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Anyong Qing and Ching Kwang Lee

Differential Evolution in Electromagnetics

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Preface

1 Motivations

After many years of development and applications, differential evolution has proven itself a very simple while very powerful stochastic global optimizer. Since its inception, it has been applied to solve problems in many scientific and engineering fields.

Nowadays, our daily life relies heavily on electromagnetics. Differential evolution has played an essential role in many synthesis and design problems in electromagnetics. This book focuses on applications of differential evolution in electromagnetics to showcase the achievement of differential evolution and further boost its acceptance in electromagnetics community.

2 Layout

This book is composed of two parts. Part one includes the first three chapters while the remaining five chapters belong to part two of this book.

2.1 Part One

This part focuses on a literature survey on differential evolution. As far as we know, it is by far the most extensive and exhaustive one.

2.1.1 Chapter 1

Chapter 1 gives details of the literature survey which covers publication collection, refining and analysis. It opens up with the purposes this literature survey aims to serve. Next, Platforms over which the literature survey is actually conducted are then discussed. Initial statistical results over these platforms are presented. After that, the refining process to remove irrelevant publications is discussed. Yearly outputs of formal publications with and without refining are presented. Result analysis, or publication classification, is then discussed. Topics according to which collected publications are clustered are suggested. In particular, theoretical studies on differential evolution are summarized. Finally, some future actions are discussed.

We have noticed several misconceptions and misconducts on differential evolution through this literature survey. They are clearly pointed out at the end of this chapter.

2.1.2 Chapter 2

Basics of differential evolution are presented in Chapter 2. It also serves the second part of this book so that repetition of description of differential evolution is avoided.

A short history of differential evolution is first discussed. It covers its inception, early years until 1998 and years from 1998 onwards. Major events in early years and key milestones in years from 1998 onwards are highlighted. The basic framework of differential evolution is then explained by revisiting the originators' inventory publication, followed by a description of the more generic classic differential evolution. Some prominent variants of the two fundamental evolutionary operations in differential evolution are presented. Next, dynamic differential evolution which was misunderstood and seriously underestimated before is briefly mentioned. Finally, essential features of differential evolution including both advantages and disadvantages are highlighted.

It has to be pointed out that a state of the art review of differential evolution is not presented in this book due to tight time limit. Such a review will be part of a forming up encyclopedia of differential evolution.

2.1.3 Chapter 3

A retrospection of applications of differential evolution in electromagnetics in and before 2008 is presented in this Chapter. The coverage of the retrospection is clearly specified right at the beginning of this Chapter. The pioneering works of applications of differential evolution in electromagnetics are highlighted. Statistical results by both publication year and subject are presented. Detailed discussion of applications of differential evolution in specific subject is then given. Involved subjects include electromagnetic inverse problems, antenna arrays, microwave & RF engineering, antennas, electromagnetic structures, electromagnetic composite materials, frequency planning, radio network design, MIMO, radar, computational electromagnetics and electromagnetic compatibility. An outlook of applications of differential evolution in electromagnetics is also presented at the end of this Chapter.

2.2 Part Two

This part presents five new applications of differential evolution in differential evolution by different research groups.

2.2.1 Chapter 4

Reconstruction of two-dimensional dielectric cylinders by using differential evolution is presented in this Chapter. The efficiency of differential evolution has been numerically shown through various examples.

In addition, the impact of initial guess on differential evolution is presented. The multiple signal classification is used to determine the number of cylinders, their approximate centers and approximate geometric dimensions while a least squares based method is used to generate an estimate of the permittivity of the cylinders. It has been shown that a proper choice of the initial guess can speed up the convergence of the optimization significantly.

2.2.2 Chapter 5

Inspection of penetrable objects by using differential evolution together with a recently proposed iterative multiscaling approach is discussed in this Chapter. The solving procedure starts from a fixed test area and successively focuses on one or more "regions of interest" in order to determine the approximate shapes of the unknown objects. At each step of the minimization process, differential evolution is used to retrieve this support by minimizing a proper functional, which relates the measured scattered field data to the data numerically produced, at any iteration, by the current solution. Several new results are included concerning the reconstruction of inhomogeneous targets under various imaging conditions. The combined strategy has been proved to be quite effective in reconstructing complex dielectric cylinders such as hollow and E-shape cylinders in noisy environment.

2.2.3 Chapter 6

In this Chapter a flexible method for prediction of far-field radiated emissions is presented. It is a promising computational alternative to the expensive large semi-anechoic chambers necessary to perform electromagnetic compatibility far-field radiated emission measurements.

In this method, the equipment under test is replaced by an equivalent set of infinitesimal dipoles (both electric and magnetic) distributed inside the volume occupied by the equipment under test which is determined from near-field measurements at a short distance of the equipment under test. A memetic metaheuristic technique combing genetic algorithms, differential evolution and downhill simplex method is used to determine the type, position, orientation and excitation current of each dipole of the equivalent set of dipoles. The information obtained from the equivalent dipole set is used to determine the radiation at the far-field, as well as to identify the radiating parts of the equipment.

2.2.4 Chapter 7

Differential evolution with Pareto tournaments (DEPT) was applied to address the multi-objective optimization of frequency assignment problem in two real-world GSM networks in this Chapter. Two performance indicators, hypervolume and coverage relation, are implemented to analyze results. Results are compared with those by other multi-objective metaheuristics. Final results show that fine-tuned DEPT outperforms both MO-VNS and MO-SVNS while performs worse than both GMO-SVNS and GMO-VNS, among which GMO-SVNS performs best.

2.2.5 Chapter 8

In this Chapter, differential evolution is combined with particle swarm optimization (PSO) and another evolutionary algorithm (EA) to create a novel hybrid algorithm, the PSO-EA-DEPSO. The alteration between PSO, PSO-EA, and DEPSO provides additional diversity to counteract premature convergence. This hybrid algorithm is then shown to outperform PSO, PSO-EA, and DEPSO when applied to wireless MIMO channel prediction.

3 Readership

As its name indicates, this book is specially prepared for electromagnetic researchers facing optimization problems. It will be particularly attractive to researchers who have been frustrated by other optimization algorithms.

This book is a premium resource for differential evolution community. People in this community will have a better understanding on differential evolution and its huge application potential.

This book is also an ideal resource for evolutionary computation community. People in this community may find it helpful in presenting a more appropriate approach to conduct concerned literature survey and providing real engineering application examples.

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