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A study of efficient and effective approaches in nature-inspired techniques for solving optimization problems

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Abstract: Nature-Inspired Techniques has been becoming the focus of research because they achieved the remarkable successes in optimization problems. The power of almost all Nature-inspired techniques comes from the fact that they imitate the best characteristic in nature. Nature-inspired algorithms are characterized by algorithmic operators mimicking computationally useful aspects of various natural phenomena. Nature inspired techniques such as swarm intelligence (SI), Nature Evolution and so on. It has demonstrated strong efficiency technique for solving complex problems and it provides optimum solution. This paper discusses a number of selected nature-inspired algorithms and various types of combinatorial optimization problems and it mainly focused on the unique attitude behind each of the techniques, their applications.

Keywords: Nature-Inspired algorithms, Optimization Problems, Swarm Intelligence (SI), Nature Evolution.

I. INTRODUCTION

Nature in itself is the most excellent instance to solve problems in an efficient and effective approach. It has constantly served as motivation for numerous scientific and technical developments. The nature has parallel, asynchronous, decentralized and collective behavior. The nature-inspired techniques are an admirable match for computing environments that demonstrate these characteristics [8]. An overview of this paper is as follows. In Section 2 categorized some of the nature inspired techniques. In Section 3 Types of optimization problems. In the next section presents solved Optimization Problems using Nature inspired technique Section 5 provides concluding marks.

II. NATURE-INSPIRED TECHNIQUES

In modern years, a lot of nature inspired Techniques have been developed for solving numerical and combinatorial optimization problems. More and more researches recommend that nature is an immense resource for inspirations to both develop intelligent systems and offer solutions to complicated problems. The following are the selected nature inspired techniques going to discusses in this paper.

a. Harmony Algorithm
b. Genetic Algorithm
c. Memetic Algorithm

A. Harmony Algorithm:

Harmony algorithm is a novel algorithm, which was motivated by musical process of searching for a perfect state of harmony. The HS algorithm imposes fewer mathematical requirements and can be easily adopted for various types of optimization problems. In the HS algorithm, musical performances seek a perfect state of harmony determined by aesthetic estimation, as the optimization algorithms seek a best state determined by objective function value.

Harmony algorithm does not require initial values for the decision variables. Furthermore, instead of a gradient search, the HS algorithm uses a stochastic random search that is based on the harmony memory considering rate and the pitch adjusting rate so that imitative information is unnecessary. The harmony in music is analogous to the optimization solution vector, and the musician's improvisations are analogous to local and global search in optimization techniques [11].

A musically pleasing harmony can be found based on three musical rules:

(i) By playing a note from harmony memory (HM).
(ii) By playing a note which is closer to another note stored in HM.
(iii) By playing an arbitrary note from the entire note range. Combination of these rules allows finding a musically pleasing harmony (best state).

Adaptation of above rules to the optimization problems is as follows:

(i) Generate a new solution vector from HM (memory consideration).
(ii) Replace a decision variable with a new one which is close to the current one (pitch adjusting).
(iii) Generate a solution vector from the possible random range (random selection). Combined utilization of these rules allows identification of the optimal or near optimal solutions.

B. Genetic Algorithm:

Genetic Algorithms (GA) are a family of computational models inspired by evolution. Genetic algorithms encode a potential solution to a specific problem on a simple chromosome like data structure and apply recombination operators to these structures so as to preserve critical information. Genetic algorithms are often viewed as function optimizers, although the range of problems to which genetic algorithms have been applied is quite broad.

An implementation of a genetic algorithm begins with a population of chromosomes, one then evaluates these structures and allocates reproductive opportunities in such a

way that those chromosomes which represent a better solution to the target problem are given more chances to "reproduce" than those chromosomes which are poorer solutions. The "goodness "of a solution is typically defined with respect to the current population.It is a search heuristic that mimics the process of natural evolution. This heuristic is routinely used to generate useful solutions to optimization and search problems [10].

Genetic algorithms belong to the larger class of evolutionary algorithms, which generate solutions to optimization problems using techniques inspired by nature. The continuing price/performance improvement of computational systems has made them attractive for some types of optimization. In particular, genetic algorithm work very well on mixed (continuous and discrete), combinatorial problems. They are less susceptible to getting 'stuck' at local optima than gradient search methods. But they tend to be computationally expensive.

To use a genetic algorithm to problem, usually the solutions are to be represented as a genome (or chromosome). The genetic algorithm then creates a population of solutions and applies genetic operators such as mutation and crossover to evolve the solutions in order to find the best one(s).

