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Building a route optimization system that takes elevation into consideration

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Catalogue

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Background

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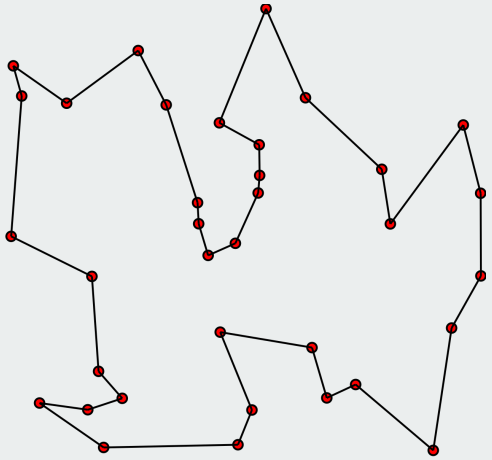
- System
  - Elevation
  - No Internet

- Traveling salesman problem
- Carbon footprint



Methodology

- Integration

2D-Road Json file

Point 1 $\{x_1, y_1\}$

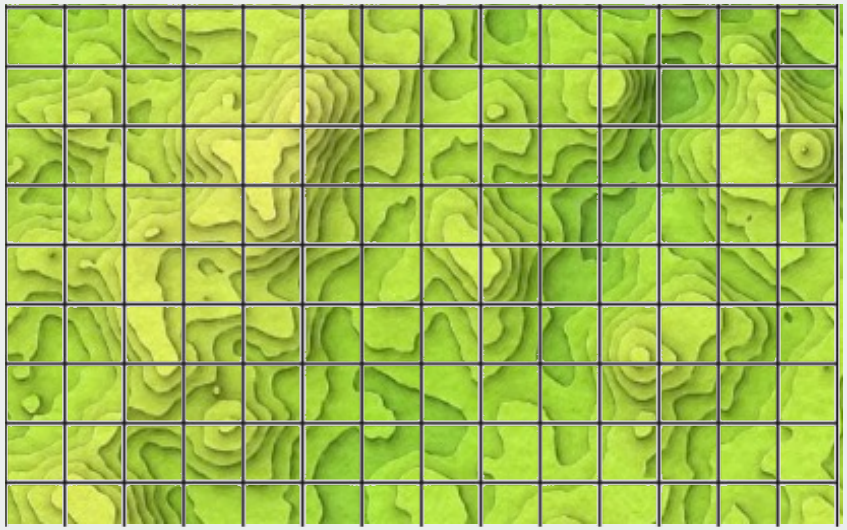
Point 2 $\{x_2, y_2\}$

Point 3 $\{x_3, y_3\}$

Point 4 $\{x_4, y_4\}$

Elevation raster file

z_a	z_b	z_c
z_d	z_e	z_f
z_g	z_h	z_i



Methodology

- Integration

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3D-Road Json file

