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Novel Knowledge based Selective Tabu Initialization in Genetic algorithm

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Abstract— Genetic algorithms facilitate the hybridization of other local search techniques to get the optimal solution and to remove the problem of genetic drift. Success of Genetic Algorithm mainly depends upon the individuals selected in the initial population and the size of population. If the individuals chosen in the initial population are poor, it will result in weaker solutions and premature convergence towards optima. This paper proposes a novel selective tabu initialization method based on tabu search that supplies more fit individuals in the beginning phase itself. The proposed tabu initialization is tested on three different instances from TSPLIB provided by Heidelberg University and the result are compared with simple random initialization and hill climbing based initialization. The implementation has been carried out using MATLAB and result shows that the proposed selective initialization by tabu search outperforms the existing random and hill climbing based initialization scheme used in genetic algorithm in terms of producing more optimal solution and better convergence speed.

Keywords—Genetic Algorithm, Hill Climbing, Hybrid genetic algorithm, Initialization, Tabu search

I. INTRODUCTION

Evolutionary algorithms (EAs) are population-based optimization algorithms that use biology-inspired mechanisms like mutation, crossover, natural selection, and survival of the fittest in order to refine a set of solution candidates iteratively. Evolutionary algorithms [1] 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]. Genetic algorithms have been applied to variety of Optimization problem like Travelling salesman, benchmark dejong's function, Protein Synthesis etc for more than four decades. Genetic algorithms are inspired from biological genetics model and most of its terminologies have been borrowed from genetics. A generic genetic algorithm consists of following operations namely: Initialization, Selection, Reproduction and Replacement. Initialization refers to the seeding 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 balance between exploitation and exploration. During replacement, the old individuals are replaced by new offspring's.

The pseudo code of the generic Genetic Algorithm is given below.

Step 1: Decide the encoding scheme and generate initial random population
Step 2: Calculate fitness value of each individual
Step 3: Select the fit individuals (individuals with high fitness values) using any selection technique
Step4: Perform crossover or recombination on the selected parents with probability Pc to create the offspring's.
Step 5: Perform mutation on the new individuals (chromosomes) formed with probability Pm
Step 6: Replace the worst parents with the good offspring's
Step 7: Check for termination criteria
If termination criterion is satisfied, then stop the algorithm
Else
Iterate steps 3 to 7

The first step in the GA is to select proper encoding technique and the population size. Large population size increases the amount of diversity in the initial population but it demands more computational effort and long execution time. Small population size limits the diversity of individuals in the solution space. Thus in each problem problems, appropriate population size should be chosen for implementing GA to get more optimal solution. The performances of genetic algorithms depend 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. In practice, the population size is finite that influences the performance of genetic algorithm and leads to

the problem of genetic drift that occurs mostly in case of multimodal search space. Incorporating 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 [3]. Providing diversity to individuals in the initial population is very much required because diversity allows the algorithm to search on the large possible solution space. If the diversity is very low, then the algorithm generally leads to premature convergence which is not desirable which is not desirable.

In this paper author proposed a novel selective initialization method based on tabu search that supplies more fit individuals in the beginning phase itself using tabu search. The proposed initialization is compared with random initialisation and hill climbing initialization [5] on standard benchmark travelling salesman problems (TSP). The paper is organized in five sections. In section 2, Literature review is given on different researches related to hybrid genetic algorithms and initialization. In section 3, memetic algorithms are discussed. Tabu search is described in section 4. Proposed Initialization along with its algorithm is provided in section 5. Implementation details and computational results are specified in section 6. Last section contains conclusion & future work.

II. LITERATURE REVIEW

Sivaraj et al [6] discussed about a novel approach to improve the performance of genetic algorithm by using initialization through tournament selection, 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 conducted experiments over a comprehensive set of benchmark functions demonstrated that replacing the random initialization with the opposition based population initialization can accelerate the convergence speed [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 algorithm.

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 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]. Malin et al [13] 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. Manju Sharma and Sanjay Tyagi [5] proposed a new initialization based hybrid algorithm that supplies more fit individuals in the beginning phase using hill climbing search. The experiment has been conducted using TSP problem The Implementation result shows that the proposed hill initialization algorithm performs better than the existing initialization scheme.

