Flower Pollination Algorithm for Global Optimization

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Abstract. Flower pollination is an intriguing process in the natural world. Its evolutionary characteristics can be used to design new optimization algorithms. In this paper, we propose a new algorithm, namely, flower pollination algorithm, inspired by the pollination process of flowers. We first use ten test functions to validate the new algorithm, and compare its performance with genetic algorithms and particle swarm optimization. Our simulation results show the flower algorithm is more efficient than both GA and PSO. We also use the flower algorithm to solve a nonlinear design benchmark, which shows the convergence rate is almost exponential.

1 Introduction

Nature has been solving challenging problems over millions and billions of years, and many biological systems have evolved with intriguing and surprising efficiency in maximizing their evolutionary objectives such as reproduction. Based on the successfully characteristics of biological systems, many nature-inspired algorithms have been developed over the last few decades [18,20]. For example, genetic algorithms were based on the Darwinian evolution of biological systems [9] and particle swarm optimization was based on the swarm behaviour of birds and fish [11,12], which bat algorithm was based on the echolocation behaviour of microbats [21] and firefly algorithm was based on the flashing light patterns of tropic fireflies [18,19]. All these algorithms have been applied to a wide range of applications.

In many design applications in engineering and industry, we have to try to find the optimal solution to a given problem under highly complex constraints. Such constrained optimization problems are often highly nonlinear, to find the optimal solutions is often a very challenging task if it is not impossible. Most conventional optimization do not work well for problems with nonlinearity and multimodality. Current trend is to use nature-inspired metaheuristic algorithms to tackle such difficult problems, and it has been shown that metaheuristics are surprisingly very efficient. For this reason, the literature of metaheuristics has expanded tremendously in the last two decades [18,20]. Up to now, researchers have only use a very limited characateristics inspired by nature, and there is room for more algorithm development.

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In this paper, we will propose a new algorithm based on the flower pollination process of flowering plants. We will first briefly review the main characteristics of flower pollination, and thus idealize these characteristics into four rules. We will then use them to develop a flower pollination algorithm (FPA), or the flower algorithm. Then, we validate it using a set of well-known test functions and design benchmark. We analyze the simulations and make comparison of its performance with genetic algorithm and particle swarm optimization. Finally, we discuss further topics for extending this algorithm.

From the biological evolution point of view, the objective of the flower pollination is the survival of the fittest and the optimal reproduction of plants in terms of numbers as well as most fittest. This is in fact an optimization process of plant species. All the above factors and processes of flower pollination interact so as to achieve optimal reproduction of the flowering plants. Therefore, this can inspire to design new optimization algorithm. The basic idea of flower pollination in the context of bees and clustering was investigated before [10], but in this paper, we will design a completely new optimization solely based on the flower pollination characteristics.

2 Characteristics of Flower Pollination

It is estimated that there are over a quarter of a million types of flowering plants in Nature and that about 80% of all plant species are flowering species. It still remains partly a mystery how flowering plants came to dominate the landscape from Cretaceous period [16,22]. Flowering plant has been evolving for more than 125 million years and flowers have become so influential in evolution, we cannot image how the plant world would be without flowers. The main purpose of a a flower is ultimately reproduction via pollination. Flower pollination is typically associated with the transfer of pollen, and such transfer is often linked with pollinators such as insects, birds, bats and other animals. In fact, some flowers and insects have co-evolved into a very specialized flower-pollinator partnership. For example, some flowers can only attract and can only depend on a specific species of insects for successful pollination [7].

Pollination can take two major forms: abiotic and biotic. About 90% of flowering plants belong to biotic pollination, that is, pollen is transferred by a pollinator such as insects and animals. About 10% of pollination takes abiotic form which does not require any pollinators. Wind and diffusion in water help pollination of such flowering plants and grass is a good example [14,7]. Pollinators, or sometimes called pollen vectors, can be very diverse. It is estimate there are at least 200,000 variety of pollinators such as insects, bats and birds.

Honeybees are a good example of pollinator, and they can also developed the so-called flower constancy [3]. That is, these pollinators tend to visit exclusive certain flower species while bypassing other flower species. Such flower constancy may have evolutionary advantages because this will maximize the transfer of flower pollen to the same or conspecific plants, and thus maximizing the reproduction of the same flower species. Such flower constancy may be advantageous