RECURSIVE T-MATRIX ALGORITHMS FOR 1-D AND 2-D CLUSTERINGS OF STRIPS

L. GUREL* AND W. C. CHEW
ELECTROMAGNETICS LABORATORY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
UNIVERSITY OF ILLINOIS
URBANA, IL 61801

I. INTRODUCTION

Recently, two recursive T-matrix algorithms have been introduced [1], [2], and their applications to scattering from dielectric [2] and conducting [3] scatterers have been discussed. In this paper, we will

(1) discuss the application of these algorithms to conducting strip geometries, and

(2) analyze the complexities of the algorithms.

The two algorithms are shown to have complexities of $O(N^2P)$ and $O(NP^2)$, where N is the number of unknowns in the problem, and P is the number of terms that satisfies a convergence criterion in the addition theorems for the cylindrical wave functions. P usually depends on N through a relation

$$P \propto N^{\alpha}. \tag{1}$$

Clearly, determining the exact nature of this relation, i.e., determining the value of α is essential since $\alpha < 1$ implies that the recursive T-matrix algorithms have complexities less than $O(N^3)$. In this paper, we will show that α is determined from the geometrical properties of the problem, namely, the clusterings of the unknowns (or strips) [3].

II. 1-D CLUSTERING OF STRIPS

For a 1-D clustering of strips (see Fig. 1), we find that [3]

$$\alpha = 1 \Longrightarrow P \propto N \tag{2}$$

which implies that the complexities of the two recursive T-matrix algorithms become $O(N^3)$ in this case. However, Fig. 2 shows that, even for the 1-D clustering case, a recursive T-matrix algorithm takes less CPU time than a method-of-moments (MOM) solution, mostly due to shorter matrix-filling time. We have applied the recursive T-matrix algorithms to the electromagnetic problem of scattering from 10 strips of width w and spacing $d = 2w$. (see Fig. 1) This is a two-dimensional geometry for a *one-dimensional finite-size frequency selective surface* (FSS). Both TM (to y) and TE (to y) polarized incident plane waves have been considered. Figures 3(a) and 3(b) show the normalized radar cross sections (RCSs) for the TM and TE cases as a function of the angle of reflection and the frequency. The normalization is such that, for each frequency, the power radiated in the total scattered field is a constant. The frequency is specified by kw where k is the free-space wavenumber and w is the actual width of each strip. These results are checked against MOM results with excellent agreements.

III. 2-D CLUSTERING OF STRIPS

For a 2-D clustering of strips (see Fig. 4), we find that [3]

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$$\alpha = \frac{1}{2} \Longrightarrow P \propto N^{1/2} \tag{3}$$

which implies that the recursive algorithms with complexities $O(N^2P)$ and $O(NP^2)$ perform as $O(N^{5/2})$ and $O(N^2)$, respectively. Figure 5 shows a comparison of the CPU times required by a MOM solution and a recursive T-matrix algorithm for 2-D problems. Figure 6 shows the comparison of the RCSs of the geometry of Fig. 4 as obtained by a MOM solution and a recursive T-matrix algorithm.

References

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[2] W. C. Chew and Y. M. Wang, "A fast algorithm for solution of a scattering problem using a recursive aggregate $\bar{\bar{\tau}}$ matrix method," *Microwave Opt. Tech. Lett.*, vol. 3, pp. 164–169, May 1990.

[3] L. Gurel and W. C. Chew, "A recursive T-matrix algorithm for strips and patches," submitted for publication, Oct. 1990.

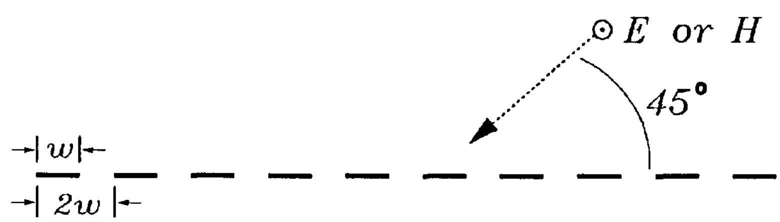

Fig. 1. TM or TE plane wave incident on a finite-size FSS of ten strips.

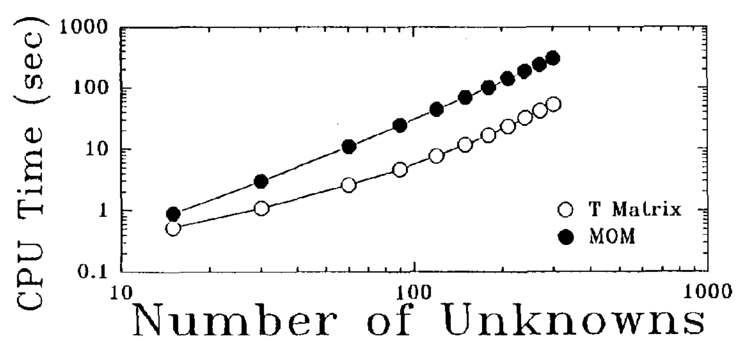

Fig. 2. Comparison of CPU times required by a MOM solution and a recursive T-matrix algorithm for a 1-D clustering case.

