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Nature Inspired Metaheuristic Algorithms

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Abstract - *Nature inspired metaheuristic algorithms are well known economical approaches for solving several hard optimization problems. It provides the components and concepts that are employed in these algorithms so as to research their similarities and variations. The classification adopted in this paper differentiates by the behaviours obtained to develop the wide variety of nature inspired algorithms. The research is directed by the presentation of control parameters, intensification, and diversification used in these algorithms and its domain specifications.*

Keywords: Metaheuristic, Diversification, Intensification, Control Parameters, Domain Specifications.

1. INTRODUCTION

In recent years, optimization is a booming research area for providing an optimal solution to complex real-time problems. Multi-dimensionality, multi-modality, multi objective, differentiability and different combinatorial characteristics are coped with these problems. The demand for solving real-time problems has attracted many researchers to develop fast, accurate and computationally powerful optimization algorithms. Researchers from various domains have introduced many numerical optimization techniques to attain better solution for these problems. Historical problem solving techniques are classified into two techniques: Extract and Heuristics methods. Logical and mathematical programming are involved in Extract methods to solve NP complete problems whereas heuristics method seems to be superior in solving NP-hard and complex optimization problems, specifically where the traditional methods fail [1].

Any advance to problem-solving, learning or discovery which spotlight on immediate near optimality rather than exact results, using realistic methods can be described as a heuristic. The present trend to use heuristic techniques over precise ones is thanks to proven fact that several time period issues are shown to stay forever wild to exact algorithms, regardless of the ever increasing computational power, merely thanks to unrealistically massive running times. Nature inspired metaheuristic algorithms mentions to high-level heuristics that mimics the biological or physical phenomena.

Metaheuristics are refined scientifically to find an optimal solution that is "good enough" in a computing time that is "small enough". Metaheuristic optimization algorithms are aids to solve wide range of real-time problems due to its (i) simplicity and easy to implement, (ii) does not need slope information, (iii) avoid local optima, (iv) can be exploited in an ample range of problems wrapping different disciplines [2]. Unique feature of Metaheuristic algorithm is different methods of search process. These algorithms most uniformly contribute in two phases: intensification and diversification [3]. Intensification phase search process begins to find the local best solution within its adjacent location however this process otherwise called as local search. Diversification phase start the search process globally in the provided search space which intend to attain the global solution however this process also called as global search. Most challenging task in the development of any metaheuristic algorithm is to find a suitable balance the intensification and diversification.

2. CLASSIFICATION OF NATURE INSPIRED METAHEURISTIC ALGORITHMS

Nature inspired metaheuristic algorithm are classified into four major divisions as shown in Fig 1.

- Evolution- Based Method
- Physics-Based Method
- Swarm-Based Method and
- Human-Based Method

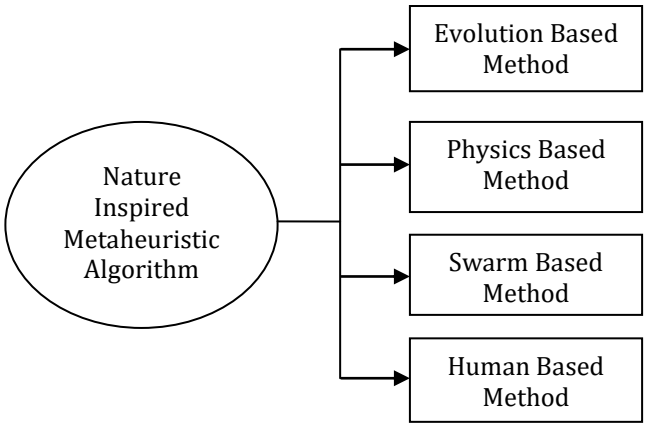

Fig 1: Classification of Nature Inspired Metaheuristic Algorithms

A. Evolution Based Metaheuristic Algorithms

Evolution-based methods [2, 4] are inspired by the laws of natural evolution. Initially the set of population are

generated stochastically then it begins search process over subsequent generations. The best individuals are collected in every generation and it taken to the next generation process likewise the process goes on until it reaches the termination criteria or the optimal solution is obtained. Genetic algorithm (GA) is most popular evolution-inspired technique that imitated by the principles of Charles Darwin Theory of survival of the fittest [4]. This method involves base process of selection, crossover and mutation to replace the worst solution in every generation.

Genetic Algorithm begins by initializing a population of solution (chromosome). Then each individual evaluates the fitness using an appropriate objective function for the problem. The best individual is selected into the mating pool, where they undergo cross over and mutation to produce a new set of solution (offspring). Memetic algorithm (MA) is another evolution based algorithm that mimics the behaviour of GA and this algorithm improve the worst solution in each generation based on its probability ratio. Evolution Strategy (ES), Genetic programming, Biogeography-Based Optimizer (BBO) are the other popular algorithms. Virulence Optimization Algorithm (VOA) is a newly developed evolutionary algorithm.

