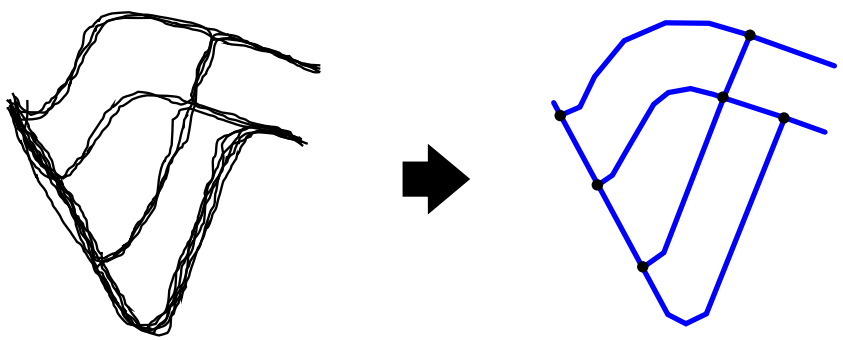
Inferring Road Networks from GPS Trajectories

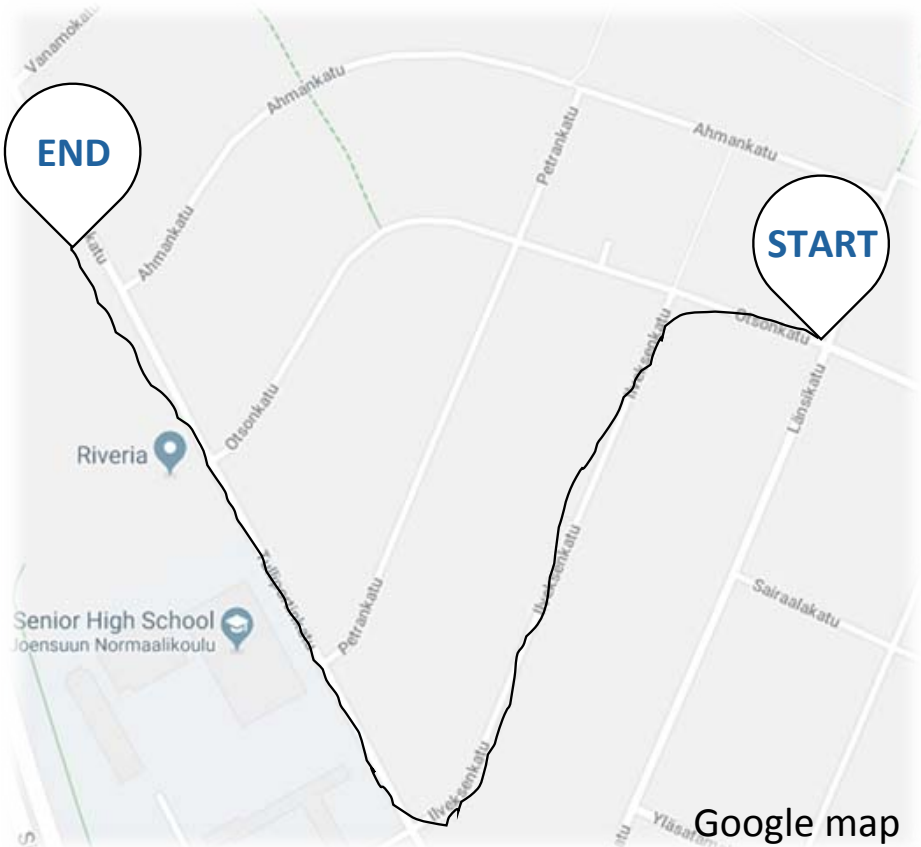


Radu Mariescu Istodor

19.12.2018

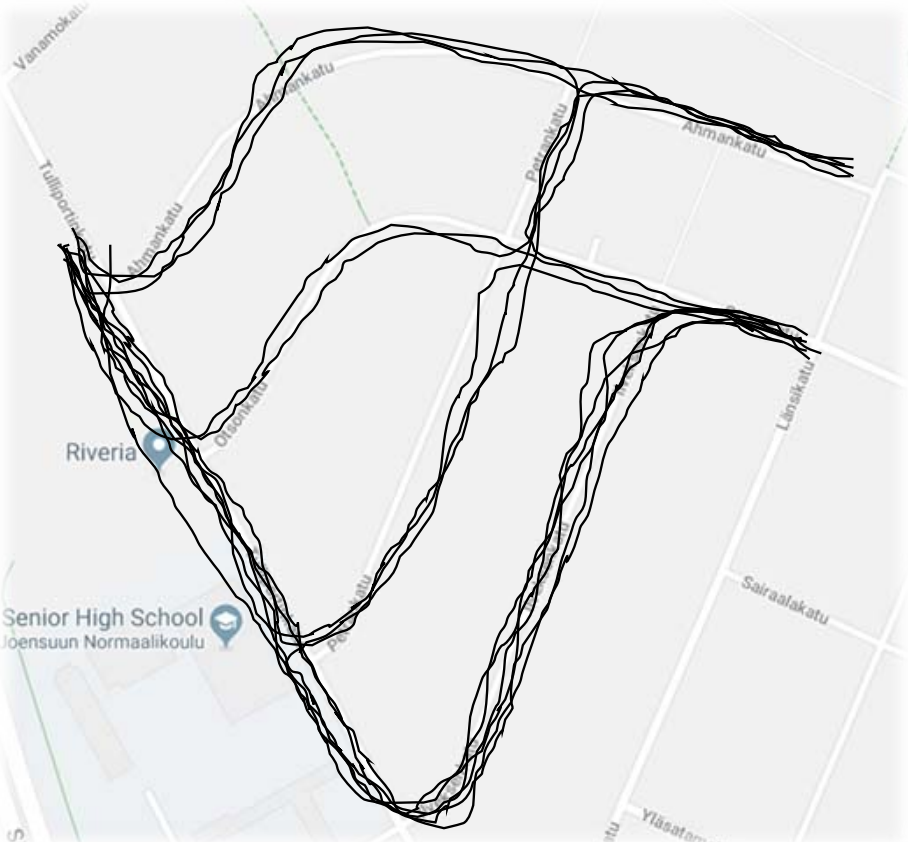
UNIVERSITY OF
EASTERN FINLAND

GPS Trajectory

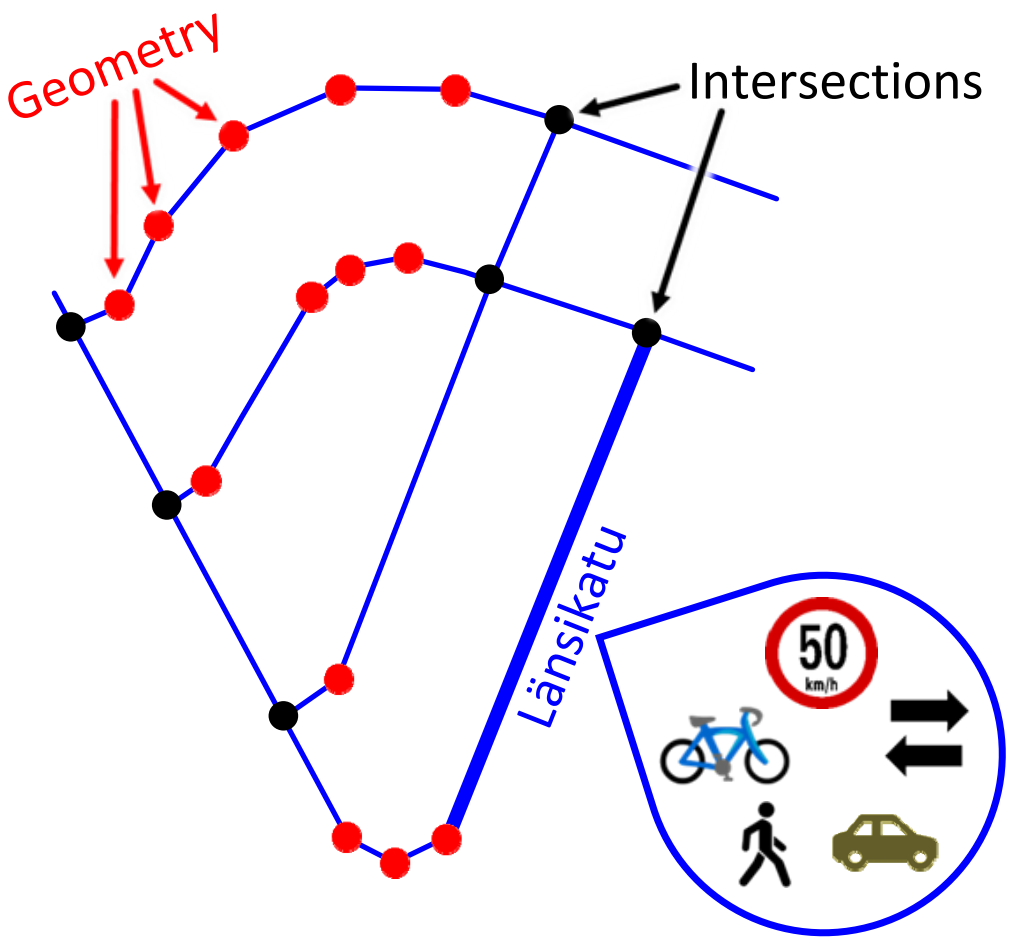


Latitude : 62.2351
Longitude : 29.4123
Timestamp : 10.10.2018
19:05

GPS Trajectories



Road Network



Satellite Images → GPS Trajectories

Chicago

Joensuu

MOPSI

Proposed Method

Mariescu-Istodor, Radu, and Pasi Fränti.
