
Towards Improving City Structure by Monitoring and Analyzing Pedestrian Mobility

Natalia Andrienko

Stefan van der Spek

Gennady Andrienko



Delft Univ. of Technology

<http://geoanalytics.net>

Data collection procedures

1. Monitoring city visitors

- GPS receivers are distributed in access points to the city
- questionnaire is used to get essential background information on the participant and the trip

2. Monitoring households

- Each household member has his/her own 'personal' device and carries it during all outdoor activity during a determined number of days
- Every participant produces multiple trips during the project
- questionnaire is used to collect general information on the household and participant

Research questions

1. Which routes are used, which destinations are visited {by different groups}?
2. What is the influence of spatial and temporal aspects?

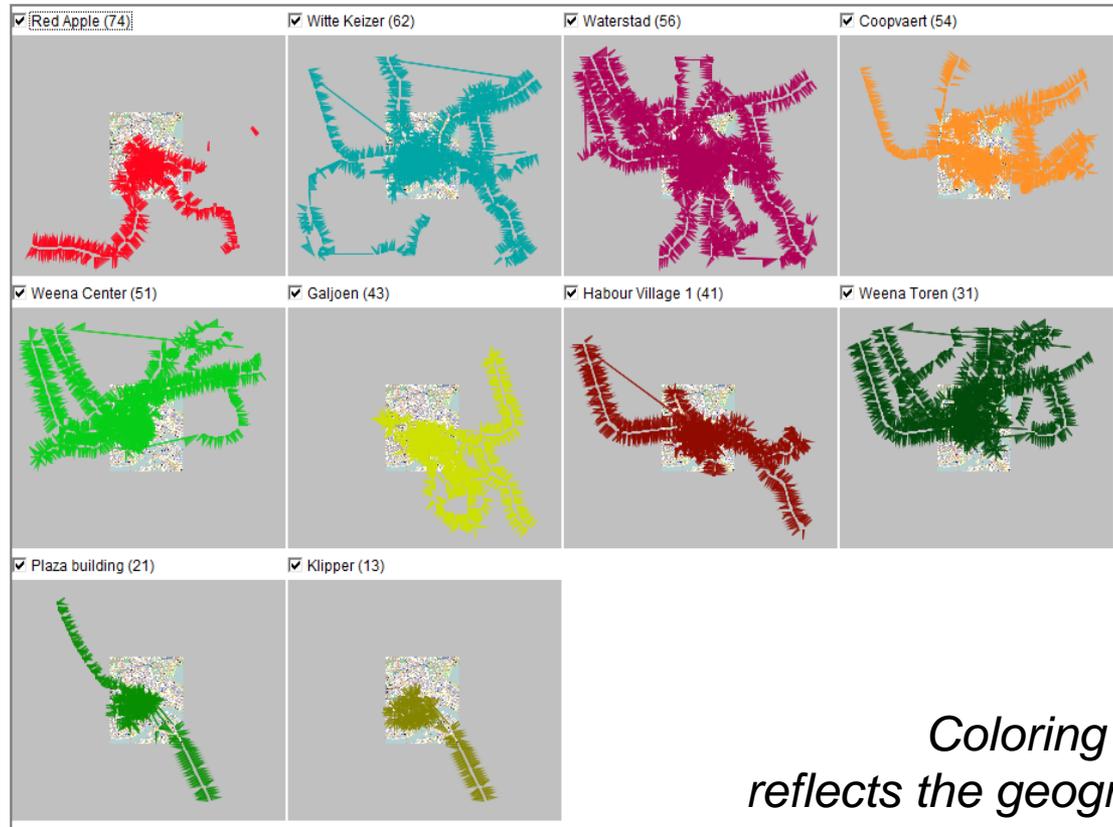
Monitoring households: HR11 project

- Residents of several high-rise buildings
- 432 daily trajectories of 303 persons have been collected during 11 days, from 26/04/2011 till 06/05/2011
- 252,756 time-stamped positions with constant sampling rate of 5 seconds
- each trajectory is associated to a residence address (building)

Summarization

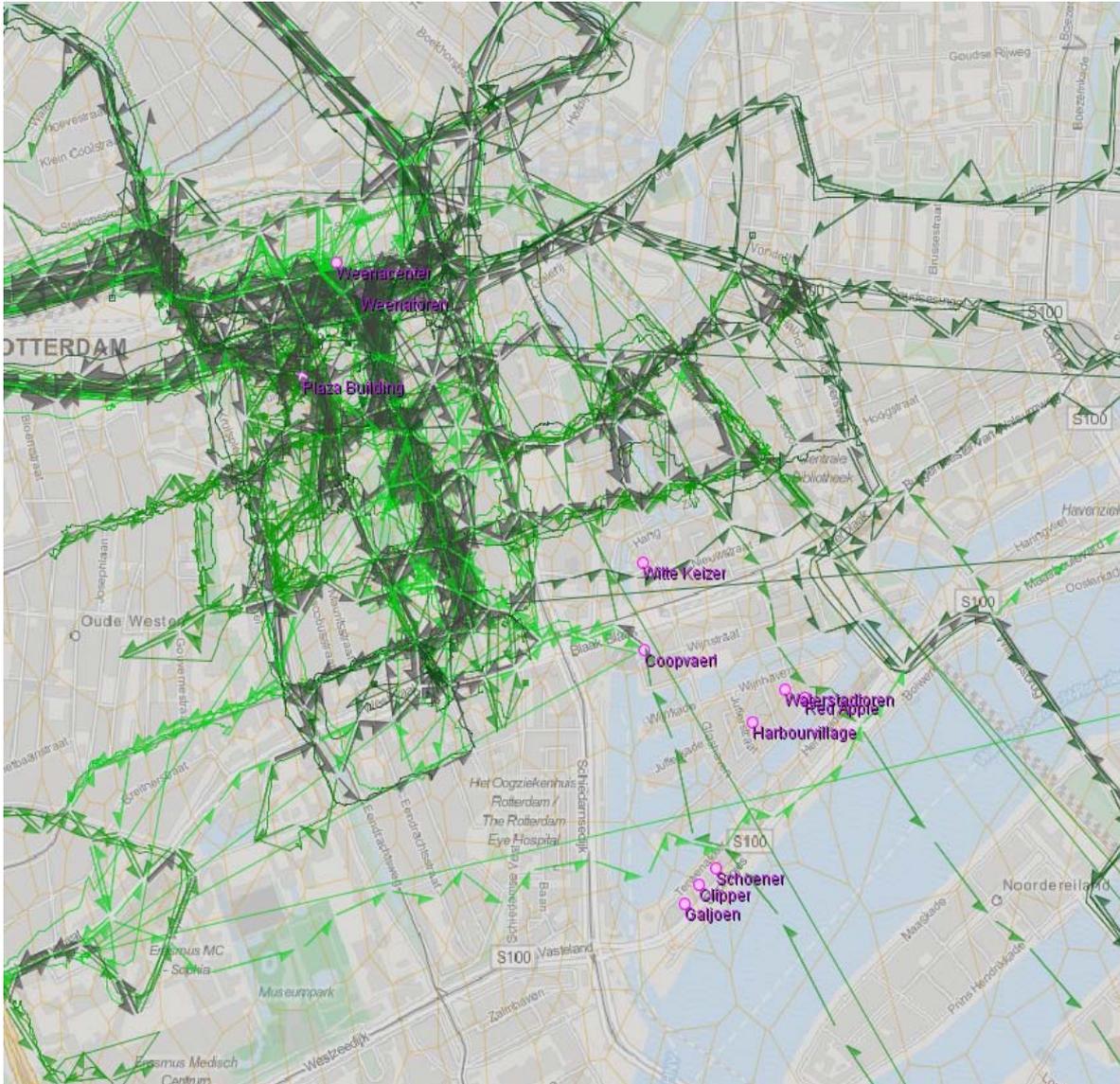
Generalize and summarize trajectories by regions of 100m radius

