INTRODUCTION TO HEURISTIC ALGORITHMS

ROUTİNG PROBLEMS WİTH OPTİMİZATİON ALGORİTHMS

GRUP 8

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PROJECT TOPIC

This project aims to plan a route between the provinces in the Central Anatolia Region and optimize this route. Our aim is to start from a starting province, travel through all the central Anatolian cities and reach the starting point again in the shortest way.

Distance information we received from the General Directorate of Highways

	ESKİŞEHİR	ANKARA	ÇANKIRI	KONYA	KIRIKKALE	AKSARAY	KARAMAN	KIRŞEHİR	NEVŞEHİR	NİĞDE	YOZGAT	KAYSERİ	SİVAS
ESKİŞEHİR	-	235,4	376,3	332,7	318,6	396,1	443,5	388,1	452,2	491,9	456,4	512,3	704,6
ANKARA	235,4	-	131,7	271,1	78,5	238,2	382,1	222,1	286,2	325,9	216,2	346,2	440,1
ÇANKIRI	376,3	131,7	-	355,8	107,1	312,8	466,7	214,6	307,3	391,3	171,2	346,7	399,2
KONYA	332,7	271,1	355,8	-	251,5	151,1	110,6	289,2	221,8	238,5	367,8	303,4	502,1
KIRIKKALE	318,6	78,5	107,1	251,5	-	208,6	362,5	110,4	203,1	287,1	139,7	242,5	363,6
AKSARAY	396,1	238,2	312,8	151,1	208,6	-	177	96,2	72,9	115,9	212,4	154,5	353,2
KARAMAN	443,5	382,1	466,7	110,6	362,5	177	-	347,2	269,7	176,6	463,4	316,1	514,3
KIRŞEHİR	388,1	222,1	214,6	289,2	110,4	96,2	347,2	-	95,4	174	115,2	134,8	327,1
NEVŞEHİR	452,2	286,2	307,3	221,8	203,1	72,9	269,7	95,4	-	85,6	156,8	80	278,7
NİĞDE	491,9	325,9	391,3	238,5	287,1	115,9	176,6	174	85,6	-	279,7	130,5	328,8
YOZGAT	456,4	216,2	171,2	367,8	139,7	212,4	463,4	115,2	156,8	279,7	-	171,5	224
KAYSERİ	512,3	346,2	346,7	303,4	242,5	154,5	316,1	134,8	80	130,5	171,5	-	196,9
SİVAS	704,6	440,1	399,2	502,1	363,6	353,2	514,3	327,1	278,7	328,8	224	196,9	-

TECHNOLOGIES USED IN THE PROJECT

NUMPY

NumPy is a Python library used for scientific computations and working with multidimensional arrays. In this code, NumPy is utilized for matrix operations.

PANDAS

In this project, pandas was used to convert incoming JSON data into DataFrame and perform data preprocessing steps.

RANDOM

Python's random module is used for random number generation. In this code, the random module is used during the creation of the initial solution and the removal process from the tabu list.

SYS

Python's sys module is used for system-related operations. In this code, the sys.maxsize constant is employed to set the initial best distance value to infinity.

INTRODUCTION OF OPTIMIZATION ALGORITHMS USED

SIMULATED ANNEALING

Simulated Annealing navigates solution space using a strategy similar to the heating and cooling process of matter in physics. It initially starts with high temperature and over time the temperature decreases. At high temperature, the algorithm accepts possible bad solutions and explores the solution space more broadly. As the temperature decreases, the accepted solutions become more selective and the algorithm tends to search for a closer solution. Simulated Annealing stands out with its ability to explore a wide solution space without getting stuck in local minima.

Parameter Settings:

- Starting Temperature: Starting at a high temperature increases the number of bad solutions that can be accepted.
- Cooling Rate: It is a factor that reduces the temperature over time.
- Action Strategies: Determines strategies that will generate random solutions and change the current solution.

INTRODUCTION OF OPTIMIZATION ALGORITHMS USED

TABU SEARCH ALGORITHMS

Tabu Search is a metaheuristic search algorithm and is known for its ability to avoid local minima in the problem-solving process. Its basic logic can be summarized as moving in a solution space and complying with certain constraints (tabu list) at each step. While this algorithm aims to find a better solution than the current solution, it also uses a flexible strategy to explore the solution space. By covering a wide solution space, Tabu Search can approach the global minimum more effectively.

