MOMGA*: Empower Urban Transport for a Greener and Smarter Future

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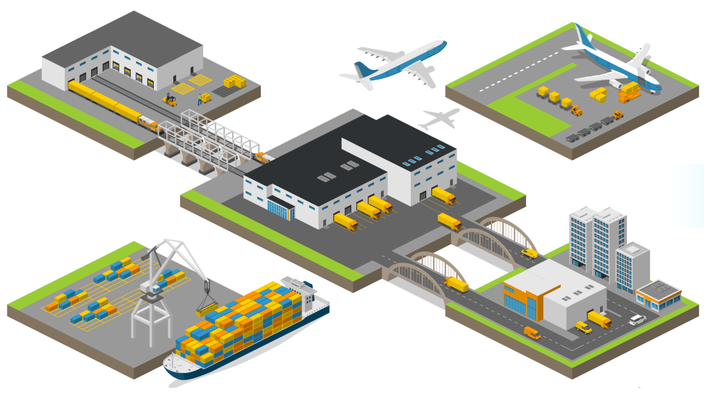
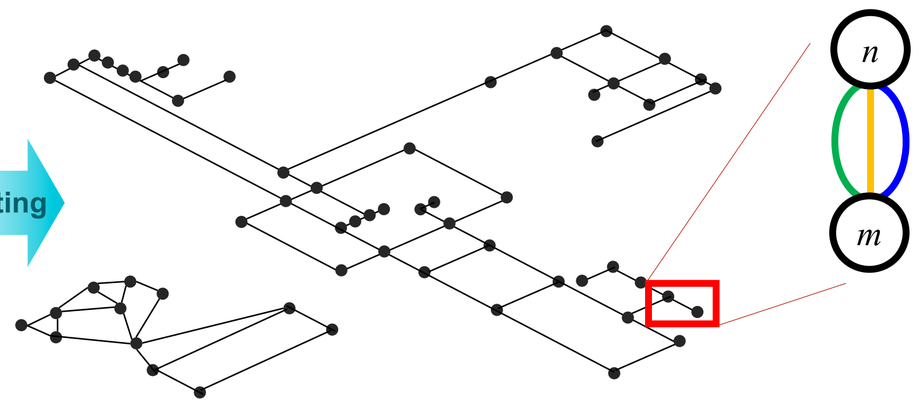


Extracting



Transport Options : Travel Modes × Distinct Advantages

$$C_{n,m} = \begin{bmatrix} c_{n,m,1,1} & \cdots & c_{n,m,1,q} \\ c_{n,m,2,1} & \cdots & c_{n,m,2,q} \\ \vdots & \ddots & \vdots \\ c_{n,m,p,1} & \cdots & c_{n,m,p,q} \end{bmatrix}$$

Modelling

Travel cost of a node pair: A cost matrix

Multi-objective Multi-graph Optimal Path Search Problem

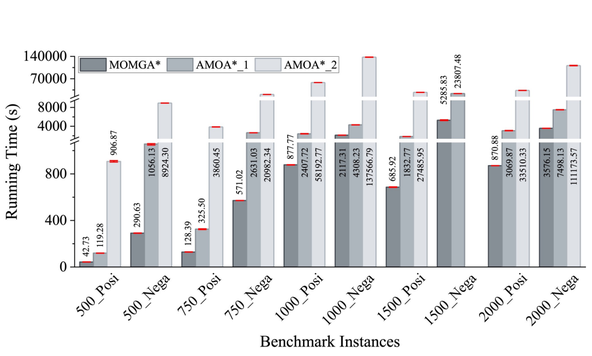
Approximate search algorithm: Sub-optimal or Near-optimal

Exact search algorithm: Computationally Expensive

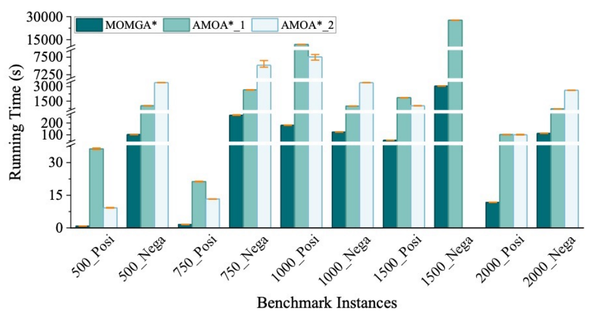
A new algorithm balancing Solution Quality & Search Efficiency!