Point 1 $\{x_1, y_1, z_1\}$

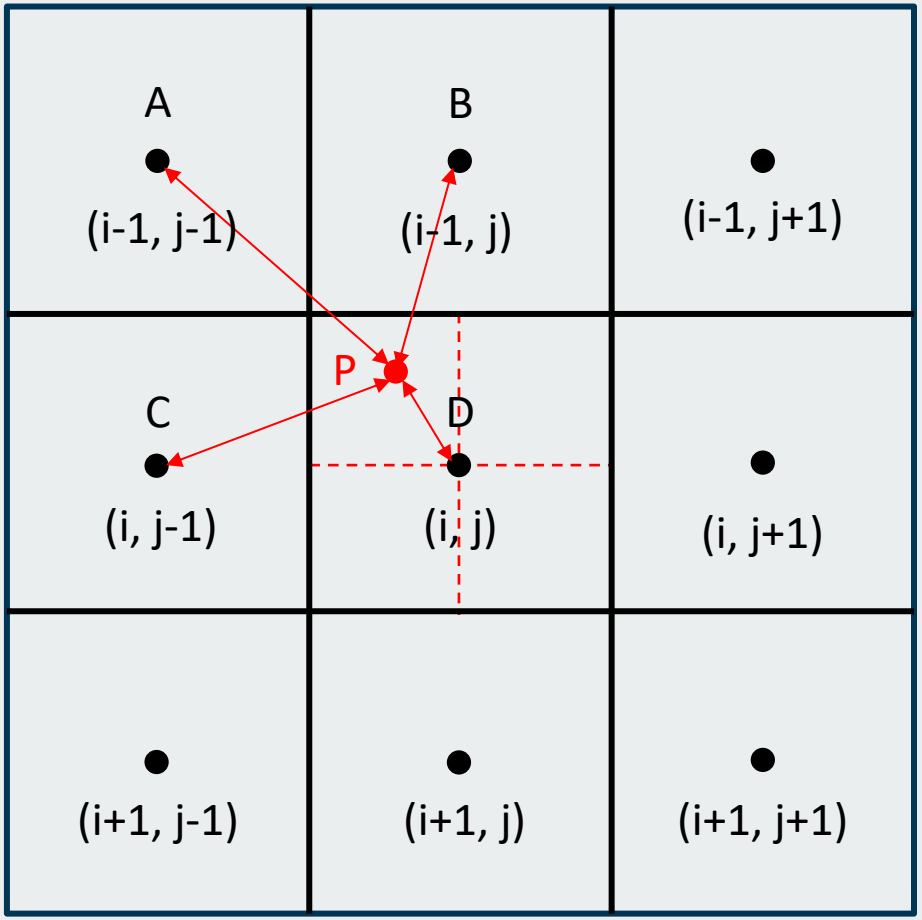
Point 2 $\{x_2, y_2, z_2\}$

Point 3 $\{x_3, y_3, z_3\}$

Point 4 $\{x_4, y_4, z_4\}$

Methodology

- Integration



1. Find the grid the point p belongs to.
2. Find the subregion
3. Use the elevation data of four grids surrounding the point p to interpolate the elevation.
4. Calculate the weight for the point p. For example: the weight of point A is: w_A = 1/distance(P, A)
5. Calculate the elevation of P

Methodology

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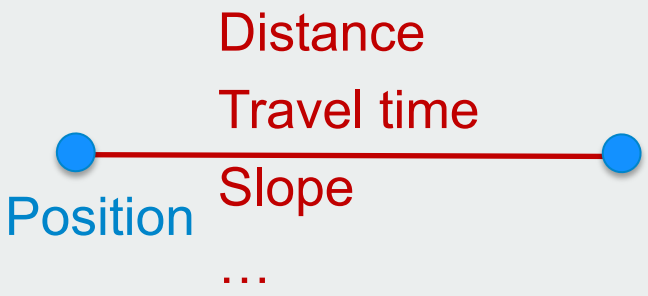
- Create Network graph



Node: Store the position info

Edge: Connect nodes

Store attributes

Methodology

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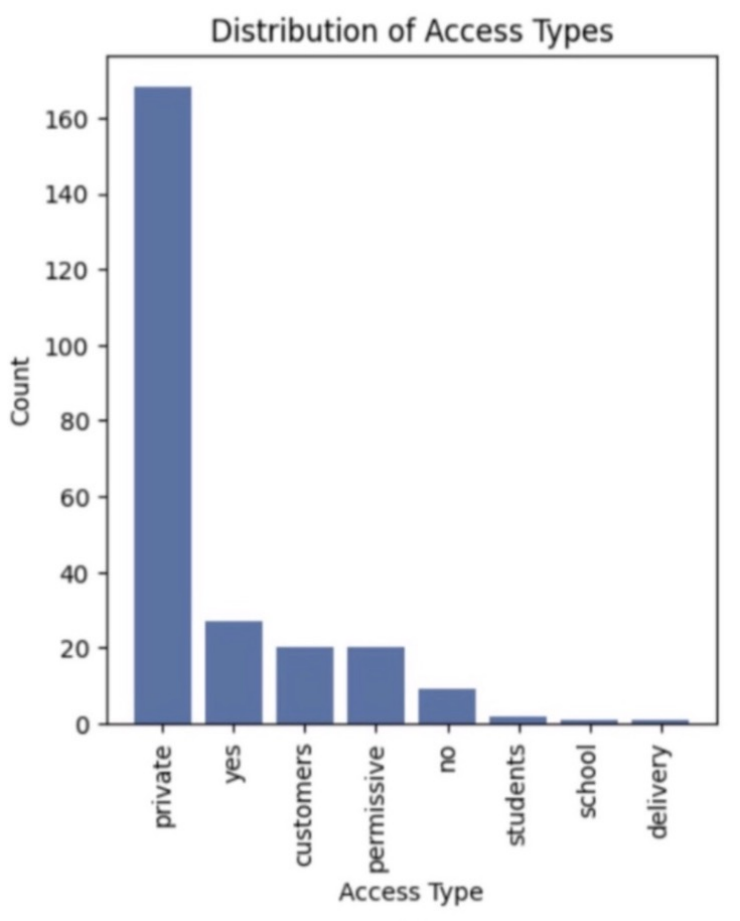
- Create Network graph