Parameter Settings:

- Taboo List: Determines which solutions will be marked as taboo.
- Aspiration Criterion: A taboo solution may cease to be taboo when a certain condition is met.
- Movement Strategies: Determines what type and distance of movements will be made.

INTRODUCTION OF OPTIMIZATION ALGORITHMS USED

ANT COLONY OPTIMIZATION

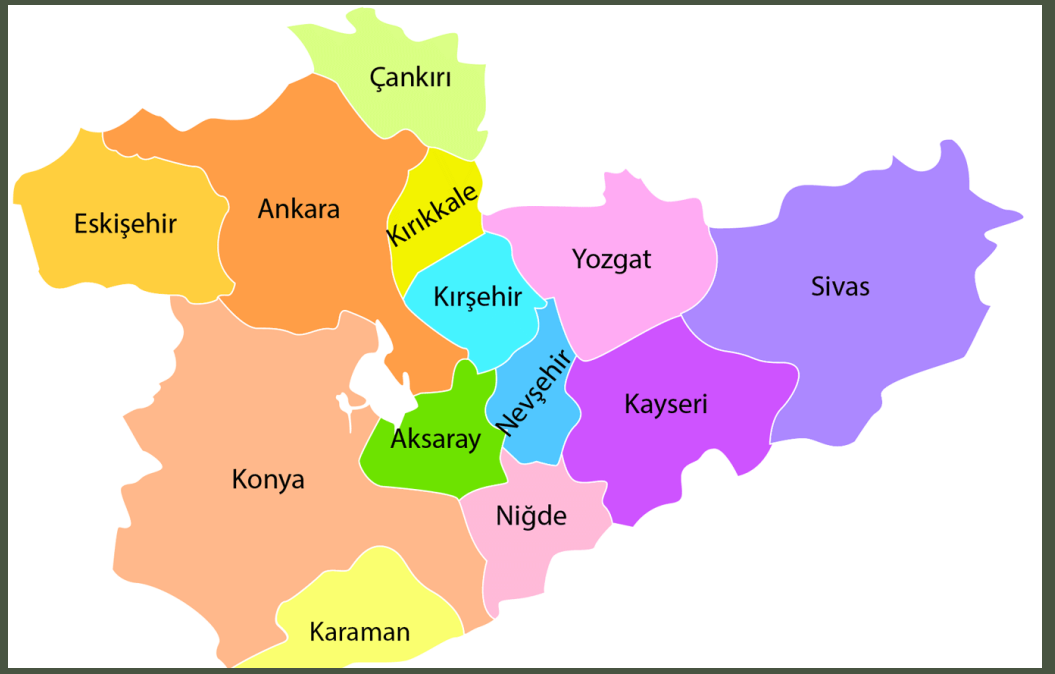
Ant Colony Optimization (ACO) is inspired by the strategy of ant colonies to find food sources. Ants can find shortcuts and the most efficient routes by communicating with each other. ACO is used to find optimal solutions in graph-based problems by mimicking this natural behavior. It tends to optimize a solution through the pheromones left by the ants. ACO aims to find the optimal route by scanning the solution space and evaluating possible solutions with pheromone release.

Parameter Settings:

- Pheromone Update Rules: Determines how the pheromone trails left by ants are updated.
- Number of Ants: Determines the number of ants that leave pheromone trails by traveling in the solution space.
- Evaporation Rate: Determines the rate at which pheromone traces disappear over time.

ENCOUNTERED CHALLENGES

The fact that Karaman province only borders Konya poses a challenge for our algorithm. The decision to remove Karaman from the route emerged as a solution to this practical difficulty. Because in planning without removing Karaman from the route, it is encountered that the route passes through Konya twice.



RESULTS

- This is the best solutions for Ant Colony Optimization.

