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A Brief Survey on Nature Inspired Algorithms: Clever Algorithms for Optimization

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***Abstract* - This paper presents a brief survey on various optimization algorithms. To be more precise, the paper elaborates on clever Algorithms – a class of Nature inspired Algorithms. The Nature Inspired Computing (NIC) is an emerging area of research that focuses on Physics and Biology Based approach to the Algorithms for optimization. The Algorithms briefed in this paper have understood, explained, adapted and replicated the phenomena of Nature to replicate them in the artificial systems. This Cross – fertilisation of Nature Inspired Computing (NIC) and Computational Intelligence (CI) will definitely provide optimal solutions to existing problems and also open up new arenas in Research and Development. This paper briefs the classification of clever algorithms and the key strategies employed for optimization.**
***Keywords:* optimization, collective intelligence, nature inspired, bio inspired algorithms**

I. INTRODUCTION

The literal meaning of optimization refers to the art of making something fully effective. This is achieved by finding an alternative with the most cost effective or highest achievable performance under the given constraints. It is by maximizing the desired factors and minimizing the undesired ones optimization is achieved. Real world optimization problems are definitely challenging to solve.

In spite of numerous optimization tools there is no assurance of arriving to an optimal solution. In general, the concept of optimization is a trial and error method. This is a wide area for research where, new algorithms have been developed to check their effectiveness for providing an optimal solution.

A broader classification of Optimization techniques categorises them into Conventional and Unconventional methods. There are enormous numbers of Survey papers on Conventional techniques. Very few surveyed the Unconventional Techniques.

The real beauty of Unconventional or Bio or Nature Inspired algorithms lies in the fact that the sole inspiration of these algorithms is derived from nature. It is a perfect optimizer and a best teacher with enormous and mysterious capabilities inspiring researchers to imitate nature in technology [1].

Algorithm refers to the procedural logic to achieve solutions for the problems in hand. The term Clever Algorithm refers to ambiguously described algorithms or inconsistent algorithms. Clever algorithms are used in fields of computational intelligence and other relevant fields. This paper presents a clear view about the fundamental concepts in Clever Algorithms. A survey of the various classes of Algorithms is presented in this paper and their inherent properties are analysed. The Classification of the Clever Algorithms and their founders are tabulated [3].

II. STOCHASTIC ALGORITHMS

This set of algorithms provide various different strategies by which 'better' and varied starting points can be generated and issued to a neighbourhood searching technique for refinement, a process that is repeated with potentially improving or unexplored areas to search.

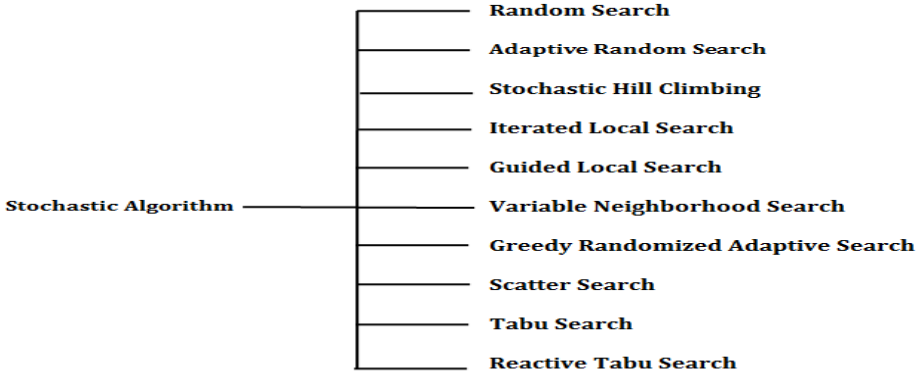

Fig.1 Classification of Stochastic Algorithms

Random Search does not need any derivatives and is related to techniques that gives minor improvements. It uses uniform probability distribution. The Adaptive Search Algorithm continuously approximates the optimal step size in the search space.

