Memetic Algorithm: Hybridization at Initialization in Genetic Algorithm with Hill Climbing

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Abstract— Genetic algorithm is a problem solving method that uses genetics as its model of problem solving. It is a search technique to find approximate solutions to optimization and search problems. Genetic algorithm handles a population of possible solutions. Each solution is represented through a chromosome and they mimic the process of natural evolution. A memetic algorithm is an extension of genetic algorithm in which genetic algorithm is hybridized with local search technique to improve the performance of genetic algorithm. This paper proposes a memetic algorithm in which hybridization is applied at initial stage using hill climbing local search. Performance of the memetic algorithm is compared with simple genetic algorithm. The experiments have been conducted using knapsack 0/1 problem and implementation is carried out using matlab. The results show that the proposed hybrid genetic algorithm is more optimized than simple genetic algorithm.

Keywords: Genetic Algorithm, Hill Climbing, Memetic Algorithm

I. INTRODUCTION

Evolutionary algorithms are the ones that follow the Darwin concept of "Survival of the fittest" mainly used for optimization problems for more than four decades. Evolutionary algorithms copy the behavior of natural selection and treat solution candidates as individuals that compete in a natural environment, some of them are genetic algorithm, genetic programming, evolution strategy etc. Genetic algorithms are adaptive optimization algorithms that mimic the process of natural selection and genetics (Goldberg & Sergest, 1897). Two competiting goals govern the design of a global search strategy: exploration and exploitation. Exploration ensures that every part of domain will be covered and exploitation concentrates the search efforts in a close neighborhood of the best detected position. The power of the genetic algorithm comes from their ability to combine both exploration and exploitation in an optimal way (Holland, 1975). Memetic algorithms are a wide class of randomized search heuristics that hybridize evolutionary algorithms with local searches (Neri et al., 2011). Preliminary memetic algorithm schemes applied single local optimization components throughout the global search (Moscatto, 1989). Recently the focus is concentrated on algorithms that take advantage of more than one local search. The different steps in genetic algorithm are initialization, selection, crossover, mutation and replacement. At initialization stage the population is randomly generated, at selection stage individuals are selected to create mating pool, crossover operator is applied to produce offspring from individual, mutation is applied to maintain diversity and at replacement stage individuals are replaced by offspring according to replacement strategy.

Some key terms in genetic algorithm are:

- Individual – any possible solution
- Population – group of all individuals
- Search space – all possible solutions to the problem
- Chromosome – blueprint for an individual
- Trait – possible aspect of an individual
- Allele – possible aspect of an individual
- Locus – the position of a gene on a chromosome
- Genome - collection of all chromosomes for an individual

II. RELATED WORK

Holland (Holland, 1975) and David Goldberg (Goldberg, 1989) by using k-armed bandit analogy showed that both exploration and exploitation are used by genetic algorithm at the same time. Due to certain parameters, it has been observed that, stochastic errors occur in genetic algorithm that leads to genetic drift (Booker, 1987). Rakesh Kumar et al. proposed a novel crossover operator that uses the principle of Tabu search. They compared the proposed crossover with PMX and found that the proposed crossover yielded better results than PMX (Kumar & Jyotishreee, 2012). H.A. Sansi et al. investigated the performance of genetic algorithm and memetic algorithm for constrained optimization knapsack problem. The analysis results showed that memetic algorithm converges faster than genetic algorithm and produces more optimal result (Sansi et al., 2011). A comparative analysis of memetic algorithm based on hill climbing search and genetic algorithm has been performed for the cryptanalysis on simplified data encryption standard problem by Poonam Garg (Garg, 2009). She concluded that memetic algorithm is superior for finding number of keys than genetic algorithm. Antariksha (Bhaduri, 2009) proposed a hybrid genetic algorithm based on GA and Artificial Immune network Algorithm (GAIN) for finding optimal collision free path in case of mobile robot moving in static environment filled with obstacles. She concluded that GAIN is better for solving such kind of problems. E. Burke et al (Burke & Smith, 2010) proposed a memetic algorithm based on Tabu search technique to solve the maintenance scheduling problem. The proposed MA performs better and can be usefully applied to real problems. Malin et al (Bjornsditter & Wessberg, 2010) proposed a memetic algorithm for feature selection in volumetric data containing spatially distributed clusters of informative features in neuroscience application. They concluded that the proposed MA identified a majority of relevant features as compared to genetic algorithm. Sivaraj et al (Sivaraj et al., 2012) discussed about a novel approach to improve the performance of genetic algorithm by using selective initialization, which aims at supplying more fit individuals in the beginning. The result shows that the selective

initialization enhances the convergence velocity and produces more optimal solution than existing schemes used in generic genetic algorithm. A novel initialization approach has been proposed by Sharyar et al which employs opposition based learning to generate initial population. The experiments conducted over a comprehensive set of benchmark functions demonstrated that replacing the random initialization with the opposition based population initialization can accelerate the convergence speed (Dawkins, 1976).