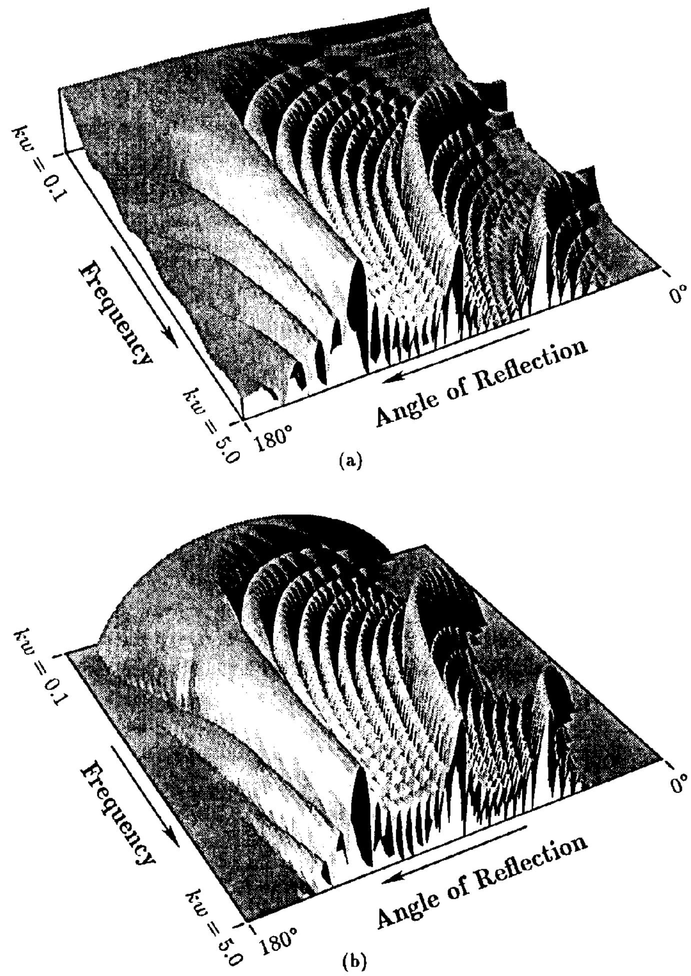

Fig. 3. Normalized RCS of the ten-strip FSS of Fig. 1 as a function of the angle of reflection and the frequency, (a) TM incidence, (b) TE incidence.

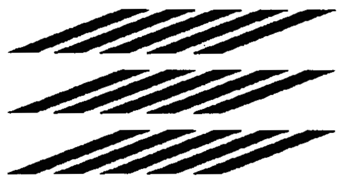

Fig. 4. An example of a 2-D clustering of strips.

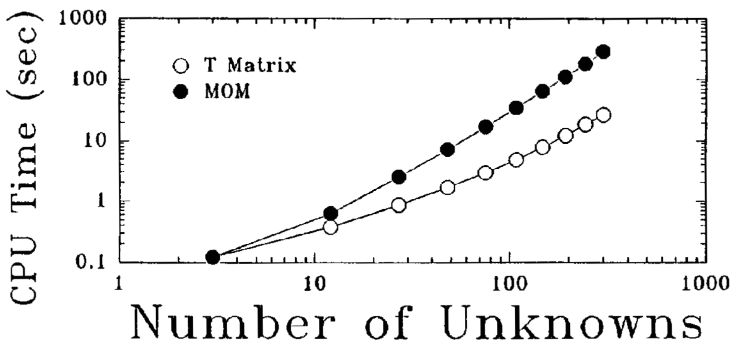

Fig. 5. Comparison of CPU times required by a MOM solution and a recursive T-matrix algorithm for a 2-D clustering case.

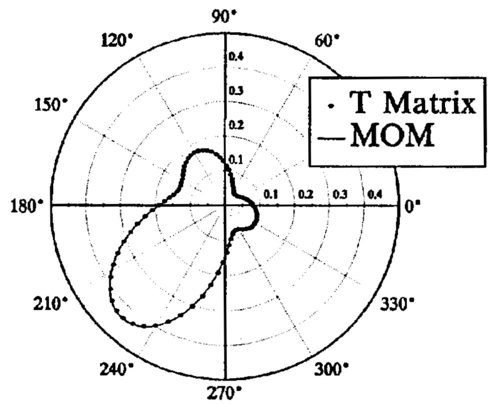

Fig. 6. Normalized RCS of 100 strips of width $kw = 0.2$ that are clustered in two dimensions (as in Fig. 4) with horizontal spacing $kd = 0.4$ and vertical spacing $kh = 0.25$. TM plane wave is incident on the strips.