

# IMPROVED TRAVELING SALESMAN PROBLEM ANALYSIS WITH NETWORK ANALYSIS TOOL

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15 September 2022



KTMMOB / UCCTEA  
İNŞAAT MÜHENDİSLERİ ODASI  
CHAMBER OF CIVIL ENGINEERS  
NCE2022.KTIMO.ORG

**2<sup>nd</sup> National Civil Engineering Symposium**  
2. Ulusal İnşaat Mühendisliği Sempozyumu  
14-15 Eylül 2022  
14-15 September 2022

**2<sup>nd</sup> Nature Inspired Solutions For The Built Environment Conference (NISE)**  
2. Uluslararası Yapılar İçin Doğadan İlham Alan Çözümler Konferansı  
16 Eylül 2022  
16 September 2022

**International Workshop on Advances in Laboratory Testing of Liquefiable Soils**  
Sıvılaştan Zeminlerde Laboratuvar Uygulamaları Uluslararası Çalıştayı  
17 Eylül 2022  
17 September 2022

Acapulco Resort  
Convention SPA Hotel

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# Outline

Traveling Salesman Problem

Proposed Approach

Case Study

Conclusions and Recommendations

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# Traveling Salesman Problem

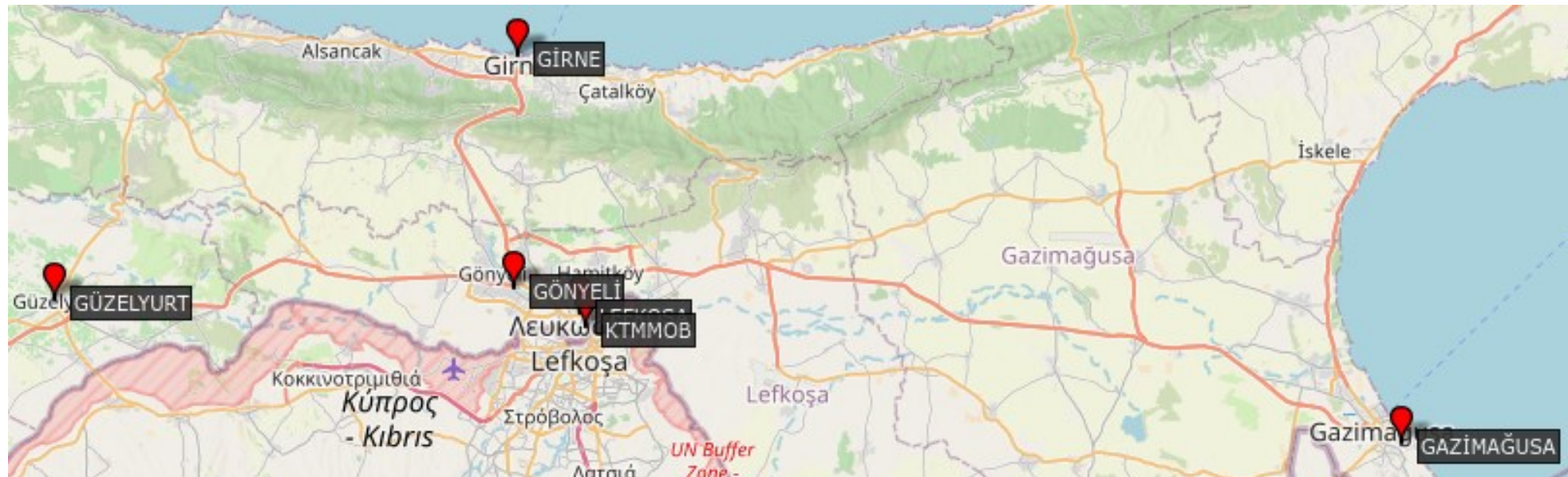
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# Definition of Traveling Salesman Problem

- "Given a list of cities and the distances between each pair of cities, what is the shortest possible route that visits each city and returns to the origin city?"



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# How TSP is applied?

- Decide on an objective function to minimize
  - Total travel distance or
  - Total travel time
- Create a distance matrix
- Create combinations (factorial of number of cities)
- Obtain total distance/time for every combination
- Select the visit order satisfying the objective function



# TSP uses distance matrix



- Using direct distance (as the crow flies)
  - “Euclidean distance”
  - By considering the earth’s curvature (Haversine formula)
- Disadvantages
  - Exclusion of street network geometry or driving direction
  - Calculation errors for small geographical areas



# Proposed Approach

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# Proposed approach

- Overcoming the disadvantage of direct distance approach
  - Road network
  - Automated data extraction
- Distance data access
  - OpenStreetMap (openstreetmap.com)
  - Open Street Routing Machine (OSRM)
  - Python





# Case Study

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# Case study

- We are planning to visit the following municipalities from the Union of Cyprus Turkish Engineers and Architects Chambers building:

LEFKOŞA

GAZİMAĞUSA

GİRNE

GÜZELYURT

GÖNYELİ

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# Case study

- We are planning to visit the following municipalities from the Union of Cyprus Turkish Engineers and Architects Chambers building:

LEFKOŞA

GAZİMAĞUSA

GİRNE

GÜZELYURT

GÖNYELİ

Objective function = Minimum total travel distance

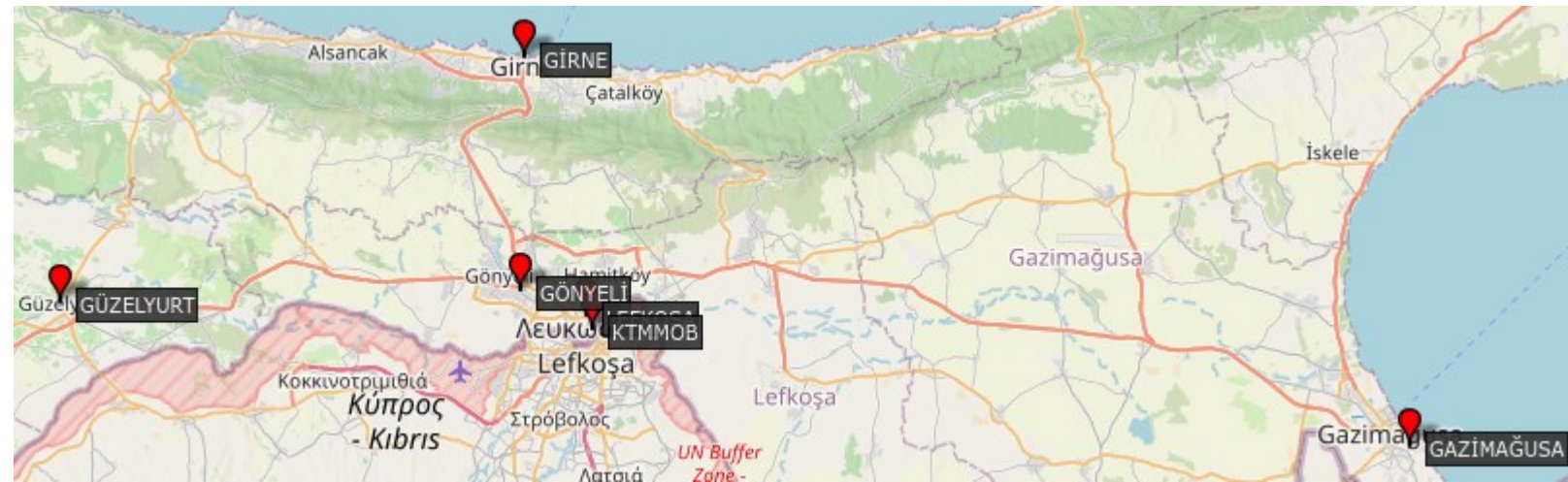


# Data for case study

- Coordinates  
(Latitude&Longitude)

```
[[[35.18294432 33.36765598]  
[35.19009679 33.36382957]  
[35.11595405 33.94596524]  
[35.34030666 33.32076442]  
[35.19839454 32.9923021 ]  
[35.20515518  
33.31782043]]
```

- On a map



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# Distance matrix from direct distance

	KTMMOB	LEFKOŞA	GAZİMAĞUSA	GİRNE	GÜZELYURT	GÖNYELİ
KTMMOB	0	868	53104	18008	34153	5158
LEFKOŞA	868	0	53563	17154	33773	4503
GAZİMAĞUSA	53104	53563	0	62025	87181	57957
GİRNE	18008	17154	62025	0	33737	15031
GÜZELYURT	34153	33773	87181	33737	0	29586
GÖNYELİ	5158	4503	57957	15031	29586	0

Unit of the distance in the table is in meters

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# Distance matrix from road network

	KTMMOB	LEFKOŞA	GAZİMAĞUSA	GİRNE	GÜZELYURT	GÖNYELİ
KTMMOB	0	1445	60892	24708	38691	7145
LEFKOŞA	1609	0	59992	23674	37657	6166
GAZİMAĞUSA	60094	59137	0	79819	93802	61571
GİRNE	25083	24204	80509	0	52179	19948
GÜZELYURT	39360	38481	94726	52093	0	32842
GÖNYELİ	6973	6094	62772	20139	32752	0

Unit of the distance in the table is in meters

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# Order of visit

- Direct distance

KTMMOB  
LEFKOŞA  
GÖNYELİ  
GÜZELYURT  
GİRNE  
GAZİMAĞUSA  
KTMMOB

$L = 183.82 \text{ km}$

48.82 km shorter than  
actual!

- Road network

KTMMOB  
LEFKOŞA  
GİRNE  
GÖNYELİ  
GÜZELYURT  
GAZİMAĞUSA  
KTMMOB

$L = 232.64 \text{ km}$



# Conclusions and Recommendations

- TSP is a tool that optimizes multiple destination problems
- Actual street network geometry and driving direction were considered for more realistic solutions
- Minimizing total travel distance or time for multiple destination trips may reduce demand for energy use and time
- TSP can be applied to other disciplines in civil engineering