Compute hourly time series of visitor counts



Coloring of trajectories in further slides reflects the geography of the origins (buildings)

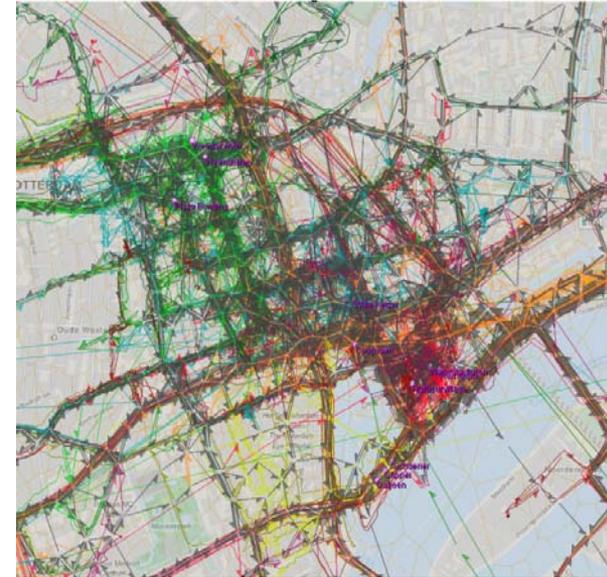
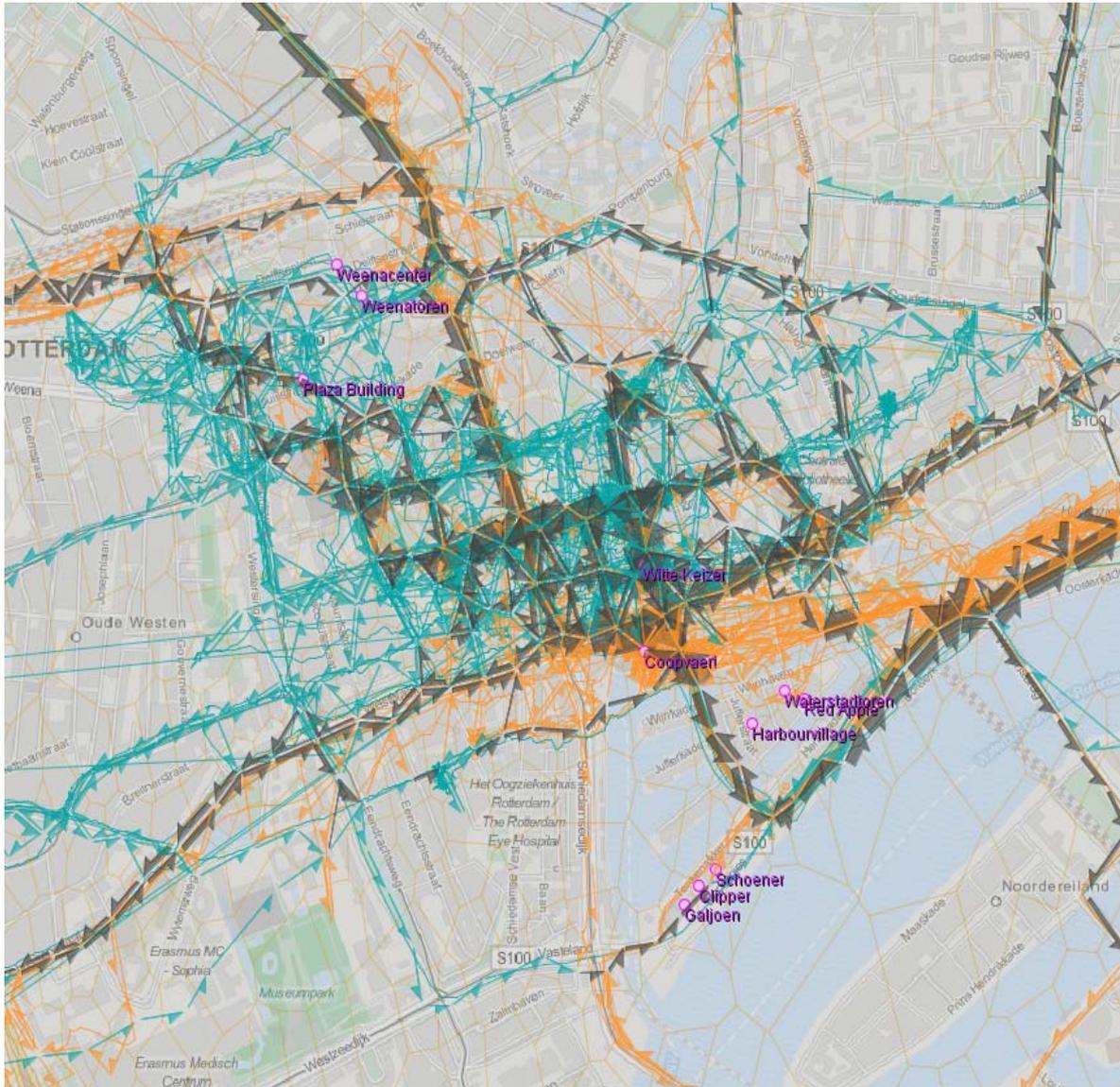
Plaza + Weena {Center+Toren}



