The Study of Sierpinski Fractal Antennas for Detecting Various Object Forms

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Abstract: - In this work leverages fractal patch antenna benefits to create a sensor detecting object variations (cube, cylinder, and sphere). CST software empowers precise complex system simulations. The antenna effectively controls and detects changes in these objects. Resonance frequency proves highly sensitive to their variation, yielding impressive performance. A significant contribution to artificial intelligence.

Key-Words: Fractal forms, sensor, antenna, CST Microwave Studio, artificial intelligence.

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1 Introduction

In this study, we harness the advantages of fractal patch antennas to design a sensor capable of detecting variations in objects such as cubes, cylinders, and spheres. We employ CST software for accurate simulations of complex systems. The triangles Sierpinski carpet antenna, composed of triangles, effectively manages and identifies alterations in these objects. The resonance frequency exhibits remarkable sensitivity to these variations, resulting in impressive performance.This research represents a significant contribution to the field of artificial intelligence. This work highlights the innovative application of the Triangles Sierpinski fractal antenna in controlling and detecting changes in object shapes, presenting a substantial contribution to the field of artificial intelligence. The antenna's unique design and capabilities make it a valuable tool for enhancing object recognition and manipulation within AI systems, offering promising opportunities for advancements in various AI applications.

2 Introduction

The term "fractal" was coined by B. Mandelbrot, derived from the Latin word "fractus," meaning irregular or broken. It was introduced to describe a novel set of objects that went beyond the traditional definitions of squares, circles, or triangles within Euclidean geometry. While Euclidean geometry worked well for well-defined shapes, it fell short when it came to describing everyday elements such as clouds, blood vessels, and irregular coastlines. Visionaries like W. Sierpinski, N. Von Koch, D. Hilbert, and H. Minkowski further enriched the field of fractal geometry. Their contributions sparked the interest of antenna engineers in exploring these geometries for potential antenna applications.

Fractal geometries have indeed had a profound impact on the field of antennas and have been applied in various telecommunications applications. Here are some key ways in which fractal geometries have influenced antenna design and performance [1-6].

One intriguing application of fractal antennas, particularly those based on Sierpinski carpet iterations, is for the control and detection of various objects such as cubes, cylinders, and spheres.

The primary objective of your work is to design antennas based on the fractal Sierpinski carpet and utilize these antennas to detect changes in the shapes of various objects.

Indeed, the choice of simulation software for antenna design depends on various factors, including antenna geometry, size, materials, and specific design aspects that need analysis. Let's take a closer look at the simulation tools you mentioned and their typical applications:

CST is a high-performance 3D electromagnetic (EM) analysis software solution dedicated to the design, analysis, and optimization of electromagnetic components and systems. CST enables us to perform complex system simulations with unparalleled accuracy. It is a powerful tool for simulating a wide range of electromagnetic phenomena, making it valuable for various applications in the fields of antennas, microwave circuits, RF systems, and more.

3 Simulation of a Sierpinsky carpet antenna

Our antennas consist of a copper ground (ground plane), patch and line microstrip (microstrip), with an FR4 dielectric substrate(see figure.1). We can calculate the width of the microstrip line by the following relation:

$$L = \frac{7.48\times h}{e^{\left(Z_0\frac{\sqrt{\varepsilon_r+1.41}}{87}\right)}} - 1.25\times t \quad (1)$$

With

L: width of the microstrip line

h: height of the dielectric

t : thickness of the line

Z_0: Impedance = 50 Ohm

ε_r: Dielectric constant (dielectric constant of FR4 = 4.3)

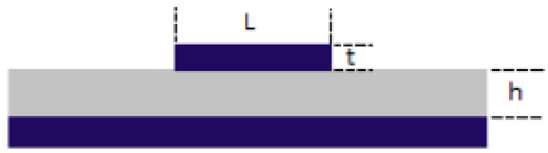

Figure.1 Presentation of characteristic necessary to calculate the width of a line microstrip

The base of a Sierpinski carpet is a square patch, the dimensions we used for the patch are 30x30 mm with a thickness of 0.035mm, a substrate of 60x60mm and a thickness of 1.56mm, for the ground plane we used the dimensions 60x60mm and the thickness 0.035mm as shown in Figure.2 .

For the first iteration and second iteration (see Figure.3 and Figure.4). An equivalent circuit is proposed for the triangles Sierpinski carpet as shown in Figure.5, we removed a square of 10x10mm from the center, the result obtained is presented in figure.6 and figure .7.

