P3

Finding k-Dissimilar Paths with Minimum Collective Length

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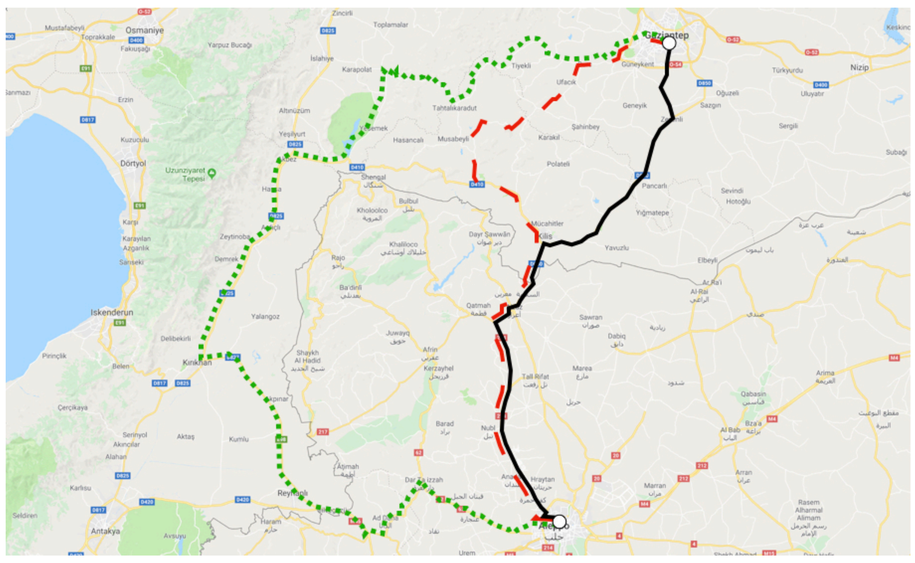
Motivational Example

Scenario: Humanitarian aid transport through unsafe regions

Idea: Distribute cargo to several vehicles to increase the chances that at least some of the goods will be delivered



Objective: Use multiple routes that

- are **dissimilar** to each other, i.e., cross different roads
- their **collective length**, i.e., the total distance covered by the vehicles, is **minimum**

k-DPwML Problem [1]

Given a source s and a target t, a k-DPwML query returns a set of k paths P from s to t, sorted in increasing length order, such that:

(a) all paths in P are pairwise sufficiently dissimilar

(b) $|P| \leq k$ and P has the maximum possible cardinality among every set of paths that satisfy Condition (a)

(c) P has the lowest collective path length among every set of paths P_{AB} that satisfy both Conditions (a) and (b)

Algorithms

Exact approach:

- Examine all paths from s to t in length order and all subsets of up to k paths **(kSP-DML)**

Heuristic aproaches:

- Examine all paths from s to t in length order minimizing the length of each subsequent result **(FindKSPD)** [1]
- Examine only the **simple single-via paths** from s to t in length order and all subsets of up to k paths **(SVP-DML)**
- Examine only the **simple single-via paths** from s to t in length order minimizing the length of each subsequent result **(SVP-D+)**

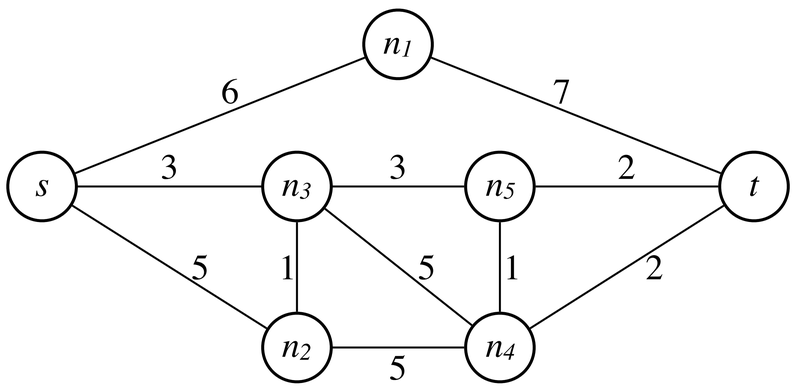
Simple Single-via Paths

Definition: Given a source node s and a target node t, the set of simple single-via paths contains:

(a) the shortest path $p(s \rightarrow t)$

(b) for every node n not on $p(s \rightarrow t)$, the shortest simple path from s to t that passes via n