The Stochastic Hill Climbing Algorithm involves iteration of a random selection of neighbour and accepts only if the result is an improvement. The Iterated local Search Algorithm samples a broader neighbourhood and uses local search algorithms to refine the results. The guided local search algorithm uses penalties to use a local search technique and to discover global optima. The search is repeated for a number of times till an optimal solution is attained.

The Variable Neighbourhood Search involves iteration of larger neighbour hoods until an improvement is located. The Greedy Randomized Adaptive Search uses sample stochastically greedy solutions and uses a local search procedure to refine local optima.

The principle behind the Scatter Search approach is that useful information about the global optima is stored in a diverse and elite set of solutions (the reference set).The objective for the Tabu Search algorithm is to constrain an embedded heuristic from returning to recently visited areas of the search space, referred to as cycling. The Reactive Tabu Search addresses this objective by explicitly monitoring the search and reacting to the occurrence of cycles and their repetition by adapting the tabu tenure (tabu list size).

TABLE I AUTHORS OF STOCHASTIC ALGORITHMS

STOCHASTIC ALGORITHMS	
ALGORITHM	**AUTHOR**
Random Search	Brooks
Adaptive Random Search	Schummer, Steiglitz
Stochastic Hill Climbing	Forrest,Mitchell
Iterated Local Search	Stuzzle
Guided Local Search	Voudouris, Tsang
Variable Neighborhood Search	Mladenovic, Hansen
Greedy Randomized Adaptive Search	Feo, Resende
Scatter Search	Glover
Tabu Search	Glover
Reactive Search	Battiti, Tecchiolli

III. EVOLUTIONARY ALGORITHMS

Evolutionary Algorithms deals with the investigation in sophisticated computational systems resembling the simplified versions of mechanisms..

