Extraction and application of map-matching anomalies to the improvement of the cycling road network infrastructure and road maps

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IDEAS TO IMPACT

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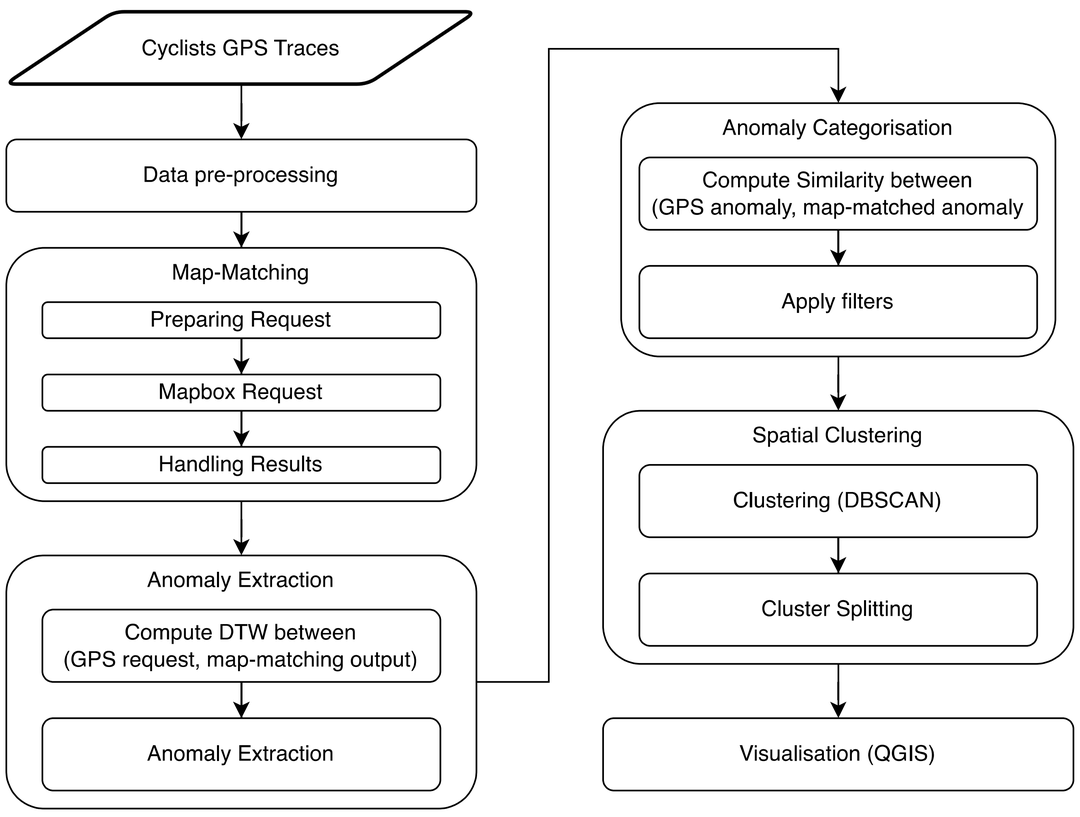
1. Introduction

1. ICT is fundamental to promoting the transition from conventional mobility modes into cycling.
2. OpenStreetMap (OSM) provides information for a wide range of applications. The data about the road network is an important part of OSM. It supports many navigation services, and it is used to describe mobility patterns;
3. Map-matching is the process of aligning a sequence of GPS points into the most probable road in the road network.
4. However, for cyclists, the concept of a road network is fuzzier, as they can use unconventional roads, such as one-ways, sidewalks, or other shortcuts.
5. This leads to **map-matching anomalies**: cases when the map-matching output clearly does not represent the path taken by the real cyclist.
6. Ultimately leading to wrong insights about cyclists' mobility behavior.

2. Objectives

Obj. 1: Develop an unsupervised computational method to process sets of cycling traces and identify city areas prone to map-matching anomalies.
Obj. 2: Explore how the knowledge about map-matching anomalies may help cities make more informal decisions about their cycling infrastructures.

3. Methodology



4. Description of Anomaly Categories

- **Most Detour:** Cases where the GPS trace is much shorter and farther than the map-matched output (TL > 40m; LI <0,7; FD > 30m).
- **Gap:** Cases where the map-matching algorithm failed to produce a map-matched segment.
- **Start/End:** Cases where the initial and final part of a map-matching output is different than the original GPS trace.
- **Long Parallel:** Cases where both geometries have similar lengths and are nearby but are sufficiently far from each other to be considered as an anomaly (TL > 40m; LI =1±0,3; FD < 30m).