Example



All s-t Paths

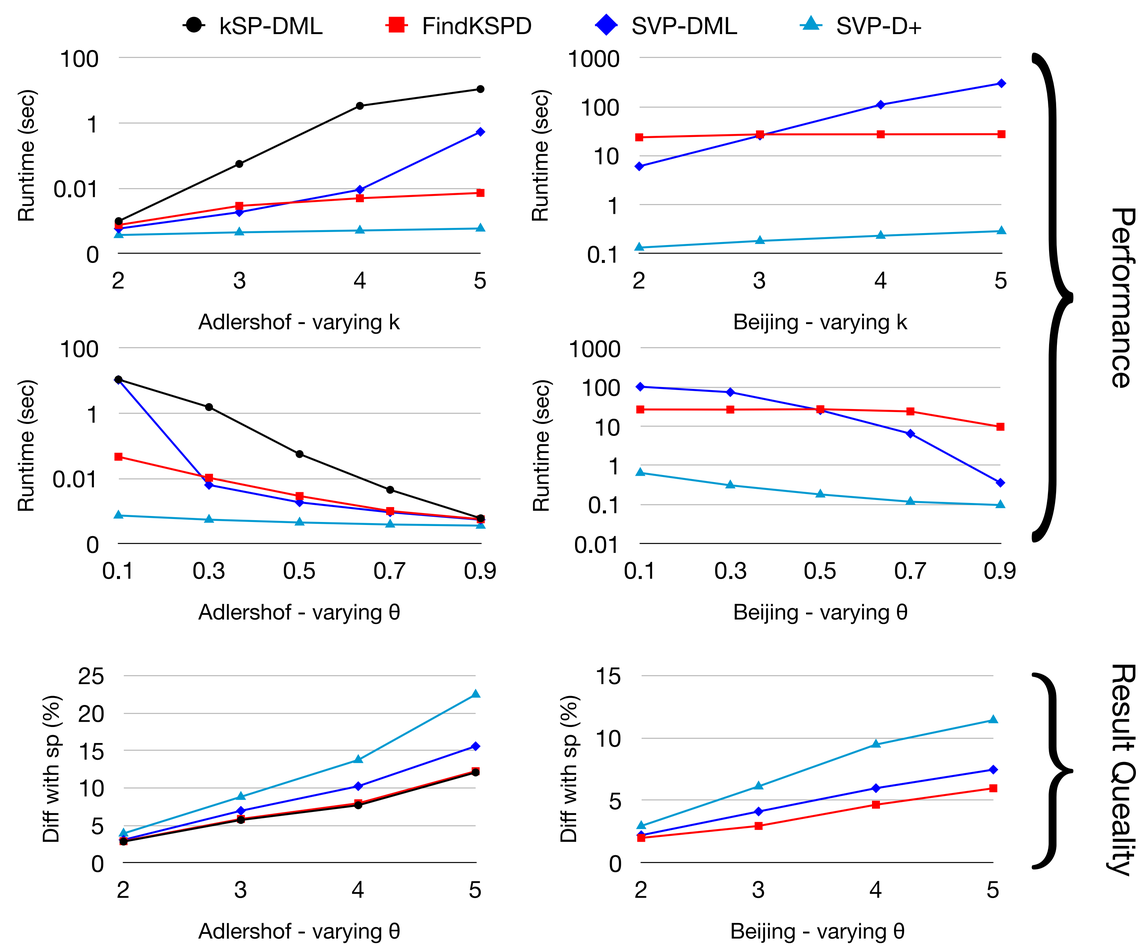
	p	$l(p)$
$p_1=p_s$	$\langle s,n_3,n_5,t\rangle$	8
p_2	$\langle s,n_3,n_5,n_4,t\rangle$	9
p_3	$\langle s,n_3,n_4,t\rangle$	10
FindKSPD → p_4	$\langle s,n_2,n_3,n_5,t\rangle$	11
p_5	$\langle s,n_3,n_2,n_4,t\rangle$	11
p_6	$\langle s,n_3,n_4,n_5,t\rangle$	11
kSP-DML → p_7	$\langle s,n_2,n_3,n_5,n_4,t\rangle$	12
[17 more paths exist but are not constructed]		

Simple Single-via paths

	i	p	$l(p)$
	p_s	$\langle s,n_3,n_5,t\rangle$	8
	$p_{ssv}(n_4)$	$\langle s,n_3,n_5,n_4,t\rangle$	9
	$p_{ssv}(n_2)$	$\langle s,n_2,n_3,n_5,t\rangle$	11
SVP-DML → SVP-D+	$p_{ssv}(n_1)$	$\langle s,n_1,t\rangle$	11

*The coloured lines indicate the last path examined by each algorithm

Experimental Evaluation



Conclusion: Solutions that iterate over the simple single-via paths are faster with only a small trade-off on the quality of the results

[1] Liu et al. *Finding Top-k Shortest Paths with Diversity*. IEEE TKDE, vol. 30(3), 488–502 (2017)

[2] Chondrogiannis et al. *Alternative Routing: K-shortest Paths with Limited Overlap*. In Proc. of the 23rd ACM SIGSPATIAL GIS Conf. 68:1–68:4 (2015)

[3] Abraham et al. *Alternative Routes in Road Networks*. ACM JEA, vol. 18, 1–17 (2013)