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FEN BİLİMLERİ ENSTİTÜSÜ
BİLİŞİM TEKNOLOJİLERİ MÜHENDİSLİĞİ ANABİLİM DALI

VERİ ANALİZİ VE PYTHON PROGRAMLAMA
(DATA ANALYSIS AND PYTHON PROGRAMMING)

MAKALE INCELEME (ARTICLE REVIEW)

MD AL AMIN HOSSAIN
218264001009

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KONYA

Title of Artıcle-1:

Heuristic smoothing ant colony optimization with differential information for the traveling salesman problem. (Li et al., 2023)

1. The Main Contribution

This study proposes the heuristic smoothing ant colony algorithm with differential edge information (HSDACO), a new algorithm that performs better than other metaheuristics for solving Travelling Salesman Problem (TSP). The authors introduce heterogeneous population automation in the initialization stage, giving each Ant more autonomy in selecting candidate solutions. They also employ a tour construction method and smooth search operators for population evolution. The pheromone update mechanism is redesigned to explore differential edges using differential information, and evolutionary state estimation and adjustment are used to monitor the appearance of stagnation states and increase the possibility of exploring global optima.

2. Data Set

In this study, the proposed HSDACO algorithm was evaluated on public TSP benchmark instances named the TSPLIB library and compared with other state-of-the-art algorithms. The benchmark instances are commonly used data sets in the field of TSP to evaluate the performance of algorithms. These data sets typically consist of a set of cities with coordinates and the distances between each pair of cities (Robert Grant Revision, 2018). For the size of the city, this study used benchmark instances ranging from 16 to 1000 that were selected from the standard TSPLIB library as well as the comparative statistical test and analysis carried out using ***Wilcoxon signed rank test*** and ***Friedmans test***.

There are certain data preprocessing requirements for TSP benchmark instances. The TSP benchmark instances usually come in the form of distance matrices, where each entry represents the distance between two cities. Before using these matrices as inputs to an algorithm, they need to be properly processed to ensure that the TSP instance is valid. The main preprocessing steps include:

- Ensuring symmetry: Since the distance between city *i* and city *j* is the same as the distance between city *j* and city *i*, the distance matrix needs to be symmetrical. If it is not, the matrix needs to be adjusted accordingly.

- Removing self-loops: The distance between a city and itself is always 0, so the diagonal entries of the distance matrix need to be removed.
- Checking for triangular inequality: The triangular inequality states that the distance between two cities cannot be greater than the sum of the distances between those cities and a third city. If the distance matrix violates this inequality, it is not a valid TSP instance and cannot be used for benchmarking purposes.

After these preprocessing steps are completed, the TSP instance can be used as input to a TSP algorithm for testing and evaluation.

3. Method

A novel ant colony optimization (ACO) algorithm called HSDACO is used in this study to address the rapid convergence to local optima and unsatisfactory computational accuracy limitations of existing ACO for solving the Traveling Salesman Problem (TSP). The HSDACO algorithm uses heterogeneous population automation, three smoothing techniques with the 2-Opt method, differential information updating mechanism, and evolutionary state estimation and adjustment to improve the quality of candidate solutions. The experimental results demonstrate that the proposed HSDACO algorithm performs substantially better than state-of-the-art algorithms in terms of solution accuracy and convergence speed for mid-scale and small-scale TSP instances.

The ant-cycle model's pheromone updating method is better at finding the optimal route but has a tendency to converge quickly without high accuracy compared to other state of art models like the ant-density model and ant-quantity model. Therefore, the proposed HSDACO algorithm focuses on exploring more potential solutions with higher accuracy. The methodological flow chart of this paper is shown in Figure 1.

4. Findings And Discussion

The effectiveness of the HSDACO algorithm was revealed after implementation, showing that its mean time consumption rank is 1.21 in small-scale TSP instances and 3.63 in middle-scale TSP instances. The HSDACO algorithm outperforms the Hybrid Ant Algorithm With Crossover Operator (HAACO), Ant Colony Optimization With Heuristic Crossover Operator (ACOH), the Memetic Algorithm With Swap Mutation And LKH Operator(MAS), Neighborhood-Based Discrete Differential Evolution (NDDE), Dynamic Self-Organizing Swarm (DSOS), and Discrete Bat Algorithm With Local Search (DBAL) in terms of accuracy., with a significance level of 1%. Although it ranks sixth among all algorithms in the study for middle-scale TSP instances, it is the lowest in small-scale TSP instances. The ablation study supports the logic and necessity of each proposed approach in solving the TSP by HSDACO, including heterogeneous population automation, 2-Opt with concave and convex settings, differential information updating mechanism, and estimation and adjustment of the evolutionary state.