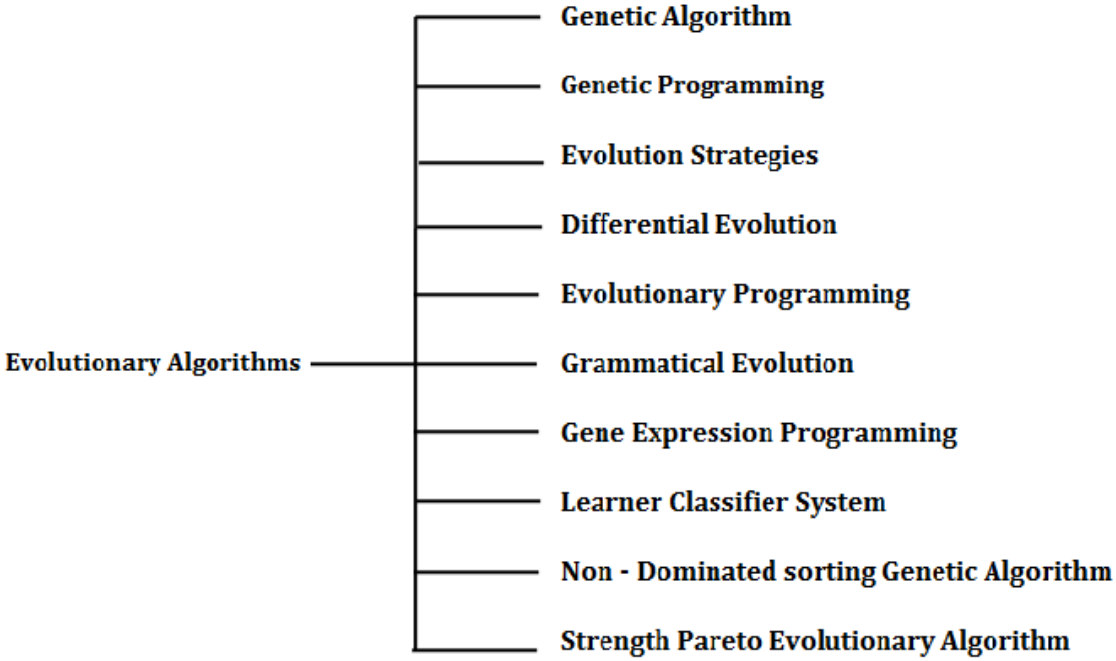

Fig. 2 Classification of Evolutionary Algorithms

The objective of the Genetic Algorithm is to repeatedly employ surrogates for the recombination and mutation genetic mechanisms on the population of candidate solutions. In Genetic Programming, the Genetic Algorithm employs induction to design a new computer program. Evolution Strategies algorithm maximizes the suitability of collection of candidate solutions in the context of an objective function from a domain. The Differential Evolution algorithm involves maintaining a population of candidate solutions subjected to iterations of recombination, evaluation, and selection. [3]

In Evolutionary Programming algorithm the suitability of a collection of candidate solutions in the context of an objective function from the domain is maximized. The idea behind the Grammatical Evolution is to adapt an executable program to a problem specific objective function. Gene Expression Programming algorithm improves the adaptive fit of an expressed program in the context of a problem specific cost function. The Learning Classifier System algorithm brings out optimization by using a payoff strategy on exposure to stimuli. The Non-dominated Sorting Genetic Algorithm improves the adaptive fit of a population of candidate solutions to a Pareto front constrained by a set of objective functions. Strength Pareto Evolutionary Algorithm locates and maintains a front of non-dominated solutions, ideally a set of Pareto optimal solutions.

TABLE II AUTHORS OF EVOLUTIONARY ALGORITHMS

EVOLUTIONARY ALGORITHMS	
ALGORITHM	**AUTHOR**
Genetic Algorithm	Holland
Genetic Programming:	Cramer
Evolution Strategies algorithm	Bienert, Rechenberg,
Differential Evolution algorithm	Storn, Price
Evolutionary Programming	Lawrence Fogel
Grammatical Evolution	Ryan, Collins and
Gene Expression Programming	Ferreira
Learning Classifier System	Holland
Non-dominated Sorting Genetic	Srinivas and Deb
Strength Pareto Evolutionary	Zitzler and Thiele

IV. PHYSICAL ALGORITHMS

Physical algorithms are those algorithms inspired by a physical Process

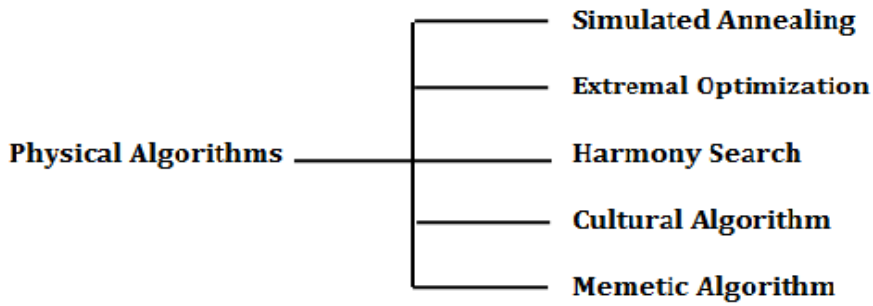

Fig. 3 Classification of Physical Algorithms

In Simulated Annealing the information processing objective of the technique is to locate the minimum cost configuration in the search space. This algorithm re samples the problem space. In Extremal Optimization the dynamics of the system result in the steady improvement of a candidate solution with sudden and large crashes in the quality of the candidate solution. The Harmony Search Algorithm uses the already available good candidate solutions to influence the new candidate solutions. As Evolution happens, individuals share their accumulated information to the other individuals. The cultural Algorithm employs this strategy.[4] The Memetic Algorithm of the information processing strategy is to exploit a population based global search technique to broadly locate good areas of the search space, combined with the repeated usage of a local search heuristic by individual solutions to locate local optimum.

