



Effect of Hybridization of Hill Climbing with Selection Operator in Genetic Algorithm

Manju Sharma¹, Sanjay Tyagi², Rakesh Kumar³
Research Scholar¹, Assistant Professor², Professor³

Department of Computer Science and Applications, K.U. Kurukshetra, Haryana
INDIA

Abstract: *Premature Convergence and genetic drift are the inherent characteristics of genetic algorithms that make them incapable of finding global optimal solution. A memetic algorithm is an extension of genetic algorithm that incorporates the local search techniques within genetic operations so as to prevent the premature convergence and improve performance in case of NP-hard problems. This paper proposes a new memetic algorithm where hill climbing local search is applied to each parent selected by selection operators. The experiments have been conducted on two TSP benchmark problems. Implementation is carried out using MATLAB and results shows that the proposed memetic algorithm maintains the balance between exploitation and exploration & outperforms genetic algorithm in terms of producing more optimal solution.*

Keywords: *Genetic algorithm, Hill climbing search, Hybrid genetic algorithm, Memetic algorithm, Selection*

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 [1]. Evolutionary algorithms are heuristic search algorithms which do not always guarantee to provide the exact optimal solutions, but they will definitely find better optimal solutions within less amount of time. Some of them are Genetic algorithms, Genetic programming, Evolutionary programming Evolutionary Strategies etc. Genetic algorithms are adaptive optimization algorithms that mimic the process of natural selection and genetics [2]. A generic genetic algorithm consists of following operations namely: Initialization, Selection, Reproduction and Replacement. Initialization refers to the generation of initial population by using some suitable encoding scheme. Selection operator selects the individuals randomly or according to their fitness. Crossover and mutation are used to maintain diversity in the population. During replacement, the old individuals are replaced by new offspring's. The cycle stops when the optimal result is achieved.

The performance of genetic algorithms depends on the balancing between the exploitation and exploration techniques. Exploitation means to use the already available knowledge to find out the better solution and Exploration is to investigate new and unknown area in search space. The power of genetic algorithms comes from their ability to combine both exploration and exploitation in an optimal way. Genetic algorithms are incapable of finding global optimal solution due to the inherent characteristics of premature convergence and genetic drift. A local search method within the genetic operators can introduce new genes than can overcome the problem of genetic drift and accelerate the search towards global optima [3]. A combination of genetic algorithm and a local search method is called as hybrid genetic algorithm or memetic algorithm. In hybrid genetic algorithms, knowledge and local search can be incorporated at any stage like initialization, selection, crossover and mutation. The finite population can cause genetic algorithm to produce solutions of low quality. Genetic algorithm is not able to locate the best solution in the best region due to its inability to make small moves in the neighborhood of current solution [4]. Using a local search method within the framework of genetic algorithm can improve the exploiting ability of search without limiting its exploring ability.

In this paper, a memetic algorithm is proposed called as Hybrid Genetic and Hill Climbing Algorithm (HGHCA) that incorporates hill climbing based local search after selection step. The proposed memetic algorithm was earlier implemented on benchmark multimodal test functions [5], but the authors feel that the proposed hybrid selection operator should be tested on Travelling Salesman Problem and results should be verified. The paper focuses on comparing the effect of proposed algorithm with different selection operators. The paper is organized in the following sections. In section 2, related literature review is given on different researches on memetic algorithm. Section 3 describes hybrid genetic algorithms approach. Hill Climbing local search along with its algorithm is described in section 4. In Section 5 proposed memetic algorithm is discussed. Implementation and computational results are provided in section 6 and concluding and future work remarks are given in section 7.

II. Literature Review

Holland [2] and David Goldberg [1] 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 [6]-[7]. 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 [8]. H.A. Sanusi 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 [9].

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 [10]. She concluded that memetic algorithm is superior for finding number of keys than genetic algorithms. Antariksha [11] 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. proposed a memetic algorithm that based on Tabu search technique to solve the maintenance scheduling problem. The proposed MA performs better and can be usefully applied to real problems [12]

III. Memetic Algorithm & Hybrid Genetic Algorithm

Incorporating problem specific information in a genetic algorithm at any level of genetic operation form a hybrid genetic algorithm [13]. The technique of hybridization of knowledge and global genetic algorithm is memetic algorithm. Memetic Algorithm is motivated by Dawkins notation of a meme. A meme is a unit of information that reproduces itself as people exchange ideas [14]. Memetic Algorithm binds the functionality of genetic algorithm with several heuristics search techniques like hill climbing, simulated annealing, Tabu search etc. A number of issues should be carefully addressed when an effective hybrid genetic algorithm is constructed. Two popular ways of hybridization depends on the concepts of "Baldwin effect" [15] and "Lamarckism" [16]. According to Baldwinian search strategy, the local optimization can interact and allow the local search to change the fitness of individual but genotype itself remain unchanged. The disadvantage of Baldwin's is that it is slow. According to Lamarckism, the characteristics acquired by individual during its lifetime may become heritable traits. According to this approach both the fitness and genotype of individuals are changed during local optimization phase.