"Cellnet: Inferring road networks from gps trajectories."
ACM Transactions on Spatial Algorithms and Systems (TSAS) 4, no. 3 (2018).

Step 1

Detecting Intersections

Step 2

Creating Road segments

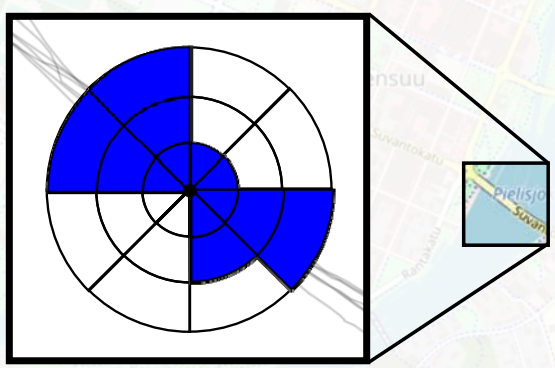
In the next slides I will:

1. Teach the background
2. Show how we did it*
3. Give you a challenge ☺

*most important steps only

Detecting Intersections

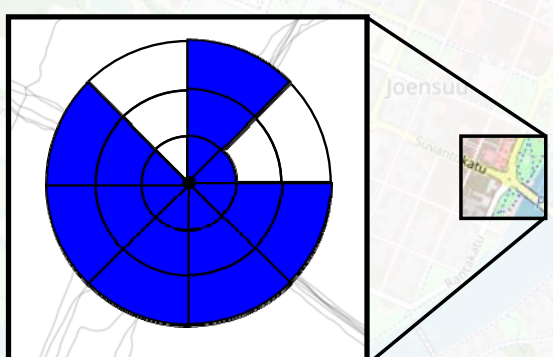
Fathi, Alireza, and John Krumm.
"Detecting road intersections from GPS traces."
Geographic Information Science (2010).