III. HILL CLIMBING

An optimization problem can usually also be modeled as a search problem, since searching for the optimum solution from among the solution space (Mitchell & Holland, 1994). The steps in hill climbing techniques are:

1) Start with the initial population, set current point as the starting point.
2) Make a move to the next solution.
3) If the move is better than the start point then set the new point as the current point and repeat step 2. If the next move is bad than previous than terminate. The last current solution is the possible optimum solution.

The move operation is problem dependent. In a discrete optimization problem, such as the Travelling Salesman Problem, a move operation would probably shuffle a couple of positions in the original solution (Mitchell & Holland, 1994). To avoid stuck at local minima random restart hill climbing is used.

IV. METHODOLOGY

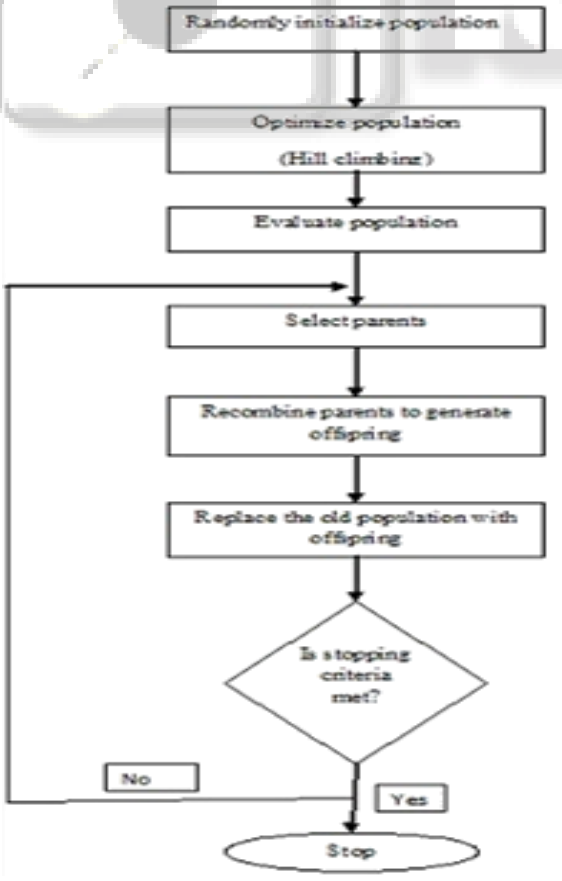

Fig. 1: Proposed Hybrid Initialization Methodology

Procedure for memetic algorithm is same as simple genetic algorithm except that a local search method is implemented in one of the stage (initialization, crossover, selection and replacement) to exploit the search space. Applying hill climbing at initialization stage work efficiently to find the optimal solution.

In the proposed work an initial population is generated randomly. The randomly generated population is passed to the hill climbing local search. After applying hill climbing population is evaluated and the evaluated population is passed to the genetic algorithm as its initial population. Knapsack 0/1 fitness function is used to calculate fitness of the population. Parents are selected for crossover, after applying crossover if the generated offspring fitness is better than the parent fitness value than parents are replaced by offspring. This procedure repeats until stopping criteria is met.

V. EXPERIMENTAL RESULTS

Using the method described in the previous section it is tried to determine the effect on the performance of GA. Mutation is used to maintain diversity in the population. Following properties of GA are used for performing experiments:

- Random initialization
- Binary encoding
- Two point crossover
- Flipping mutation
- 0.9 crossover probability
- Mutation probability 0.1

Following graphs shows the performance of Simple GA and Hybrid GA which uses the function of Knapsack 0/1 function as fitness function. Knapsack 0/1 function gives the profit value of both GA and Hybrid GA