IV. Hill Climbing Local Search

Hill Climbing algorithm searches for a better solution in the neighborhood. If it finds a better solution, it changes the current solution with this new one. If the new solution is not the better one then the algorithm stops and keeps the current local optimum solution. The simplex method of linear programming is also a hill climbing procedure that moves from one extreme point solution to another, using an exact neighborhood.

Algorithm Hill Climbing (Iterative improvement)

```
begin  $i$ :=initial solution
repeat generate an  $s \in \text{Neighbour}(i)$ ;
if  $\text{fitness}(s) > \text{fitness}(i)$  then  $i:=s$ ;
until  $f(s) \leq f(i)$  for all  $s \in \text{Neighbour}(i)$ ;
end
```

V. Proposed Memetic Algorithm

Genetic algorithm is not able to locate the best solution in the best region due to its inability to make small moves in the neighborhood of current solution. Using a local search method within the framework of genetic algorithm can improve the exploiting ability of search without limiting its exploring ability.

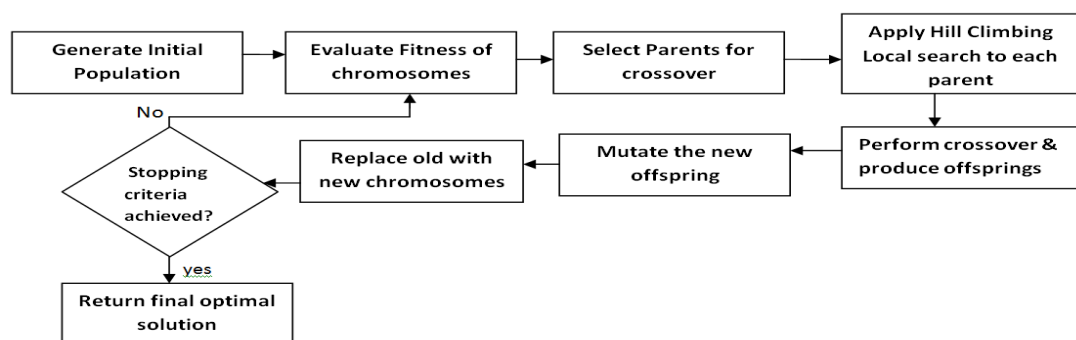


Figure 1 Proposed Memetic Algorithm Flowchart

The proposed memetic algorithm as shown in fig 1, applies hill climbing local search to each parent individual selected by any traditional selection method. Applying local search to each individual before passing them for reproduction, results in the incorporation of good building blocks. If the parent chromosomes contain good genetic information, then the offspring obtained from crossover will share the good features. In the proposed approach, parent selected using roulette wheel selection or rank selection has been used as initial point to carry out hill climbing search. Local search after the selection process maintains the balance between the exploitation and exploration that prevents the algorithm from premature convergence problem. Better children can be obtained by combining good parents else it severely hampers offspring quality.

VI. Implementation & Observations

In this paper, code is developed for genetic algorithm in MATLAB R2011a. The problem considers is the Travelling salesman problem. Travelling salesman problem (TSP) is one of the important NP hard problems often used as a benchmark for optimization techniques. TSP has several applications like planning, logistics, manufacture of microchips and DNA sequencing. TSP problem is to find the Hamiltonian Path or shortest distance through a set of vertices, such that each vertex is visited exactly once. Code considers the benchmark TSP problems namely EIL51 (51 cities) & EIL76 (76 cities) as the test problems taken from TSPLIB. Parameters used for implementation are-

- Fitness Function: Objective value of function (Minimum tour length)
- Population size: 50
- Selection: Roulette wheel selection, Rank selection + Elitism
- Crossover: Partially Matched Crossover (PMX) with $pc=0.7$
- Mutation: Inversion Mutation with $pm=0.01$
- Algorithm ending criteria: Execution stops on reaching ngen generations.