Galjoen + Klipper



Witte Keizer + Coopvaert

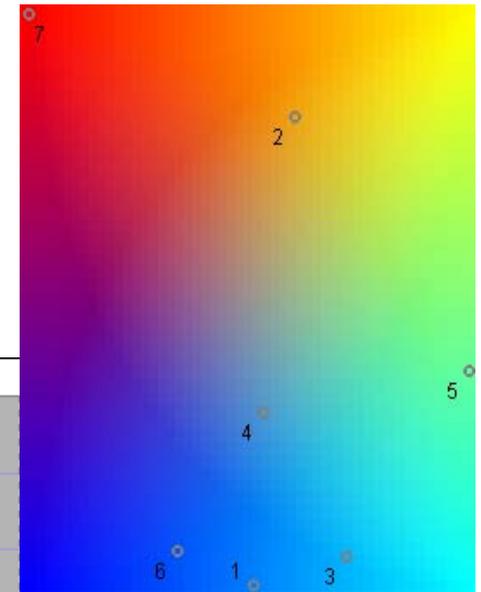
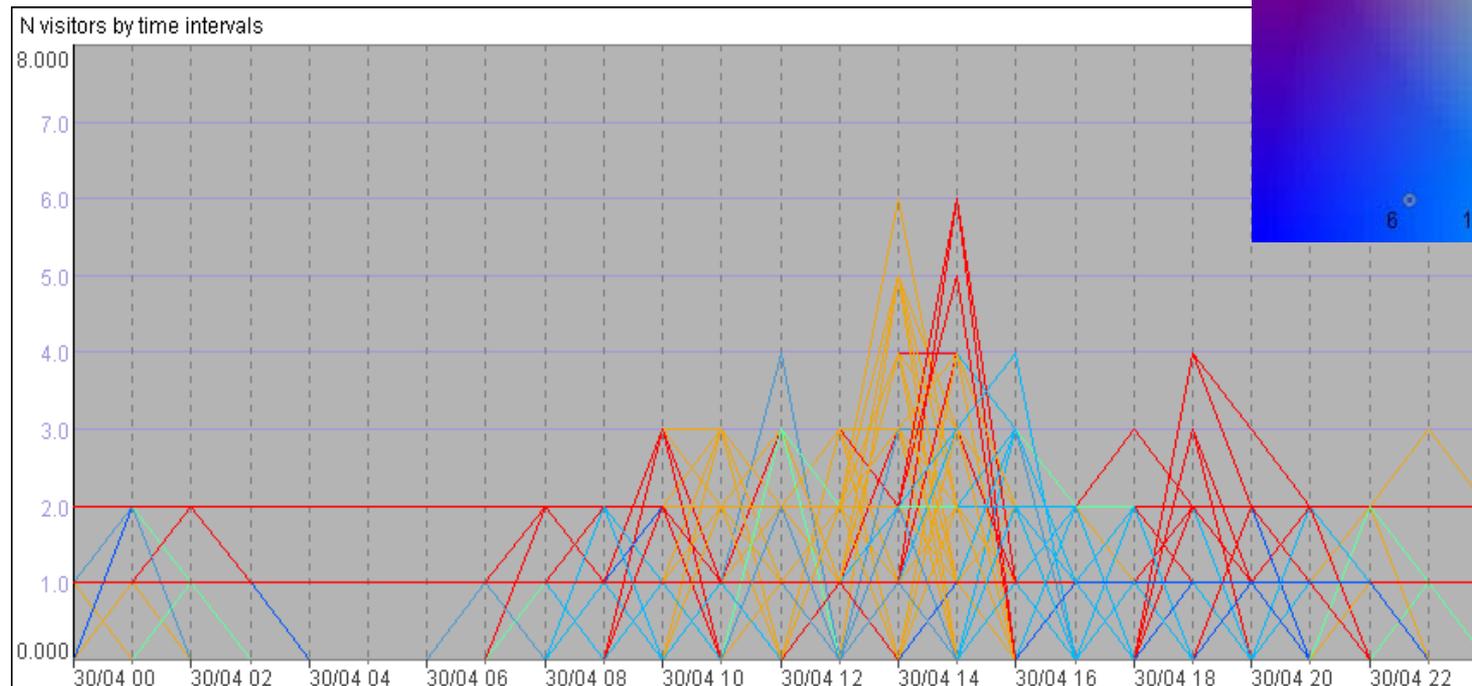


