Smart Route Recommendations based on Historical GPS Trajectories and Weather Information

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- Introduction
- Approach Overview
  - Intersections detection
  - Features extraction
  - Route planning
- Results

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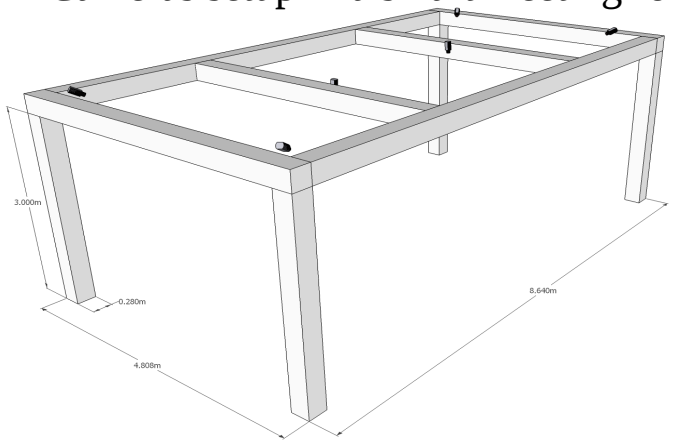
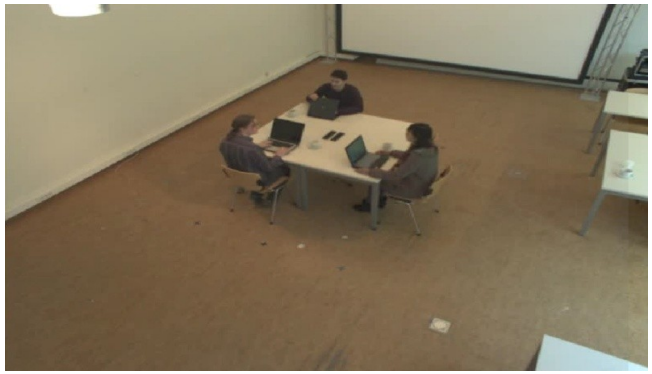
Room layout exploring and behavior analysis from people's trajectories in smart environments