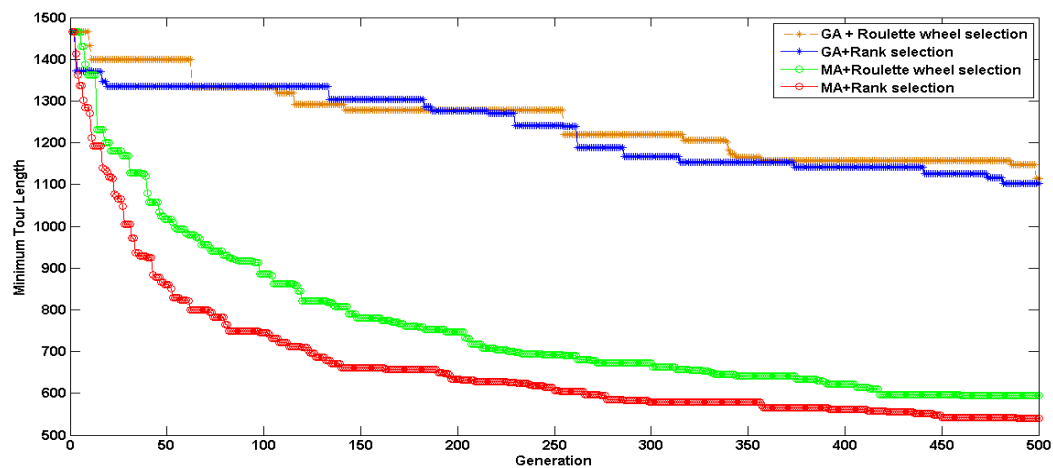


Figure 2 Comparison of Minimum Tour Length in EIL51

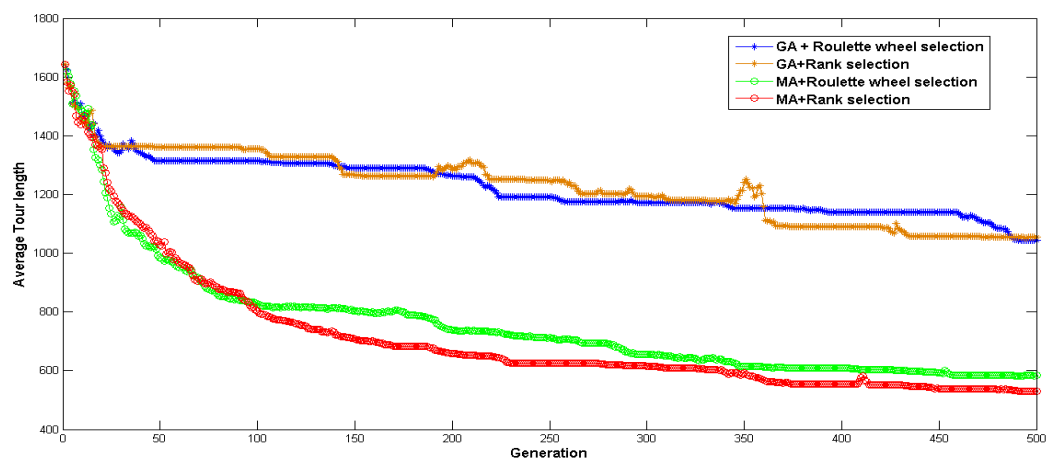


Figure 3 Comparison of Average Tour Length in EIL51

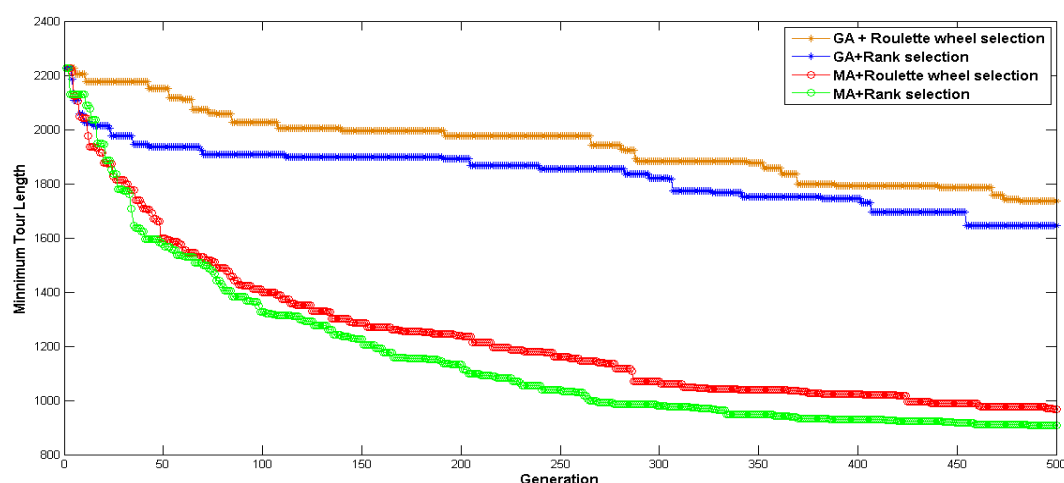


Figure 4 Comparison of Minimum Tour Length in EIL76

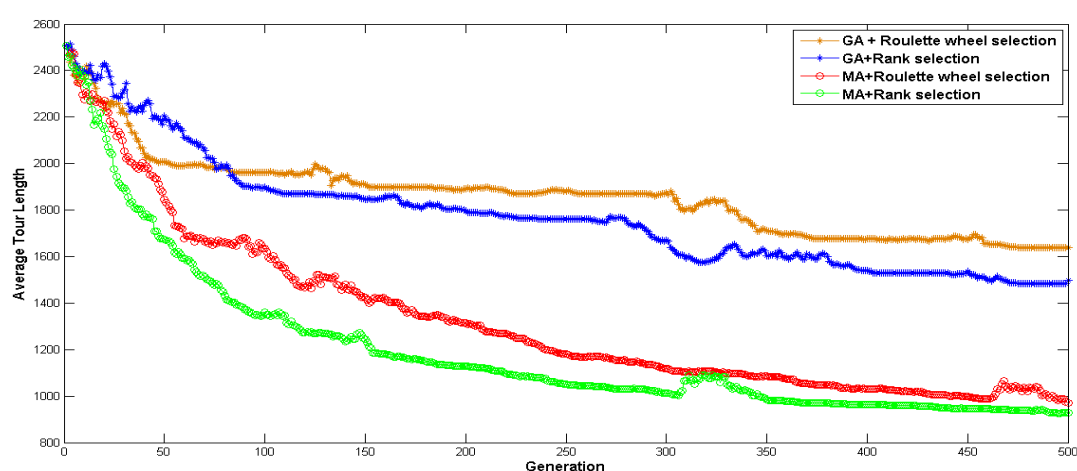


Figure 5 Comparison of Average Tour Length in EIL76

Minimum and Average value of Tour length is computed and plotted to compare the performance of genetic algorithm and proposed memetic algorithm using roulette wheel and rank selection. Figure 2 and Figure 3 depicts the comparison of minimum and average tour length in two approaches for EIL51 TSP problem. & Figure 4 and Figure 5 depicts the comparison of minimum and average tour length in two approaches for EIL76 TSP problem. Code checks the performance of genetic algorithm by using roulette wheel & rank selection first, then using the proposed hill climbing based memetic algorithm. It was observed that the rank selection is more promising than the roulette wheel selection. Roulette wheel selection had more of exploitation approach and converged earlier than rank selection. On the contrary, rank selection had more of exploratory nature and kept on exploring new solutions. Further, when hill climbing local search was combined with these selection methods, the results drastically improved. It is clear from the figures that proposed memetic algorithm maintains the balance between the exploration and exploitation and outperform the simple genetic algorithm.

Table 1 Comparison of Tour Length in different Generation

Selection		RWS		RS		MRWS		MRS	
		Fmin	Favg	Fmin	Favg	Fmin	Favg	Fmin	Favg
