# IMPROVED TRAVELING SALESMAN PROBLEM ANALYSIS WITH NETWORK ANALYSIS TOOL

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# Outline

Traveling Salesman Problem

Proposed Approach

Case Study

Conclusions and Recommendations

# Traveling Salesman Problem

# 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?"
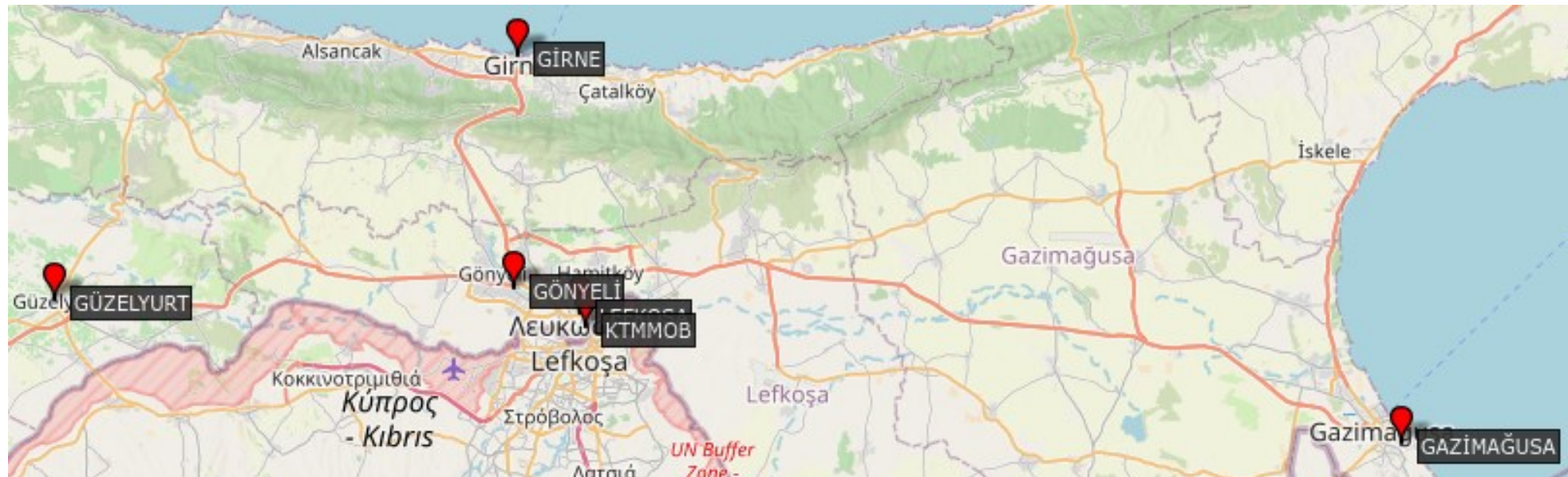
# How TSP is applied?

- 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 flie
  - "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

# 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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- 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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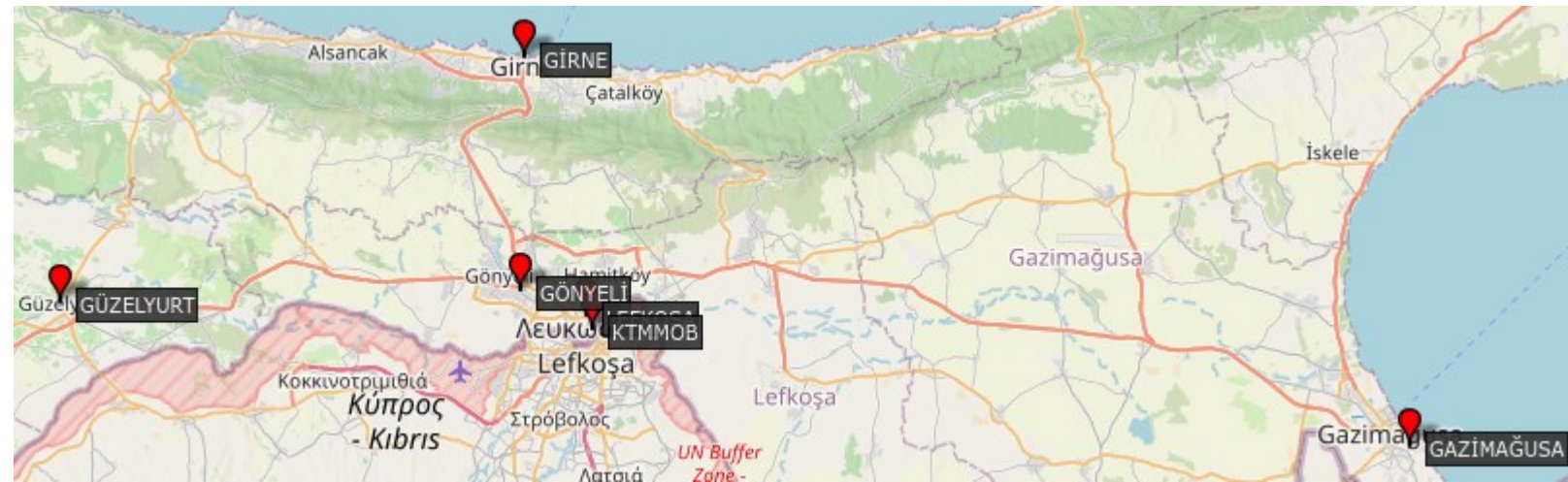<span style="color:red">Objective function = Minimum total travel distance</span>

# 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

# 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

# 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

# Order of visit

- **Direct distance**

  KTMMOB
  LEFKOŞA
  GÖNYELİ
  GÜZELYURT
  GİRNE
  GAZİMAĞUSA
  KTMMOB
  L = 183.82 km
  48.82 km shorter than actual!

- Road network

  KTMMOB
  LEFKOŞA
  GİRNE
  GÖNYELİ
  GÜZELYURT
  GAZİMAĞUSA
  KTMMOB
  L = 232.64 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