ANT COLONY OPTIMIZATION		
Route	**Total Distance**	**Best**
Aksaray -> Niğde -> Nevşehir -> Kayseri -> Sivas -> Kırşehir -> Yozgat -> Çankırı -> Kırıkkale -> Ankara -> Eskişehir -> Konya -> Aksaray	1996	Yes
Ankara -> Çankırı -> Kırıkkale -> Kırşehir -> Yozgat -> Sivas -> Niğde -> Kayseri -> Nevşehir -> Aksaray -> Konya -> Eskişehir -> Ankara	2019	Yes
Çankırı -> Kırıkkale -> Ankara -> Eskişehir -> Konya -> Aksaray -> Kırşehir -> Kayseri -> Nevşehir -> Niğde -> Sivas -> Yozgat -> Çankırı	2025	Yes
Eskişehir -> Ankara -> Kırıkkale -> Çankırı -> Kırşehir -> Yozgat -> Sivas -> Kayseri -> Nevşehir -> Niğde -> Aksaray -> Konya -> Eskişehir	1937	Yes
Kayseri -> Kırşehir -> Yozgat -> Kırıkkale -> Çankırı -> Ankara -> Eskişehir -> Konya -> Aksaray -> Niğde -> Nevşehir -> Sivas -> Kayseri	2025	Yes
Kırıkkale -> Çankırı -> Yozgat -> Sivas -> Kayseri -> Nevşehir -> Kırşehir -> Aksaray -> Niğde -> Konya -> Eskişehir -> Ankara -> Kırıkkale	1971	Yes
Kırşehir -> Nevşehir -> Yozgat -> Sivas -> Kayseri -> Niğde -> Aksaray -> Konya -> Eskişehir -> Ankara -> Çankırı -> Kırıkkale -> Kırşehir	1986	Yes
Konya -> Niğde -> Aksaray -> Nevşehir -> Kayseri -> Sivas -> Yozgat -> Kırşehir -> Çankırı -> Kırıkkale -> Ankara -> Eskişehir -> Konya	2012	Yes
Nevşehir -> Kayseri -> Niğde -> Aksaray -> Konya -> Eskişehir -> Ankara -> Kırıkkale -> Çankırı -> Sivas -> Yozgat -> Kırşehir -> Nevşehir	2064	Yes
Niğde -> Nevşehir -> Kayseri -> Kırşehir -> Aksaray -> Konya -> Eskişehir -> Ankara -> Kırıkkale -> Çankırı -> Yozgat -> Sivas -> Niğde	2025	Yes
Sivas -> Kayseri -> Kırşehir -> Niğde -> Nevşehir -> Aksaray -> Konya -> Eskişehir -> Ankara -> Kırıkkale -> Çankırı -> Yozgat -> Sivas	1963	Yes
Yozgat -> Kırşehir -> Kırıkkale -> Çankırı -> Ankara -> Eskişehir -> Aksaray -> Konya -> Niğde -> Nevşehir -> Kayseri -> Sivas -> Yozgat	2075	Yes

RESULTS

- This is the best solutions for Simulated Annaeling Algorithm.

SIMULATED ANNEALEING		
Route	**Total Distance**	**Best**
Aksaray -> Niğde -> Nevşehir -> Kayseri -> Sivas -> Yozgat -> Kırşehir -> Kırıkkale -> Çankırı -> Ankara -> Eskişehir -> Konya -> Aksaray	1886	Yes
Ankara -> Çankırı -> Kırıkkale -> Kırşehir -> Yozgat -> Sivas -> Kayseri -> Nevşehir -> Niğde -> Aksaray -> Konya -> Eskişehir -> Ankara	1885	Yes
Çankırı -> Kırıkkale -> Kırşehir -> Yozgat -> Sivas -> Kayseri -> Nevşehir -> Niğde -> Aksaray -> Konya -> Eskişehir -> Ankara -> Çankırı	1885	Yes
Eskişehir -> Ankara -> Çankırı -> Kırıkkale -> Kırşehir -> Yozgat -> Sivas -> Kayseri -> Nevşehir -> Niğde -> Aksaray -> Konya -> Eskişehir	1885	Yes
Kayseri -> Sivas -> Yozgat -> Kırşehir -> Kırıkkale -> Çankırı -> Ankara -> Eskişehir -> Konya -> Aksaray -> Niğde -> Nevşehir -> Kayseri	1886	Yes
Kırıkkale -> Çankırı -> Ankara -> Eskişehir -> Konya -> Aksaray -> Niğde -> Nevşehir -> Kayseri -> Sivas -> Yozgat -> Kırşehir -> Kırıkkale	1886	Yes
Kırşehir -> Yozgat -> Sivas -> Kayseri -> Nevşehir -> Niğde -> Aksaray -> Konya -> Eskişehir -> Ankara -> Çankırı -> Kırıkkale -> Kırşehir	1885	Yes
Konya -> Aksaray -> Niğde -> Nevşehir -> Kayseri -> Sivas -> Yozgat -> Kırşehir -> Kırıkkale -> Çankırı -> Ankara -> Eskişehir -> Konya	1886	Yes
Nevşehir -> Kayseri -> Sivas -> Yozgat -> Kırşehir -> Kırıkkale -> Çankırı -> Ankara -> Eskişehir -> Konya -> Aksaray -> Niğde -> Nevşehir	1886	Yes
Niğde -> Aksaray -> Konya -> Eskişehir -> Ankara -> Çankırı -> Kırıkkale -> Kırşehir -> Yozgat -> Sivas -> Kayseri -> Nevşehir -> Niğde	1885	Yes
Sivas -> Kayseri -> Nevşehir -> Niğde -> Aksaray -> Konya -> Eskişehir -> Ankara -> Çankırı -> Kırıkkale -> Kırşehir -> Yozgat -> Sivas	1885	Yes
Yozgat -> Sivas -> Kayseri -> Nevşehir -> Niğde -> Aksaray -> Konya -> Eskişehir -> Ankara -> Çankırı -> Kırıkkale -> Kırşehir -> Yozgat	1885	Yes

