Simulated Kalman Filter: A Novel Estimation-based Metaheuristic Optimization Algorithm

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In this paper, a new population-based metaheuristic optimization algorithm, named Simulated Kalman Filter (SKF) is introduced. This new algorithm is inspired by the estimation capability of the Kalman Filter. In principle, state estimation problem is regarded as an optimization problem, and each agent in SKF acts as a Kalman Filter. An agent in the population finds solution to optimization problem using a standard Kalman Filter framework, which includes a simulated measurement process and a best-so-far solution as a reference. To evaluate the performance of the Simulated Kalman Filter algorithm, it is applied to 30 benchmark functions of CEC 2014 for real-parameter single objective optimization problems. Statistical analysis is then carried out to rank SKF results to those obtained by other metaheuristic algorithms. The experimental results show that the proposed SKF algorithm is a promising approach, and has a comparable performance to some well-known metaheuristic algorithms.

Keywords: Optimization, metaheuristics, Kalman, estimation.

1. INTRODUCTION

Optimization is often required in solving engineering problems. Exact optimization methods normally fail to solve complex nonlinear and multimodal problems that exist in most real world applications in reasonable computational time. Thus, metaheuristic optimization methods are often sought to solve these kind of problems. Although there exist many metaheuristics optimization methods developed to solve all kinds of optimization problems, there is always a possibility to develop new algorithm that would outperform other algorithms for some specific optimization problems[1].

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Metaheuristic algorithms are general algorithms that can be adapted into solving a wide range of optimization problems. Metaheuristic algorithms are mostly population-based. They rely on collection of agents to look for a near optimum solution within a reasonable computational effort. Metaheuristic algorithms are often sought because of their flexibility and the simplicity in their design and implementation[2]. Population-based metaheuristics algorithms normally have an iterative behaviour. Generally, this type of algorithm starts with the initialization of the population. Solutions of the initial population are then evaluated. Next, the algorithms iteratively generate a new population to replace the current population. During this step, the agents' search direction is defined. The way this step is performed differentiates an algorithm to another. The process will eventually stop when the stopping condition is met.

Several population-based metaheuristic algorithms have been developed over the past 20 years. Most of them are inspired by nature. Existing algorithms can be divided into four categories based on their source of inspiration[3]; bio-inspired swarm intelligence (SI) based, bio-inspired (non-SI) based, physics or chemistry based, and those that are not inspired by nature. Bio-inspired algorithms dominates the nature-inspired algorithms classification category. Among the famous and relatively new bio-inspired algorithms are Particle Swarm Optimization[4], Bee Colony Optimization[5], Cuckoo Search[6] and Firefly Algorithm[7]. All of them belongs to Swarm Intelligence based algorithm. There are also famous algorithms that belong to physics inspired algorithm such as Gravitational Search Algorithm[8] (GSA) and Black Hole[9] (BH) algorithm. GSA is a well-known population-based metaheuristic algorithm inspired by physical phenomenon of Newtonian gravity and motion. BH algorithm is another recent population-based metaheuristic algorithm inspired by physical phenomenon. BH algorithm gets its inspiration from the black hole phenomenon.

Some researchers are looking away from nature for their source of inspiration. One example of a non-nature inspired optimization algorithm is Heuristic Kalman Algorithm[10] (HKA) by Toscano and Lyonnet in 2009. This population-based optimization algorithm is based on Kalman estimation method. HKA uses an entirely different principle compared to other known stochastic optimization algorithm because it is intended to produce