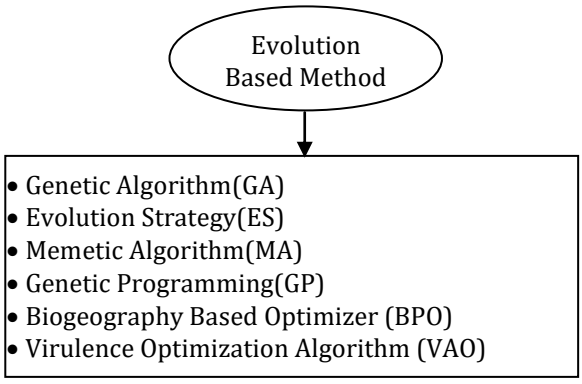

Fig 2: Classification of Evolution Based Methods

B. Physics Based Metaheuristic Algorithms

Physics-based methods mimic the physical rules in the universe [2]. Simulated Annealing (SA) [5] models the physical process of warming a material and then gradually decreasing the temperature to decrease defects, thus reducing the system energy. Simulated annealing presents an appropriate measure of eccentrics into things to get away local maxima ahead of schedule in the process without getting off course late in the game, when an answer is in closeness. This algorithm better suits in recognizing optimal solution and never considers the technique for starting stage.

Big-Bang-Big- Crunch (BBBC), Gravitational Local Search (GLSA), Gravitational Search Algorithm (GSA), Central Force optimization (CFO), Black Hole (BH) algorithm, Artificial Chemical Reaction Optimization Algorithm (ACROA), Galaxy-Based Search Algorithm (BBSA), Ray Optimization (RO) algorithm, Charged System Search (CSS), Small-World Optimization Algorithm (SWOA) and Curved Space Optimization (CSO) are the most popular algorithms.

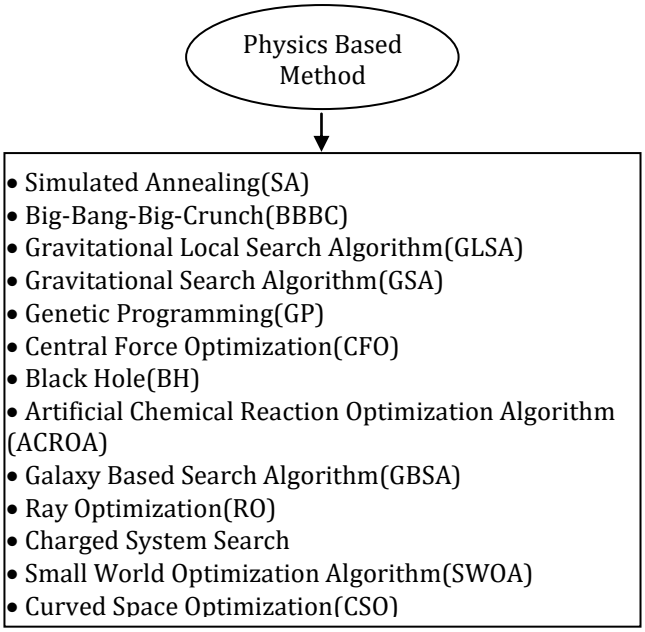

Fig 3: Physics Based Methods

C. Swarm Based Metaheuristic Algorithms

Swarm-based method mimics the social behaviour of groups of animals [2].

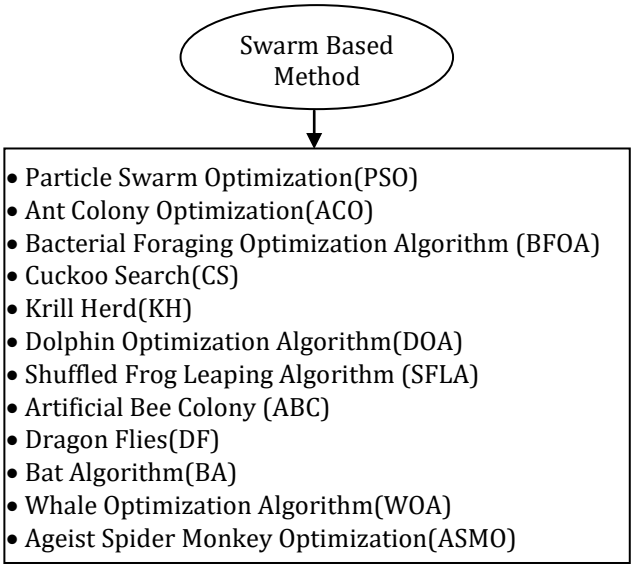

Fig 4: Swarm Based Methods

One of the most popular algorithms is Particle Swarm Optimization (PSO) [6], which mimics the behaviour of fish schooling and birds flocking. Kennedy and Eberhart developed PSO to solve real-time problems by pertaining the best solution identification in a given search space. In PSO,

Individual is considered as particles which search around the search space to find the best solution. Cognitive and social parameters are aids to explore the exploitation (local search) and exploration (global search) in a search space. Ant colony optimization (ACO) [7] is considered as another well-known Swarm based algorithm.

