Journal of Scientific & Industrial Research
Vol. 79, October 2020, pp. 928-930

Solving Travelling Salesman Problem using Discreet Social Group Optimization

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Received 12 September 2019; revised 22 April 2020; accepted 25 May 2020

In this paper, a modified version of social group optimization (SGO) has been proposed i.e discreet social group optimization (DSGO), to find out the optimal path for travelling salesman problem (TSP), which is one of the well known NP-Hard problems. Its performance has been compared with Genetic Algorithm (GA) and Discrete Particle Swarm Optimization (DPSO) and the results found are competitive. It is observed that DSGO converges faster than DPSO and GA and also provides more optimal results for bigger size data.

Keywords: Travelling salesman problem, DSGO, Optimal path

Introduction

Travelling Salesman problem (TSP) is an NP-Hard problem in combinatorial optimization which talks about the shortest route possible that visits every pair of cities exactly once and returns to the starting point from the given set of cities. The problem was first formulated in 1930 and it is one of the most intensively studied problems in optimization and it has got its importance in operations research and theoretical computer science. Since it takes exponential time to find the optimal solution, the Meta-heuristic optimization algorithms have been taken into consideration to solve these problems since 1960s. Meta-heuristic optimization algorithms have been more in the topic of research field than deterministic search optimization technique since they are more efficient in getting the solution of global optimization problems. These Meta-heuristic techniques are time saving and simplify the complex problems by converting the target into mathematical form and then try to solve the exponential time optimization problem in polynomial time through randomized solutions.

There have been many works on finding the optimal path for TSP using diffferent algorithms. Razali *et al.*[1] used GA, Huilian *et al.*[2] used Discreet PSO, Divya *et al.*[3] used Ant systems and Akhand *et al.*[4] used Discreet spider monkey optimization. In this paper Discrete Social group optimization (DSGO) technique has been used to achieve the same. DSGO is a discretized adaptation of Social group optimization (SGO) which was proposed by Satapathy *el al.*[5] SGO is based on the social behaviour of an individual in a community or society.

Proposed Methodology

Discrete SGO uses crossover operator for discretization. An algorithm cannot be used for a discrete problem, as it is used for a continuous problem. SGO finds solution in continuous space, but TSP has discreet solutions i.e. the arrangement of cities. Hence DSGO could be used for that.

Here each individual is represented by one possible solution of TSP. Crossover operator is used when the individuals change their traits in hope of betterment. Here, the crossover operator is denoted by '¤'. For better understanding an illustration of the crossover operator has been provided in Illustration 1. The number of traits to be changed is decided by the crossover length denoted by cLen and always the crossover point is chosen to be a random number in the range of [1, n-1], where n represents total number of cities. Suppose, the given equation is

Xi' = Xi ¤ (cLen) Xj

Here, Xi' represents result of crossover of i-th person (represented by Xi), with j-th person (represented by Xj) having a crossover length of cLen.

Illustration 1 — Working of Crossover Operator

Suppose total number of cities = 10, cLen = 0.2, then crossover length is 0.2*10=2, crossover point = 8

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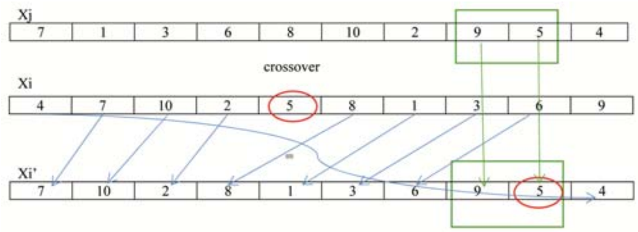

Xi and Xj are the two individuals and Xi' is the resultant individual, after crossover.

The comparison is done between the fitness of Xi and Xi'. If Xi' is found better than Xi, then Xi is replaced with Xi' else Xi' is discarded.

DSGO Algorithm

1 Initialization of Population randomly. Dimension of population is the total number of cities.
2 Following steps are repeated for each iteration and also population is updated -

Improving phase

It is about propagation of knowledge from the best person to the rest of the individual which in turn help the other person to improve their knowledge in the group. In a group of N persons, 'gbest' is chosen. gbest $_=$ min $\{f_i\}$, where i= {1, 2, 3, … N} and f_i is the fitness of person i.

For i : 1 to N
$X_i' = X_i$ ¤ (cLen)X_{gbest}
End

Here, cLen = C * r, where 'C' is the self introspection parameter which ranges from [0, 1]. For TSP, suitable value of C was observed in the range of 0.4 to 0.6 and 'r' is any random number in the range of [0–1]. X_i' is replaced with Xi, if its fitness is better than Xi.

Acquiring phase

In this phase person acquires knowledge by interacting with the best person of the group and also randomly with any other person. A person acquires more knowledge if the other person has more knowledge than him or her.