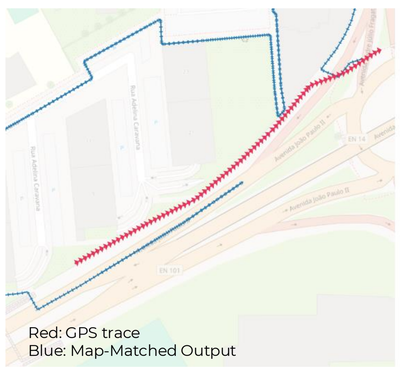
Similarity Measures

- **GPS Trace Length (TL):** The length of the GPS trace that represents the cyclist's path.
- **Length Index (LI):** The ratio between the GPS trace and map-matched output length.
- **Frèchet Distance (FD):** "A man is walking his dog on a leash. Both walk on two different paths and can vary their speed. What is the length of the shortest leash that can be used to transverse their paths?"

5. Results

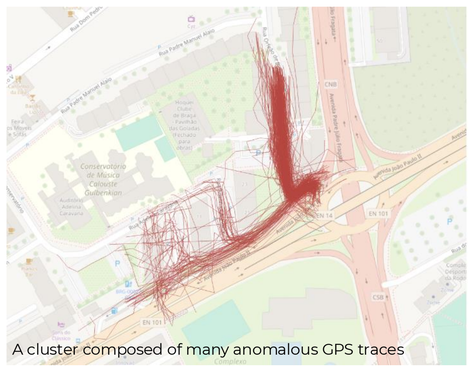
Phase	Description	Count	%
Preprocessing	Initial Cyclists GPS Traces	16.292	-
	Trips Excluded	1.258	7,72
	Trips Used	15.034	92,3
	Sub-traces (after pre-processing)	16.746	-
Map-Matching	Map-Matching requests	43.761	-
	Map-match: Error	320	0,7
	Map-match: One-Segment	37.998	86,8
	Map-match: Multiple-Segments	5.443	12,4
Anomaly Extraction	Potential Map-matching anomalies	153.303	-

1. Anomaly Extraction

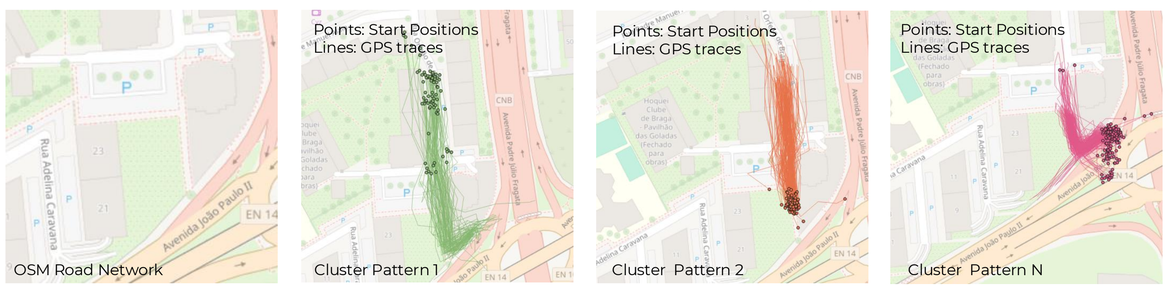


2. Categorization

3. Clustering



4. Cluster Splitting



6. Evaluation

Category	Total Clusters	Clusters Analysed	RN or CB	% (RN or CB)	IE only	GPS only
Most Detour	112	40	35	87,5	3	2
Gap	71	40	25	62,5	8	6
Start/End	154	40	30	75,0	6	4
Long Parallel	234	40	26	65,0	0	9

Errors caused by: **RN** – Road network data problems; **CB** – Incompatible cyclist behavior; **IE** – Internal map-matching errors; **GPS** – Low GPS quality

7. Jobs to be Done

The outputs produced at the different stages can be used to develop:

- **Global Visualizations:** Visualization of map-matching errors at the city level;
- **Local Visualizations:** Visualization of map-matching anomalies at specific locations; Easier to interpret the results and discover what caused each anomaly.
- **Metrics at the city level:** Measure the global impact for cyclists; It allows benchmarking of cities;
- **Metrics at a cluster level:** Measuring what impact each cluster has for cyclists; Allows municipalities to prioritize efforts.

8. Future Work

1. Development of a collaborative web-based application for people to submit their GPS activities and improve the OSM road network.

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