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A Review on Microstrip Antenna Optimization using Bio-Inspired Optimization Techniques

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Abstract: Soft computing techniques like neural network, genetic and other optimization techniques proved to be an effective way to solve the problem of getting optimum value of antenna parameters for a particular frequency band. It provides a solution for high dimension problems with multiple local optima. Parameters like gain, return loss and directivity are optimized for a microstrip antenna. This paper highlights the implementation of neural network and other bio-inspired optimization techniques like Particle –Swarm Optimization (PSO), Differential Evolution (DE) Techniques and Genetic Algorithm on Microstrip antenna Dimensions which results in better Performance.

Index Terms: Optimization, Particle Swarm Optimization (PSO), Genetic Algorithm (GA), Differential Evolution (DE), Biogeographic – Based Optimization (BBO).

I. INTRODUCTION

The continuous use of antenna in wireless communication systems has led to increased constraints in terms of its cost, size, gain, polarization, reconfigurability and may more performance parameters. Typically antennas are designed based on the theoretical calculations and then simulated on various simulators to achieve desired goals. Therefore, in order to meet these challenges a novel antenna design solutions and strategies are made that includes amalgamation of existing full-wave electromagnetic solvers with different optimization schemes. Broadly defining, optimization is the process of adjusting a set of pertinent input parameters to characterize a device, a mathematical process, or an experiment with the objective to find the minimum or maximum desired output quantities [1].

The input typically consists of parameters; the process or function is known as the cost function, objective function, or fitness function; and the output is the cost or fitness.

The optimization schemes can be classified into local and global optimization techniques.

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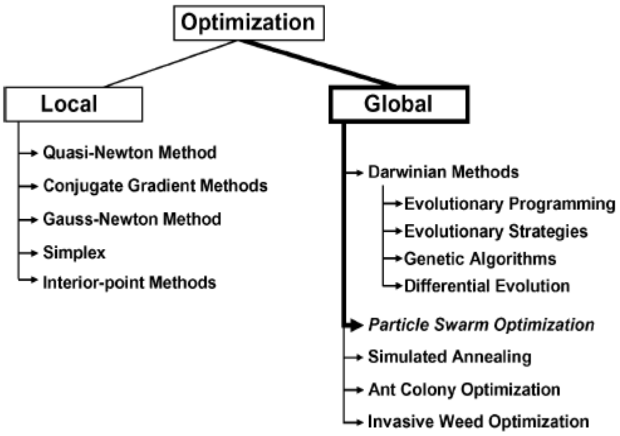

Figure 1 Classification of Optimization Techniques [1]

II. ANTENNA DESIGN USING VARIOUS OPTIMIZATION TECHNIQUES

Various Optimization techniques have been implemented for Microstrip antenna designing either simple or complex structure or algorithm is then coupled with electromagnetic simulation softwares like HFSS or IE3D. An aperture Coupled Microstrip antenna with parametric dimensions is chosen for implementing GA,PSO and DE algorithms.Various parameters like patch length (a), patch width (b), slot length (La) and slot width (Wa), width of microstrip line (W) and open stub length (Ls) are to be optimized for impedance matching over a specified range of frequencies (in this case 5.5-5.7 GHz). The substrate height and dielectric constant are chosen as 1.57 mm and 2.4 respectively [2].

The algorithms are implemented on MATLAB .The optimization algorithms are supposed to generate the dimensions of the aperture coupled patch antenna for optimum matching over the given frequency band .The fitness or cost of each solution in any generation of an optimization algorithm is evaluated by exporting the data from MATLAB to Method of Moments based Electromagnetic simulation software IE3D and then simulating the antenna structure [2].

Different set of optimal values for patch length, patch width, slot length, slot width, width of microstrip line and open stub length are obtained by 3 different optimization schemes. There is very less significant differences between the values of a, b, La and Wa as obtained from the three optimization schemes but major differences can be observes in the stub parameters (W and Ls) which results in the impedance matching quality varies among the three schemes.

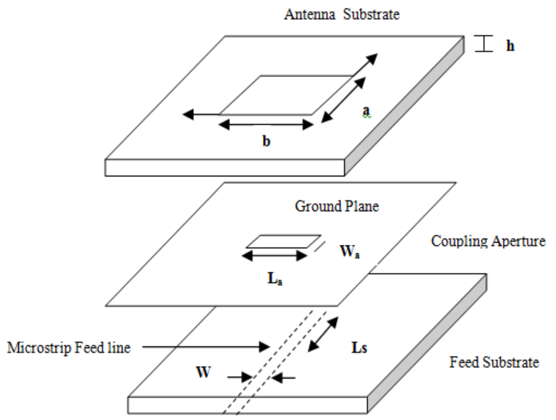

Figure 2 Aperture Coupled Microstrip Antenna

Parameters	GA	PSO	DE
a(mm)	14.10	13.86	14.47
b(mm)	19.89	18.78	19.97
L_a(mm)	7.23	7.02	6.69
W_a(mm)	6.74	6.72	8.23
W(mm)	1.77	3.45	3.59
L_s(mm)	4.6	2.97	5.82
Best Fitness Value	10.05	5.80	4.60

