Validation of Maneuvering Target RCS by Computation based on Feature Selective Validation(FSV)

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Abstract—**Computational electromagnetics is one of the important means to estimate maneuvering target radar cross section (RCS) , and the correction of its computation result is the essential basis of the further analysis of target RCS. Anciently, the experience was usually used for the validation of target RCS by computational electromagnetic, for example the computational results were often simply compared with other computational results or measured results by observation, so this kind of validation is cursory and imprecise. In order to predict the community of computational and measured results of target RCS, the feature selective validation technique is used to compare these data in this paper. A missile target RCS is computed by MoM/PO, and compared with measured data with FSV technique. The comparison demonstrates that there is great community of the two measures, and the computational result could provide theory basis for studying dynamic RCS of maneuvering target.**

Keywords—Computational electromagnetics; FSV; RCS; Measured data

I. INTRODUCTION

Radar cross section of Maneuvering targets is of considerable importance in identifying targets such as aircrafts and missiles. There are usually several methods such as theory computation, computer simulations and measurement for deriving the RCS of maneuvering targets. Where computation electromagnetics are widely used for predicting the RCS，the physical diffraction theory (PDT) [1] and shooting and bouncing rays(SBRs) were implemented to compute the RCS of complex radar targets [2]. More rigorous frequency-domain (e.g., moment method-based) and time-domain (e.g., finite difference time domain [FDTD]-based) algorithms may be applied [3]. Commercial software packages are available, such as FEKO, HFSS, and ADS.

During the computation of the RCS, the correction of its computation result is the essential basis of the further analysis of target RCS. Anciently, the experience was usually used for the validation of target RCS by computational electromagnetic, for example the computational results were often simply compared with other computational results or measured results by observation, so this kind of validation is cursory and imprecise. For example, the FDTD computational result is compared with the Mie method by observation in [4]. In order to predict the community of computational and measured results of target RCS, the feature selective validation technique is used to compare these data in this paper. FSV method is able to provide the community with a simple computational method that can be used to predict the assessment of RCS data by computational electromagnetic as it would be undertaken by individuals or teams of engineers.

II. FEATURE SELECTIVE VALIDATION

When called on to assess the level of agreement between two datasets, most engineers will identify the most significant aspects of the traces and perform a visual comparison, and they can only give a considered opinion into the quality of the comparison. Correlation is the best-known and widespread technique of comparing datasets, but correlation only gives an overall view of the similarity between two curves, and doesn't give a detailed comparison. In this section, the applicability effectiveness and the procedure of the FSV technique are given.

A. Applicability effectiveness

As a technique to be used for validation, there are six points proposed to discuss the effectiveness of the FSV technique:

a) Implementation of the validation should be simple.

b) The technique should be computationally straightforward, requiring a modest processor and relatively little memory.

c) The technique should mirror human perceptions and should be largely intuitive.

d) The method should not be limited to data from a single application area.

e) The technique should provide tiered diagnostic information.

f) The comparison should be commutative.

Funding by: The Natural Science Foundation of China 61301236

B. *The procedure for implementing the FSV method*

The FSV method is based on the decomposition of the original data into two parts: amplitude (trend/envelope) data and feature data. The former component accounts for the slowly varying data across the dataset and the latter accounts for the sharp peaks and troughs.

The procedure for implementing the FSV method is as follows.

a) Read data, obtain the overlap window and ensure coincident pairs of data points.

b) Fourier Transform both datasets.

c) Calculate the low dataset using the transformed data.

d) Calculate the high dataset using the transformed data.

This section has demonstrated how the component parts of the FSV method can be calculated. In [5] the detailed processes are illustrated.

III. DATA COMPARISON OF COMPUTATION AND MEASURED RESULTS

A. *The model of Missile*

In order to validate the computational results of target RCS, in this section a missile's model is firstly shown in Fig.1, then the computational results by MoM/PO are given, simultaneously the measured results are also given in the same condition; finally the computational RCS data is compared with the measured data in the same condition by FSV.

