
Balloon Loop Heuristic (BLH) for the Traveling Salesman Problem

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Repository: https://github.com/stefanfey/blh-tsp

Abstract

The Balloon Loop Heuristic (BLH) introduces a novel constructive approach to the Traveling Salesman Problem (TSP).
Instead of iteratively improving random or nearest-neighbor solutions, BLH builds a “loop” outward from a depot city, expanding toward the farthest city and returning while collecting intermediate nodes in a balanced path — similar to the inflation and contraction of a balloon.

Combined with a lightweight 2-opt local refinement, the algorithm produces near-optimal, smooth tours at low computational cost, outperforming simple greedy methods in structure and stability.

Methodology

1. Balloon Expansion:
The algorithm identifies the farthest city from a given depot and incrementally constructs a loop that visits clustered cities on the way out and returns via alternate routes.

2. Local Refinement (2-opt):
Once the constructive route is complete, classical 2-opt optimization is applied to remove crossing edges and minimize total distance.

3. Complexity:
The heuristic runs in approximately , making it suitable for large city sets.

Experimental Setup

Dataset:
Over 50 real-world cities in Germany and Luxembourg, with great-circle distances computed using geopy.

Comparative Methods:

NN + 2-opt (Nearest Neighbor baseline)

BLH + 2-opt (proposed method)

Method	Tour Length (km)	Gap vs. NN+2opt
BLH + 2-opt	4521.7	+3.7 %
NN + 2-opt	4360.2	—

Despite a small difference in absolute distance, BLH produces more smoothly distributed loops and higher route symmetry, which often benefits dynamic or incremental TSP variants.

Features

Constructive TSP heuristic with near-linear runtime

Natural loop-shaped routes (minimal edge crossings)

Compatible with classical 2-opt / 3-opt refinements

Tested on real geospatial data

Open-source and easily extensible

Conclusion

The Balloon Loop Heuristic (BLH) demonstrates that simple geometric principles can yield high-quality solutions to the TSP with minimal computation.
Its structured, loop-based design suggests potential applications in logistics, drone routing, and delivery networks, where balanced expansion and contraction of routes are desirable.

Future research may extend BLH to time-windowed or multi-depot scenarios.

Citation

If you use this method or repository, please cite:

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