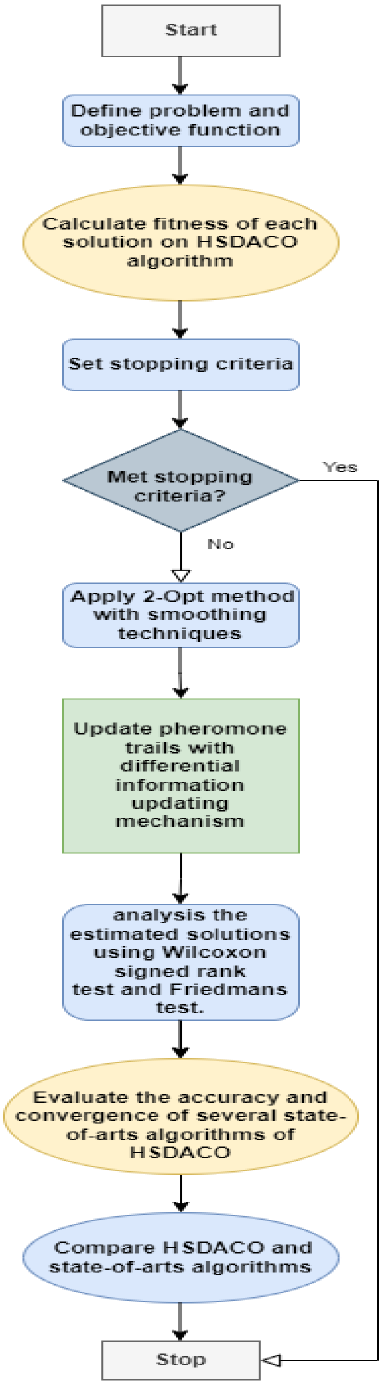

Figure 1. methodological flowchart of review paper 1

Overall, the results of the comparison with state-of-the-art algorithms in TSP benchmark instances have further validated the outstanding performance of the proposed HSDACO algorithm. However, the solving speed of the HSDACO algorithm for middle-scale TSP instances needs improvement. Some main findings of this research paper are shown in Figure 2.

Table 6
Results of the proposed algorithm HSDACO on the mid-TSP instances.

Instance	Opt	HSDACO			
		Avg	Std (‰)	Avg_it	Time
rd400	**15281**	15284.42	0.20	216.50	5923.96
fl417	**11861**	**11861**	0.00	214.60	8171.48
pr439	**107217**	107259.36	0.39	790.20	39990.12
pcb442	**50778**	51181.40	7.94	527.90	6796.35
att532	**86729**	87122.20	4.53	623.50	12031.77
rat575	**6773**	6841.65	10.04	302.40	41466.15
d657	**48912**	49184.39	5.56	277.50	22366.67
gr666	**294358**	301073.23	22.81	840.25	64342.60
rat783	**8806**	8837.58	3.58	339.42	34336.46
dsj1000	**18659688**	18897396.15	16.84	415.52	182880.73

Best results appear in bold.

Table 8
Friedman's test result using TSP instances with other contrast algorithms.

Instance	Index	Algorithms						
		HAACO	ACOH	MAS	NDDE	DSOS	DBAL	HSDACO
Small-scale	Accuracy	2.92	2.26	3.25	3.05	3.80	2.00	**1.55**
	Time	3.50	2.61	2.68	1.24	3.80	2.50	**1.21**
Middle-scale	Accuracy	2.38	4.00	2.50	3.05	3.80	2.00	**1.13**
	Time	3.13	2.13	1.45	**1.20**	3.80	2.50	3.63

Significant at 1% level of significance.
Best results appear in bold.