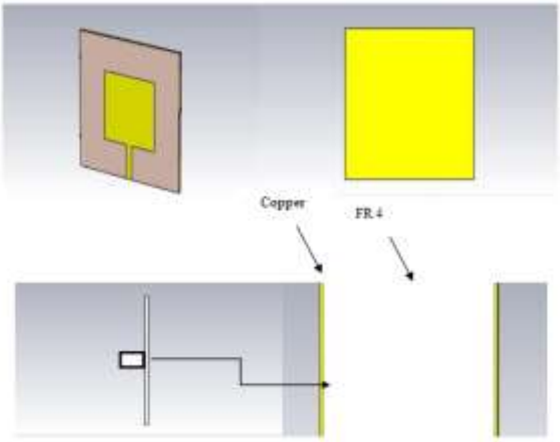

Figure.2 *Simulation of a square patch by CST*

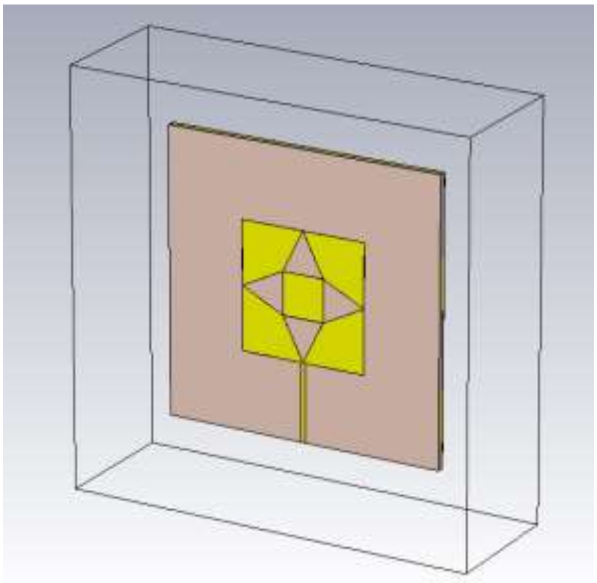

Figure.3 *Triangles Sierpinski carpet iteration 1 by CST*

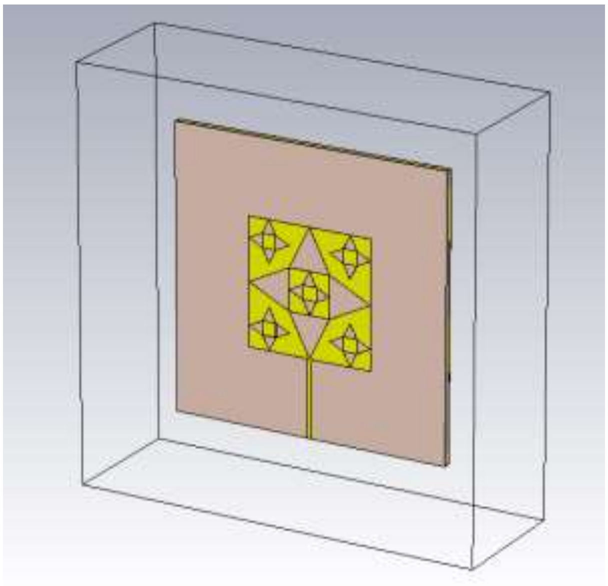

Figure.*4 .Triangles Sierpinski carpet iteration 2* by CST

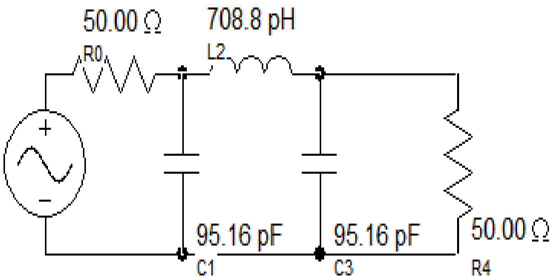

Figure. 5. *Equivalent circuit model of triangles Sierpinski carpet iteration 2*

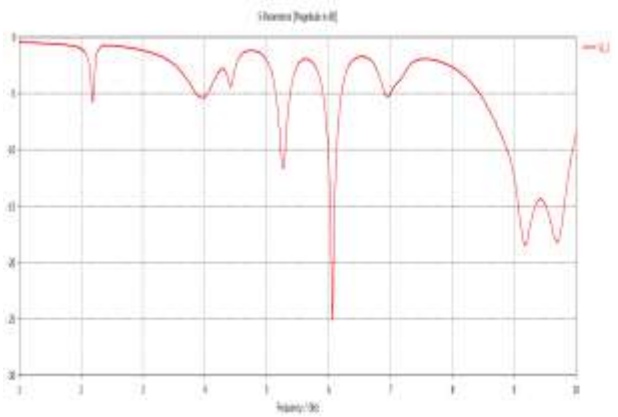

Figure .6 Parameter S11 of the 1st iteration triangles Sierpinsky carpet

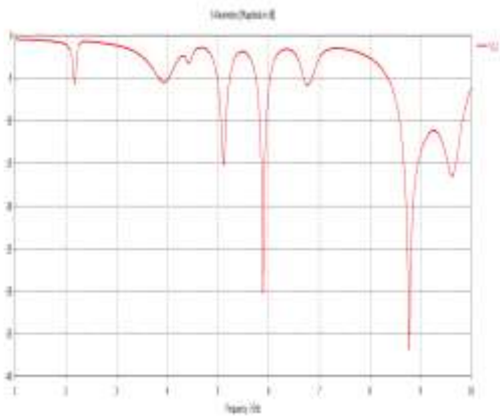

Figure .7 Parameter S11 of the 2nd iteration triangles Sierpinsky carpet

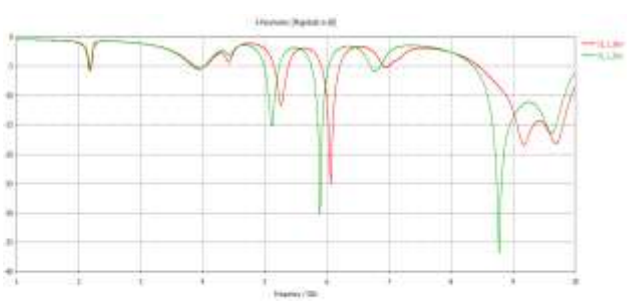

Figure .8 Comparative analysis between the parameter S11 of the 1st iteration and the 2nd triangles Sierpinsky carpet.

According to the curve of the parameter S11 presented in figure .6 and figure .7 , we notice that the Sierpinsky carpet antenna of iteration 1 has a frequency band minimum 2.1GHz and maximum 9.6GHz.

