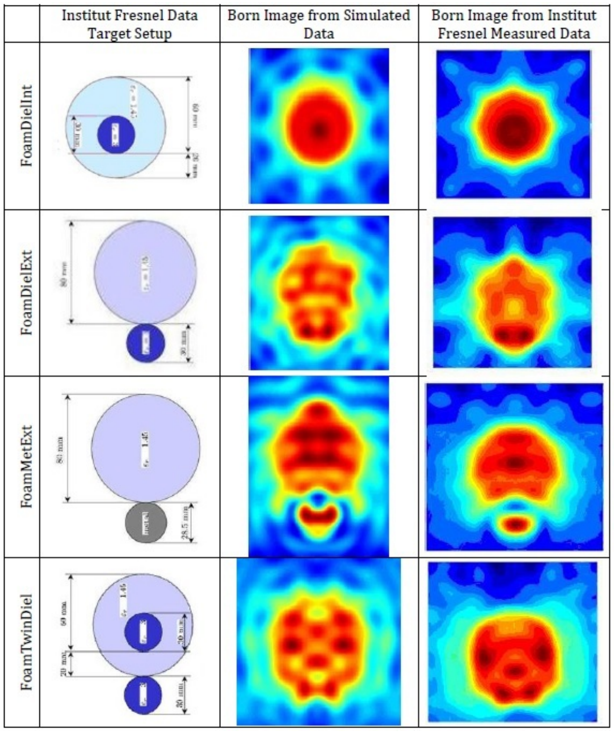

Figure 3: Comparison of images optained from COMSOL and Measured Data