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CYLINDRICAL TARGET RECONSTRUCTION USING THEIR FREQUENCY AND TIME DOMAIN RCS VALUES

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1. Introduction

Target identification is one of the important topics for remote sensing and next generation radar technologies, and various methods, which are mainly based on the signal processing techniques or numerical methods, have been proposed previously. Radar Cross Section (RCS) is one of the fundamental values to evaluate the equivalent size of the scatterer, and it is known that RCS changes according to the scatterer's shape[1, 2]. Authors have already been studied that high frequency asymptotic techniques such as the Geometrical Theory of Diffraction (GTD)[3] and the Equivalent Source Method (ESM)[4] can be confidently used for analyzing various electromagnetic wave scattering by large polygonal scatterers[5].

In this paper, a simple target reconstruction algorithm is proposed for polygonal cylindrical scatterers using high frequency techniques. This reconstruction algorithm is mainly based on our previous finding that for polygonal objects, the main contribution to the backscattering arises from the edge diffracted waves at the facets at the specular reflection direction, and each facet size can be estimated by the local RCS maxima and its lobe width[6]. We have already proposed a reconstruction algorithm for closed cross sectional convex objects by simply connecting these facets in order[7]. While this algorithm works well for convex bodies, the order of specular reflection direction may be interchanged when the surface of the scattering body has concave portions. In this paper, another reconstruction algorithm is proposed using monostatic RCS data in the time domain as well as in the frequency domain.

2. Reconstruction Algorithm

Let us briefly explain the reconstruction algorithm using the scattering model as shown in Fig.1. This target shape has a concave portion, so that the previous reconstruction algorithm can not be applied.

Step 1: Measure the angle dependency of the monostatic RCS return from the target (see Fig.2(a)). Detecting the RCS local maxima and the first nulls before and after the local maxima. Utilizing the previously proposed algorithm[7], one can determine the number of the facets N_1, their specular reflection angle θ_n, the width a_n, the longitudinal length b_n of each facet $n = 1, ..., N_1$. These values will be used as initial values for estimating facet size.

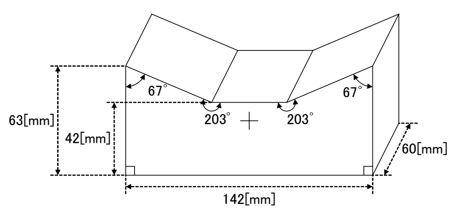

Figure 1: Cylindrical scatterer (Model 1).

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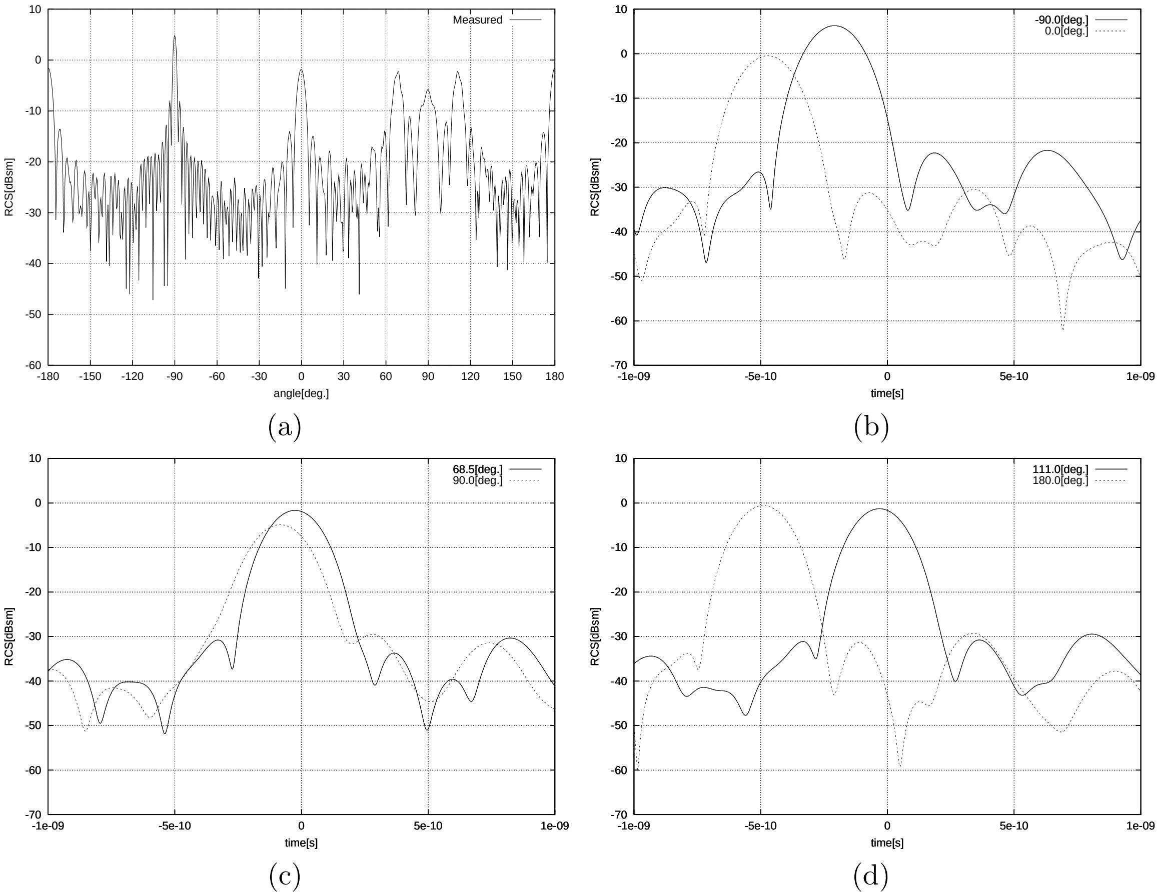