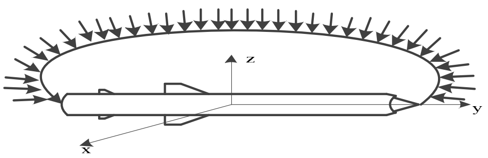
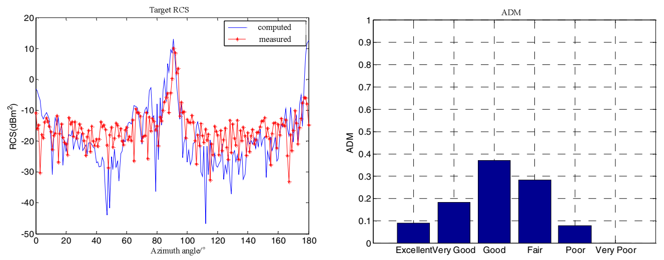


Fig 1 Model of the validation target

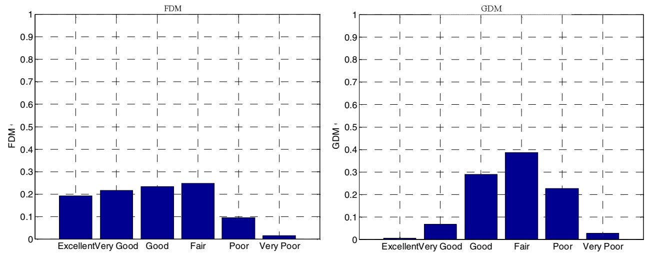
As shown in Fig 1, the observation sequence is: 0°~180° at the azimuth direction (from the front to the end), and 0 at the elevation direction. The incident wave is vertical polarization.

B. *Comparison of the RCS data*

To validate the computed RCS, Fig. 2 shows the comparison result of these two approaches to deriving the missile target.



(a) Comparison of RCS data (b) Amplitude difference of RCS data



(c) Feature difference of RCS data (d) Global difference of RCS data

Fig 2 Analysis of target RCS by FSV.

As shown in Fig 2(a), the two datasets seem to be in great agreement with each other, and the resulting point-by-point ADM, FDM, and GDM are shown in Figs. 2(b)~(d). The statics result is given in Table I.

TABLE I. STATICS RESULT OF RCS

statics / data	Max	Min	Mean	Middle
measured	10.0389	-33.1406	-7.9599	-16.5221
computed	13.0375	-46.8589	-2.8290	-19.8298

Through comparing the analysis result of FSV with the statics data, it can be concluded that there is a little difference of the maximum value between these two RCS sequences, and there are certain difference of the minimum value and mean value. As seen from Fig 2, the amplitude difference and feature difference have good agreement, and the global difference measurement results show that the 80% value is good, and these results are also consistent with the explicit comparison of RCS data.

IV. CONCLUDING REMARKS

In order to provide a scientific method to validate the computation result of maneuvering target RCS, This paper set show that FSV can be used to obtain a comparison between two sets of data.

REFERENCES

[1] Jeng, S. K., Near-field scattering by physical theory of diffraction and shooting andbouncing rays, IEEE Trans on A P, 46: 551-558, 1998.

[2] Bhalla, R., and Ling, H., 3D scattering center extraction using the shooting and bouncingray technique, IEEE Trans on AP, 44: 1445–1453, 1996.

[3] Meng Wengong, and Ma Dongli, "Research on the fast calculation method of wide angle and wide band RCS pattern of scatter based on FDTD," in Aeronautical Computer Technique, vol. 39 , 1963,pp 35-38.

[4] Zhang Shitan, Ren Xiaohong, Yang Lixia. "A novel method of object bistatic rcs based on FDTD method and its application," Journal of Microwaves. 2011, 27(3):5-8.

[5] Alistair P. Duffy, Anthony J.M.Martin and Antonio Orlandi, "Feature selective validation(FSV) for validation of computational electromagnetics(CEM). PartI-the FSV method," IEEE Transl. EC., vol. 48, pp. 449-459, August 2006.