Clustering places by the dynamics of visits

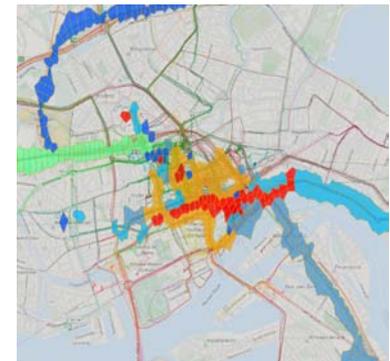
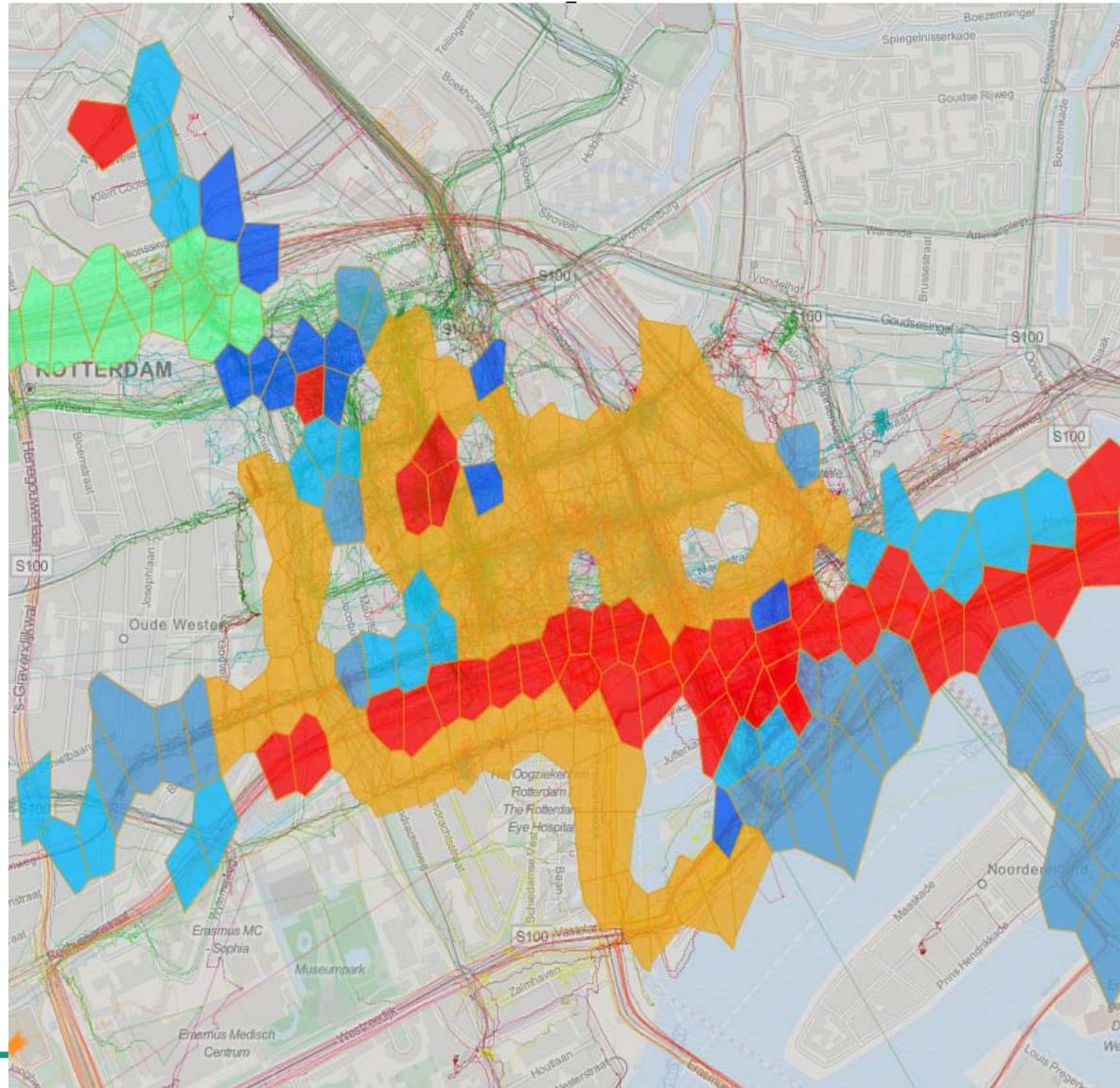
Saturday, 30.04.2011, hourly time series

Clustering by kMeans, 7 clusters

Assigning colors to clusters using Sammon's projection

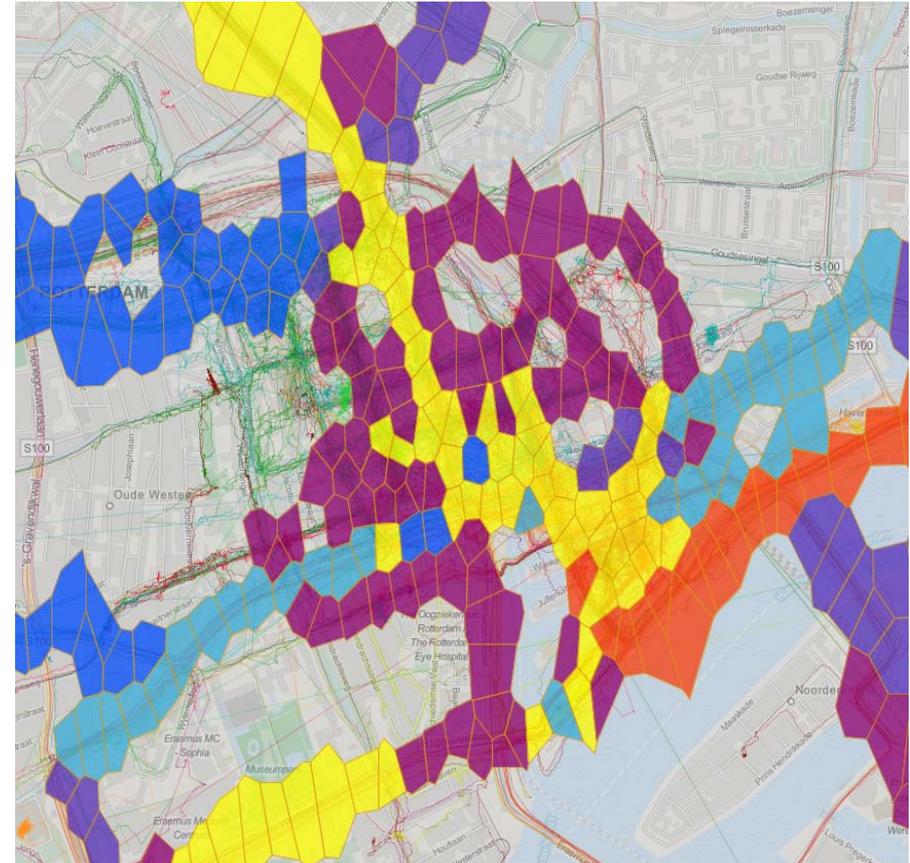
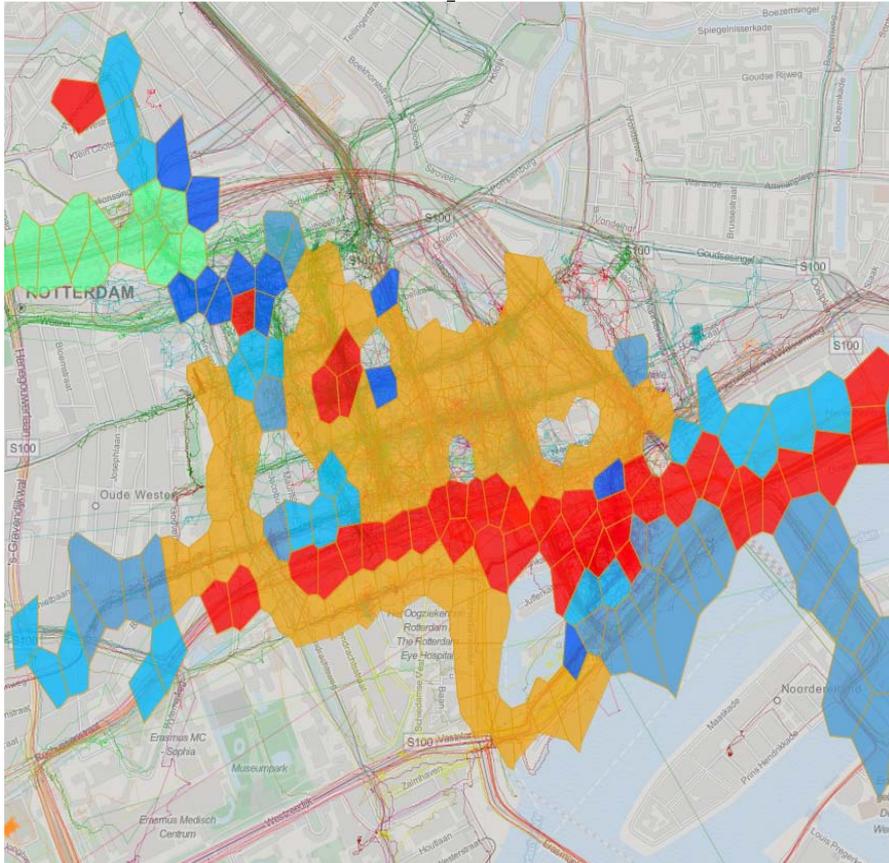