Figure 2: RCS measurement data of model 1 used for reconstruction. (a) Angular dependency in the frequency domain at 24GHz. (b) Time response in the time domain. For angle $\theta = -90°, 0°$. (c) For angle $\theta = 68.5°, 90°$. (d) For angle $\theta = 111°, 180°$.

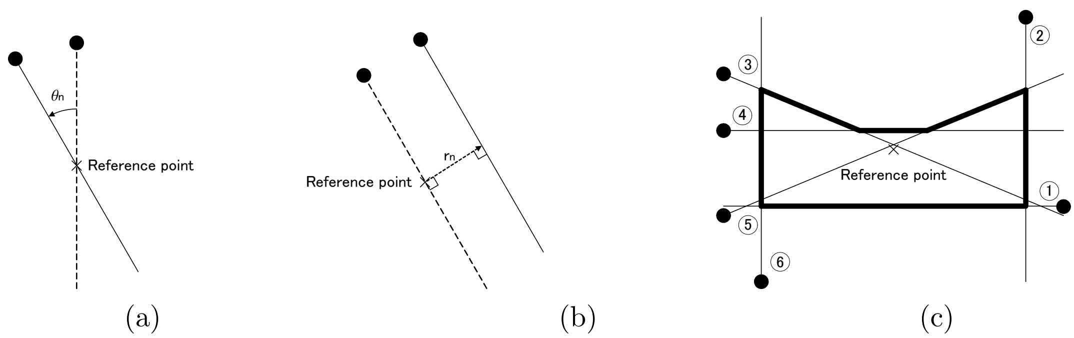
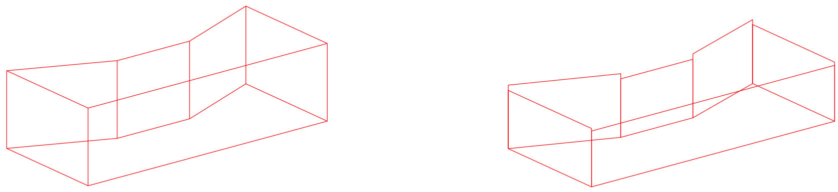


Figure 3: Reconstruction algorithm. (a) Rotation. (b)Translation. (c) Reconstruction.



(a) (b)

Figure 4: Reconstructed objects in three dimensional view (Model 1). (a) Original model. (b)Reconstructed model

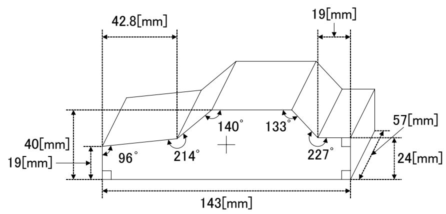


Figure 5: Cylindrical scatterer (Model 2).

Step 2: Measure the time domain RCS response at each specular reflected angle θ_n (see Fig.2(b), (c), (d)). Again look for local maxima (wavefront arrivals) and their time difference t_n from the reference point (the scattering center). If two major peaks are detected, the target object may have two facets parallel each other.

Step 3: Draw the wavefront (straight) lines for each facets by rotating them with angle θ_n (see Fig.3 (a)), and translating by $r_n (= ct_n/2,\ c:$ light speed) (see Fig.3 (b)).

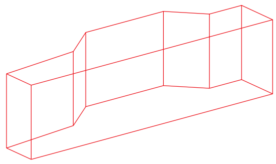
Step 4: Mark intersection coordinates and draw the possible outline of the target (see Fig.3 (c)). Determine the target shape by comparing the size of each facet with their initial values.

3. Reconstructed results and discussion

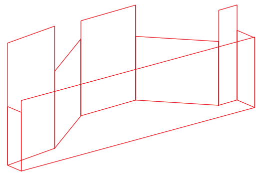
Figure 4 shows the three dimensional view of the reconstructed scatterer, model 1 from its RCS data in Fig.2. Very good agreement can be observed between the original object and reconstructed one. Another example of the reconstruction is shown here for an automobile model (model 2) illustrated in Fig.5. Reconstructed result is shown in Fig.6. While the cross section (8-side polygon) is well reconstructed, rather big error can be seen at longitudinal length b_n. This is due to the fact that there are three facets that are mostly parallel each other, and interference between them would be pretty big.

4. Conclusions

In this paper, reconstruction algorithm has been proposed for cylindrical objects using the RCS data in the frequency and time domain. In order to verify the proposed algorithm, test RCS data have been measured from model targets, and try to reconstruct the target objects. It is found that this algorithm works well to reconstruct the polygonal target with concave surface.



(a)



(b)

Figure 6: Reconstructed objects in three dimensional view (Model 2). (a) Original model. (b)Reconstructed model

Acknowledgement

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