A Modified Migration Model Biogeography Evolutionary Approach for Electromagnetic Device Multiobjective Optimization

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Abstract— In this paper, we present an efficient and robust algorithm for multiobjective optimization of electromagnetic devices. The recently developed biogeography-based optimization (BBO) is modified by adapting its migration model function so as to improve its convergence. The proposed Modified Migration Model biogeography-based optimization (MMMBBO) algorithm is applied into the optimal geometrical design of an electromagnetic actuator. This multiobjective optimization problem is solved by maximizing the output force as well as minimizing the total weight of the actuator. The comparison between the optimization results using BBO and MMMBBO shows the superiority of the proposed approach.

***Index Terms*— Actuator, biogeography-based optimization, electromagnetic device, evolutionary computation.**

I. INTRODUCTION

In last decades, several evolutionary algorithms (EAs) have been utilized for the optimization of electromagnetic devices, such as genetic algorithm, etc. Recently, a biogeography-based optimization (BBO) technique has been presented as an alternative global heuristic algorithm [1], which emulates the geographical distribution of biological organisms. In fact, BBO is based on the migration of species across habitats [2]. In the BBO model, problem solutions are represented as islands, and the sharing of features between solutions is represented as immigration and emigration between the islands. In BBO algorithm, habitats and habitat suitability index (HSI) are respectively the analogous to the problem solution and fitness in other EAs. Migration in BBO is reciprocal which means there is both immigration and emigration between habitats. Their respective rates, λ and μ, are determined using the HSI of a habitat; a habitat with a high HSI has a low immigration rate and consequently a high emigration rate, and vise versa. The migration rates are directly related to the number of species (S) in a habitat. This migration process increases the diversity of the habitat and contributes for species information sharing and the mutation probability. These concepts are used in the BBO algorithm to find the optimal solution. The immigration and emigration rates are calculated respectively using $\mu_s = \left(ES/S_{\max}\right)$, and $\lambda_s = I\left(1-\left(S/S_{\max}\right)\right)$, where E and I are the maximum rate of emigration and immigration. $S_{\max}$ is the largest possible number of species.

II. MODIFIED MIGRATION MODEL BIOGEOGRAPHY-BASED OPTIMIZATION

In the BBO algorithm, there are two main operators: migration and mutation. The selection of the optimal solution is fundamentally based on immigration and emigration rates [3]. Consequently, in this paper, we propose a new formulation for the migration model that describes immigration and emigration rates in order to improve the convergence performance for the optimization problems, for example $\mu_s = \left(ES^n/S_{\max}\right)$, where ($n$) controls the convergence of the optimal solution. The BBO and MMMBBO are used to for the optimal geometrical design of an electromagnetic actuator, see [4]. The multiobjective optimization problem is formulated to maximize the output force and to minimize the total weight.

III. PRELIMINARY RESULTS

The BBO and MMMBBO have been successfully applied into our electromagnetic application, which is modeled using 2D finite element method. Fig. 1 shows a comparison between the convergence history of the BBO and MMMBBO. The fitness values for both approaches are given in the caption. In the full paper, we present the complete algorithm with the mathematical impact of the proposed modification. Comparison with other EAs will be provided.

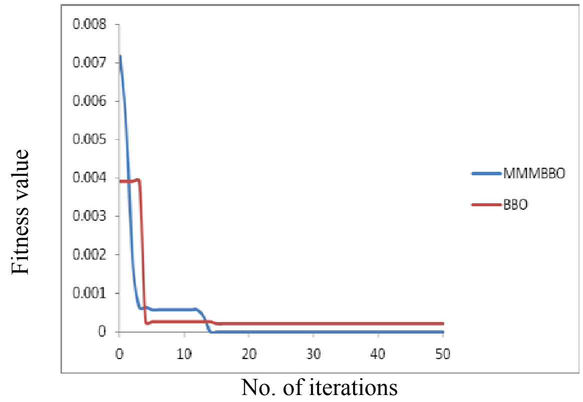

Fig. 1. The comparison between the convergence history of the BBO and MMMBBO (n = 6). The fitness values of the BBO and MMMBBO are 2.06e^{-4} and 1.417e^{-8}, respectively.

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