III. HYBRID GENETIC ALGORITHMS

Incorporating problem specific information in a genetic algorithm at any level of genetic operation form a hybrid genetic algorithm [14].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 [15]. Memetic Algorithm binds the functionality of genetic algorithm with several heuristic's 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" [16] and "Lamarckism" [17]. According to Baldwinian search strategy, the local optimization can interacts 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. TABU SEARCH

Tabu Search (TS) has been developed by Glover [18] in the mid 1980s. Tabu Search extends hill climbing by the concept that it declares solution candidates which have already been visited as tabu. Hence, these solutions must not be visited again and the optimization process is less likely to get stuck on a local optimum. The simplest realization of this approach is to use a list tabu which stores all solution candidates that have already been tested. If a newly created

phenotype can be found in this list, it is not investigated but rejected right away. Of course, the list cannot grow infinitely but has a finite maximum length n. If the n + 1st solution candidate is added, the first one must be removed. Tabu search can be applied to both continuous and discrete solution spaces. Tabu search obtains solutions that often surpass and rival the best solutions previously found by other approaches.

V. PROPOSED TABU INITIALIZATION

In the proposed algorithm the initial population is generated by applying tabu search to each individual generated randomly which controls the flow of the chromosomes in the genetic algorithm process. The aim of applying more fit individuals in the beginning phase is to increase the chance of obtaining better optimal solution. Tabu search is applied to each individual, so as to store its best neighbors in the tabu list and then the best solution from the list is selected as tabu that represents the initial population. Tabu search generates initial solution from different area of search space and seed better population to the algorithm in order to maintain a balance between exploitation and exploration.

The outline of proposed algorithm is as follows.

Step 1 Selective Initialization: Generate a population of n individuals. Apply Tabu search procedure to each n solution in the population using tabu list (of size t) that contains the best neighbors of that individual. The last individual from tabu list is selected as its best solution. After tabu search is applied to each n solution in current population, the current population is replaced with its generated best solution (i.e. Lamarckian approach).

Step 2 Evaluation: Calculate the fitness of each solution in population.

Step 3 Selection: Repeat procedure to create a mating pool.

a) Assign rank to each individual according to its fitness. Worst individual is given the rank 1.

b) Then apply the roulette wheel procedure to select the individual in order to generate the mating pool. The individuals are placed on the wheel according to their rank proportion.

Step 4 Crossover and Mutation: Apply a crossover operation to each selected pair of parents from mating pool with the crossover probability P_c. A new solution is generated from each pair. Then apply mutation operation to each new solution with mutation probability P_m.

Step 5 Elitist Strategy: Select the best individual from the initial population and pass it directly to next generation by replacing it with the worst individual of population generated after step 4.

*Step 6 Replacemen*t: Replace the current population by individuals generated in above step and return to step 2 until termination criteria not reached.

The structure of the proposed methodology is given in the figure 1.