Gen=100	Eil51	1265	1562	1164	1552	1011	1461	1046	1414
	Eil76	1866	1911	1820	1862	1536	1633	1486	1563
Gen=200	Eil51	1234	1285	1203	1237	770	853	707	719
	Eil76	1783	1821	1637	1813	1116	1284	1099	1221
Gen=500	Eil51	990	1137	937	1119	588	646	570	577
	Eil76	1536	1736	1736	1645	977	1054	908	920
Gen=1000	Eil51	923	993	898	898	573	574	488	523
	Eil76	1529	1533	1332	1499	746	839	732	749

Table 1 shows the comparison result of four approaches namely GA+ Roulette wheel selection (GRWS), GA+ Rank selection, MA+ Roulette wheel selection (MRWS), MA+ Rank selection (MRS) for different generation. It is clear from the table values that the proposed algorithm is better than genetic algorithm in all the cases.

VII. Conclusion

The paper compares two algorithms namely genetic algorithm and proposed memetic algorithm on the standard benchmark TSP problems using different combination of selection operators. The proposed memetic algorithm applies hill climbing local search to each parent individual selected by roulette wheel or rank selection method. Applying local search to each individual before passing them for reproduction, results in the incorporation of good building blocks. The Hill climbing local search allows the genetic algorithm to improve the exploiting ability of search without limiting its exploring ability. The proposed algorithm improves the performance in terms of convergence and optimal solution as well as maintains diversity in the population & solves the problem of premature convergence and genetic drift. This algorithm can be tested and implemented in different combination of crossover and initialization in future to substantiate its performance.

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