

# Recent Advances in Evolutionary Optimization Techniques in Applied Electromagnetics

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**Abstract**— This presentation will focus on: **(a)** a tutorial introduction to GA, PSO and CMA-ES by describing in a novel fashion the underlying concepts and recent advances for those who have used these techniques and for those who have not had any experiences in these areas, **(b)** a unique approach in performing fundamental comparative studies among these algorithms, **(c)** demonstration of the potential applications of these algorithms to a variety of electromagnetic and antenna designs, and **(d)** assessment of the advantages and the limitations of these techniques.

## I. INTRODUCTION

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 finding the minimum or maximum desired output quantities as depicted in Fig. 1. The input typically consists of parameters; the process or function is known as the cost function, the objective function, or fitness function, and the output is the cost or fitness.



Fig. 1. Optimization adjusts the pertinent input parameters in order to either minimize or maximize the desired output quantities of interest.

There are clearly many different optimization methods applicable to variety of applications. Due to their unique properties as global optimization algorithms nature-inspired optimization techniques have been at the forefront of research within

applied electromagnetic community. The ever increasing advances in computational power have additionally fuelled this temptation. The well-known brute force design methodologies are systematically being replaced by the state-of-the-art Evolutionary Optimization (EO) techniques. In recent years, EO techniques are finding growing applications to the design of all kind of systems with increasing complexity. These algorithms are stochastic techniques which direct the optimizer towards the most likely position based on previously tested points. Some of the paramount features of these algorithms are list in Fig. 2.

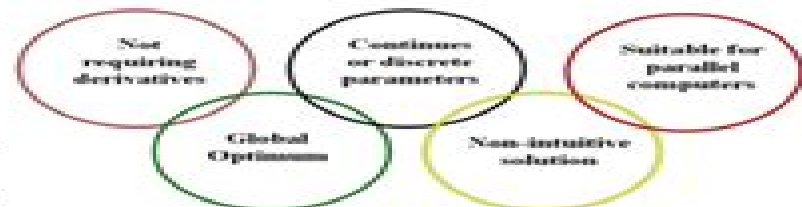


Fig. 2. Winning features of evolutionary optimization techniques.

Among various EO's, nature inspired techniques such as Genetic Algorithms (GA), Particle Swarm Optimization (PSO) and the Covariance Matrix Adaptation (CMA) Evolution Strategies (ES) have attracted considerable attention. GA utilizes an optimization methodology which allows a global search of the cost surface via the mechanism of the statistical random processes dictated by the Darwinian evolutionary concept (adaptation, selection, survivability and mutation). PSO is a robust stochastic evolutionary computation technique based on the movement and intelligence

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