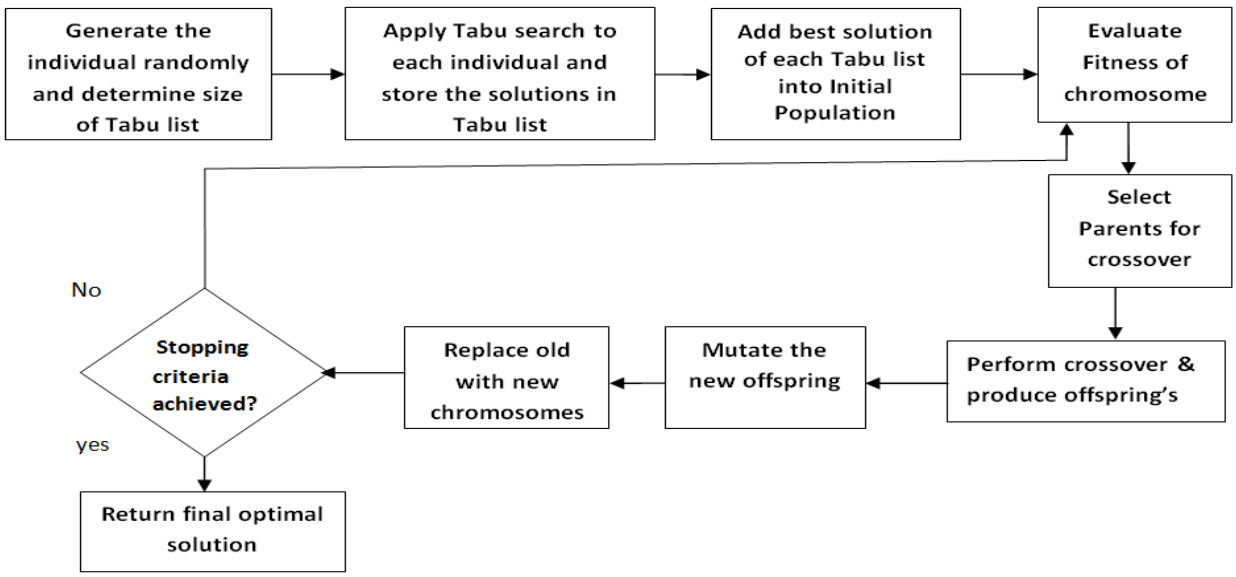

Fig 1 Proposed Selective Initialization by Tabu Search

VI. IMPLEMENTATION & OBSERVATIONS

In this paper, MATLAB code has been developed to find the performance of proposed tabu selective initialization, hill climbing based initialization and random initialization in genetic algorithm using the same selection, crossover and mutation operator. The code considers the benchmark TSP oliver30, EIL51 and EIL76 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. Min and Average value of Tour length is computed for 100 generation and plotted to compare the performance of three

initialization approaches. This section contains the result of code runs. Comparison of three approaches is based on their respective function values.

Parameters used for implementation are-

- Population size: 20
- Number of generations: 100
- Encoding: Permutation encoding
- Selection: Rank selection + Elitism
- Crossover operator: Partially Mapped crossover operator.
- Mutation: Inversion Mutation
- Crossover probability (p_c=0.7)
- Mutation probability (p_m=0.01)

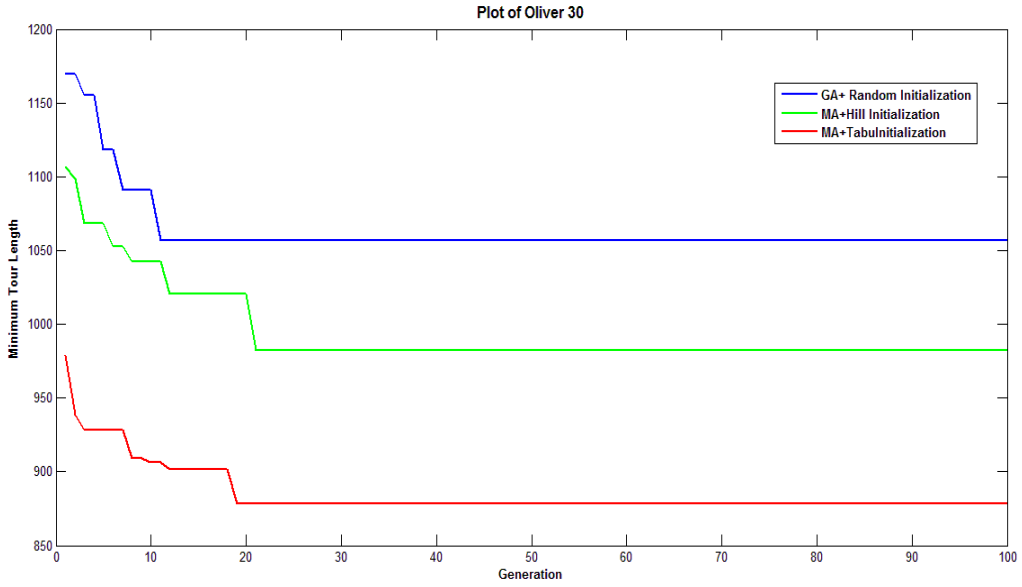

Fig. 2 Comparison of Minimum Tour length between three Initialization approaches in oliver30

