Different population-based algorithms for Travelling Salesman Problem: A Review Paper

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Abstract -In this review paper, travelling salesman problem (TSP) is used as a domain. TSP is widely used to test new heuristics and is a well-known classical NP-complete combinatorial optimization problem in operation research area. From different fields such as artificial intelligence, physics, operations research etc. this problem has attracted many researchers. TSP has been studied thoroughly in late years and many algorithms have been developed. To address this problem using classical methods many attempts had been made such as integer programming and graph theory algorithms. In TSP the rules are very simple. TSP states that the nodes that must be visited once should not be visited again. TSP has huge search space. To find the optimal solution is very difficult. In this paper, a survey and comparative analysis are done for better results in TSP. The basisof the literature survey identify some research gaps on which further work can be done. The comparative analysis is done on the basis of contrasting parameters by comparing the differentpopulation-based algorithms.

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I. INTRODUCTION

In recent years, TSP a classic combinatorial problem is one of the most competently studied problems in optimization. In 1800's, this problem was introduced by the British mathematician Thomas Kirkman and the Irish mathematician W.R. Hamilton. This problem is known to be NP-complete and cannot be solved in polynomial time. It is very simple to state but very difficult to solve. To find a possible tour in which a traveling salesman visits each city exactly once and come back to the starting city from a given pool of cities, this is called TSP. The problem is to find the shortest possible path from the given pool of cities. The main aim of TSP is to minimize the total cost or distance covered throughout the tour. Thus, it craves the use of techniques that are able to find better quality solutions in a reasonable time.

To solve loads of optimization problems the population-based optimization algorithms have been widely used and successfully applied. Unlike traditional single-point based algorithms such as hill-climbing algorithms, thepopulation-based optimization algorithmssolve the problem by sharing the information to collaborate among a set of points called population. There are other loads of population-based algorithms existed. The evolutionary algorithms including evolutionary programming, evolution strategy, genetic algorithms which were inspired by biological evolution, the very first algorithms of population-based algorithms [1]. The recently occurred population-based algorithms are usually called nature-inspired optimization algorithms including evolution inspired algorithms.The nature-inspired optimization algorithms are categorized as swarm intelligence (SI) algorithms.SI is the collective behavior of all individuals that make the algorithm to be effective in problem optimization. It is the study of the collective behavior of social insects or other species of animals that live in that society. Until some stopping condition is met, SI algorithms keep and respectively improves a collection of potential solutions. The solutions are loaded randomly in the search space. To move toward the better results in the solution search space, all individuals move collectively and in a cooperative manner. In SI algorithms, there are several solutions sustain at the same time. The self-organization is an important characteristic of SI systems. With low-level interactions within agents, the swarm is capable of providing global responses. Among the various debatable global optimization techniques designed initially for non-linear continuous function optimization, SI algorithms endeavor a number of attractive features, global search capability, and easy implementation.Some of the examples of such algorithms in this area are Particle swarm optimization (PSO), Ant colony optimization (ACO) etc. These algorithms represent only simple objects such as birds in particle swarm optimization and ants in ant colony optimization.

The branch of SI that is used for solving many engineering optimization problems is called particle swarm optimization (PSO).In 1995, Kennedy and Eberhart developed PSO, a meta-heuristic population based on global optimization [2]. PSO offers the benefit such as global research and easy implementation while maintaining strong convergence capabilities. PSO is a biological nature-inspired optimization technique based on replicating the behavior of swarms such as bird blocks or school of fish.

It is an extremely simple algorithm and having a low number of control parameters, these are the main advantages of PSO [3]. Favorably, the PSO is easy to be parallelized as while moving in the search space the particles do not depend on each other. Many approaches affirm multiple swarm versions of the PSO and resemble multiple particles at a time. The search performance of the PSO reveal excellent results with a small population and by increasing the population size the performance of the PSO can be improved [3].