For i : 1 to N
Randomly select one person Xr, where i != r
If fitness (Xi) < fitness(Xr)
Xi' = [{X_i ¤ (cLen1)Xr} ¤ (cLen2)*X_{gbest}]
Else
Xi' = [{Xr ¤ (cLen1)X_i} ¤ (cLen2)*X_{gbest}]
End If
End For

Here cLen1 and cLen2 are two independent random values in the range of [0, 1]. These random numbers affect the stochastic nature of algorithm and hence yield better result by not getting trapped in the local minima.

Results and Discussion

The dataset are taken from https://people.sc.fsu.edu/~jburkardt/datasets/tsp/tsp.html and implemented with GA[1], DPSO[2] and DSGO. The values of control parameters of the algorithms are presented in Table 1. Each simulation has been repeated for 10 times and average value has been taken as the final value. Reaching maximum iteration has been considered as the stopping criterion. The optimal value returned by the algorithms, when implemented upon five dataset is given in Table 2. In D0, P01 and GR17 dataset, all the three algorithms have obtained the optimal result, but from Fig. 1. (a), (b) and (c), it can be observed that, DSGO converges faster than the other two. For FRI26 and DANTZIG42, DSGO provides more optimal result than the other two and also converges faster, which is shown in Fig 1. (d) and (e).

Table 1 — Values of Control parameters used for simulation

Population	50
Max Iteration	500
GA	
Mutation rate for GA	0.75
Selection Type	Tournament
Tournament Size	2
DPSO	
Hfactor	0.4
C1 (crossover length)	0.5
C2 (crossover length)	0.4
Diversity	0.4
DSGO	
C (Self-Introspection parameter)	0.4

Table 2 — Optimal result obtained from GA, PSO and DSGO for the dataset

Dataset	No. Of Cities	Minimal Cost	GA	DPSO	DSGO
D0	11	253	253.45	253.36	253.07
P01	15	291	291.28	291.23	291.12
GR17	17	2085	2085.32	2085.41	2085.16
FRI26	26	937	1239.33	1240.72	937.27
DANTZIG42	42	669	929.28	1321.18	771.35

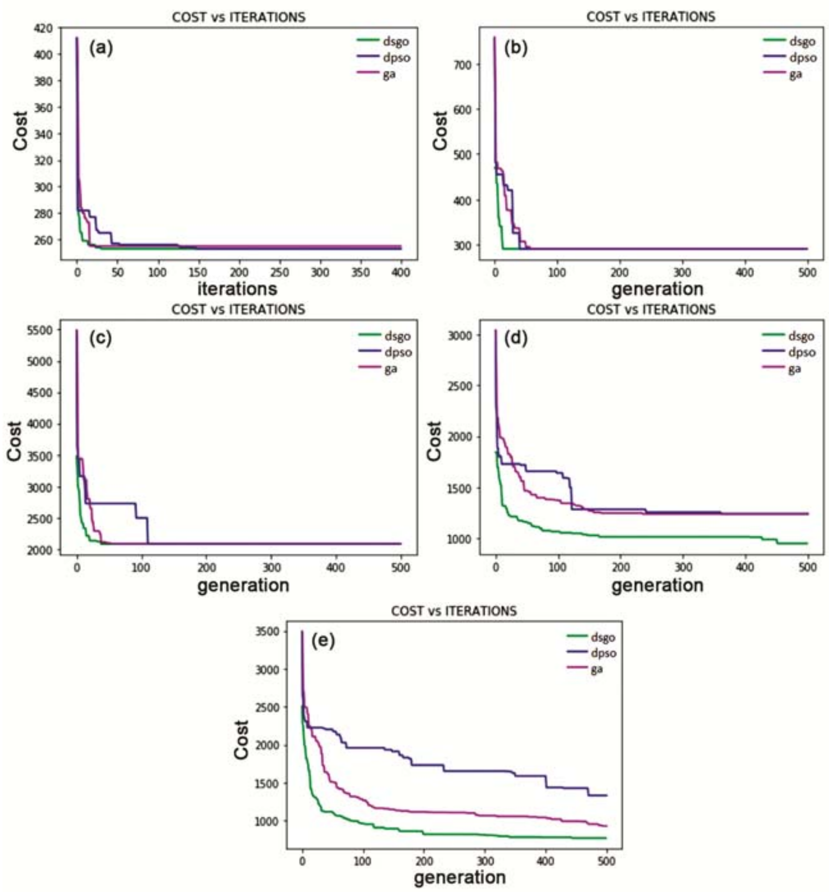

Fig. 1 — Convergence graph of GA, DPSO and DSGO for the datset (a) D0 (b) P10 (c) GR17 (d) FRI26 (e) DANTZIG42

Conclusions

From the results, it could be concluded that, DSGO performed better than GA and DPSO in terms of convergence and finding the optimal solution. DSGO is also a reliable algorithm for scalable input. Such type of algorithms could be used in finding optimal path of automated path planning systems, flight path planning etc. Also, these algorithms could be applied to other similar problems and better results may be expected.

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