Descriptor

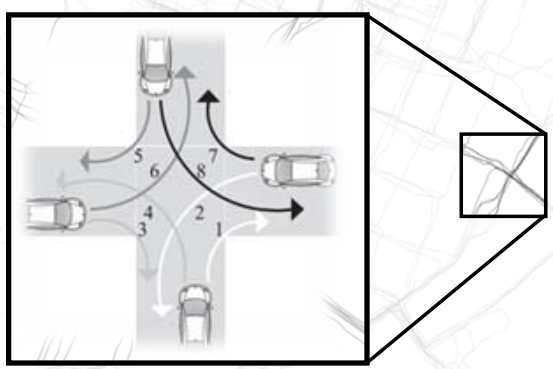
Detecting Intersections

Fathi, Alireza, and John Krumm.
"Detecting road intersections from GPS traces."
Geographic Information Science, pp. 56-69 (2010).



Detecting Intersections

Karagiorgou, Sophia, and Dieter Pfoser.
"On vehicle tracking data-based road network generation."
Advances in Geographic Information Systems (2012).

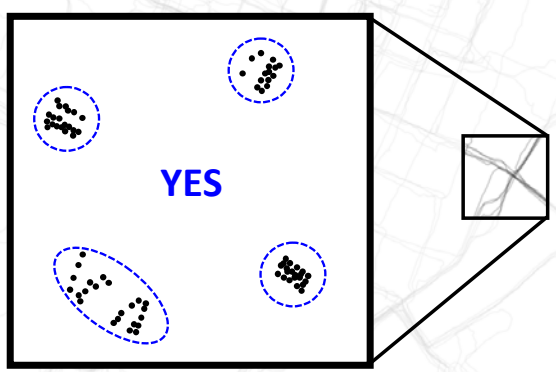


Turning patterns

Detecting Intersections

PROPOSED

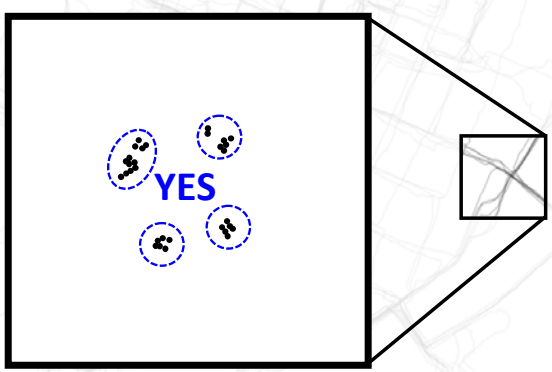
Mariescu-Istodor, Radu, and Pasi Fränti.
"Cellnet: Inferring road networks from gps trajectories."
ACM TSAS (2018).



Detecting Intersections

PROPOSED

Mariescu-Istodor, Radu, and Pasi Fränti.
"Cellnet: Inferring road networks from gps trajectories."
ACM TSAS (2018).

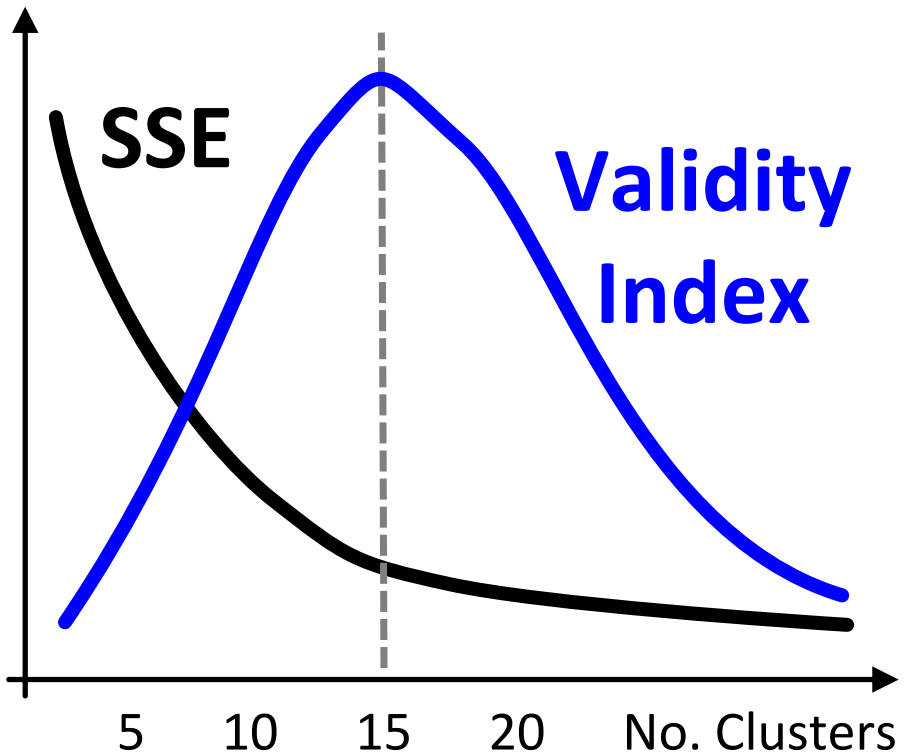


Still works...

Random Swap

Fränti, Pasi, and Juha Kivijärvi.
"Randomised local search algorithm for the clustering problem."
Pattern Analysis & Applications (2000).

Sum of squared errors

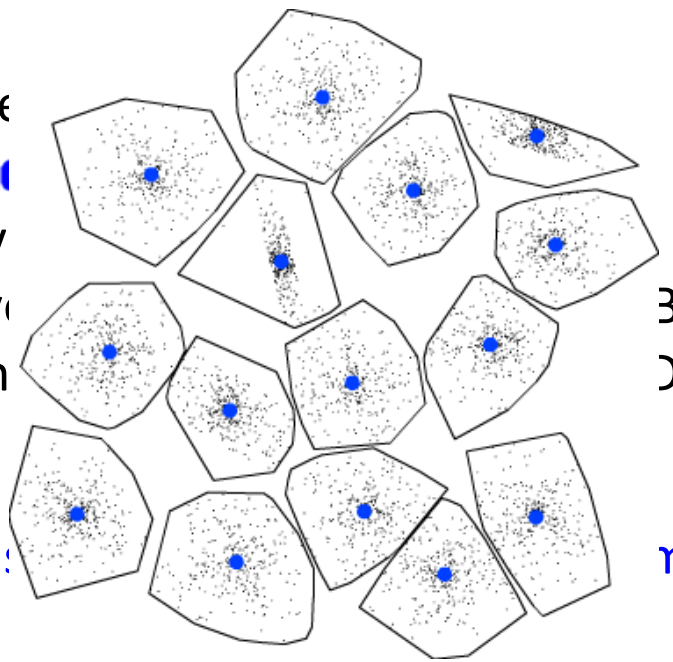


WB
Rate
Silh
Dav
Bay
Min

BIC)
DL)

Rou

man.