TABLE III AUTHORS OF PHYSICAL ALGORITHMS

PHYSICAL ALGORITHMS	
ALGORITHM	**AUTHOR**
Simulated Annealing	Kirkpatrick, Gelatt, and Vecchi
Extremal Optimization	Boettcher and Percus
Harmony Search	Geem et al
Cultural Algorithm	Reynolds
Memetic Algorithm	Moscato

V. PROBABILISTIC ALGORITHMS

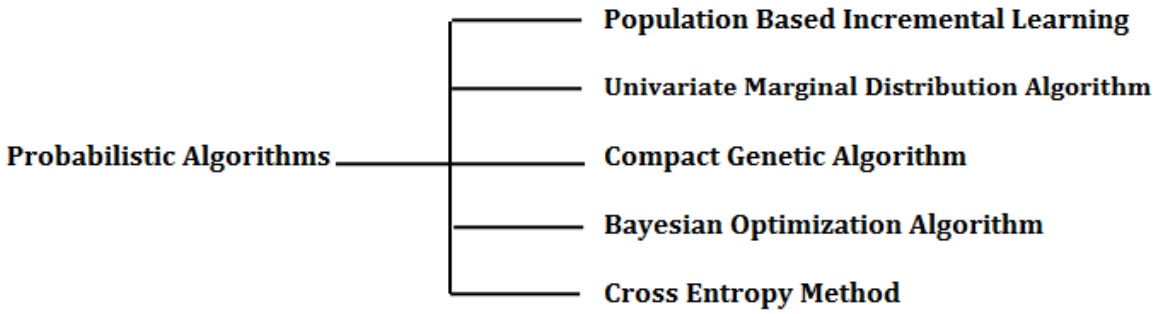

Fig. 4 Classification of Probabilistic Algorithms

Probabilistic Algorithms are those algorithms that model a problem or search a problem space using an probabilistic model of candidate Solutions.

The information processing objective of the Population-Based Incremental Learning (PBIL) algorithm [3] is to reduce the memory required by the genetic algorithm. This is done by reducing the population of candidate solutions Univariate Marginal Distribution Algorithm. The information processing strategy of the algorithm is to use the frequency of the components in a population of candidate solutions in the construction of new candidate solutions.

The behaviour of a much smaller memory footprint is simulated in a Compact Genetic Algorithm. The Bayesian Optimization Algorithm constructs a probabilistic model that describes the relationships between the components of fit solutions in the problem space. The information processing strategy of the Cross-Entropy Method algorithm is to sample the problem space and approximate the distribution of good solutions.

TABLE IV AUTHORS OF PROBABILISTIC ALGORITHMS

PROBABILISTIC ALGORITHMS	
ALGORITHM	**AUTHOR**
Population-Based Incremental	Baluja
Univariate Marginal Distribution	M¨uhlenbein
Compact Genetic Algorithm	Harik, Lobo, and Goldberg
Bayesian Optimization Algorithm	Pelikan, Goldberg,and
Cross-Entropy Method	De Boer et al

VI. SWARM ALGORITHMS

Swarm intelligence deploys the idea of Collective Intelligence(CI). When a huge number of agents (homogenous) work in cooperation, for the accomplishment of a particular task, it is referred to as Collective Intelligence. Ex – Fish, Ants etc., CI is self-organizing and decentralized. Usually agents use this technique to solve their living issues like search of food, shelter , prey evading etc.,