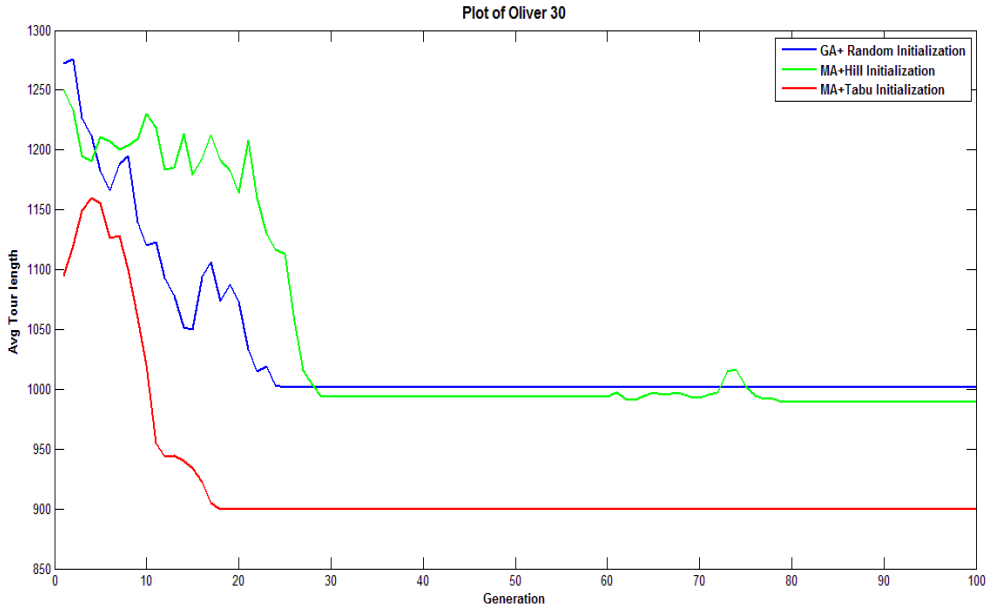

Fig. 3 Comparison of average Tour length between three Initialization approaches in oliver30

Figure 2 , Figure 4 and Figure 6 depicts the minimum tour length for Oliver30, EiL51 and EiL76, respectively. Figure 3, depicts the average tour length for oliver30 and Figure 5, Figure 6 depicts the average tour length for Eil51 & EiL76 respectively. Figures compares the fitness values of three initialization approaches.

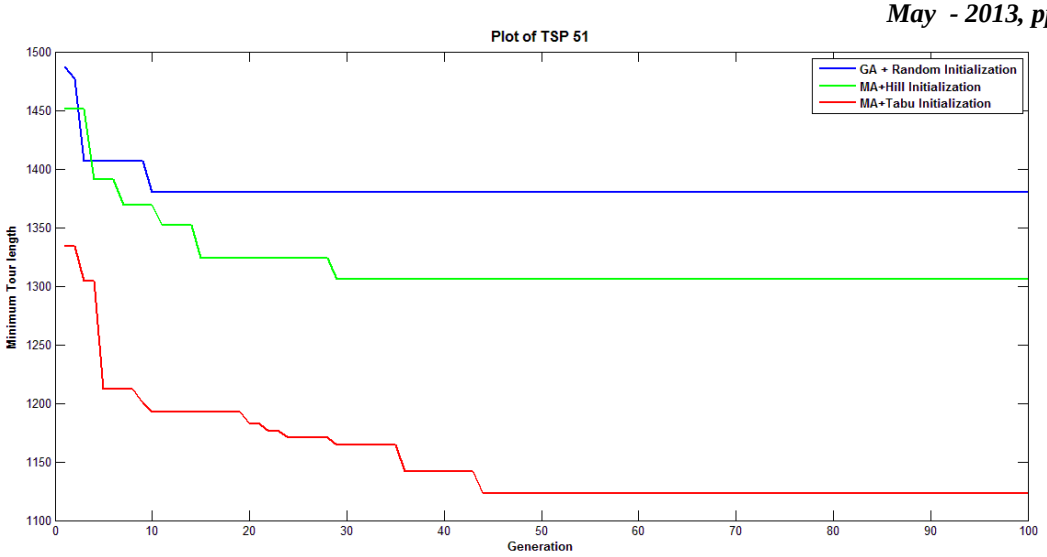

Fig. 4 Comparison of Minimum Tour length between three Initialization approaches in EiL51