Figure .8 presents the parameters S11 of the 1st iteration and the 2nd iteration of the triangles Sierpinsky carpet antenna simulated by CST, according to the curves we notice that there is a small difference in the frequency domain between the two iterations.

We will use three different shapes (cube, cylinder, and sphere) in glass, the dimensions are presented in the following table:

Form	Diameter/dimension	Height
Cube	25 mm	-
Cylinder	25 mm	25 mm
Sphere	25 mm	-

detection by Sierpinsky carpet

We conduct a comparative study between triangles Sierpinsky carpet and Sierpinsky it2 carpet for object detection sensor

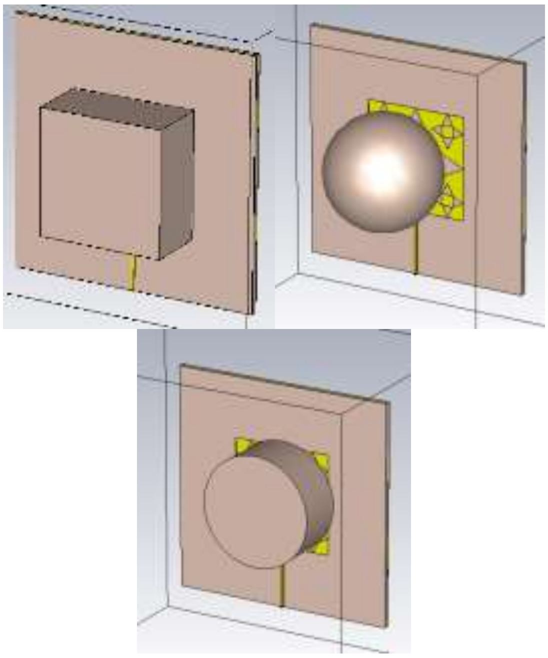

Figure .9 object detection by Triangles Sierpinsky carpet

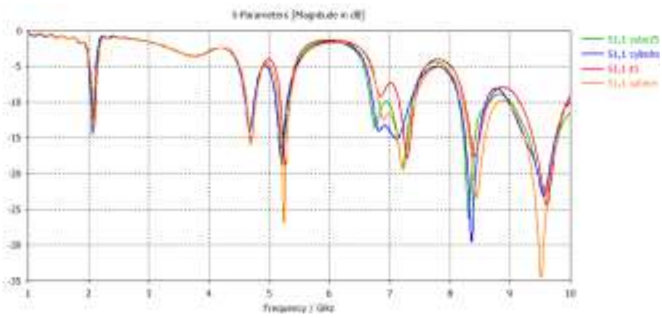

Figure .10 S11 simulation result for 2nd iteration of the triangles Sierpinsky carpet antenna