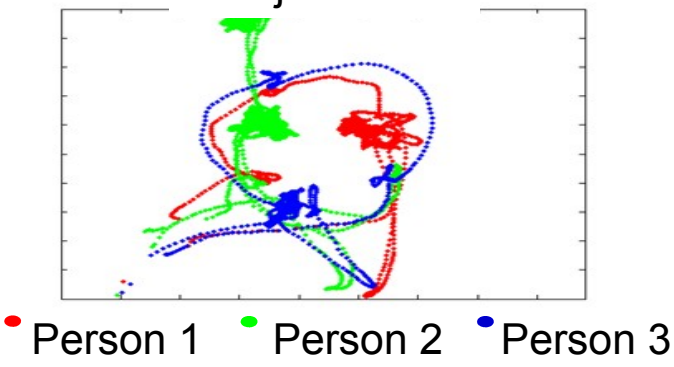
Cameras setup in a smart meeting room



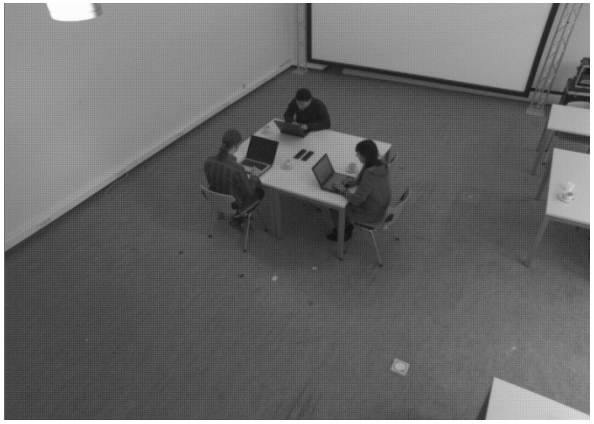
Initial image



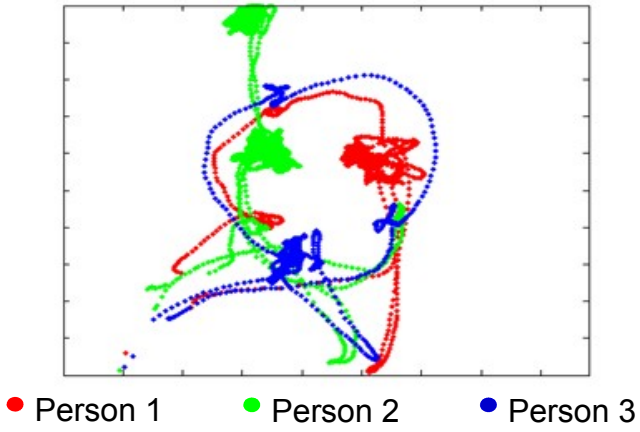
Trajectories



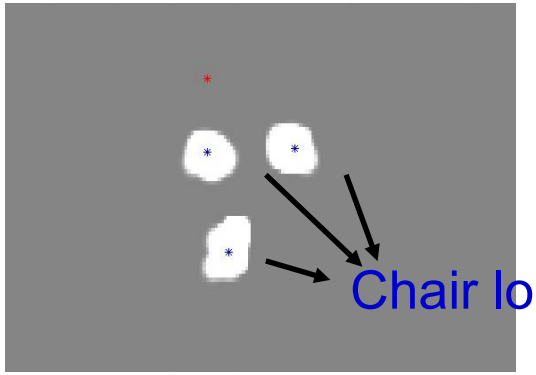
Initial image



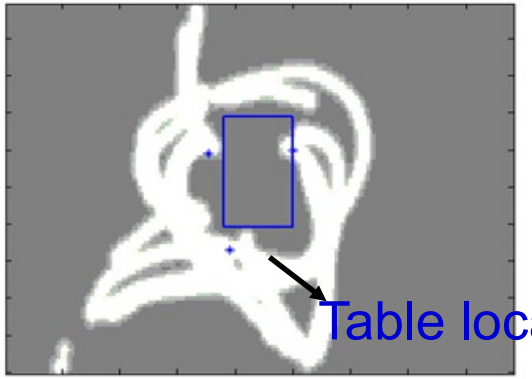
Trajectories



Occupancy map for sitting space



Occupancy map for walking space



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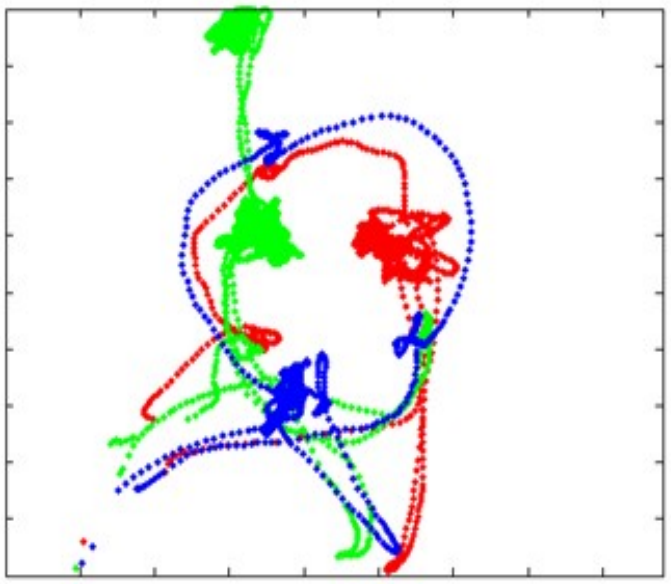
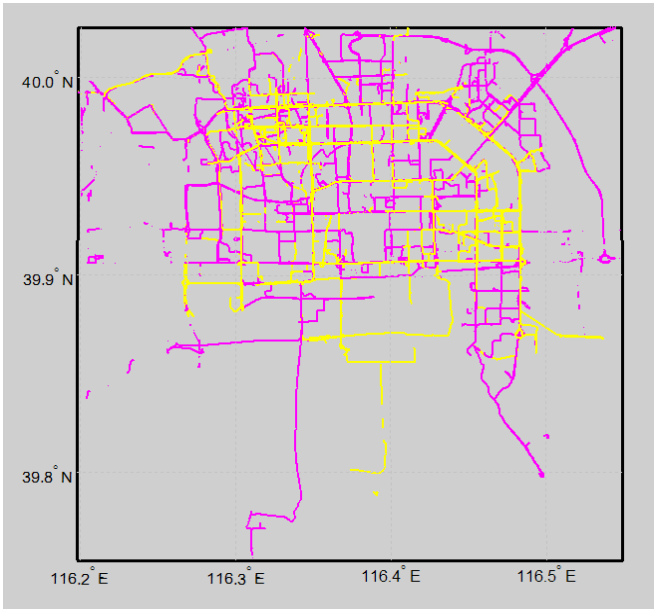
Trajectories from
a multi-camera tracking system