Considering:

1. Road type
2. Access type
3. One-way road

Road type	Speed limit (km/h)
Primary	50
Secondary	50
Tertiary	50
Trunk	50
Residential	20
Motorway	80
Service	20
Unclassified	50

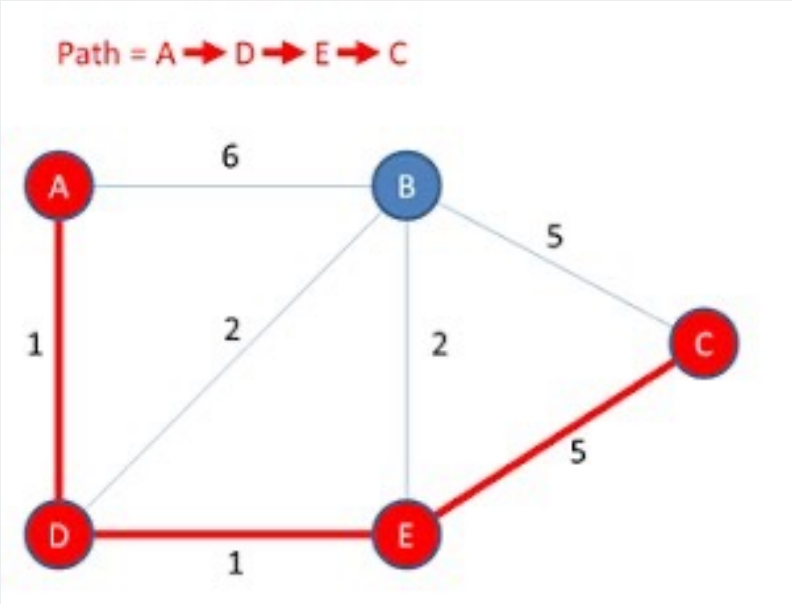


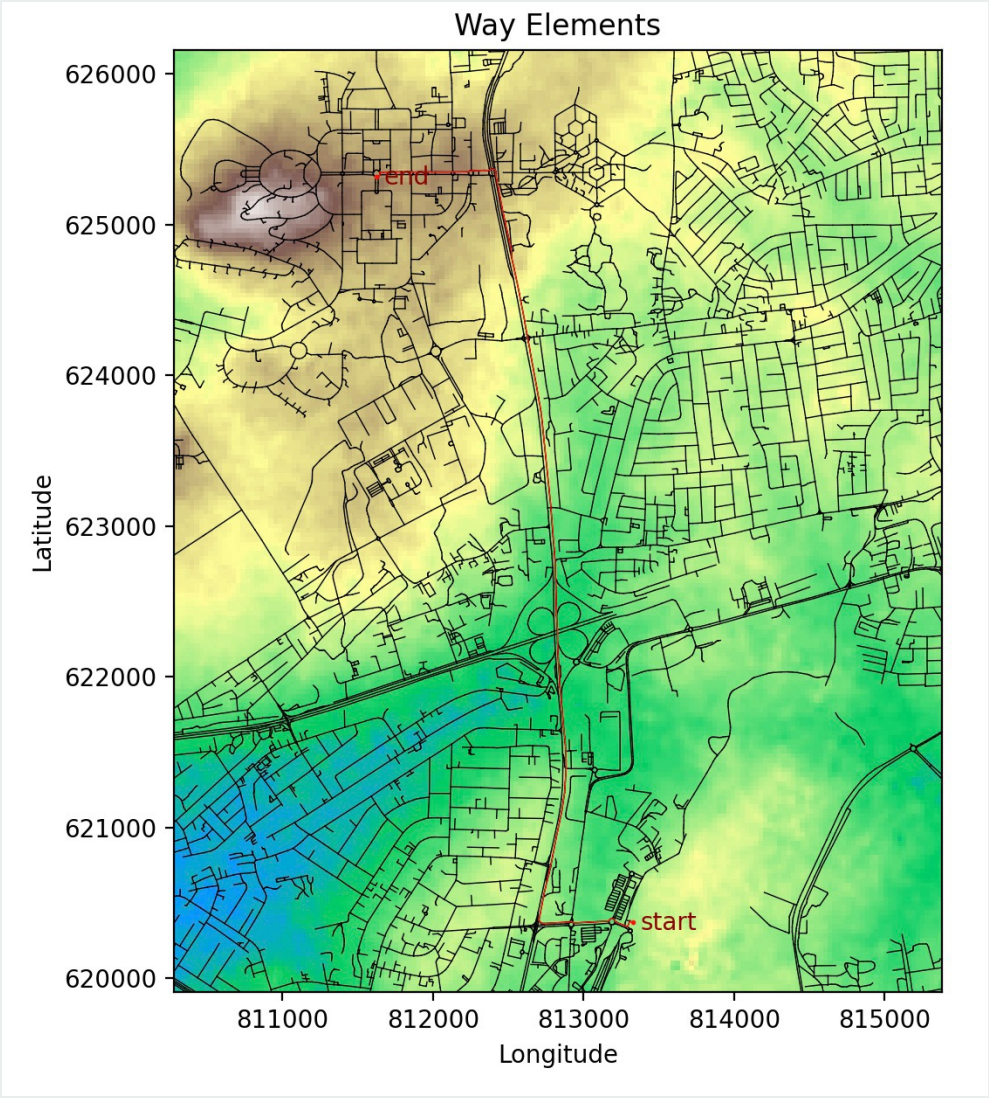
Methodology

- Route planning

Dijkstra algorithm

Find the path with least distance/time