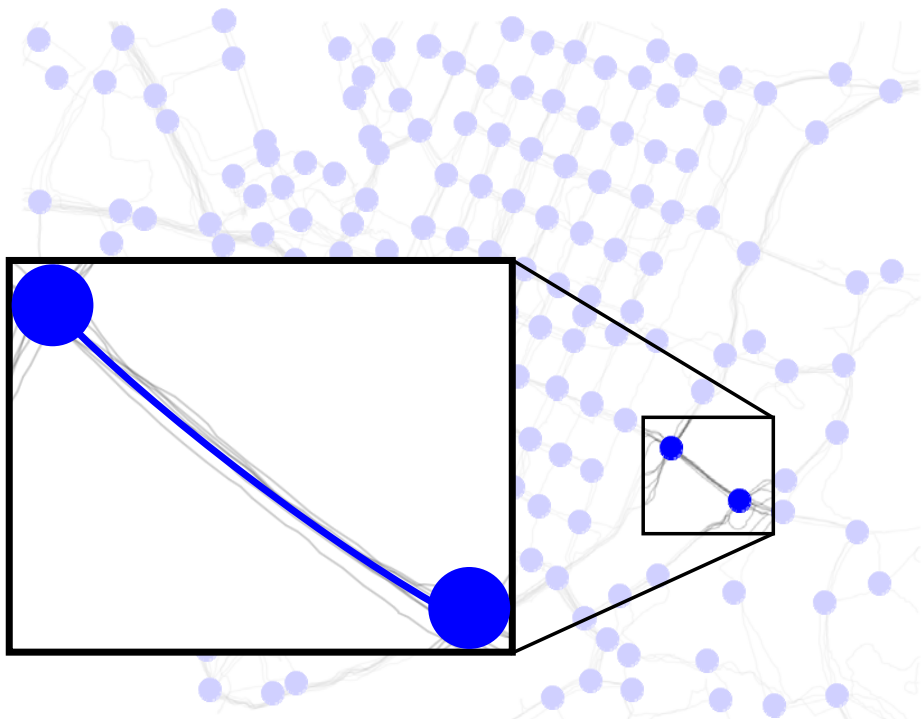


(1990)

S2 (synthetic) dataset

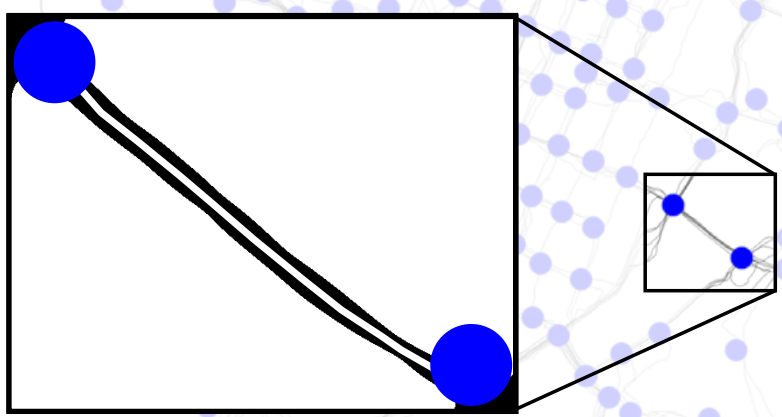
cs.uef.fi/sipu/datasets

Creating Road segments



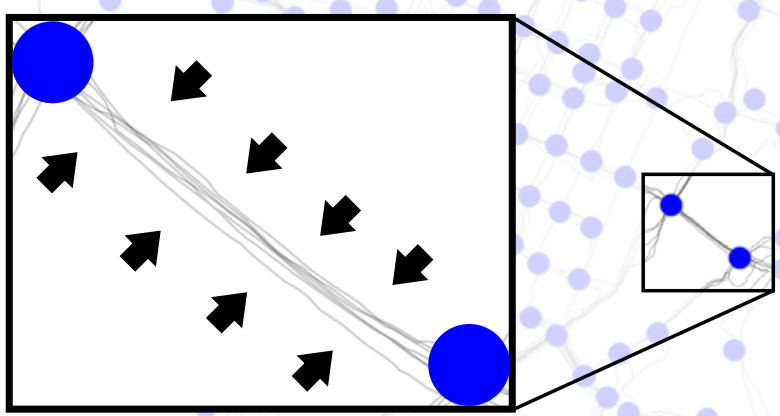
Creating Road segments

Davies, Jonathan J., Alastair R. Beresford, and Andy Hopper.
"Scalable, distributed, real-time map generation."
Pervasive Computing (2006).



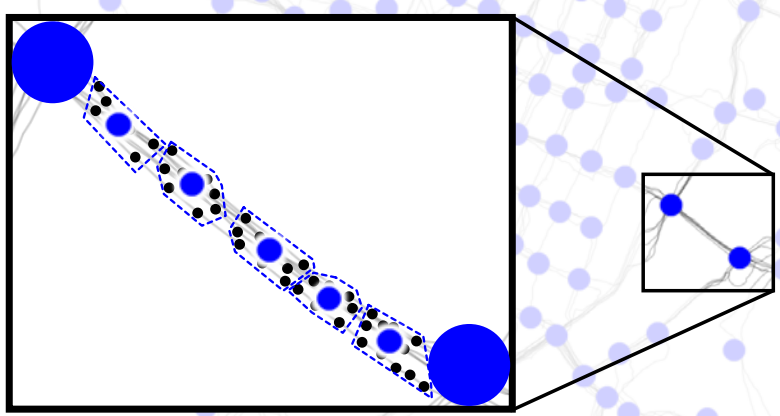
Creating Road segments

Cao, Lili, and John Krumm.
"From GPS traces to a routable road map."
Advances in geographic information systems (2009).