Vast variety of optimization algorithms are introduced in Swarm Intelligence. Still swarm based approach attracts many researchers to develop effective algorithms for different engineering applications. Bacterial foraging behaviour (BFO), Cuckoo Search (CS) algorithm, Krill Herd (KH) algorithm, Dolphin Optimization Algorithm (DOA), Shuffled Frog Leaping Algorithm (SFLA), Artificial Bee Colony (ABC) algorithm, Dragon Flies (DF) algorithm, Bat Algorithm (BA) are other swarm based algorithms. Whale optimization algorithm (WOA), Ageist Spider Monkey Optimization (ASMO) [8], Lions Algorithm (LA) [9] is newly introduced algorithms.

D. Human Based Metaheuristic Algorithms

Human based methods inspired by the advancement in level of searching strategy [2]. Rao et al [10] proposed an algorithm named as Teaching-Learning-Based Optimization (TLBO), which the behaviour of traditional teaching-learning phenomenon of a class room.

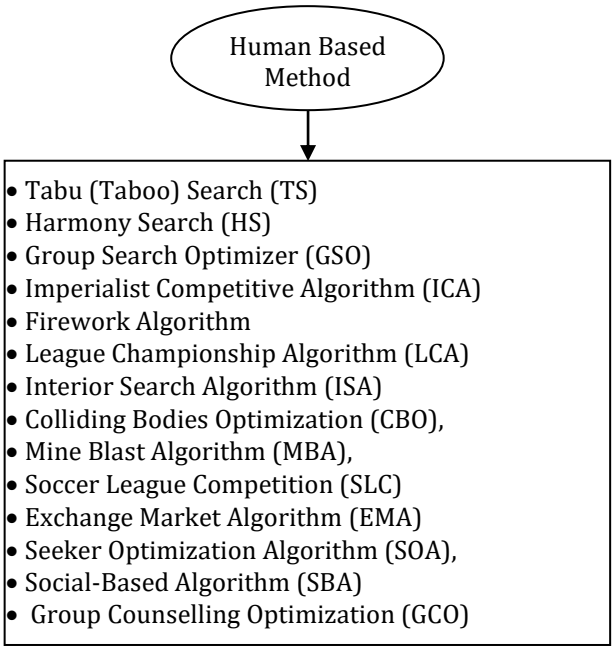

Fig 5: Human Based Methods

Some of the other most popular algorithms are as Tabu (Taboo) Search (TS), Harmony Search (HS), Group Search Optimizer (GSO), Imperialist Competitive Algorithm (ICA), Firework Algorithm, League Championship Algorithm (LCA), Interior Search Algorithm (ISA), Colliding Bodies Optimization (CBO), Mine Blast Algorithm (MBA), Soccer League Competition (SLC) algorithm, Exchange Market Algorithm (EMA) , Seeker Optimization Algorithm (SOA), Social-Based Algorithm (SBA), and Group Counselling Optimization (GCO) algorithm. In such a way, metaheuristic algorithms are divided in such which try to find the best optimum values of objective functions for problem specific. The following section describes these metaheuristic algorithms based on its use of domain applications.

3. METAHEURISTIC ALGORITHMS WITH ITS DOMAIN SPECIFICATION

In the last decade, nature inspired metaheuristic algorithms are emerging as viable tools and alternatives to more traditional real-time applications. Among the many metaheuristic algorithms, some of the main algorithms are tabulated with their developers, control parameters, domain specifications, intensification and diversification. Researchers developed their metaheuristic algorithms with two different motives such as problem specific algorithms and generic algorithms with improvising intensification (local search) and diversification (global search) in search space. The intensification and diversification factors are measured based on the control parameter modifications in the entire discussed algorithm.

4. CONCLUSION

This work reviewed several important nature inspired metaheuristic algorithms closely emerging with new ideas and applications. We classified this emerging research area into four divisions based on its behaviours. Evolution based methods purely mimics the behaviour of biological evolution however physics based methods mimics the behaviour of physical rules in the universe. Swarm based methods mimics the behaviour of group of animals whereas human based methods inspired by the self-learning. Generally, almost of all the methods performs with heuristics population-based search methodologies that integrate stochastic diversity and selection. It has been endorsed that the growth of metaheuristics and applications in the past years is very extreme and has been practiced to various problems.

5. FUTURE WORK

This study can be further extended to freshly introduce metaheuristic hybrid algorithms with their modifications (in improving diversity and intensifications) and its potency in real world applications.

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