AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Application of Optimization Techniques to Antennas

A thesis submitted in partial fulfillment of the requirements of the degree of

Master of Science in Engineering Mathematics and Physics and Engineering Mechanics (Engineering Mathematics)

by

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Bachelor of Science in Electrical Engineering

Faculty of Engineering – German University in Cairo - 2012

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(ii) due acknowledgement has been made in the text to all other material used.

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Abstract

"Application of Optimization Techniques to Antennas"

In recent years, modern wireless communication systems and information transfer have highlighted the major need for antenna design advancements as an essential part of any wireless system. Microstrip patch antenna fulfills the desired wireless systems' necessities. These antennas have triggered extensive research due to their significant advantages which includes compact size, low profile, light weight, low volume, relatively low manufacturing cost, ease of fabrication, and compatibility with integrated circuits. Microstrip patch antennas have led to diversified applications utilizing microwave systems such as biomedical systems, radars, mobile, satellite communications, and global positioning satellite (GPS).

The main aim of this thesis is utilizing evolutionary algorithms to design a low profile and efficient antenna which can be attained in the antenna design construction to meet the extensive emerging applications in wireless communication systems. Evolutionary algorithms have emerged as a promising solution to optimize some designs of microstrip antenna seeking an efficient performance in addition to compromising competing goals simultaneously. Two distinct design geometries have been implemented in the scope of this research.

Evolutionary algorithms are applied to cross aperture coupled circularly polarized microstrip antenna which is designed to attain a low axial ratio over a wide bandwidth and optimal impedance matching. The microstrip antenna is designed. A 50Ω microstrip feed line is used. A software simulation program (CST microwave studio) is used to compare the performance of the antenna in terms of return loss and axial ratio with evolutionary algorithms. Two distinct evolutionary algorithms; Particle Swarm Optimization (PSO) and Genetic Algorithm (GA) have been utilized in the fitness function optimization to ensure optimal axial ratio and impedance matching. The optimal patch dimensions, the aperture length, and the microstrip feed line length are obtained from both methods and their performances are compared. Moreover, the antenna is fabricated and the network analyzer is used for measuring the return loss. A

comparative analysis is carried out demonstrating a high agreement between measured and simulated return loss.

Moreover, the artificial neural networks (ANNs) is employed in WiFi antenna design and modeling where ANN is used to predict the antenna characteristics to be compatible with the demand of wireless communication devices. The ANN is favored over other modeling techniques as it models non-linear relationships between the antenna input and output, needs less computation time compared to computer aided designs that use numerical methods intensively as well as reduction of mathematical computational complexties. Thus, the ANN is employed to model the antenna design parameters. This is attained by the use of ANN toolbox with the aid of MATLAB.

The ANN prior training data set is provided by CST simulator. The ANN is trained using Feed Forward Back propagation algorithm by adjusting the weights to model the particular learning task. The feed forward and back propagation is repeated until the error is minimal enough. Finally, the antenna is analyzed and verified against manifuctured antenna achieving compatiable results.

Keywords: Microstrip Antenna, Particle Swarm Optimization, Genetic Algorithm, Artificial Neural Networks, WiFi Antenna.

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Notation

Abbreviation	Description
GPS	Global Positioning Satellite
PSO	Particle Swarm Optimization
GA	Genetic Algorithm
ANNs	Artificial Neural Networks
MPA	Microstrip Patch Antenna
VOP	Vector Optimization Problem
CI	Computational Intelligence
pbest	Personal best
gbest	Global best
BP	Back Propagation
ABC	Artificial Bee Colony
DE	Differential Evolution
RFID	Radio Frequency Identification
ACO	Ant Colony Optimization
LM	Levenberg-Marquart
MSE	Mean Square Error
MLP	Multilayer Perceptron
FFBP	Feed-Forward Back-Propagation