Saturday, 30.04.2011



Compare 2 days (Sat 30.04. – Sun 01.05.)

Colors are not consistent across different days



Monitoring city visitors: 2012 project

- 544 daily trajectories have been collected during 4 days, from 03/05/2012 till 06/05/2012
- Starting from 3 different parking garages in the city center
- 623,835 time-stamped positions, constant sampling rate of 5 seconds

Extracting and clustering stops

Stop: BRD(3min)<50m

ST clusters of stops:

25m, 10min, 5 neighbors

1st round of interpretation

After removing noise:

S clusters of stops:

25m, 5 neighbours

8: 10 objects (0.2%)
 9: 13 objects (0.3%)
 10: 69 objects (1.6%)
 11: 13 objects (0.3%)
 12: 8 objects (0.2%)
 13: 8 objects (0.2%)
 14: 7 objects (0.2%)
 15: 11 objects (0.3%)
 16: 14 objects (0.3%)
 17: 6 objects (0.1%)
 18: 29 objects (0.7%)
 19: 5 objects (0.1%)
 20: 20 objects (0.5%)
 21: 7 objects (0.2%)
 22: 9 objects (0.2%)
 23: 19 objects (0.4%)
 24: 9 objects (0.2%)
 25: 6 objects (0.1%)
 26: 8 objects (0.2%)
 27: 8 objects (0.2%)
 28: 5 objects (0.1%)
 noise: 3944 objects (92.2%); active: 0 objects

Total: 4277 objects; active: 333

Points from Trajectories from DELFT_TRIPS_RD_ND\$\$\$ (jim.iais.fraunhofer.de): starts

Total: 544 objects

Trajectories from DELFT_TRIPS_RD_ND\$\$\$ (jim.iais.fraunhofer.de)