Creating Road segments

Edelkamp, Stefan, and Stefan Schrödl.
"Route planning and map inference with global positioning traces."
Computer Science in Perspective (2003).

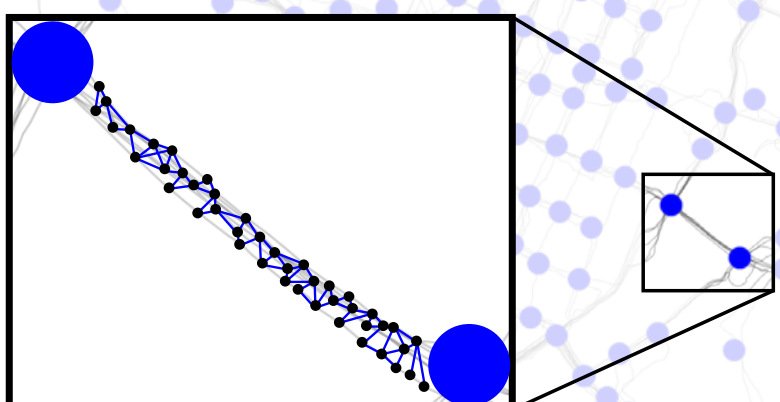


Clustering

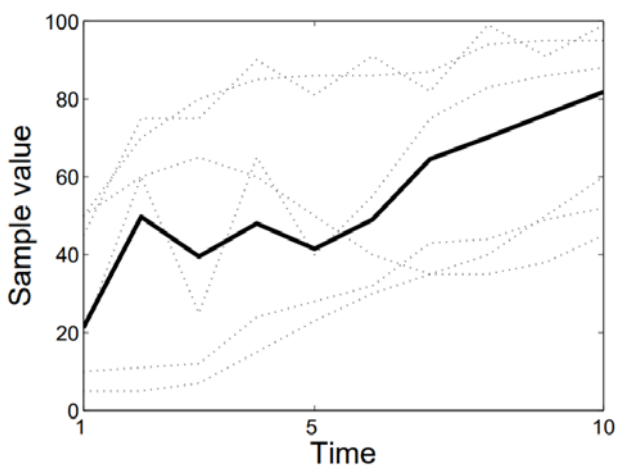
Creating Road segments

PROPOSED

Mariescu-Istodor, Radu, and Pasi Fränti.
"Cellnet: Inferring road networks from gps trajectories."
ACM TSAS (2018).