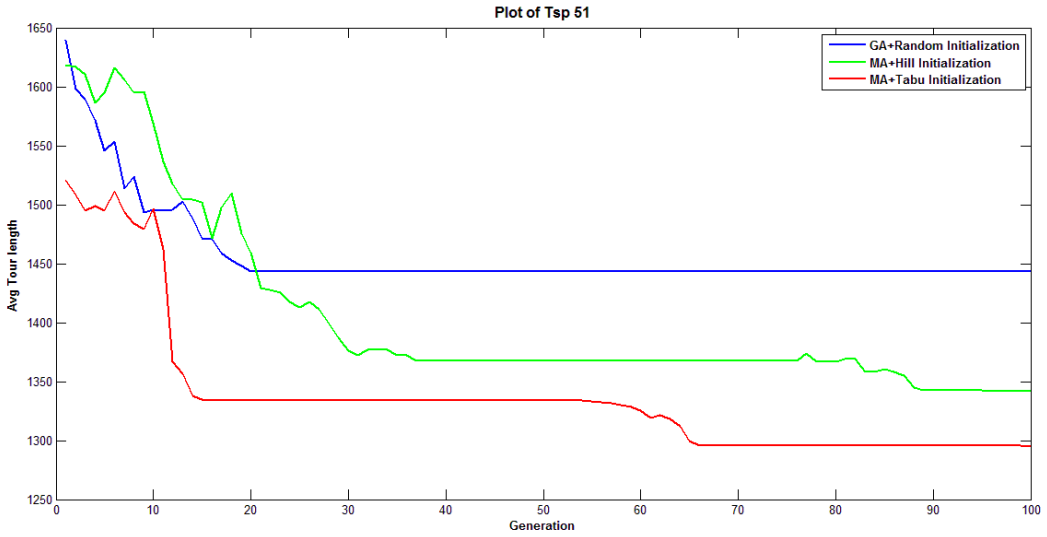

Fig. 5 Comparison of Average Tour length between three Initialization approaches in EiL51