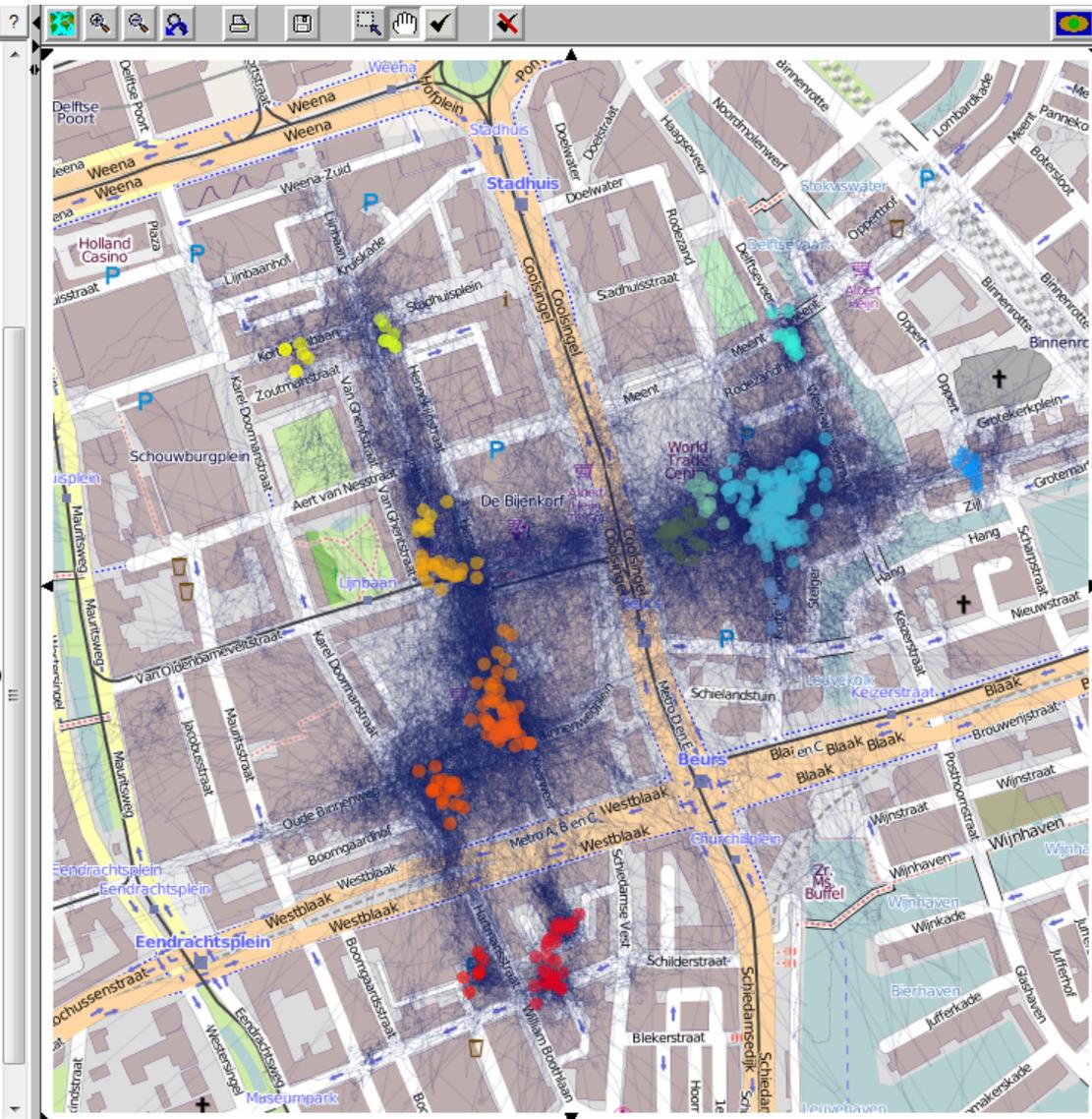
Total: 544 objects; active: 138

Open Street Map

Total: 0 objects

Territory: Rotterdam

Background



<input checked="" type="checkbox"/>	20	(20)
<input checked="" type="checkbox"/>	23	(19)
<input checked="" type="checkbox"/>	16	(14)
<input checked="" type="checkbox"/>	9	(13)
<input checked="" type="checkbox"/>	11	(13)
<input checked="" type="checkbox"/>	15	(11)
<input checked="" type="checkbox"/>	4	(10)
<input checked="" type="checkbox"/>	8	(10)
<input checked="" type="checkbox"/>	22	(9)
<input checked="" type="checkbox"/>	24	(9)
<input checked="" type="checkbox"/>	5	(8)
<input checked="" type="checkbox"/>	12	(8)
<input checked="" type="checkbox"/>	13	(8)
<input checked="" type="checkbox"/>	26	(8)
<input checked="" type="checkbox"/>	27	(8)
<input checked="" type="checkbox"/>	6	(7)
<input checked="" type="checkbox"/>	14	(7)
<input checked="" type="checkbox"/>	21	(7)
<input checked="" type="checkbox"/>	1	(6)
<input checked="" type="checkbox"/>	2	(6)
<input checked="" type="checkbox"/>	3	(6)
<input checked="" type="checkbox"/>	7	(6)
<input checked="" type="checkbox"/>	17	(6)
<input checked="" type="checkbox"/>	25	(6)
<input checked="" type="checkbox"/>	19	(5)
<input checked="" type="checkbox"/>	28	(5)
<input type="checkbox"/>	noise	(3944/0)