Multi-objective Multi-graph A*

- A heuristic search algorithm MOMGA* is proposed.
- Applicable to any transportation scenes that are modelled as multi-objective multi-graphs.
- Can be accelerated by heuristic functions (admissible or likely-admissible).
- Comprehensive improvements over its previous version are observed.

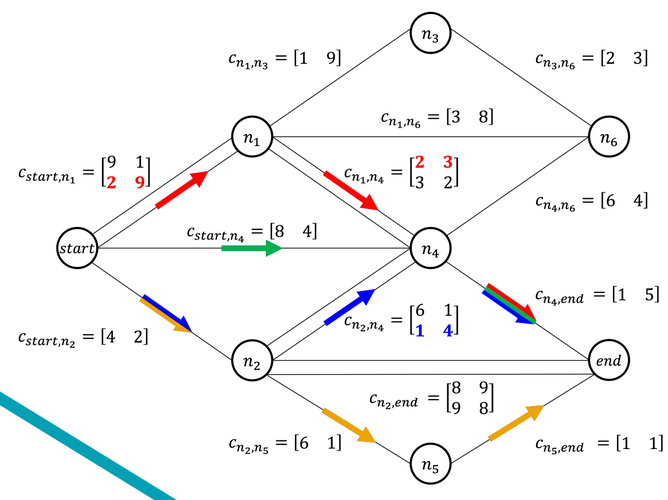


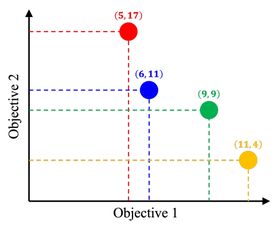
Search without heuristics



Search with admissible heuristics

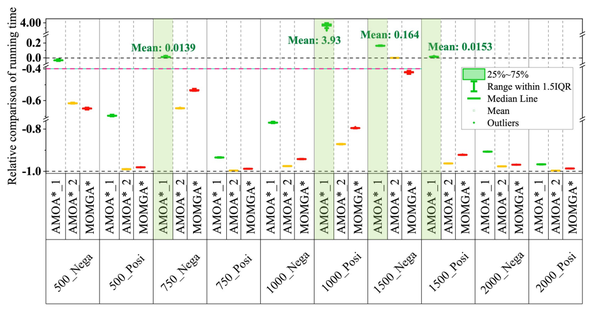
Optimisation: Minimise Multiple Travel Costs





Example of multi-objective multi-graph search

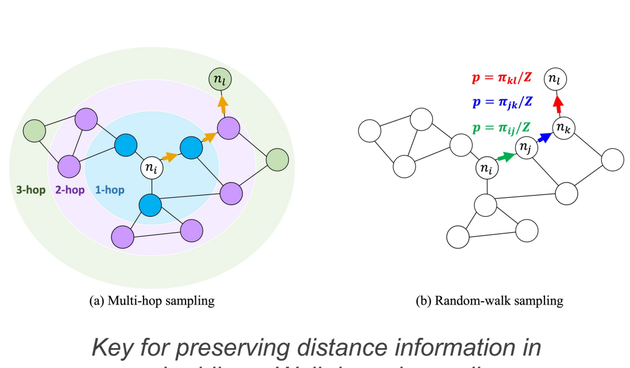
Running Time Reduction: **50.85% ~ 98.49%**, with finding **all optimal solutions**. Effective utilisation of heuristics **ensured**.



Effective utilisation of admissible heuristics

Learning Heuristics

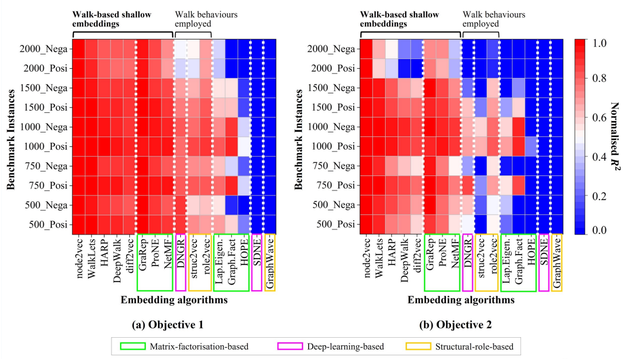
- A likely-admissible learning heuristic function is developed to speed up MOMGA* search.
- First utilised in multi-objective optimisation.
- Node embedding methods are used to extract node features.
- Walk-based shallow embeddings are identified as the key to accurately predict shortest path costs.