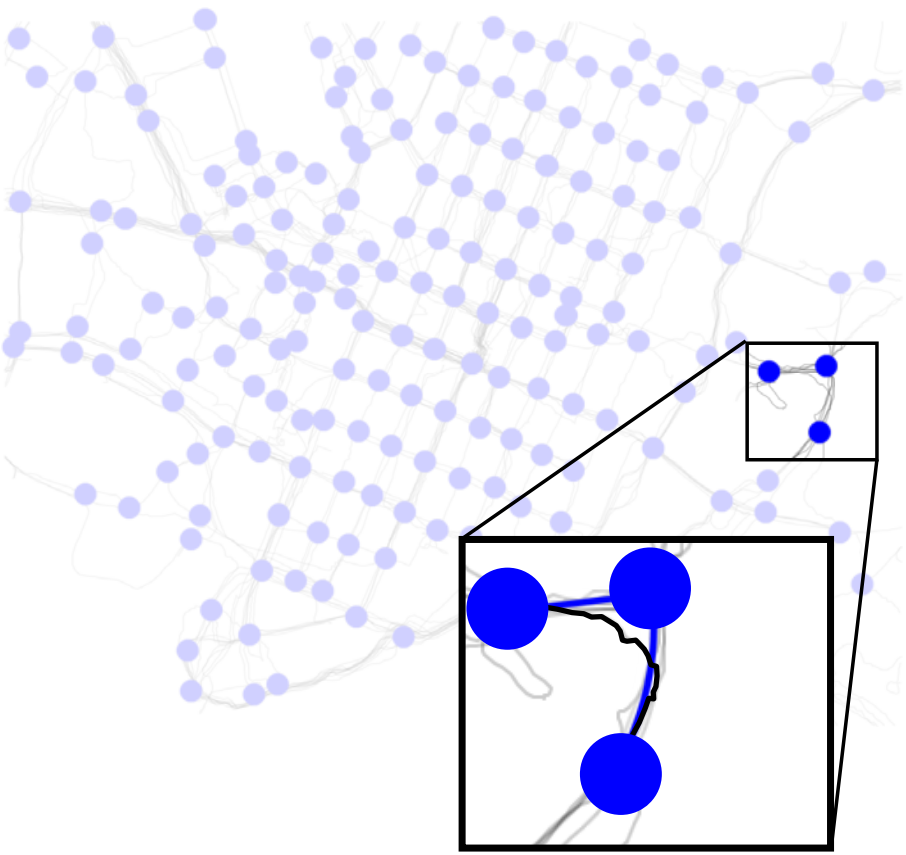


DTW averaging



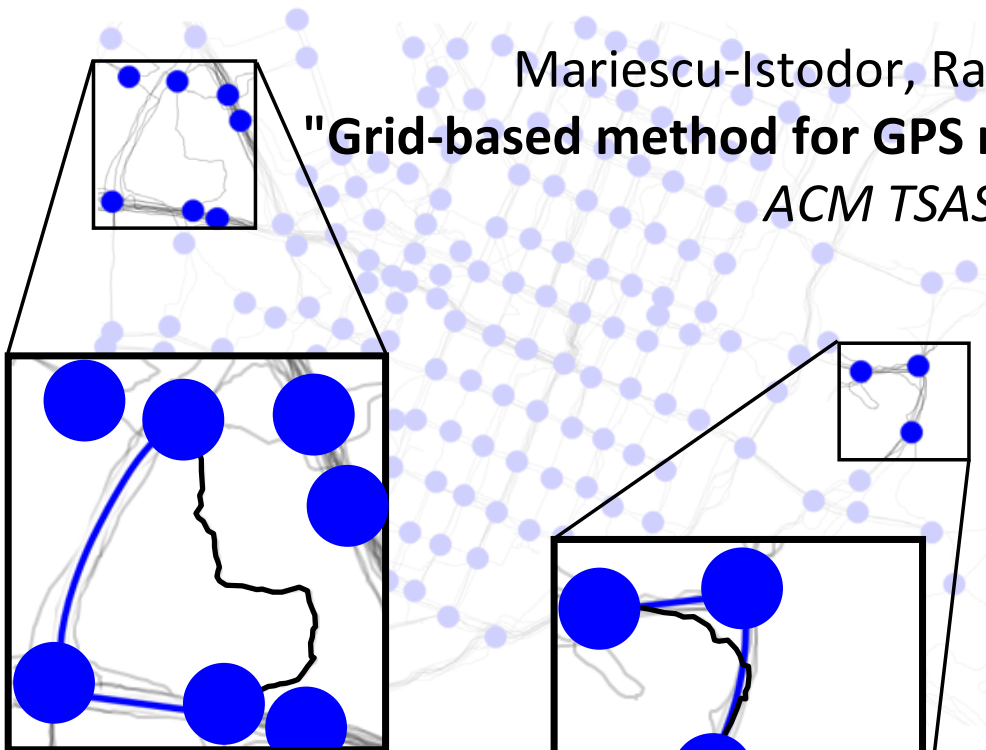
Hautamäki, Ville, Pekka Nykänen, and Pasi Fränti.
"Time-series clustering by approximate prototypes."
ICPR pp. 1-4. (2008).

Accepted connections



length (**α**) ≃ length (**α**)

Accepted connections



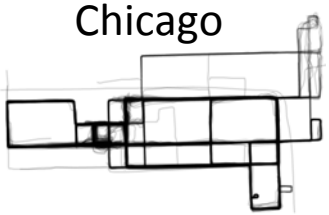
Mariescu-Istodor, Radu, and Pasi Fränti.
"Grid-based method for GPS route analysis for retrieval."
ACM TSAS (2017).

sim (**α**, **α**) = 0

sim (**α**, **α**) = 96%

length (**α**) ≃ length (**α**)

Evaluation

Chicago 	42 %	28 %	10 %	87 %
	P = .97			2 R = .83
Joensuu 	46			68 %
	P = .56 R = .38	P = .24 R = .87	P = .13 R = .33	P = .68 R = .49

$$precision = \frac{correct}{correct + false\ detected}$$

$$recall = \frac{correct}{correct + missed}$$

$$f - score = 2 \cdot \frac{precision \cdot recall}{precision + recall}$$

Challenge:

Average GPS segments

http://cs.uef.fi/sipu/segments

Other useful links:

http://cs.uef.fi/mopsi/routes/network

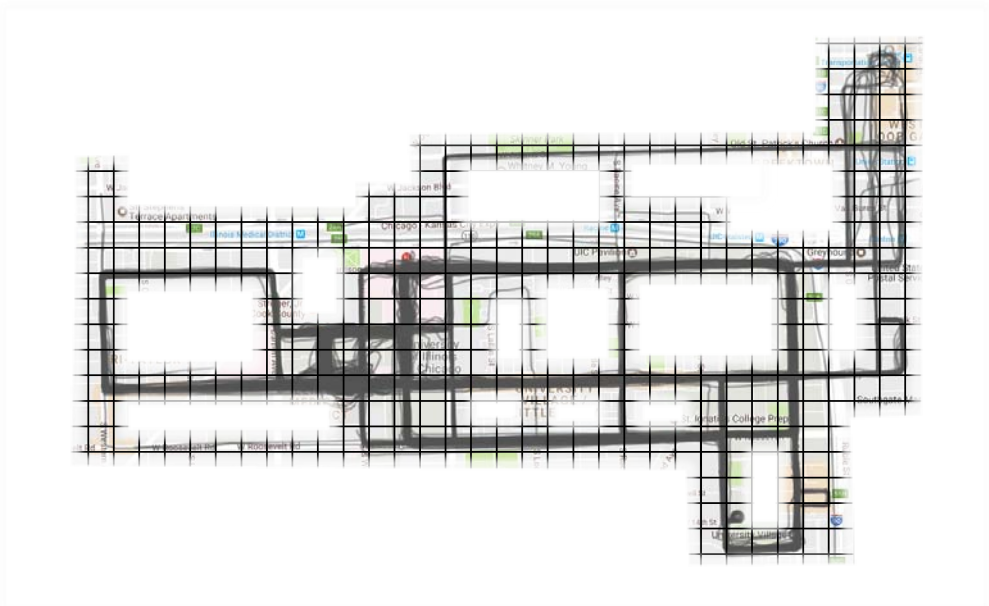
http://cs.uef.fi/mopsi/routes/dataset

Radu Mariescu-Istodor

radum@cs.uef.fi

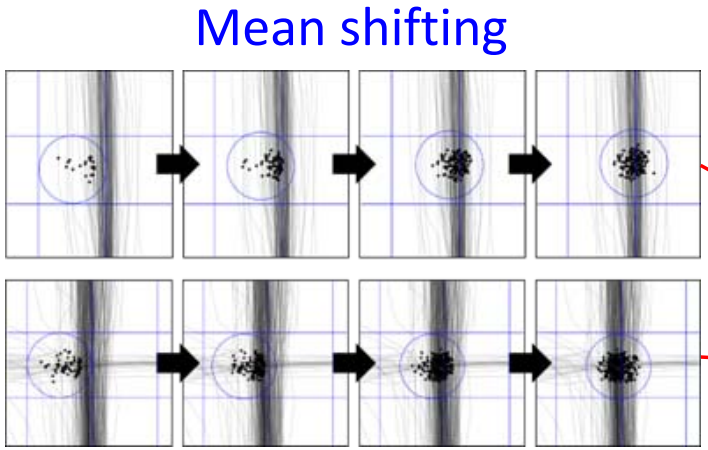
UNIVERSITY OF
EASTERN FINLAND

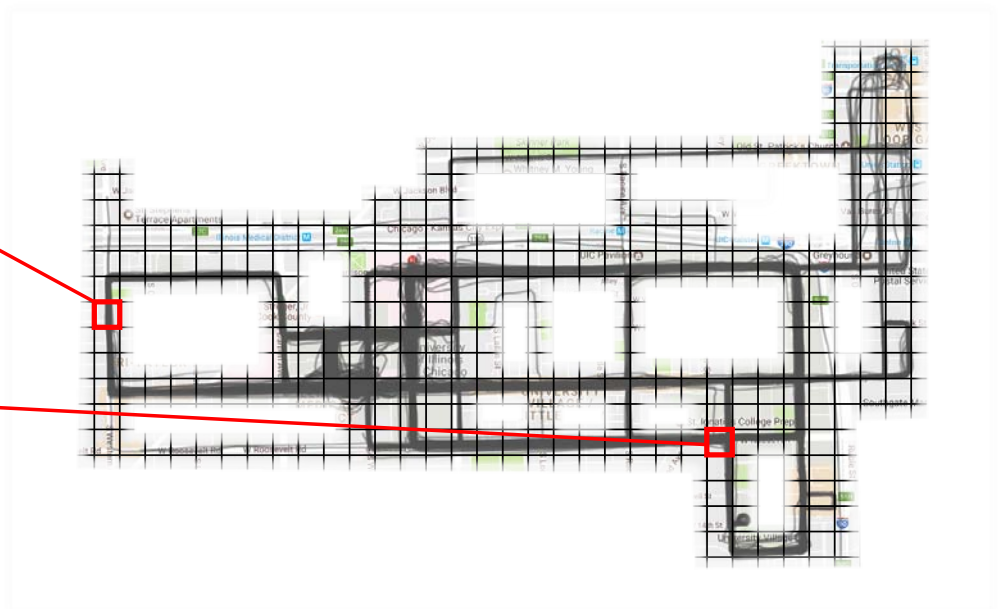
Choosing the test locations



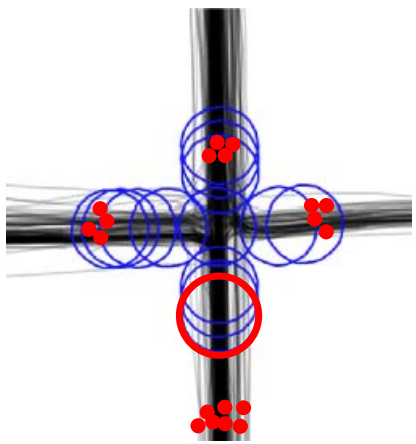
Choosing the test locations

Mean shifting





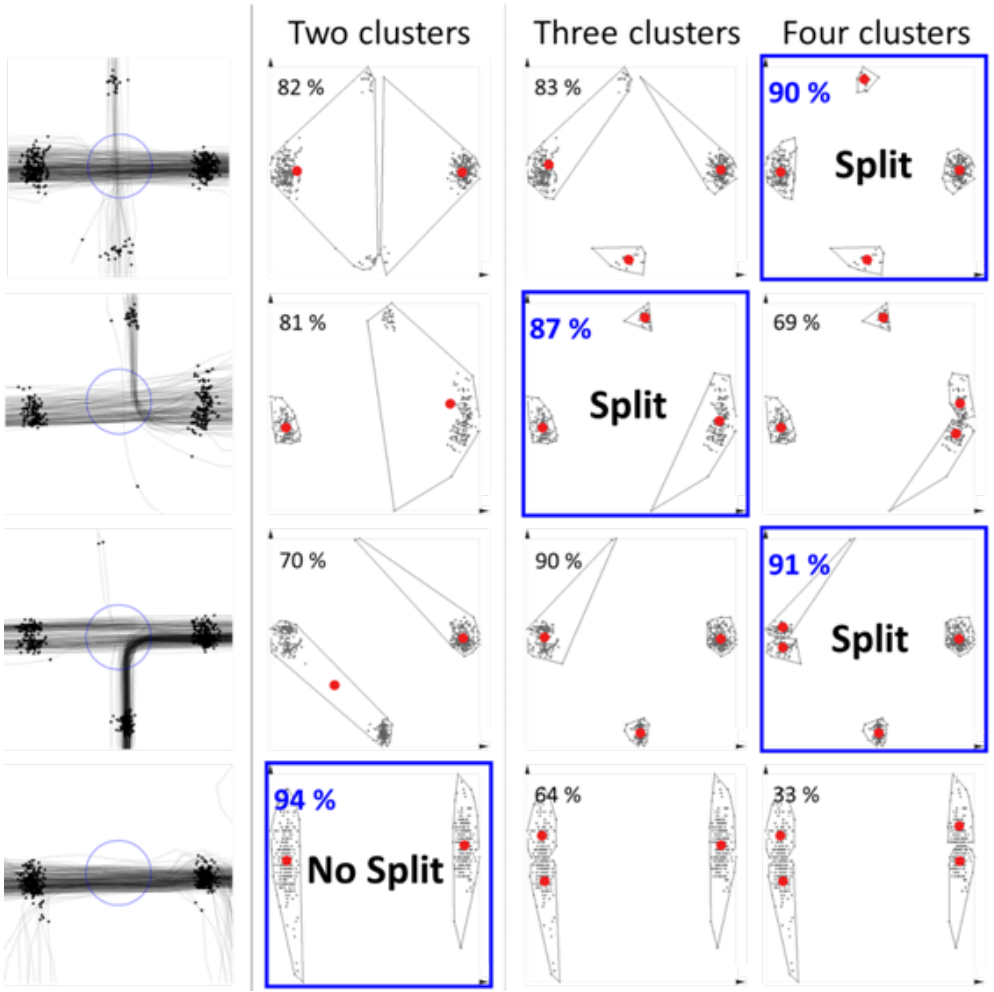
Too many detections!



