

# Junction-aware Multi-Criteria Bicycle Route Planning

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We developed an intelligent route planning system that helps cyclists discover routes that best suit their needs. Proposed solution takes into account the difficulty of manoeuvres at junctions and employs multi-criteria route search with several speed-up heuristics.

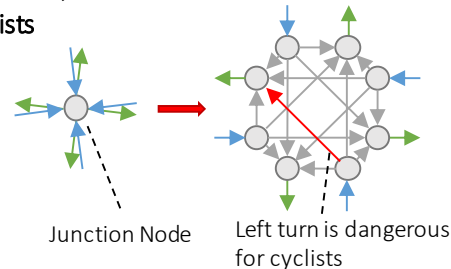


## Motivation

- Cycling is crucial for achieving more sustainable urban mobility
- Navigating on a bike is challenging – fragmented cycling infrastructure, hills
- Cyclists have multiple route choice criteria: *trip distance, turn frequency, slope, junction control, manoeuvres at junctions, surface quality, traffic volumes, ...*
- Multi-Criteria Bicycle Route Planner is **needed**, but **none exists**

## Extended Cycleway Graph Model

- OpenStreetMap → graph model for planning
- Extension of graph model – certain maneuvers at junction are more dangerous than others (left turn ≠ right turn)



## Multi-Criteria Bicycle Route Planning

- Three criteria (distance, elevation gain, and bike friendliness)
- Solves issues of single criteria approach with weighted sum of cost vector
- Pareto set of routes
- Optimal MCD algorithm too slow – we proposed Pruning heuristics



Optimal Pareto set



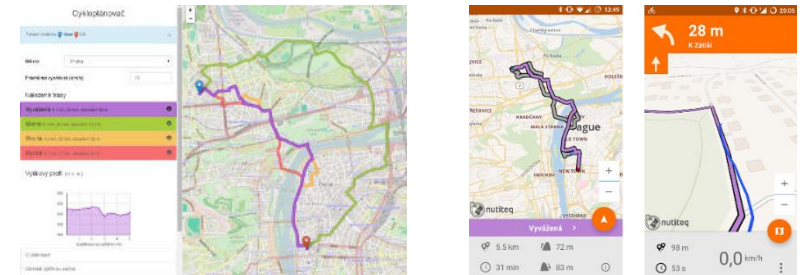
Pruning heuristic Pareto set

## Evaluation of the Best Pruning Heuristic

- Speed up – **4000x** faster than optimal MCD algorithm
- Solve problems on graphs with **141 117** nodes and **323 114** edges in **2.3** seconds on average – whole city of Prague
- Approximately **10.6%** difference in each criterion from optimum

## Practical Deployment

- World unique bicycle route planner with real users
- RESTful API – daily serves **200** requests on average
- Web frontend [www.cykloplanovac.cz](http://www.cykloplanovac.cz)
- Android application – **1900** active users
- Tracked data helps to improve routing and to analyse problems in cycling infrastructure



## Publications

- Hrnčíř, J., Žilecký, P., Song, Q., & Jakob, M. (2015). **Speedups for Multi-Criteria Urban Bicycle Routing**. In Proceedings of ATMOS 2015 workshop (pp 16-28).
- Hrnčíř, J., Žilecký, P., Song, Q., & Jakob, M. (2015). **Practical Multi-Criteria Urban Bicycle Routing**. Submitted to IEEE Transactions Intelligent Transportation Systems.
- Song, Q., Žilecký, P., Jakob, M., & Hrnčíř, J. (2014). **Exploring Pareto Routes in Multi-criteria Urban Bicycle Routing**. In Proceedings of IEEE ITSC 2014 (pp. 1781-1787).