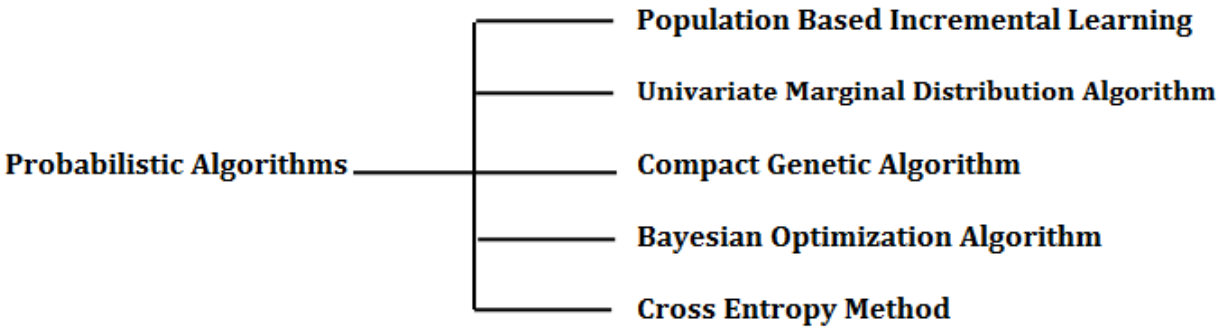

Fig. 5 Classification of Swarm Algorithms

The goal of the Particle Swarm Optimization algorithm achieve particle local optimisation by assigning initially random positions to all particles in the space and small initial random velocities. The Ant System strategy is to exploit historic and heuristic information to construct candidate solutions and fold the information learned from constructing solutions into the history. Ants wander around for food, once it locates the food it lays down pheromone in the environment. Numerous trips are made by additional ants resulting in more pheromone deposition.

A positive feedback process routes more and more ants to productive paths that are in turn further refined through use. This is the idea behind the Ant Colony System. The Bacterial Foraging Algorithm mimics the behaviour of E.coli Bacteria that perceives the direction to food based on the gradients of chemicals in their environment. Similarly, bacteria secrete attracting and repelling chemicals into the environment and can perceive each other in a similar way. Using locomotion mechanisms (such as flagella) bacteria can move around in their environment, sometimes moving chaotically (tumbling and spinning), and other times moving in a directed manner that may be referred to as swimming [3].

TABLE V AUTHORS OF SWARM ALGORITHMS

SWARM ALGORITHMS	
ALGORITHM	**AUTHOR**
Particle Swarm Optimization	Eberhart and Kennedy
Ant System	Dorigo, Maniezzo, and Colorni
Ant Colony System	Dorigo and Gambardella
Bees Algorithm	Pham et al
Bacterial Foraging Algorithm	Liu and Passino

VII. IMMUNE ALGORITHMS

A simplified description of the immune system is an organ system intended to protect the host organism from the threats posed to it from pathogens and toxic substances. Pathogens encompass a range of microorganisms such as bacteria, viruses, parasites and pollen.

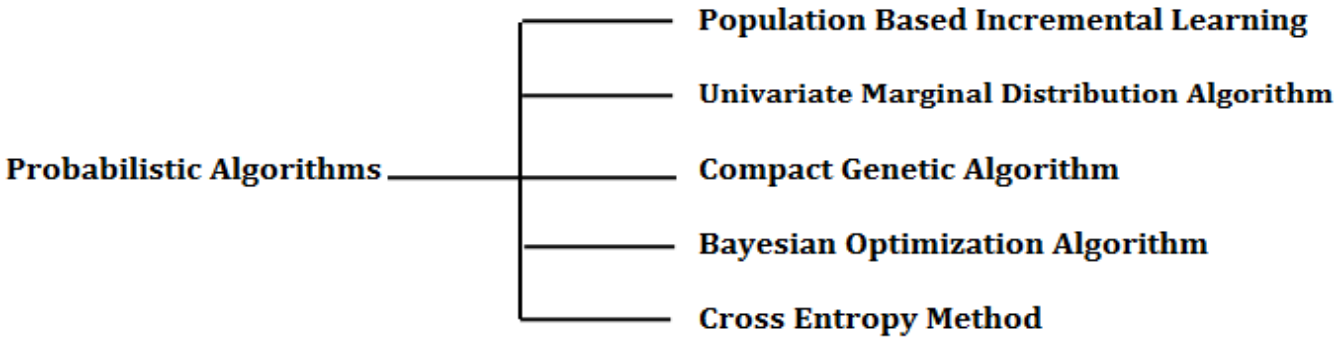

Fig. 6 Classification of Immune Algorithms

The information processing principles of the clonal selection theory describe a general learning strategy. This strategy involves a population of adaptive information units (each representing a problem-solution or component) subjected to a competitive processes for selection, which together with the resultant duplication and variation ultimately improves the adaptive fit of the information units to their environment [3].

