Fast and Reliable Monostatic RCS Computation as a Function of Frequency and Angle of Observation via the Reduced-Basis Method

Valentín de la Rubia[1], Jesús Rubio[2], José María Gil[1], and Juan Zapata[1]

[1] Universidad Politécnica de Madrid, 28040 Madrid, Spain
e-mail: valentin.delarubia@upm.es
[2] Universidad de Extremadura, 10071 Cáceres, Spain
e-mail: jesusrubio@unex.es

Finite Element Methods (FEM) have proven to be robust in solving electromagnetic scattering problems. Nowadays, engineers rely on full-wave analysis to actually design a electrical response for microwave applications. Reduced-order models may be of help in this regard, since many modifications can be carried out on a given structure, until some target electrical response is achieved. Indeed, model order reduction will be as valuable as FEM analysis if the reduced-order model is a reliable surrogate of the original problem.

In this work, we focus on a rapid and reliable frequency-parameter and angular-response sweep in monostatic RCS prediction via the reduced-basis method. This is done by understanding how these two parameters contribute to the actual physics in the problem. Spherical mode expansion is taken into account to truncate the computational domain. We pay special attention to come up with a formulation dropping singularities in the frequency axis out of the Maxwell operator. As a result, we directly work with an S-formulation for the Maxwell system. Other formulations that suffers from interior resonance problems drive the reduced-order model to fail in the neighborhood of these resonances, and force to sample these artificial resonances. However, the S-formulation shifts these resonances out to the complex plane and, as a result, the Maxwell operator is no longer singular in the frequency axis.

The proposed model order reduction is based upon the following observation: should the field solution of the original system be considered as a function of a parameter, namely, frequency or observation angle for monostatic RCS signature computation, the field solution resides on a very low dimensional subspace induced by the parameter variation. We propose a model order reduction approach where field solutions at different parameter values are used as new basis for Galerkin projection. In addition, the accuracy of the reduced-order model is certified by means of the residual error of the reduced field solution throughout the whole parameter band of interest. As a result, a fully automatic and completely reliable model order reduction process is achieved.

Several radar signature images both for frequency and observation angle in real-life applications such as turbine inlet engines will illustrate the capabilities of this approach.