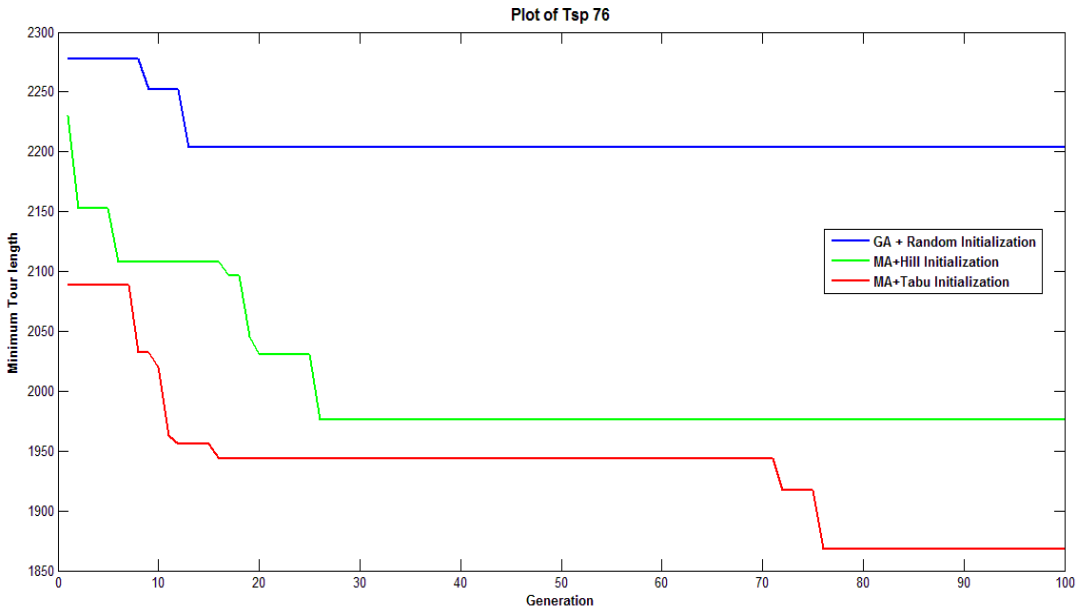

Fig. 6 Comparison of Minimum Tour length between three Initialization approaches in EiL76

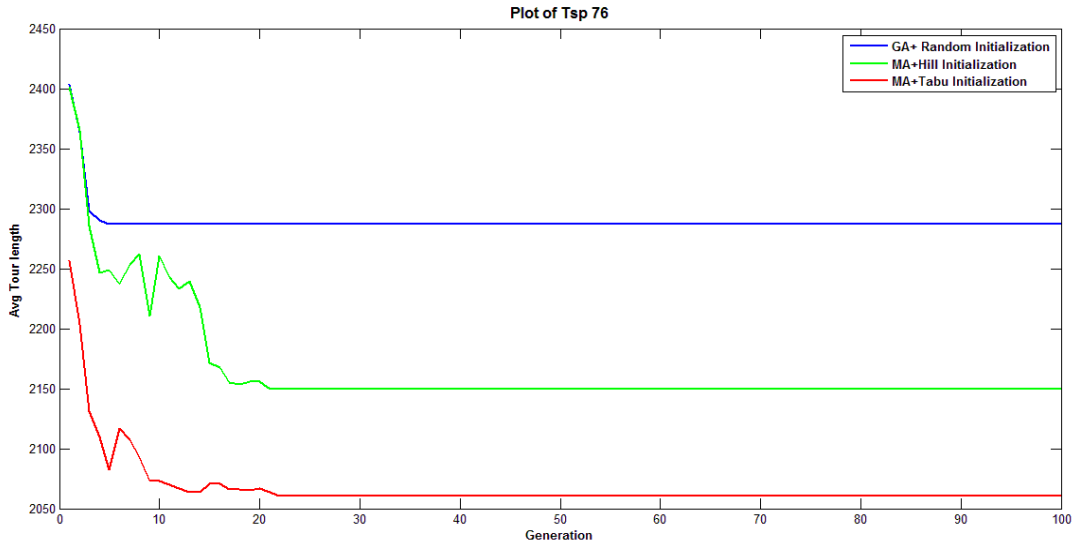

Fig. 7 Comparison of Average Tour length between three Initialization approaches in EiL76

It has been observed from the Figures that the proposed selective tabu initialization based memetic algorithm has outperformed hill climbing based intiaalization and random initialization in terms of convergence and optimal solution. The proposed tabu initialization maintains more diversity in population and prevent algorithm to stick in local optima and genetic drift problem.

VII. CONCLUSION

Although there is no optimization algorithm that guarantees to produce the best optimal solution, but all evolutionary algorithms including Genetic Algorithm are able to find near optimal solution. If the best chromosomes are introduced into the initial population, Genetic Algorithm is guaranteed to produce better optimal results. By using this idea this paper proposes a new selective tabu initialization that supplies the initial population through tabu search. The proposed tabu initialization selects individuals throughout the search space that main diversity in population. The proposed tabu initialization is compared with hill climbing initialization and random initialization. The result shows that the hill climbing initialization is better than random one but the proposed tabu initialization outperforms the both approaches. Tabu Initialization approach effectively generates the more optimal solution and enhances the convergence speed towards optima. As a future work, selective tabu initialization will be used for initializing the population in Genetic Algorithm in other types of problems. The algorithm can be adapted for other evolutionary algorithms also. This algorithm can be tested and implemented in different combination of crossover and selection in future to substantiate its performance.

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