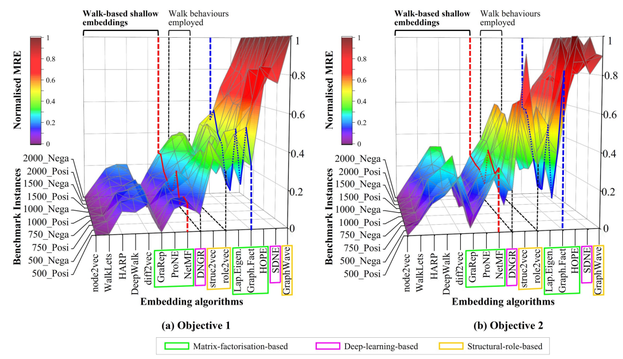
(a) Multi-hop sampling (b) Random-walk sampling

Key for preserving distance information in embeddings: Walk-based sampling

Walk-based sampling is beneficial for **all categories of node embedding methods** to preserve **distance-related information**.

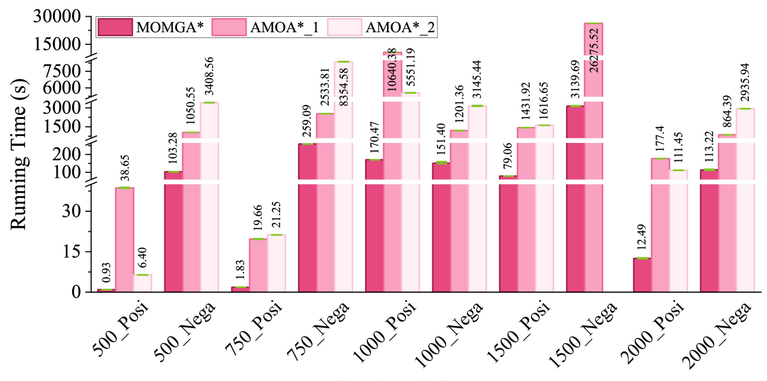


Prediction accuracy of embedding methods: R^2

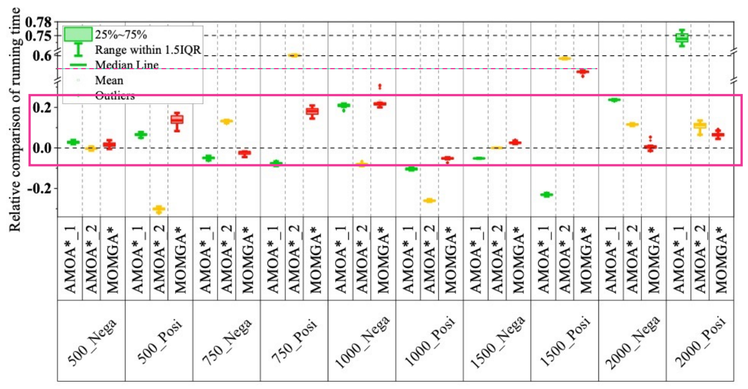


Prediction accuracy of embedding methods: MRE

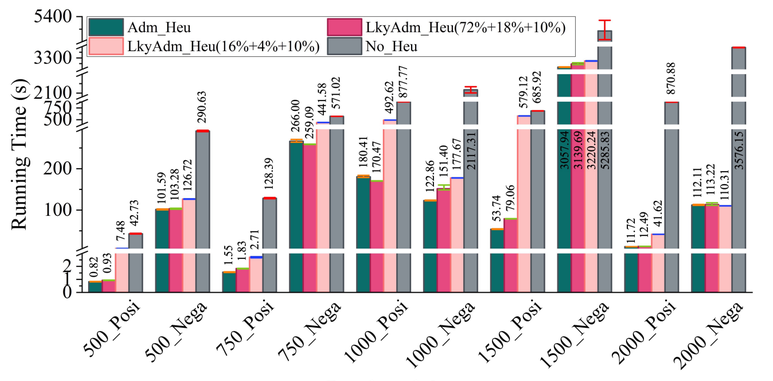
MOMGA* with Likely-admissible Learning Heuristics



Search with the likely-admissible heuristics



Efficiency between with likely-admissible and admissible heuristics



MOMGA under different heuristic conditions*

Potentials

Ministry of Transport
Decarbonising Transport

Transport for London
Multi-modal transport + Sustainability

The NATS group
Airspace efficiency & Net zero emissions

Port of London
Port loading & unloading management

Research Review

Multi-graph modelling proposed for **airport ground movement 2016**

Founded by **EPSRC**, to the value over **£1M 2018 -- 2022**

Applied to **multi-modal urban transport scene 2019**

AMOA*: **16% less taxiing time** & **13% less fuel consumption 2020**