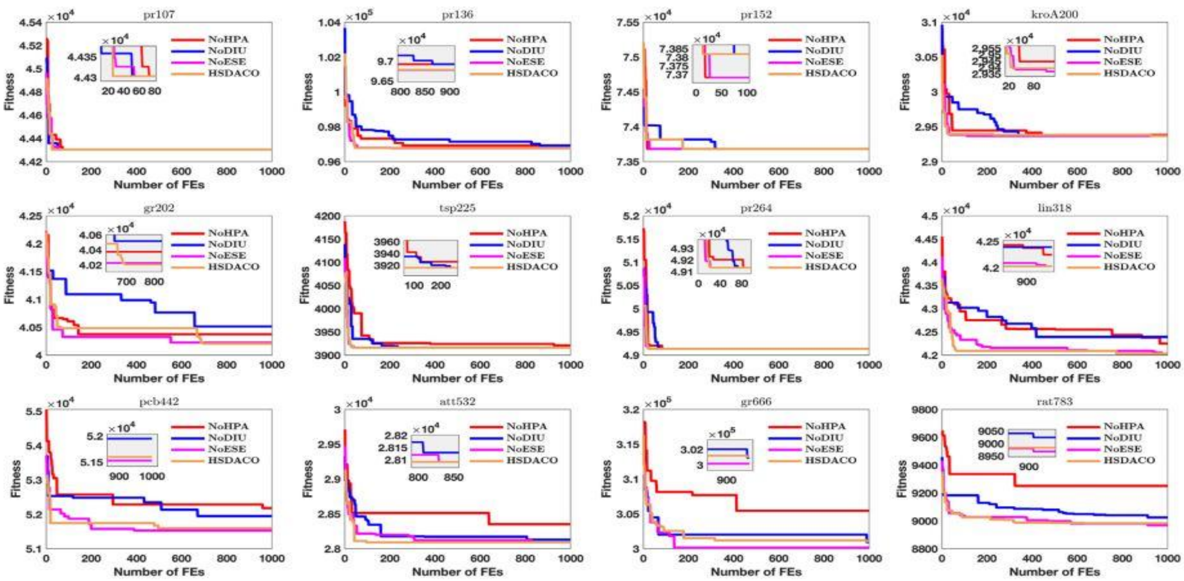

Fig. 9. Convergence of HSDACO with different approaches in solving the TSP.

Figure 2. Some results of this research paper

5. Limitations

Some challenges of this study can be addressed in the future term:

- Recent metaheuristics optimization algorithms such as grey wolf optimizer (GWO), black hole algorithm (BHA), Ant lion optimizer (ALO), etc can be used to easily solve TSP problems by abundant performance complexity.
- The domain of research could be expanded to cover more complex TSP instances with additional constraints in order to strengthen the algorithm's theoretical base and real-world applications.
- Efficient heuristic approaches need to be designed to reduce the time complexity of the algorithm and to improve its overall performance.
- Flexible parameter tuning techniques may be implemented to simplify the workload associated with selecting parameters, which plays a crucial role in the ant colony algorithm and requires significant preparation.

Title of Article-2:

A Comparative Analysis of Optimization Heuristics Algorithms as Optimal Solution for Travelling Salesman Problem. (Ajayi et al., 2022)

1. The Main Contribution

The main contribution of the research paper is the examination and development of effective and efficient optimization techniques to obtain the shortest or suboptimal path for the Travelling Salesman Problem (TSP), which is a combinatorial optimization problem. The paper highlights the feasibility of Heuristic Algorithms for solving TSP, particularly the Ant Colony Optimization Algorithm, which is reported to be more effective in solving shortest-path problems than other algorithms. The research also compares the performance of Dijkstra's Algorithm and Particle Swarm Optimization (PSO) with ACO for simulations with a given route length, showing that more iterations lead to more accurate results with the PSO algorithm.

2. Data Set

This research study used symmetric TSP instances for the analysis purpose of proposed algorithms. In the context of the Traveling Salesman Problem (TSP), symmetric instances refer to situations where the distance between two cities is the same regardless of the direction traveled. In other words, the distance from City A to City B is the same as the distance from City B to City A same as in Table 1. This is a common assumption in many TSP applications and is used in this research paper for experimental purposes.

Table 1. An example of symmetric tsp instances is Cities with a given Distance (miles)

Distance (miles)	Lagos	Kano	Ibadan	Kaduna	Port Harcourt	Maiduguri	Zaria	Aba	Jos	Ilorin
Lagos	0	519	73	394	275	763	437	288	446	162
Kano	519	0	449	126	510	313	82	482	146	363
Ibadan	73	449	0	325	280	702	367	285	384	89
Kaduna	394	126	325	0	398	398	45	374	108	241
Port Harcourt	275	510	280	398	0	644	441	34	378	308
Maiduguri	763	313	702	398	644	0	372	610	318	629
Zaria	437	82	367	45	441	372	0	415	115	282
Aba	288	482	285	374	34	610	415	0	348	303
Jos	446	146	384	108	378	318	115	348	0	313
Ilorin	162	363	89	241	308	629	282	303	313	0

3. Method

The method of this research paper includes conducting experiments with a given set of cities and routes to compare the performance of ACO and Dijkstra's algorithm. The paper analyzes the impact of parameters such as the number of ants on the quality of solutions in the ACO algorithm. The novelty of the research lies in the use of the ACO algorithm which is stochastic, population-based, and provides multiple suboptimal solutions with a low number of iterations. The research fills the research gap in finding an efficient and powerful optimization algorithm for TSP, particularly in cases with a large number of cities. The research also compares the performance of ACO with Dijkstra's Algorithm and shows that the ACO algorithm provides relatively good results in a short time, making it useful for solving practical problems. The results reported in the research are beneficial to the transport and logistics industry. The methodological flow chart of this paper is shown in Figure 3.