Methodology

- Pointer network

Adjacent Matrix

$$\begin{matrix} 0 & D_{12.} & D_{13} & D_{14} \\ D_{21} & 0 & D_{23} & D_{24} \\ D_{31} & D_{32} & 0 & D_{34} \\ D_{41} & D_{42} & D_{43} & 0 \end{matrix}$$

D_{ij} : Actual distance from *i* to *j*

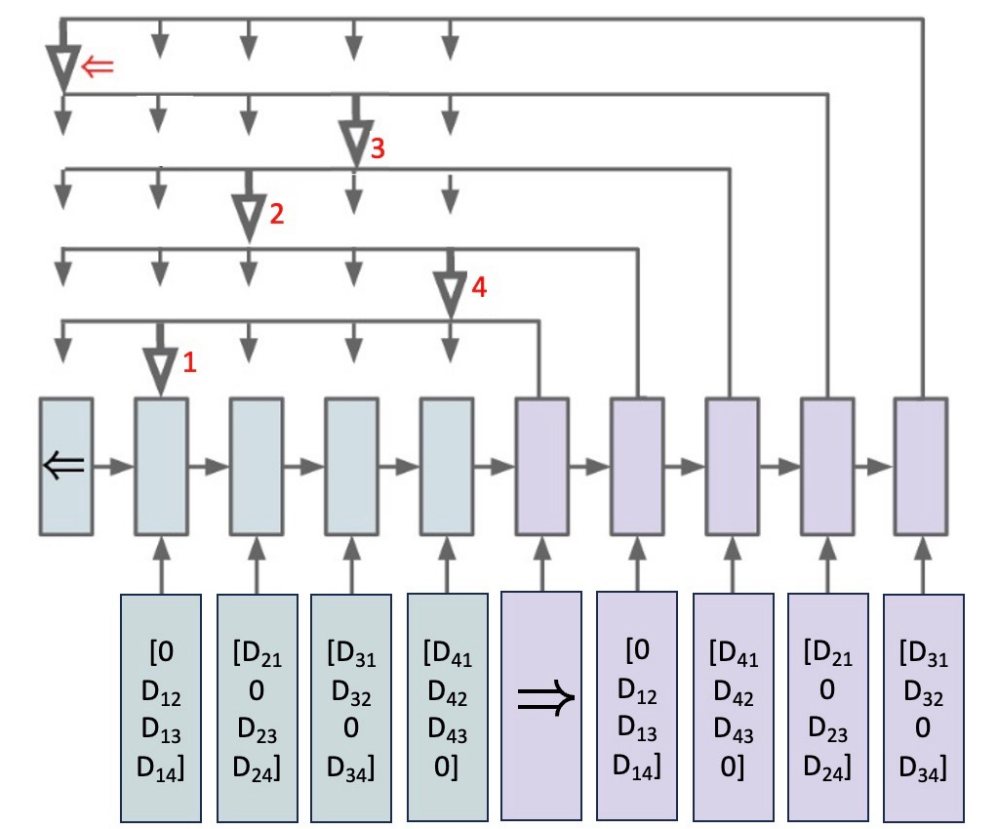
To handle TSP in real-world street:

❌ Simple straight-line distance

✅ Actual distance along the street

Methodology

- Pointer network



Input:
Adjacent Matrix

0	$D_{12.}$	D_{13}	D_{14}
D_{21}	0	D_{23}	D_{24}
D_{31}	D_{32}	0	D_{34}
D_{41}	D_{42}	D_{43}	0

Output:
List of optimised route
[1,4,2,3]

Result

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- Integration and Network

case unit	distance km	distance(Google) km	Relative Error	time minute	time(Google) minute	Relative Error
1	6.55	6.5	0.77%	12.85	13	1.15%
2	6.94	7.7	9.9%	14.32	15	4.5%
3	7.5	7.4	1.4%	13.62	13	4.8%
4	5.4	6.8	20.6%	12.18	22	44.6%
5	9.97	9.7	2.7%	18.89	21	10.04%

100 random paths are tested:

RMSE of distance: 11.95%
RMSE of travel time: 23.73%

Result

- Pointer network

Criterion

Accuracy: The values and order of the output list need to be correct

Mean route length ratio: The ratio between length of predicted route and of optimal route

Accuracy: 67%
Mean route length ratio: 1.02

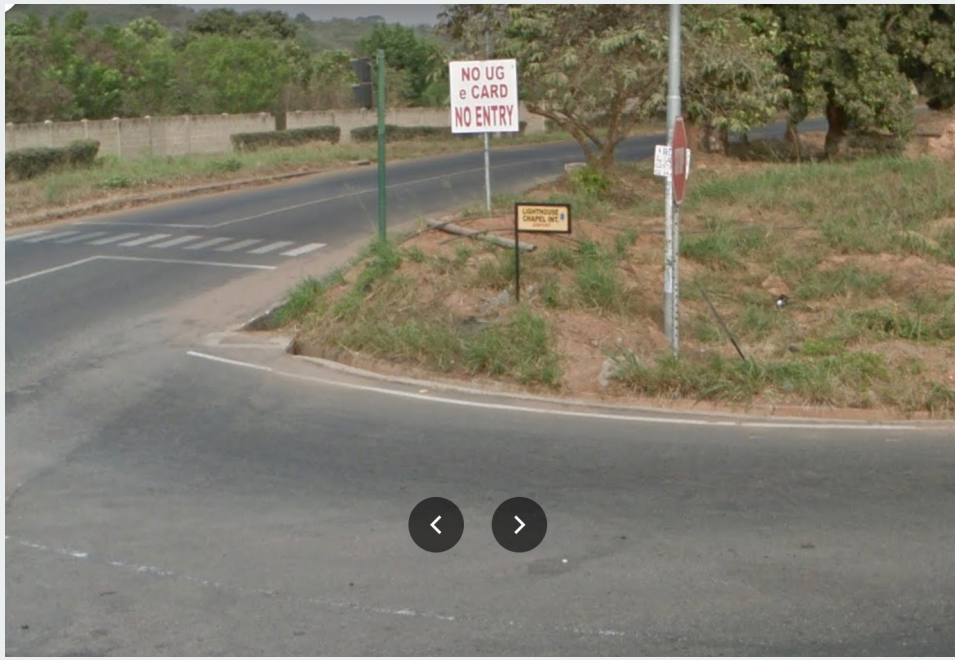
Optimal route: [0 4 1 2 3]

✅ Predicted route: [0 4 1 2 3]

❌ Predicted route: [0 4 1 3 2]

Limitation

- Data quality



Some roads are one-way roads but do not show up in the road data

Limitation

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- Assumptions

1. The ratio of traffic to capacity is 0.5 for all road segments.
2. No Traffic light
3. Clear road

Error in travel time

Conclusion

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The route planning function:

- 11.95% relative error for finding the shortest path
- 23.73% relative error for finding the most time-saving path compared to Google Maps.

Pointer Network:

- 67.0% of the accuracy of the model
- 1.02 of average route length ratio compared to the optimal route length.

Conclusion

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Thanks for listening!