RESULTS

- This is the best solutions for Tabu Search Algorithm.

TABU SEARCH ALGORITHMS		
Route	**Total Distance**	**Best**
Aksaray -> Eskişehir -> Ankara -> Çankırı -> Kırıkkale -> Kırşehir -> Yozgat -> Sivas -> Kayseri -> Nevşehir -> Niğde -> Konya -> Aksaray	1678	Yes
Ankara -> Eskişehir -> Konya -> Aksaray -> Niğde -> Nevşehir -> Kayseri -> Sivas -> Yozgat -> Kırşehir -> Kırıkkale -> Çankırı -> Ankara	1650	Yes
Çankırı -> Eskişehir -> Konya -> Aksaray -> Niğde -> Nevşehir -> Kayseri -> Sivas -> Yozgat -> Kırşehir -> Kırıkkale -> Ankara -> Çankırı	1621	Yes
Eskişehir -> Konya -> Aksaray -> Niğde -> Nevşehir -> Kayseri -> Sivas -> Yozgat -> Kırşehir -> Kırıkkale -> Çankırı -> Ankara -> Eskişehir	1556	Yes
Kayseri -> Sivas -> Yozgat -> Kırşehir -> Kırıkkale -> Çankırı -> Ankara -> Eskişehir -> Konya -> Aksaray -> Niğde -> Nevşehir -> Kayseri	1689	Yes
Kırıkkale -> Eskişehir -> Konya -> Aksaray -> Kırşehir -> Nevşehir -> Niğde -> Kayseri -> Sivas -> Yozgat -> Çankırı -> Ankara -> Kırıkkale	1693	Yes
Kırşehir -> Eskişehir -> Ankara -> Kırıkkale -> Çankırı -> Yozgat -> Sivas -> Kayseri -> Nevşehir -> Niğde -> Konya -> Aksaray -> Kırşehir	1667	Yes
Konya -> Eskişehir -> Ankara -> Çankırı -> Kırıkkale -> Kırşehir -> Yozgat -> Sivas -> Kayseri -> Nevşehir -> Niğde -> Aksaray -> Konya	1555	Yes
Nevşehir -> Eskişehir -> Ankara -> Çankırı -> Kırıkkale -> Kırşehir -> Yozgat -> Sivas -> Kayseri -> Niğde -> Konya -> Aksaray -> Nevşehir	1715	Yes
Niğde -> Eskişehir -> Konya -> Aksaray -> Kırşehir -> Kırıkkale -> Ankara -> Çankırı -> Yozgat -> Sivas -> Kayseri -> Nevşehir -> Niğde	1657	Yes
Sivas -> Eskişehir -> Ankara -> Kırıkkale -> Çankırı -> Yozgat -> Kırşehir -> Aksaray -> Konya -> Niğde -> Nevşehir -> Kayseri -> Sivas	1558	Yes
Yozgat -> Eskişehir -> Ankara -> Çankırı -> Kırıkkale -> Kırşehir -> Aksaray -> Konya -> Niğde -> Nevşehir -> Kayseri -> Sivas -> Yozgat	1659	Yes

THANK YOU