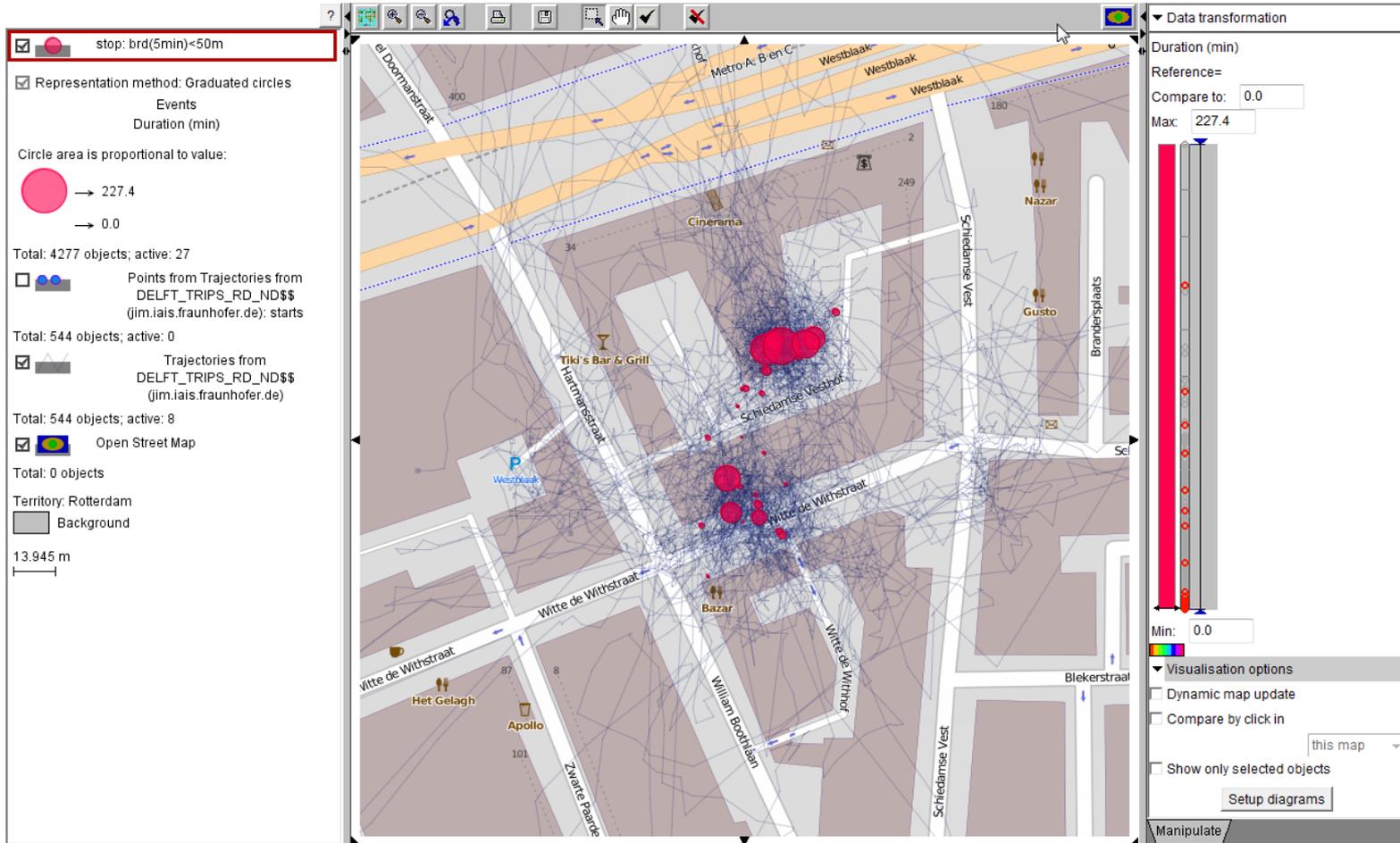
29 classes in total; 29 shown

remove empty classes from list

Broadcast classification

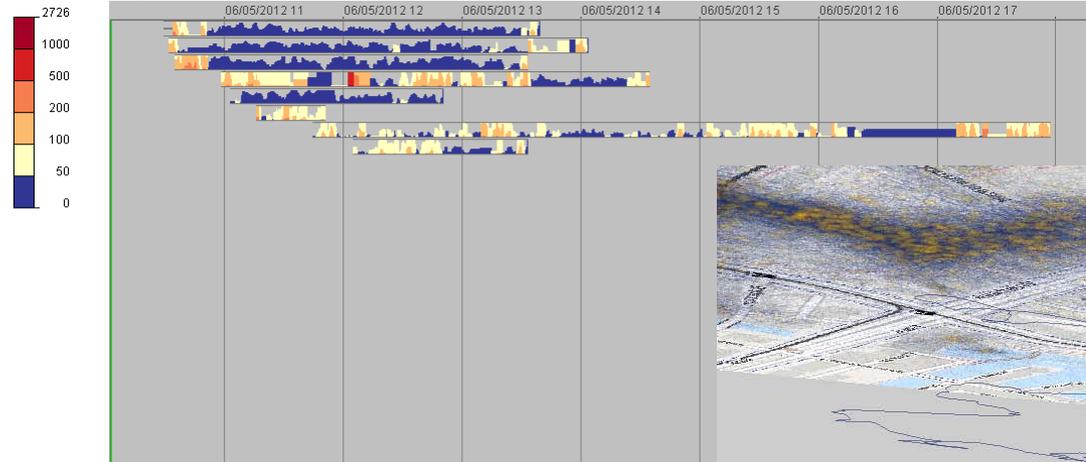
Iris, Descartes, CommonGIS, V-Analytics 1995-2010: Rotterdam 2012 - 3 days

S-Cluster 3 – cinema/café's



Cinema - cont

Bounding rectangle diagonal by time intervals: 3minutes



Clear Points: 623835-623835-14397; 100%-100.0%-2.3% Segments: 544-544-8. Trajectories: 544-544-8; 100