Non-intersections

Roundabout

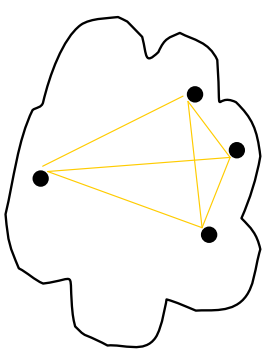
Silhouette Coefficient:



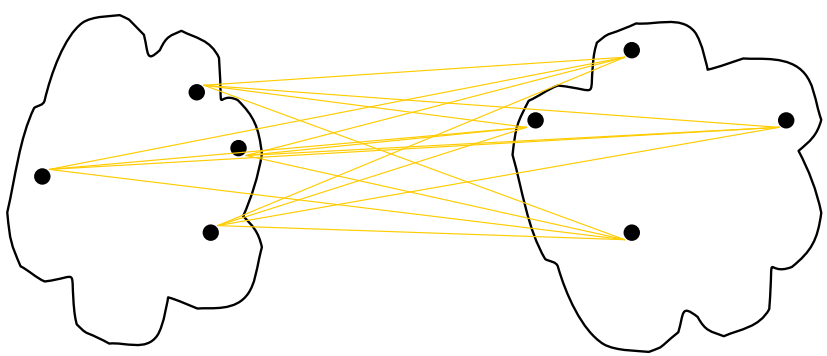
Silhouette coefficient

[Kaufman&Rousseeuw, 1990]

- Cohesion: measures how closely related are objects in a cluster
- Separation: measure how distinct or well-separated a cluster is from other clusters



cohesion



separation

Silhouette coefficient

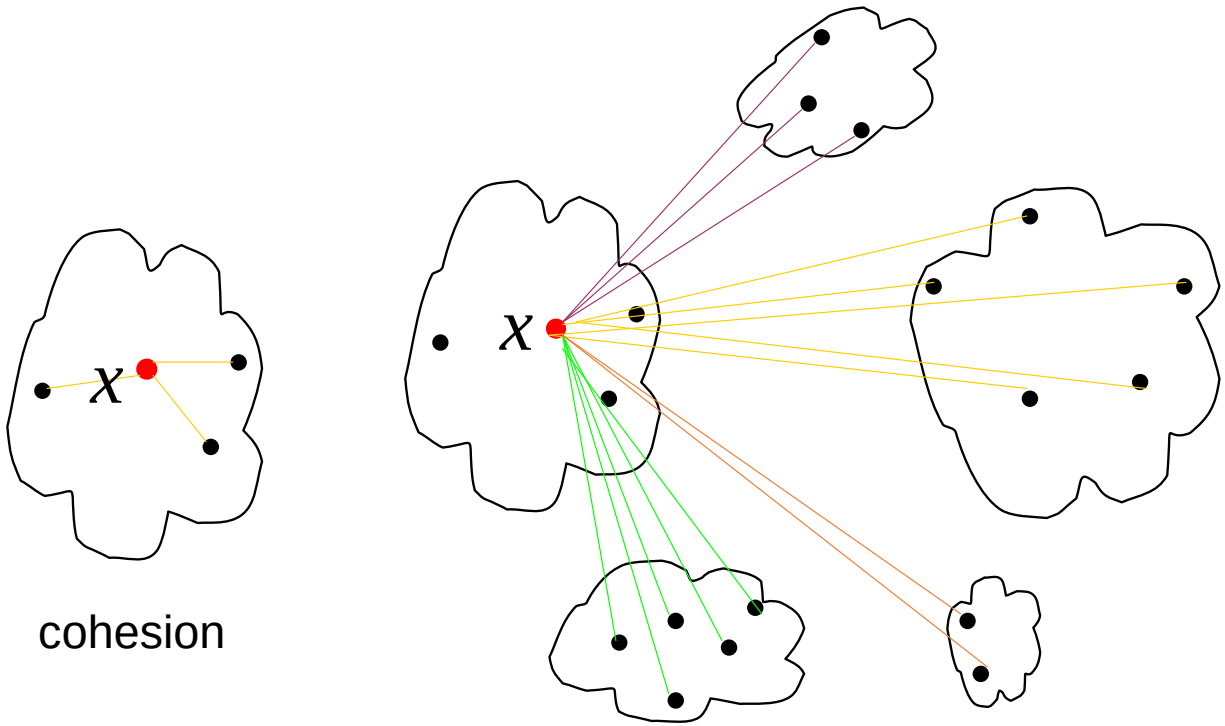
- *Cohesion* $a(x)$: average distance of x to all other vectors in the same cluster.
- *Separation* $b(x)$: average distance of x to the vectors in other clusters. Find the minimum among the clusters.
- *silhouette* $s(x)$:

$$s(x) = \frac{b(x) - a(x)}{\max\{a(x), b(x)\}}$$

- $s(x)$ = [-1, +1]: -1=bad, 0=indifferent, 1=good
- Silhouette coefficient (SC):

$$SC = \frac{1}{N} \sum_{i=1}^{N} s(x)$$

Silhouette coefficient



$a(x)$: average distance in the cluster

b(x): average distances to others clusters, find minimal

Detecting Intersections

- no intersection case -