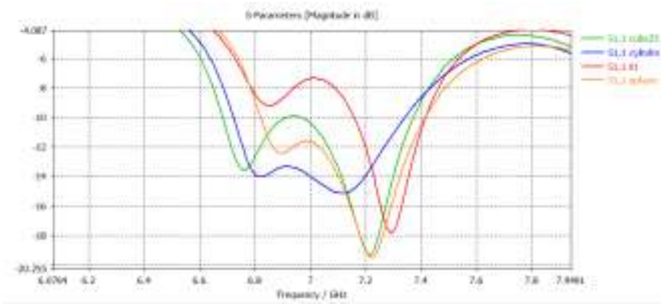

Figure .11 Zoomed of S11 simulation result for the Triangles Sierpinsky carpet for fr =6.1 GHz to 7.8 GHz

Figure .12 and Figure .13 present the curves of parameter S11 of carpet antenna Sierpinsky it2 carpet and the different objects according to the frequency, according to the two figures, it is clearly noticed that there is a change and a difference between the four curves, then we can say that our fractal is well detected the change of the objects.

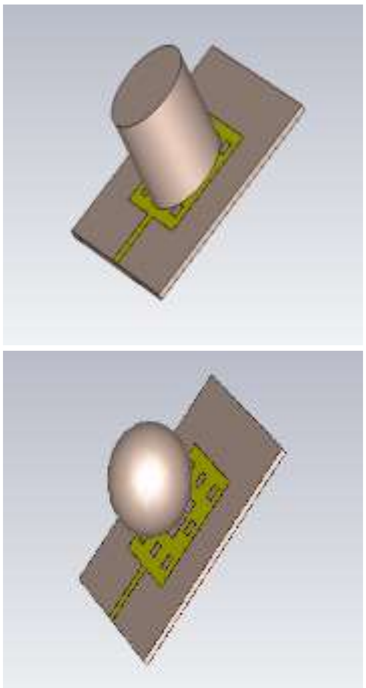

Figure .12 object detection by Sierpinsky it2 carpet

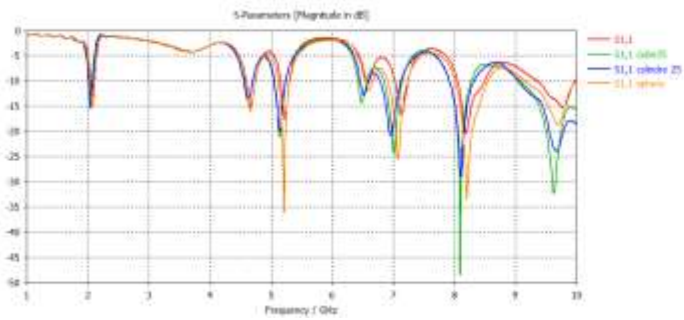

Figure .13 S11 simulation result for the 2nd Iteration

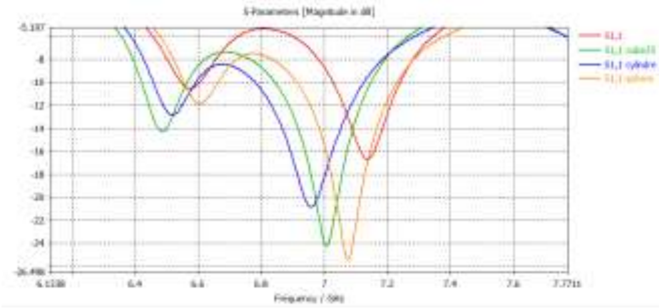

Figure .14 Zoomed of S11 simulation result for the 2nd Iteration for fr =6.1 GHz to 7.8 GHz

The curves figure .10 and figure .13, present the result of CST simulation of detections of the various objects, it is noted that the curves S11 according to the frequency of each object compared with the Sierpinsky antenna. the Triangles Sierpinski fractal antenna has emerged as a remarkable technology in its capacity to effectively control and detect changes in object forms. This achievement holds great promise for making significant contributions to the field of artificial intelligence.

4 Conclusion

In the article, we delved into the simulation aspect of fractal antennas using CST software, focusing on simulating a fractal antenna based on the Sierpinski carpet. The outcomes yielded positive results; all antennas successfully detected changes in the objects. However, the triangles Sierpinski carpet antenna stood out with notably clearer results compared to the other antennas. This distinction became evident due to a significant difference observed among the four curves generated by this particular antenna. The antenna's ability to precisely monitor and respond to alterations in object shapes is poised to revolutionize various applications within AI, from object recognition to robotics and beyond. As we continue to explore and harness the potential of this antenna, we anticipate exciting developments that will drive forward the capabilities and sophistication of artificial intelligence systems, ultimately ushering in a new era of innovation and practicality in this dynamic field.

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Conflict of Interest

The author has no conflict of interest to declare that is relevant to the content of this article.