Modified Spider Monkey Optimization for Traveling Salesman Problem

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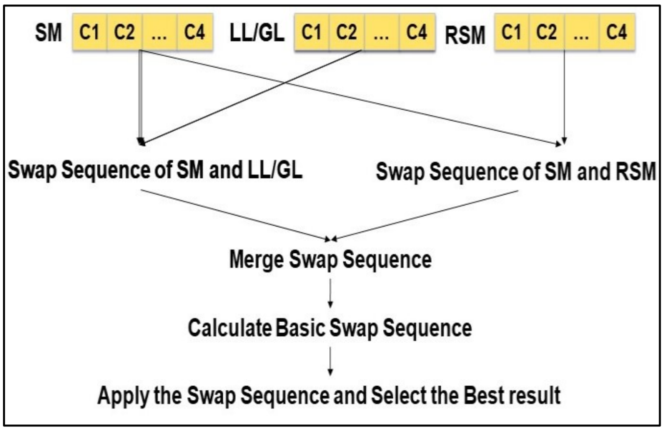
Abstract: **Traveling Salesman Problem (TSP) is the problem faced by a salesman who starts from a specific city and travels all the other cities in the shortest conceivable path. Spider Monkey Optimization (SMO) is developed for numerical optimization inspired by the intelligent foraging behavior of spider monkeys. This thesis investigates a new effective optimization method to solve TSP based on the social behavior of spider monkeys. In the proposed Modified SMO (MSMO), every spider monkey represents a TSP solution; and Swap Sequence (*SS*) and Swap Operator (*SO*) based operations are employed for interaction among monkeys to obtain the optimal TSP solution. The SOs are generated using the experience of a specific spider monkey as well as the experience of other members (local leader, global leader, or randomly selected spider monkey) of the group. In case of updating a solution of spider monkey with generated SS a Partial Search (*PS*) and Basic Swap Sequence (BSS) technique is considered to achieve the best outcome with full or partial SS**.

Methodology: There are six phases to solve the SMO for TSP problem: Local Leader phase, Global Leader phase, Local Leader Learning phase, Global Leader Learning phase, Local Leader Decision phase, and Global Leader Decision phase. In the beginning, a population of N spider monkeys (SMs) is initialized with random TSP tours and fitness of those are measured. The population may be divided into n groups and the local leaders (LLs) of individual groups are selected based on the fitness. Among the local leaders, the best one is chosen as the global leader (GL). In Local Leader Phase In this step, each SM updates or changes its solution based on its current involvement, Local leader involvement and the involvement of randomly selected group members of that group. Global Leader Phase follows the same process. The procedure of updating a SM based on the Local leader/ Global Leader is demonstrated in Figure for better understanding.



In the Local Leader Learning phase and Global Leader Learning phase, the local leaders (LLs) and global leader (GL) are updated respectively. In Local Leader Decision phase and Global Leader Decision phase, if the LL is not updated for a certain period of time, Local leader initializes all the group's members again and the GL takes the decision to divide the group into subgroups or join all the groups into one group. If the termination criterion is met, the TSP solution of the Global leader is considered as the outcome of the proposed MSMO approach.

Proposed Algorithm: In the proposed algorithm there are 5 steps. The following algorithm shows the proposed MSMO algorithm for solving TSP.

Algorithm: MSMO Algorithm to solve TSP
Step 1: Initialization
Step 2: Select *GL* and LL_k of the k^{th} group
Step 3: For each solution SM_i in the group
a. Calculate *SS*, BSS, and modify SM_i
b. Compute the *prob(i)*
c. Based on the *prob(i)* calculate *SS*, BSS, and update SM_i
d. Update LL_k and *GL*
e. Initialize either randomly or following an Eq.
f. Divide the population or combine all groups
Step 4: If (termination condition is met), Goto **Step 3**
Step 5: The global Supreme Leader *GL* as a solution

Result: A set of benchmark problems were chosen as a test set and the outcome of the experiment compares to Velocity Tentative PSO (VTPSO) and a prominent method Ant Colony Optimization (ACO) to solve TSP. The following shows the comparison of the performance of ACO, VTPSO, and MSMO on 20 different runs for each TSP instance. The best value (i.e., smallest cost) among the three methods was shown in bold-face type and the worst value (i.e., biggest cost) was indicated by underlined face type.

SL.	Problem name	Minimum Tour Cost		
		ACO	VTPSO	MSMO
01.	Kroa100	24504.9	21307.44	**21298.21**
02.	Gr137	896.07	714.18	**709.48**
03.	Pr152	79153.02	74414.17	**74243.91**
04.	D198	17301.47	16066.44	**15978.13**
05.	Tsp225	4396.39	4095.01	**4013.68**
06.	Gil262	2730.52	2547.16	**2543.15**
07.	Lin318	47442.95	44724.38	**44118.66**
08.	Fl417	13296.85	12376.53	**12218.98**
09.	Gr431	2334.63	2021.95	**1993.15**
10.	D493	39254	37132.09	**36844.63**

Conclusion: MSMO follows self-organization as well as separation of labor properties for finding intelligent operations for TSP. The proposed MSMO is shown to produce an optimal solution within a minimal time than conventional methods such as VTPSO and ACO in solving benchmark TSPs. Experimental results demonstrate the effectiveness of the proposed MSMO to solve TSP.

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