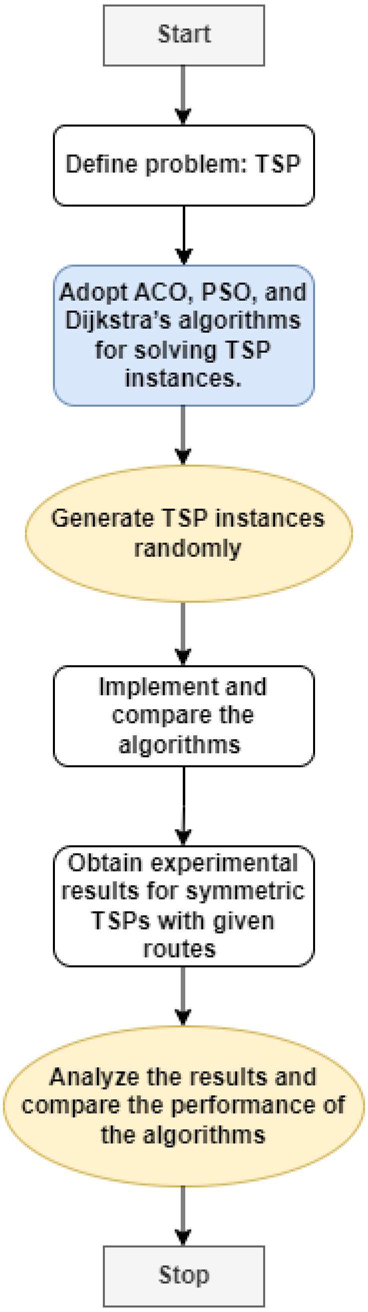

Figure 3. methodological flowchart of review article 2

4. Findings And Discussion

The study found that the quality of solutions achieved by ACO depends on the number of ants used. A smaller number of ants allow for faster changes in the path, while a higher number of ants leads to a higher accumulation of pheromone on paths and better results. Both ACO and Dijkstra's Algorithm gave better results than random route generation. Results from ACO showed the best routes and total length, while Dijkstra's Algorithm showed the minimum cost for source and destination nodes. PSO gave better results than ACO with slower convergence, requiring more iterations for accurate results. The main finding of this research paper is shown in Figure 2.

Table F: Comparison results of PSO and ACO Algorithms simulations with a Random generation of routes(length) with given number of cities(nodes) respectively

S/No	No. of Iteration	PSO (Best Route)	ACO (Best Route)
1	Iteration 1	28.6077	74.0643
2	Iteration 2	27.2666	74.0643
3	Iteration 3	27.2666	74.0643
4	Iteration 4	27.2666	74.0643
5	Iteration 5	27.2666	73.5397
6	Iteration 6	27.2666	74.0643
7	Iteration 7	27.2666	63.8209
8	Iteration 8	27.2666	63.8209
9	Iteration 9	27.2666	63.8209
10	Iteration 10	27.2666	63.8209
11	Iteration 11	27.2666	63.8209
12	Iteration 12	27.2666	63.8209
13	Iteration 13	27.2666	63.8209
14	Iteration 14	27.2666	63.8209
15	Iteration 15	27.2666	63.8209
16	Iteration 16	26.6397	63.8209
17	Iteration 17	26.6397	63.8209
18	Iteration 18	26.6397	63.8209
19	Iteration 19	26.4314	63.8209
20	Iteration 20	26.4314	63.8209
21	Iteration 21	26.4314	63.8209
22	Iteration 22	25.1228	63.8209
23	Iteration 23	25.1228	63.8209
24	Iteration 24	25.1228	63.8209
25	Iteration 25	25.1228	63.8209
26	Iteration 26	25.1228	63.8209
27	Iteration 27	25.1228	63.8209

Figure 4. A Result of this research paper

5. Limitations

Some challenges of this study:

- The study focused on the TSP problem and may not be applicable to other optimization problems.
- The proposed ACO algorithm may not be the most efficient or optimal solution for all TSP instances.
- The experiments were conducted using a limited set of parameters, and further experimentation with different values may yield different results.
- The study did not compare the proposed ACO algorithm with other state-of-the-art TSP algorithms, which could provide further insights into its performance.
- The research was limited to simulation experiments, and real-world experiments may yield different results.

- The research was limited to a single objective function and did not consider multi-objective optimization.
- The proposed algorithm may be sensitive to the initial conditions, and further investigation into its robustness is needed.
- The scalability of the proposed algorithm for large-scale TSP instances is not clear and requires further investigation.

References and Links

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