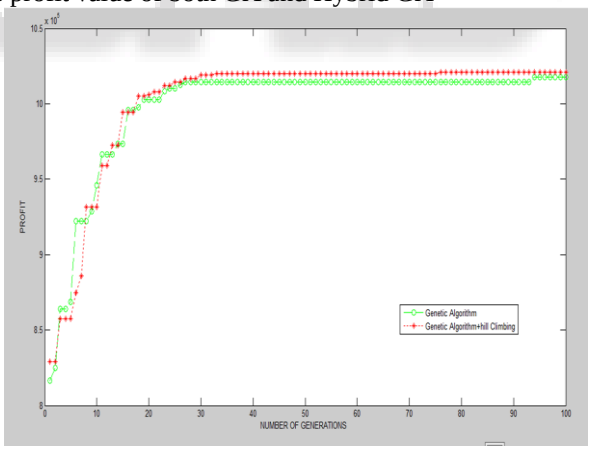

Fig. 2: GA – 1033038, Hybrid GA – 1053643

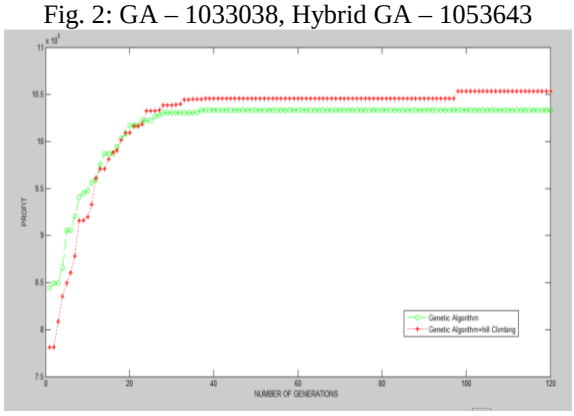

Fig. 3: GA- 1033038, Hybrid GA- 1053643

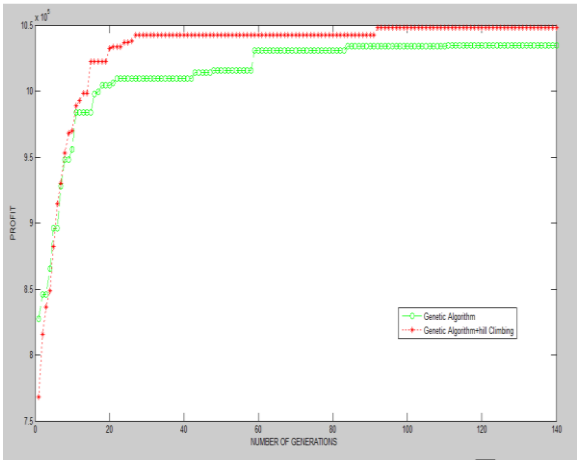

Fig. 4: GA-1034621, Hybrid GA- 1048003

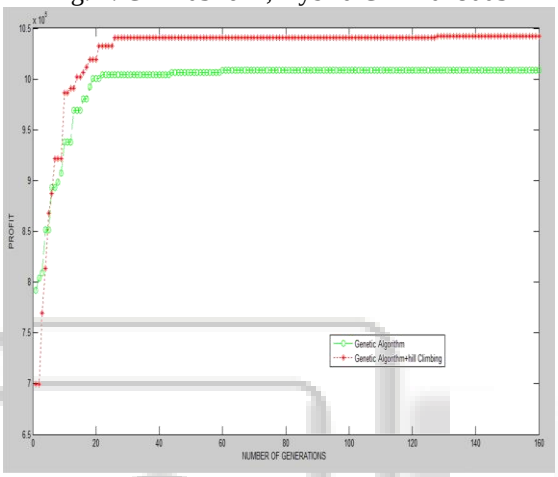

Fig. 5: GA- 1008975, Hybrid GA-1042383

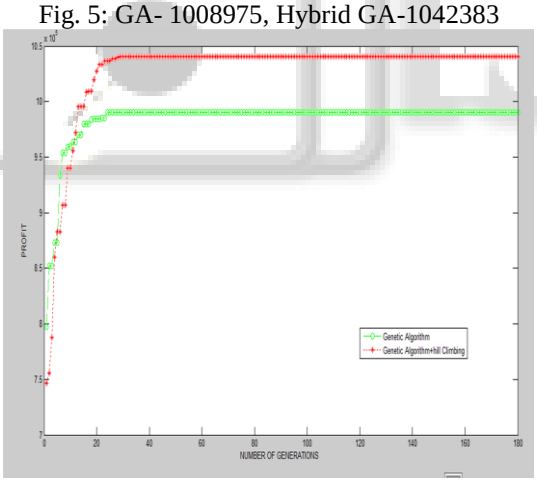

Fig. 6: GA- 990656, Hybrid GA- 1040656

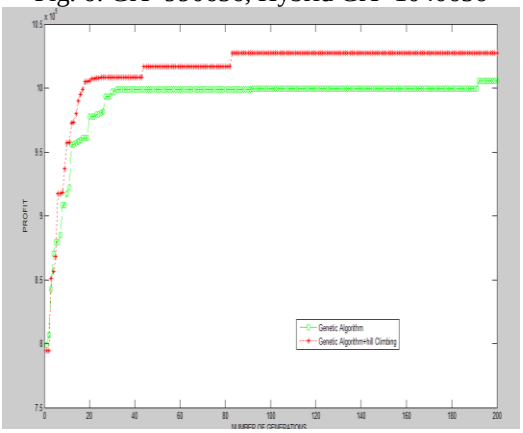

Fig. 7: GA- 1005775, Hybrid GA- 1027314

Results of knapsack 0/1 function with population size = 70

Figure	Generation	Genetic Algorithm	Memetic Algorithm
1	100	1017543	1020741
2	120	1033038	1053643
3	140	1034621	1048003
4	160	1008975	1042383
5	180	990656	1040656
6	200	1005775	1027314

Table-1: Result of Knapsack

VI. Conclusion and Future Work

The paper has compared simple genetic algorithm and proposed memetic algorithm on the knapsack 0/1 test function. It was found that the proposed memetic algorithm result is better than the simple genetic algorithm. The proposed work uses the concept of hill climbing local search at initialization stage and gives the new population then new population is passed to GA, GA gives the result according to their fitness value. Hybridization of GA improves the performance of genetic algorithm in terms of convergence and optimal solution. This algorithm can be tested and implemented in different combination of selection, crossover and replacement in future to substantiate its performance.

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