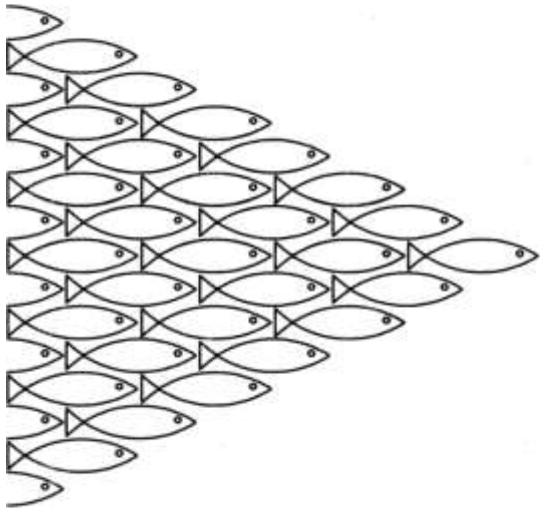

FIGURE 1. School of fish

II. LITERATURE SURVEY

In 2012**, Dwivedi et al. [4]**discusseda genetic algorithmfor solving the TSP. In their work with the reduction of cost, they offered a solution which includes implementation of the genetic algorithm in order to give a maximal approximation of the problem. Using new crossover technique for thegenetic algorithm that develops ahigh-quality solution to the TSP, this paper presents an approach to find the nearly optimized solution to such type of problems. The efficiency of the crossover operator and some existing crossover operators is compared. The aim of the proposed work here is to compare the efficiency of the new crossover operator with some existing crossover operators. An example of 7 cities graph through matrix representation ins taken and on the basis of calculations, they reached on an experimental result that their new crossover operator is qualified for calculating an approximately optimal path for TSP using a genetic algorithm in less time. The proposed crossover operator used here is asequential constructive crossover (SCX) and experimental results show that SCX is better in terms of quality of solutions and cost as well as solution times.

In 2015, **Roy et al. [5]**discussed an effective adaptive genetic algorithm to solve the constrained solid TSP in crispy, fuzzy and rough environments. The probabilistic selection technique and adaptive crossover operator aremodeled with arandom mutation in the proposed algorithm. Due to different risk/discomfort factors and other system parameters are presented in each environment. The 11 instances from TSPLIB is considered and experimental results are calculated in different environments.

In 2015, **Kang et al. [6]**discussedbidirectional constructive crossover for anevolutionary approach to solvingthe TSP. In this paper, a special crossover operator known as SCX with bidirectional and circular search in the construction of offsprings is proposed by the authors. It is known that SCX is preferable to other crossover operators in the aspect of fitness of the genes and convergence speed. In the proposed work, the researchers also constructed a simple and effective index management so that the search for the candidate nodes during the offspring construction can be achieved in an efficient way. The proposed bidirectional crossover SCX presents the better convergence speed and even better solutions when compared to those of SCX in the observational experiments.

In 2016, **Masutti and Castro [7]** discussed a bee-inspired algorithm to solve the TSP. In swarm intelligence field, the bee-inspired algorithms acquiring tremendous consideration for providing good solutions in reasonable time to complex problems. In this paper, the work takes optBees algorithm for continuous optimization and proposes the mandatory modifications to solve the TSP by generating TSPoptBees. The proposed algorithm is classified using benchmark instances and then the results are compared to an0ther similar algorithm from the past. The experimental results show that the TSPoptBees exceeded the other ones in 16 instances out of the total of 26 in compliments to the average solution.

In 2016,**Jiang [8]** discussed discrete bat algorithm (DBA) for solving the TSP. In this paper, the numerical instances by using 33 benchmark instances are tested with sizes ranging from 55 to 318 nodes from the TSPLIB and the results of DBA is compared with other three existing works. The percentage deviations of DBA are better than that of the three existing methods and within fulltime in empirical experimental results. The experimental results show that 81.82% of these 33 benchmark instances, the DBA has much better performance than the other three algorithms and has attained the best-known solution.

