


Chapter 1

Meta Heuristic Algorithm: Concepts and Techniques

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ABSTRACT

Metaheuristic algorithms represent a key area of optimization research that generates interest for many academicians and researchers in today's technology landscape. Researchers have been using these methods as a problem-solving approach for many decades when applied to combinatorial optimization problems, which has now grown into a significant research field through its incorporation of nature-inspired selection and evolutionary problem-solving principles. This study examines the basic principles of metaheuristic algorithms and discusses their key characteristics while categorizing them and comparing their common approaches. This paper examines Genetic Algorithms, Particle Swarm Optimization, Grey Wolf Optimization, Water Wave Optimization, and Ant Colony Optimization by reviewing their operational mechanisms and evaluating their strengths and drawbacks. This paper aims to enhance understanding and encourage the development of novel strategies that leverage these powerful optimization tools for emerging challenges.

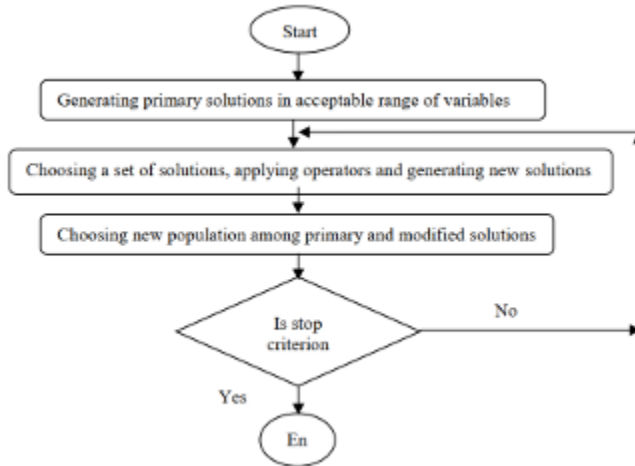
INTRODUCTION

A metaheuristic method (MHA) is particularly relevant in the context of solving search and optimization problems. It describes a technique that uses one or more heuristics and therefore inherits all the three properties mentioned below. Thus,

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MHA (Sengupta et al., 2016) (i) seek to find a near-optimal solution, instead of specifically trying to find the exact optimal solution, (ii) usually have no rigorous proof of convergence to the optimal solution, and (iii) are usually computationally faster than exhaustive search. These methods are iterative and often use stochastic operations in their search process to modify one or more initial candidate solutions (usually generated by random sampling of the search space) (Figure 1). Since many real-world optimization problems are complex due to their inherent practicalities, classical optimization algorithms may not always be applicable and may not perform well in solving such problems pragmatically. Realizing this fact and without disregarding the importance of classical algorithms in the development of the field of search and optimization, researchers and practitioners sought metaheuristic methods so that a near-optimal solution could be obtained in a computationally tractable manner, instead of waiting for a provable optimization algorithm to be developed before attempting to solve such problems. The ability of the MHA to handle different complexities associated with practical problems and arrive at a reasonably acceptable solution is the main reason for the popularity of metaheuristic methods in the recent past.

Figure 1. General workflow of metaheuristic algorithms



Most MHA are motivated by natural, physical, or biological principles and try to mimic them at a fundamental level through various operators. A common theme seen across all metaheuristics is the balance between exploration and exploitation (Sengupta et al., 2016) (Figure 2). Exploration refers to how well the operators diversify solutions in the search space. This aspect gives the metaheuristic a global search behavior. Exploitation refers to how well the operators can utilize the in-

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