C. Memetic Algorithm:

Memetic Algorithm (MA) inspired by both Darwinian principles of natural evolution and Dawkins' notion of a meme, the term "Memetic Algorithm" (MA) was first introduced by Moscato in his technical report in 1989 where he viewed MA as being close to a form of population-based hybrid genetic algorithm (GA) coupled with an individual learning procedure capable of performing local refinements. The metaphorical parallels, on the one hand, to Darwinian evolution and, on the other hand, between memes and domain specific (local search) heuristics are captured within memetic algorithms thus rendering a methodology that balances well between generality and problem specificity. The method is proved to be of practical success in a variety of problem domains and in particular for the approximate solution of Optimization problems [9].

The adjective `memetic' comes from the term 'meme', coined by R. Dawkins to denote an analogous to the gene in the context of cultural evolution. The term 'meme' is defined as "the basic unit of cultural transmission, or imitation". Examples of memes are tunes, ideas, catch-phrases, clothes fash-ions, and ways of making pots or of building arches. Just as genes propagate themselves in the gene pool by leaping from body to body via sperms or eggs, so memes propagate them in the meme pool by leaping from brain to brain via a process which, in the broad sense, can be called imitation.

In a memetic algorithm the population is initialized at random or using a heuristic. Then, each individual makes local search to improve its fitness. To form a new population for the next generation, higher quality individuals are selected. The selection phase is identical inform to that used in the classical genetic algorithm selection phase. Once two parents have been selected, their chromosomes are combined and the classical operators of crossover are applied to generate new individuals [9]. The latter are enhanced using a local search technique. The role of local search in memetic algorithms is to locate the local optimum more effective.

III. TYPES OF COMBINATORIAL OPTIMIZATION PROBLEMS

Combinatorial optimization is a split of optimization that is associated to operations research, algorithm theory, and computational complexity theory. It had important applications in several fields, including artificial intelligence, mathematics, and software engineering. Combinatorial optimization problems can be viewed as searching for the best element of some set of discrete items, therefore, in principle, any sort of search algorithm or metaheuristic can be used to solve them. However, generic search algorithms are not guaranteed to find an optimal solution, nor are they guaranteked to run quickly.

Combinatorial optimization problems involve finding values for discrete variables such that the optimal solution with respect to a given objective function is found. A combinatorial optimization problem is either maximization or a minimization problem which has an associated set of problem instances. The term instance refers to a problem with specified values for all the parameters. When attacking a combinatorial optimization problem it is useful to know how difficult it is to find an optimal solution. Combinatorial optimization problems are usually called as search problems. Metaheuristics are general frameworks for heuristics in solving difficult optimization problems, often combinatorial optimization problems, like

a. Cutting-stock problem
b. Routing Problems
c. Network design problems
d. Assignment problems
e. Scheduling problems

IV. SOLVED OPTIMIZATION PROBLEM USING NATURE-INSPIRED ALGORITHM

The following Table I is the Nature-Inspired algorithms specifics to optimization problem.

Table I Nature-Inspired Algorithms Specific to Optimization Problem

Year	Algorithm name	Author name	Journal/Conference/ Book name	Applications
2011	HSA	Pan Q., Suganthan P.N., Liang J.J. and Tasgetiren M.F [3]	Expert Systems with Applications	Flow Shop Scheduling Problem(FSSP)
2010	HSA	Mohammed Azmi Al-Betar and Ahamad Tajudin Khader[2]	Springer Science and Business Media, LLC	University Course Timetabling(UCTP)
2009	GA	Hanif Khan F., Khan N., Inayatullah S., and Nizami S.T[5]	International Journal of Basic & Applied Sciences	TSP
2010	Novel global harmony search algorithm(NGHS)	Zou D., Gao L., Li .S, Wu J. and Wang X.[1]	The Journal of Systems and Software	Task Assignment Problem (TAP)

2009	Hybrid GA	Zhao FG, Sun JS, Li .SJ and Liu .WM[4]	International Journal of Automation and Computing	Traveling Salesman Problem (TSP)
2010	MA	Padmavathi S., Shalinie S.M and Abhilaash R.,[6]	International Journal of Advance. Soft Computer Application	Task scheduling
2009	MA	Nysret Musliu Werner Schafhauser and Magdalena Widl.,[7]	The VIII Metaheuristics International Conference	Scheduling Problem

V. CONCLUSION

Harmony Algorithm (HS), Genetic Algorithm (GA), Memetic Algorithm (MA) belongs to the group of Nature-Inspired technique. These algorithms have established strong efficiency for solving complex problems and it provides optimum solution. This paper mainly addresses some selected nature-inspired techniques and various types of combinatorial optimization problems and it mainly focused on the unique approach behind each of the techniques, their applications.

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Ms.T.Hashni received her B. Sc degree in Computer science, M.Sc degree in Information Technology and M.Phil in Computer Science in 2008, 2010, 2012 in Bharathiar University, India. She awarded as Rank Holder in Bharthiar University for her Post Graduation. She is currently working as Asst. Professor in the P.S.G.R.Krishnammal College for Women, Coimbatore Her area of interest includes Distributed Computing, Agent based Computing and Nature-Inspired computing.

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