In 2016, **Zhou and Song [9]** discussed partheno-genetic algorithm to solve the TSP. The paper's aim is to use a more effective partheno-genetic algorithm to solve the TSP and to provide ideas for further improvement of the genetic algorithm. A comparison between the proposed algorithm and the existingalgorithm shows its strength. The comparison test presents that the new selection operation method and mutation causes the algorithm more stable and effective. When compared with the existing algorithm, the proposed algorithm can instantly converge to the optimal solution and is apparently higher.

In 2016, **Hua et al.[10]**discussed the hybridization of discrete particle swarm optimization (DPSO) technique with brainstormoptimization (BSO) for solving the TSP problem. The proposed hybrid algorithm acquires exchange operator from DPSO and handles inversion idea from chromosome structure. To calculate the performance of the proposed algorithm, the BSO-DPSO algorithm is applied to data sets Oliver30, EIL51, and ST70 from the TSPLIB standard database and is compared with other algorithms from the literature. The experimental results show that the proposed hybrid algorithm can deal with the TSP problem well and the effectiveness of the mutation process and local search technique. The results present that the proposed BSO-DPSO algorithm accomplishes satisfactory results and insurances a high coverage rate.

III. COMPARATIVE ANALYSIS

The comparative analysis of different population-based techniques is carried out by analyzing the various parameters which we studied in a literature survey. Among various parameters used, the crossover and mutation are on the top. The crossover and mutation operators are the foundation of these population-based algorithms. As the central problem in TSP is that the salesman has to visit each city exactly once and the overall cost of the tour carried by the salesman must be low. Thus, to achieve this aim the combination of the given list of cities is considered so that we can achieve the low cost and the property of the TSP problem also not get disturbed. The crossover is the process of combining multiple candidate solutions and getsnew solutions and the mutation is the process of flipping the items of candidate solutions for better results. All the evolutionary algorithms are iterative in nature and by applying the various operators in parallel helps to achieve theoptimal solution of TSP problem.Also, we have done a comparative analysis of different techniques on the basis of different parameters like crossover, mutation, time complexity etc.

TABLE 1.Comparative analysis of different algorithms for TSP

Parameters	Genetic Algorithm [4]	Adaptive-genetic algorithm [5]	Bidirectional constructive crossover [6]	Bee-inspired algorithm[7]	Discrete bat algorithm[8]	Partheno-genetic algorithm[9]	DPSO-BSO[10]
Crossover operator	Sequential crossover	Adaptive crossover	Bidirectional sequential crossover	-	-	-	-
Mutation operator	Random mutation	Probabilistic mutation	-	-	-	Random mutation	Inverse mutation
Selection operator	Selection by fitness criteria	Probabilistic selection	Circular search	Probability selection	-	Selection by fitness value	-
Insertion	No	No	No	Yes	No	Yes	Yes
Factors considered for TSP	Population size and speed	Fuzzy rough cost	Population size, cost and coverage speed	Solution cost and distance between two bees	Population size, velocity, loudness and rate of pulse emission of bat	Population, route and mutation rate	Population size
Time complexity	Less but might not find thebest solution	High	Average	High with increase in number of cities	Average	High with increase in number of iterations	Average

IV. CONCLUSION

The TSP is very difficult to solve as itsfocuses on finding the shortest tour that visits each node/city in a pool of given list exactly once and then returns to the starting point. To solve this problem in polynomial time and to get the optimal solution, a number of algorithms are proposed in recent years. We have done literature survey on this problem and conclude that the hybridization of algorithms is done for better optimal results. Also, we have done a comparative analysis of different algorithms on the basis of different parameters like crossover, mutation, time complexity etc. From the comparative analysis, we conclude that the hybridization of any algorithm with PSO can give the satisfactory results in reasonable time. We choose PSO because it has a low number of control parameters and is a very simple algorithm to implement.

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