Chapter 1
Realizing the Need for Intelligent Optimization Tool

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ABSTRACT

A large number of traditional optimization tools are available in the literature, as each of these techniques is suitable to solve a particular problem. Realizing this fact, non-traditional optimization tools have been proposed, which are supposed to be robust enough to solve a variety of problems. Moreover, these tools should be able to reach the optimal solutions quickly and as accurately as possible. The family of non-traditional optimization tools has become bigger, nowadays, which contradicts the very purpose of developing non-traditional optimization tool. In this write-up, the reasons behind this fact have been discussed in detail, and the need for an intelligent optimization tool has been felt, which is supposed to be problem-independent.

INTRODUCTION TO OPTIMIZATION

It is assumed that there exist a number of possible solutions to a particular problem, and the best one is to be detected. The principle of optimization is used to select the best one out of all possibilities. Mathematically, gradient of a function to be optimized is utilized, as its rate of change is seen to be the maximum along this direction. For a function, there could be either the maximum or minimum or saddle point(s). A saddle point (also known as inflection point) is one, which is neither a maximum nor a minimum. There exit a variety of optimization problems, such as linear and non-linear ones; real-valued, integer and mixed-integer ones; constrained and un-constrained ones; static and dynamic ones; and others. An optimization algorithm generally starts from randomly generated initial solution(s) and moves towards the optimal solution iteratively. It is to be noted that there are two important parameters for any iterative optimization tool, namely search direction and step length. These parameters vary from one tool to another, and consequently, a number of optimization tools are available in the existing literature. An efficient optimization tool should be able to reach the optimal solution accurately but at the cost of low computation.

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TRADITIONAL TOOLS FOR OPTIMIZATION

There exist various traditional (also known as conventional) tools for optimization, and these are broadly classified into two groups, namely direct search methods and gradient-based search methods. The search is guided by the value of objective function in a direct search method, whereas the search direction is decided by the gradient information of objective function in the gradient-based methods. A direct search method may take a number of iterations to reach the optimized solution. On the other hand, a gradient-based method can yield the optimized solution through a comparatively less number of iterations. However, the chance of its solution for getting stuck at the local minimum is more, as gradient is a local property of the surface of objective function. Interested readers may refer to Rao (1978), Deb (1995) for the detailed description of these traditional tools for optimization. Traditional tools for optimization have the following demerits:

- A particular traditional tool may be required to solve a specific problem more efficiently. Therefore, traditional tools may not be robust enough to solve a variety of problems. For example, in order to solve optimization problem involving integer variables, a special type of tool called integer programming algorithm is to be used.
- Gradient-based optimization tools cannot be used to solve the problems involving discontinuous objective functions.
- The possibility of the solutions of a gradient-based method to reach the local minima is more due to the reason mentioned above.
- Direct search methods may unnecessarily consume more time to search and find the optimized solution.
- As the traditional optimization tools start with a single initial solution selected at random, they cannot be used for parallel computing.

NATURAL COMPUTING

It is a family consists of three types of methods, such as those use inspiration from nature to solve the problems, those utilize computers to model and analyze natural phenomena, and those that use natural materials like molecules to perform computation. The tools and techniques like evolutionary algorithms, artificial neural networks, swarm intelligence, artificial immune systems, DNA computing, quantum computing, and others, are coming under the umbrella of natural computing. It is to be noted that non-traditional optimization algorithms, as discussed below, are also considered to be important members of this big family.

NON-TRADITIONAL TOOLS FOR OPTIMIZATION

To overcome the above drawbacks of the traditional tools, a number of non-traditional (also called unconventional) optimization tools had been proposed. By copying the mechanisms of biological adaptation and evolution, various tools like Genetic Algorithms (GAs) (Holland, 1975), Genetic Programming (GP)
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