Gaussian Artificial Bee Colony Algorithm Approach Applied to Loney's Solenoid Benchmark Problem

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Abstract— Optimization metaheuristics, such as particle swarm optimization, ant colony and bacterial foraging strategies have become very popular for electromagnetic device design. The Artificial Bee Colony algorithm is another example of bio-inspired swarm intelligence approach which is competitive with other population-based algorithms and has the advantage of using fewer control parameters. In this work, a standard and an improved version of the algorithm are applied to Loney's solenoid problem, showing the suitability for electromagnetic optimization.

I. Introduction

A typical example of the rough objective function surface typical of many electromagnetic problems is shown by Loney's solenoid benchmark problem [1]. Such problems are ideally suited for stochastic techniques which escape from local minima.

The Artificial Bee Colony (ABC) algorithm is a new stochastic population-based metaheuristic approach originally proposed by Karaboga [2],[3]. The method is inspired by the intelligent foraging behavior of honeybee swarms and due to its simplicity, robustness and ease of implementation appears to be very promising.

This paper proposes an improved version of ABC called Gaussian ABC (GABC) to solve Loney's solenoid benchmark problem and its performance is compared with that of the classical ABC.

II. Fundamentals of the ABC Algorithm

In the ABC algorithm the colony of artificial bees contains three groups of individuals: employed bees (placed randomly in the food source), onlookers (waiting in the dancing area for making decision on which food sources to be chosen) and scouts (performing random search).

A poor balance between exploration and exploitation may result in a weak optimization method which may suffer from premature convergence, trapping in a local optima, and stagnation.

In the classical ABC a uniform distribution is used to produce a candidate food position from the old one in memory, while the proposed GABC efficiently combines exploitative local search and explorative global search processes by a mix of Gaussian and uniform distributions.

III. Loney's Solenoid Design

Loney's solenoid design problem consists in determining the position and size of two correcting coils in order to generate a uniform magnetic flux density B within a given interval on the axis of a main solenoid. The problem has two degrees of freedom (the separation s and the length l of the correcting coils) with box bounds. The objective function F has three distinct basins of attraction: $F > 4\cdot10^{-8}$ (high level region), $3\cdot10^{-8} < F < 4\cdot10^{-8}$ (low level region), and $F < 3\cdot10^{-8}$ (global minimum region) [4]. The control parameters of ABC and GABC were a colony size of 10 (number of employed bees plus number of onlooker bees) and a stopping criterion of 120 iterations, i.e. both approaches performed 1,200 objective function evaluations in each run. Table I shows the results over 30 runs, where p is the probability of adopting a truncated Gaussian distribution instead of the uniform one.

TABLE I
SIMULATION RESULTS OF F IN 30 RUNS

Optimization Method	$F(s, l)\cdot10^{-8}$			
	Maximum (Worst)	Mean	Minimum (Best)	Std. Dev.
ABC	12.9079	4.4730	3.1714	1.7350
GABC(p=0.1)	14.3622	4.4412	2.3255	2.0717
GABC(p=0.2)	31.5616	5.5583	2.3518	6.0964
GABC(p=0.3)	10.0411	4.4234	2.6713	1.3947
GABC(p=0.4)	11.3620	4.8194	2.5895	1.8954
GABC(p=0.5)	71.6379	7.1162	2.7847	12.8822
GABC(p=0.6)	**8.8187**	**4.3204**	**2.1389**	**1.2294**
GABC(p=0.7)	90.1864	7.8573	2.3705	16.0761
GABC(p=0.8)	121.4797	11.280	3.2370	21.8866
GABC(p=0.9)	45.3149	7.9055	3.1588	8.3816
GABC(p=1.0)	44.1409	5.9651	2.6492	7.4684

IV. Conclusion

This paper proposes an extension of the standard ABC algorithm with the aim of improving the balance between exploration and exploitation of the search space. Preliminary results show that such improvement is indeed possible. Deails of the algorithm will be presented in the full paper.

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