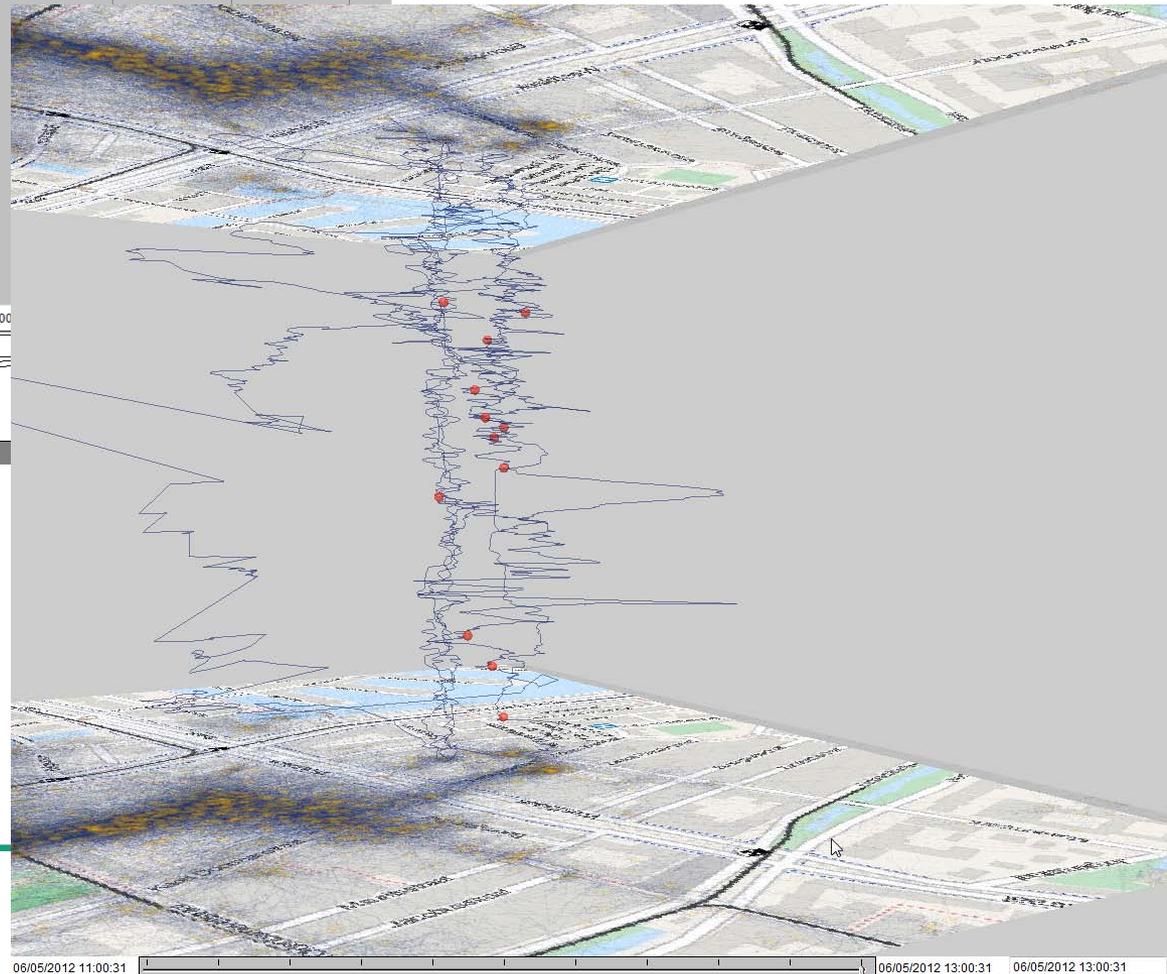
03/05/2012 09:40:44

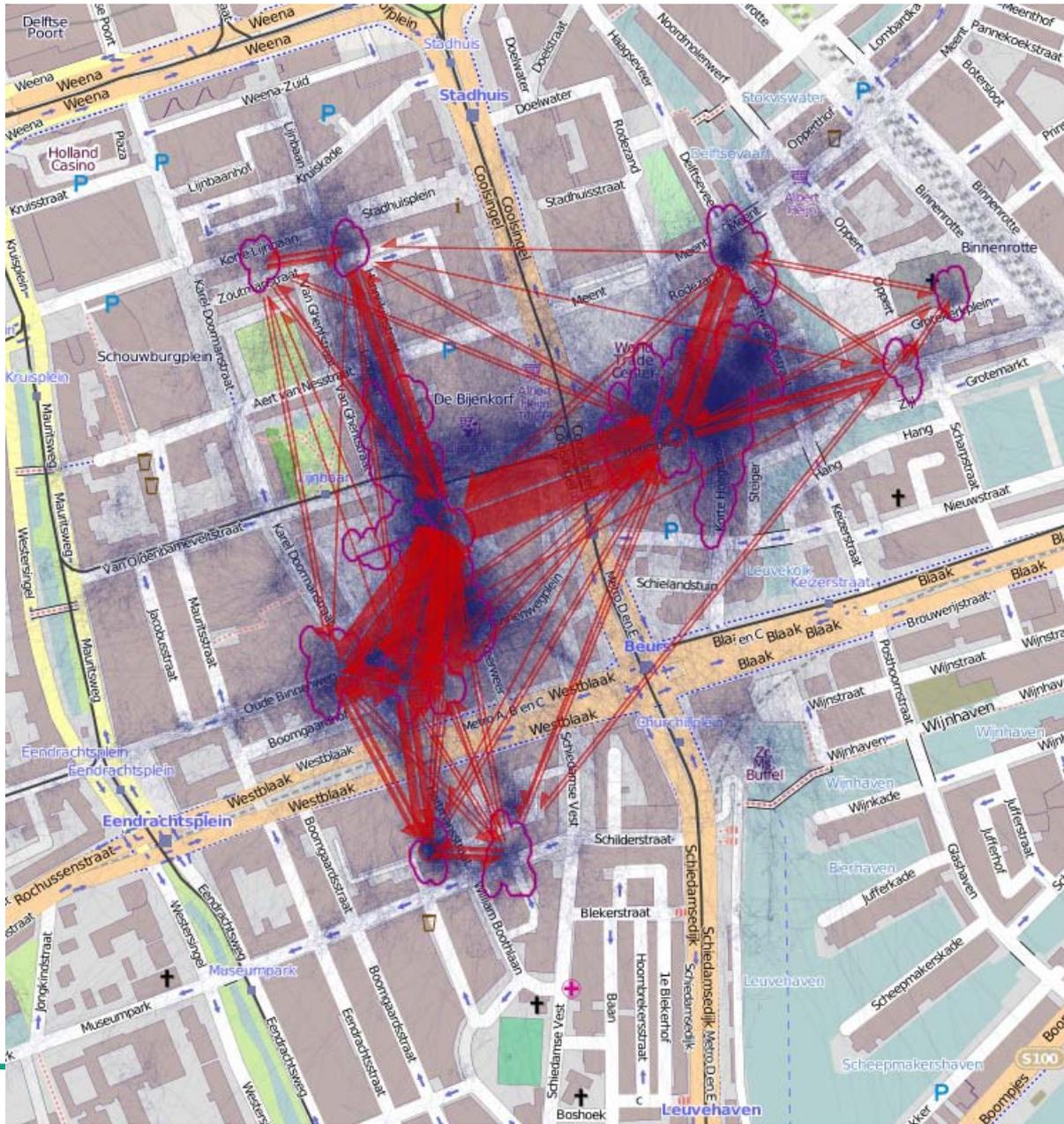
Full extent 06/05/2012 10:03:03 29886 sec.

fix fix

follow time filter

time data display classes





Findings, recommendations

Visitors starting at different parking garages behave differently

Local authorities can be advised to improve corridors connecting these locations and find ways to encourage visitors to use alternative paths

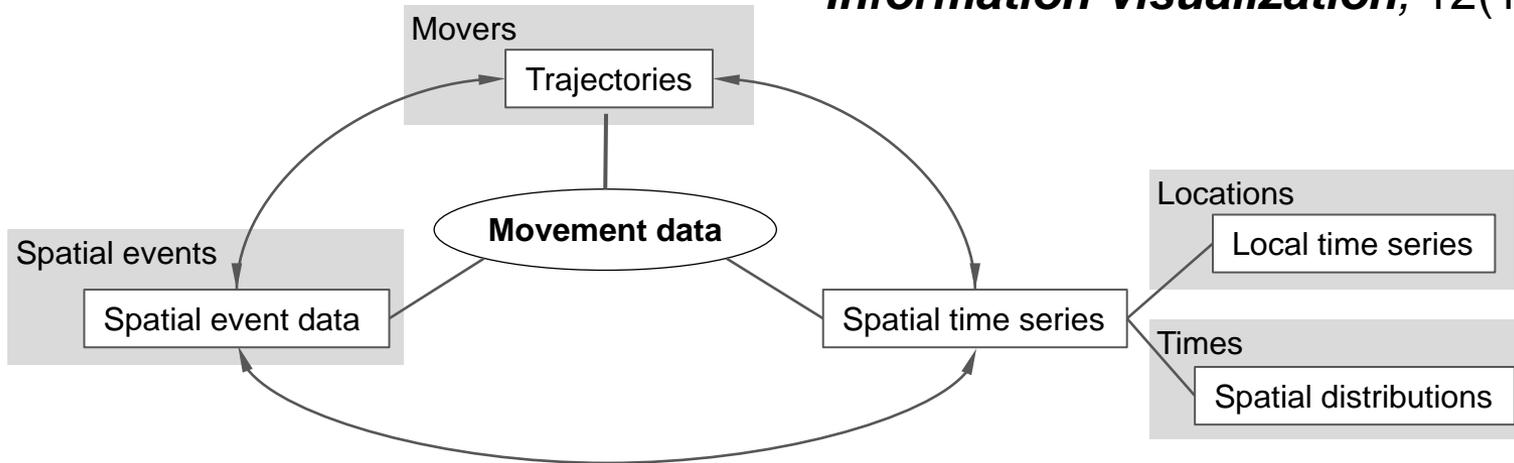
Proper data cleaning needed

Missing methods for understanding group movement and behaviour

Details:

Visual Analytics of Movement: an Overview of Methods, Tools, and Procedures
Information Visualization, 12(1), pp.3-24, 2013

What we can do



Detect stops, analyze stop patterns in S & T

Detect places (as concentrations of stops), analyze dynamics of POI attendance,
clustering places by similarity of dynamics,
clustering times by similarity of situations

Analysis of flows between places, detection of usual behaviors

Detection of unusual behaviors / events