A Metaheuristic Optimization Algorithm Inspired by the Effect of Sunlight on the Leaf Germination

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ABSTRACT

This paper develops a nature-inspired metaheuristic algorithm named sun and leaf optimization (SLO) which is inspired by the effect of sunlight on the leaves germination. In SLO, candidate solutions in the state space are considered as leaves grown on a tree, and high-quality solutions are considered as greener leaves germinated in the direction of sunlight. On a tree, usually greener leaves are found closed to each other, because such area is probably exposed more to the sun and hence it is suitable for hosting other greener leaves. Inspired by this phenomenon, in SLO, during the search, the authors take the existence of high quality solutions as a sign of promising areas for finding optimum; thus, they generate more candidate solutions near the higher quality solutions to search those areas more painstakingly. Wind effect is imitated to escape the local optima. The evaluation results demonstrate the high performance of proposed algorithm.

KEYWORDS

Leaf Germination, Metaheuristic Optimization Algorithms, Nature Inspiration, Sunlight

1. INTRODUCTION

Optimization problems are addressed in different fields such as engineering design, production systems, economics, etc., and hence there is the need for efficient computational algorithms which can effectively solve optimization problems (El-Nasser, Said, Mahmoud, & El-Horbaty, 2014). One group of efficient optimization algorithms are those inspired by nature which fall into the category of metaheuristic algorithms (Yang, 2010). Nature, here, refers to each part of the physical world which is not intentionally designed by man (Chiong, 2009). In fact, to design such algorithms, we find some similarities between our optimization problems and the problems existing in nature. Afterwards, we investigate how nature solves its problems. This metaphor helps us to reflect upon new methods to solve our own problems. If we ponder our problems based on such metaphors, our mind will be much flexible in seeking the solution (Chiong, 2009).

Nature-inspired algorithms, like other metaheuristic algorithms, reduce the computational time at the cost of reducing the quality (Yang, 2010). These algorithms have been very popular in recent years, because many of the optimization problems existing in the real world are large, complicated and dynamic. To solve such problems, one must use methods which can find acceptable solutions
within a reasonable time (Chiong, 2009). Therefore, in recent years different optimization algorithms have been inspired by nature. Examples include genetic algorithm (Holland, 1975), ant colony algorithm (Dorigo, 1992), particle swarm optimization algorithm (Kennedy & Eberhart, 1995), honey bee algorithm (Nakrani & Tovey, 2004; Pham, Ghanbarzadeh, Koc, Otir, Rahim, & Zaidi, 2005; Karaboga, 2005), firefly algorithm (Yang, 2008), cuckoo search algorithm (Yang & Deb, 2009), bat-inspired algorithm (Yang, 2010), bacterial foraging optimization algorithm (Passino, 2010), and penguins search optimization algorithm (Gheraibia & Moussaoui, 2013). These algorithms have been successfully used to solve many optimization problems (Zhang & Wong, 2015; Gebreslassie & Diwekar, 2015; Wanga, Luob, & Waltera, 2015; Wanga, Luob, & Waltera, 2015; Forsatia, Keikhab, & Shamsfar, 2015; Massana, Waganb, Shaikhc, & Abrod, 2015; Dasguptaa & Das, 2015; Hasançebia & Carbasb, 2014; Tana & Lina, 2015; Golkar, Amnieh & Kaedi, 2015; Shamaei & Kaedi, 2016).

In this paper, a new algorithm is developed for solving optimization problems. This algorithm has gained inspiration from the effect of sunlight during the germination and growth of tree leaves. In the rest of paper, first the effect of sunlight on the germination of leaves is discussed. Afterwards, the developed algorithm named sun and leaf optimization (SLO) is presented. Next, the SLO algorithm is used to solve three standard benchmark problems and the results of the algorithm are compared to those of some other metaheuristic algorithms. Finally, some conclusions are drawn.

2. SUNLIGHT AND ITS EFFECT ON TREE LEAF DENSITY

One of the important factors influencing the growth of trees is sunlight. Trees which are exposed to direct sunlight have leafier branches and greener leaves. Besides, the side of tree which has more contact with the sunlight is leafier than the other side. For example, in the northern hemisphere, the southward side of trees has more contact with the sunlight (Figure 1). Therefore, the southward side of the trees is leafier than the northward side (this is the opposite in the south hemisphere). This is used in geographical navigation. However, this navigation has errors and exceptions too, because other factors than sunlight may also affect the density of leaves on different parts of trees. For example, leaf density on the side exposed to wind blow is lower than that on the side safe from wind blow. Moreover, the presence of shade on trees (e.g. the shade of other trees in dense jungles) can also change the direction of leaf density in trees.

Figure 1. Sunlight orientation and the Earth
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