Table 1 Values Obtained from the Three Algorithms [1]

It is found from the comparative analysis of these three Optimization Techniques that Impedance matching as obtained in case of DE is far better compared to those in case of GA and PSO. The return loss plots obtained using the optimal parameter values as obtained from DE, PSO and GA are shown in Figure 3. Although the bandwidth is maximum for GA, its impedance matching quality is poorest among the three. On the other hand, in the case DE the impedance matching quality is the best but bandwidth is marginally less than the other two cases.

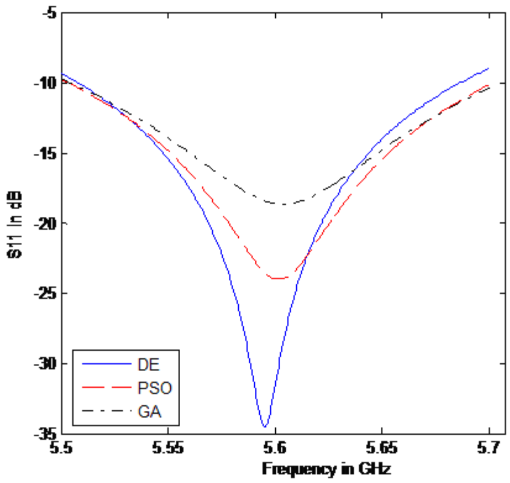

Figure3 Comparison of Return Loss for DE, GA and PSO [2]

III. BIOGEOGRAPHIC BASED OPTIMIZATION TECHNIQUE

Biogeographic Based Optimization (BBO) Technique is a new bio-inspired and population based optimization algorithm for global optimization. BBO has features in common with other biology-based optimization methods, such as GAs and particle swarm optimization (PSO). This makes BBO applicable to many of the same types of problems that GAs and PSO are used for, namely, high-dimension problems with multiple local optima.

Mathematical models of biogeography describe how species migrate from one island to another, how new species arise, and how species become extinct. The term "**island**" here is used descriptively rather than literally. That is, an island is any habitat that is geographically isolated from other habitats. Geographical areas that are well suited as residences for biological species are said to have a high **habitat suitability index (HSI)**.

The variables that characterize habitability are called **suitability index variables (SIVs)**. SIVs can be considered the independent variables of the habitat, and HSI can be considered the dependent variable.Habitats with a high HSI tend to have a large number of species, while those with a low HSI have a small number of species. Habitats with a high HSI have many species that **emigrate** to nearby habitats [3].

A comparative analysis between several convention methods and BBO is shown for a Rectangular Microstrip Antenna for calculating accurate resonant frequency. Initializing parameters for BBO has been set and algorithm is implemented for various set of dimensions of antenna as Patch Length (L), Patch Width (W), height of substrate (h) and Dielectric constant (ε_r).Results for various resonant frequency (f_{rm}) and antenna dimensions for microstrip antenna obtained from conventional method and BBO is highlighted in the paper [4]. Results for resonant frequency obtained from conventional method in comparison with the resonant frequency obtained from BBO is as shown in Table 2.

Patch No.	L (Cm)	W (Cm)	ε_r	h (Cm)	f_{rm} (MHz) using conventional method	f_{rm} (MHz) using BBO
1	1.185	0.790	2.22	0.017	8450	8435.6
2	2.500	2.000	2.22	0.079	3970	3970.8
3	1.183	1.063	2.22	0.079	7730	7722.8
4	1.000	0.910	2.22	0.127	4600	4601.8
5	1.860	1.720	2.33	0.157	5060	5057.4
6	1.412	1.337	2.55	0.200	6200	6204.2
7	1.200	1.120	2.55	0.242	7050	7058.5
8	1.485	1.403	2.55	0.252	5800	5800.9
9	1.630	1.530	2.5	0.300	5270	5273.1
10	1.280	1.170	2.8	0.300	6570	6569.3
11	1.080	0.776	2.55	0.330	8000	7994.4
12	1.018	0.905	2.5	0.300	7990	7983.5

Table 2 Results for Resonant Frequency and Dimensions of Rectangular Microstrip Antenna [4]

IV. CONCLUSION

From different reviewed papers, it is concluded that Bioinspired optimization techniques provide a new approach towards antenna designing even taking concern of its complexity. Overall, optimization plays a paramount role in the present and future designs of antennas to meet the ever demanding needs of wireless communication systems.

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