The Negative Selection Algorithm uses self non self discrimination process via negative selection. The Artificial Immune Recognition system begins with an initial collection of general immune cells in response to the environment.

A fascinating network theory and signalling information is available with immune network theory. The Dendritic Cell Algorithm prepares a set of dendritic cells that provides context specific information about how to classify input patterns.

TABLE VI AUTHORS OF IMMUNE ALGORITHMS

IMMUNE ALGORITHMS	
ALGORITHM	**AUTHOR**
Clonal Selection Algorithm	de Castro and Von Zuben
Negative Selection Algorithm	Forrest et al.
Artificial Immune Recognition	Watkins
Immune Network Algorithm	Farmer et al.
Dendritic Cell Algorithm	Greensmith, Aickelin and

VIII. NEURAL ALGORITHMS

A Biological Neural Network refers to the elements in the nervous system, consisting of neurons communicating with each other through electrochemical signals. This idea of communication gave rise to the following list of Neural Algorithms.

TABLE VII AUTHORS OF NEURAL ALGORITHMS

NEURAL ALGORITHMS	
ALGORITHM	**AUTHOR**
Perceptron	Rosenblatt
Back Propagation	Bryson and Hoin
Hopfield Network	Hopfield
Learning Vector Quantization	Kohonen, Barna, and Chrisley
Self-Organizing Map	Kohonen

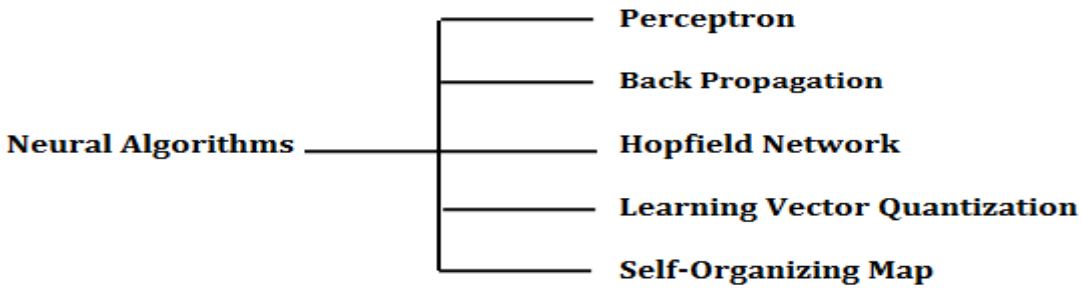

Fig. 7 Classification of Neural Algorithms

The information processing objective of the Perceptron technique is to model a given function by modifying internal weightings of input signals to produce an expected output signal. The system is trained using a supervised learning method, where the error between the system's output and a known expected output is presented to the system and used to modify its internal state. The Back Propagation algorithm, one of the oldest techniques of Neural Networks models a given function by modifying the internal weightings of the input signal to produce the expected output signal. The Hopfield pattern associates the components of an input pattern with a holistic representation of the pattern called Content Addressable Memory (CAM). The Learning Vector Quantization prepares a set of codebook (or prototype) vectors in the domain of the observed input data samples and to use these vectors to classify unseen examples.[5] The Self-Organizing Map optimally places a topology (grid or lattice) of codebook or prototype vectors in the domain of the observed input data samples.

IX. CONCLUSION

It is obvious that the field of Clever Algorithms is rapidly growing. The Unconventional methods of Optimization are rapidly exploited areas of research. This paper presents a critical survey of clever algorithms. Clever algorithms are used extensively not only in artificial intelligence but also in automation in other real life domains like military, healthcare, manufacturing, mining etc. There are many practical concerns with this clever algorithms like ensuring the correct implementation of the algorithms, issues regarding which software platform to use for implementing such algorithms, how to test the validity of the algorithms, issues to consider while comparing the clever algorithms. These aspects are actively being looked upon.

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