An Archived firefly Algorithm; A mathematical software to solve univariate nonlinear equations

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Abstract - The future of optimization is now being conquered by modern meta-heuristic algorithms. Genetic algorithms, differential evolution, harmony search, firefly algorithm and cuckoo search are such meta-heuristic algorithms which have marked their success over many optimization tasks. Simplicity of the algorithm, less memory consumption and the accuracy of the approximations can be stated as the major reasons for their popularity. In this article, we are presenting a software solution that proposes some modifications to the existing firefly algorithm. The modification; archived firefly algorithm [AFFA] exhibits the ability of finding almost all the real and complex roots of a given nonlinear equation within a reasonable range. The software implementation includes two main properties; an archive to collect the better fireflies and a flag to determine poor performance in firefly generations. The new modification is tested over Genetic algorithms (GA), a phenomenal in the field of nature inspired algorithms and also with a modified GA embedded with same properties the AFFA has. A simple GUI is developed using Matlab GUIDE to present the findings. Computer simulations show that the AFFA performs well in solving nonlinear equations with real and complex roots within a specified region. The suggested method can be further extended to solve a given system of nonlinear equations.

Index Terms - Firefly Algorithm, Nonlinear Equations, Archive, Real Roots, Complex Roots.

I. INTRODUCTION

Optimization leads the world for finding the best from being better. Hence the computer scientists are looking forward for finding various approaches that can contribute towards optimization. Natural optimization techniques are among them and are becoming popular due to the long lasting existence of the real world such natural practices. Genetic algorithms; which have come to the stage around 1970 going along with the theory of evolution by Charles Darwin, can be identified as one of the first such algorithms and still plays an important role among nature inspired algorithms [1, 2]. Ant colony optimization algorithms which mimic the ants' strange communication behavior are other popular algorithms which have been adopted for many real world optimization tasks [3, 4]. Bat inspired algorithm [5], Cuckoo birds algorithm [6], Firefly algorithm [7] are more recent nature inspired algorithms that represent different real world optimized phenomena. These algorithms can be classified in to two main fields as Evolutionary algorithms and Swarm intelligence algorithms. Evolutionary algorithms are population based algorithms which uses mutation, recombination, and natural selection to reproduce better generations [8]. Genetic algorithms, differential evolution [9] and genetic programming [10] are example evolutionary algorithms. Swarm intelligence, by its name mimics the collective behavior of different elements in the natural world. Particle swarm optimization [11], ant colony systems, firefly algorithms are some examples. One of the most advantageous properties of these algorithms is that most of them are the type of meta-heuristic. Therefore these algorithms can be adopted to solve a variety of optimization problems rather than heuristic algorithms. This paper aims to present the research carried out to find the accountability of using a modern nature inspired algorithm; firefly algorithm to solve univariate nonlinear equations having real and complex roots and the mathematical software that has been developed to accomplish the task.

II. NONLINEAR EQUATIONS

Solving a nonlinear equation is finding x which satisfies $f(x) = 0$, where $f(x)$ is nonlinear. Many numerical methods exist, but they have some major drawbacks like need of derivative information, strongly depends on the initial guess, inability of giving all the roots within an interval. When the equation is having either real and complex roots or complex roots only, the situation is even more