Smart meeting room

GPS tracks



Beijing city

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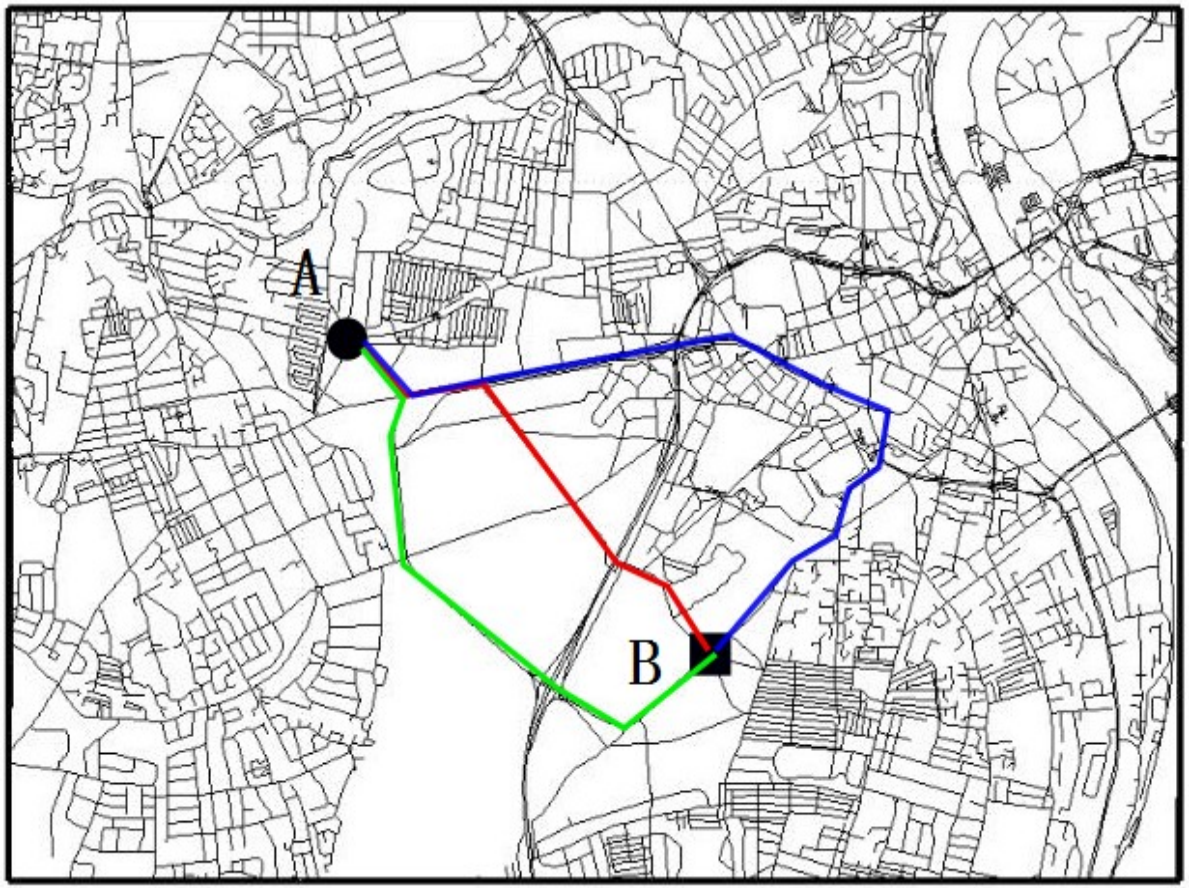
Aim: find the optimal route between two places



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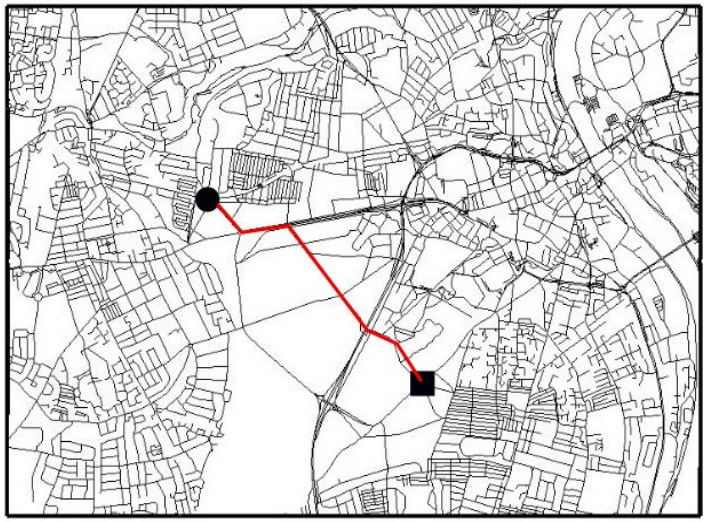
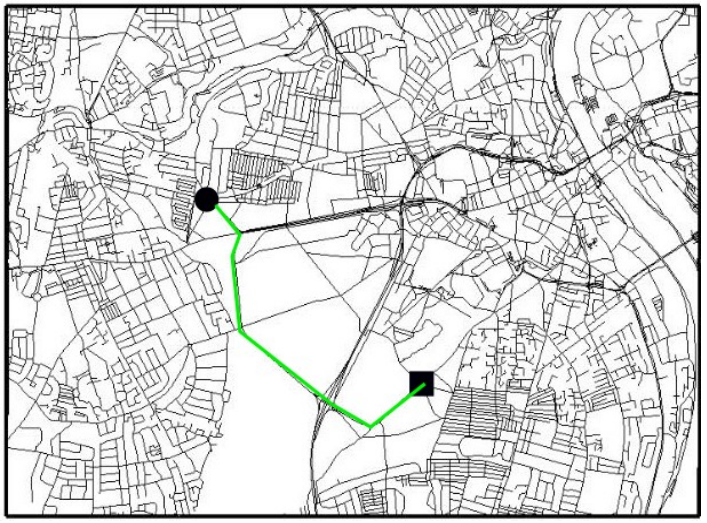
Traditional method:

the shortest geographic route



Our method with consideration of

- **the prior users' experience**
- **environmental factors**



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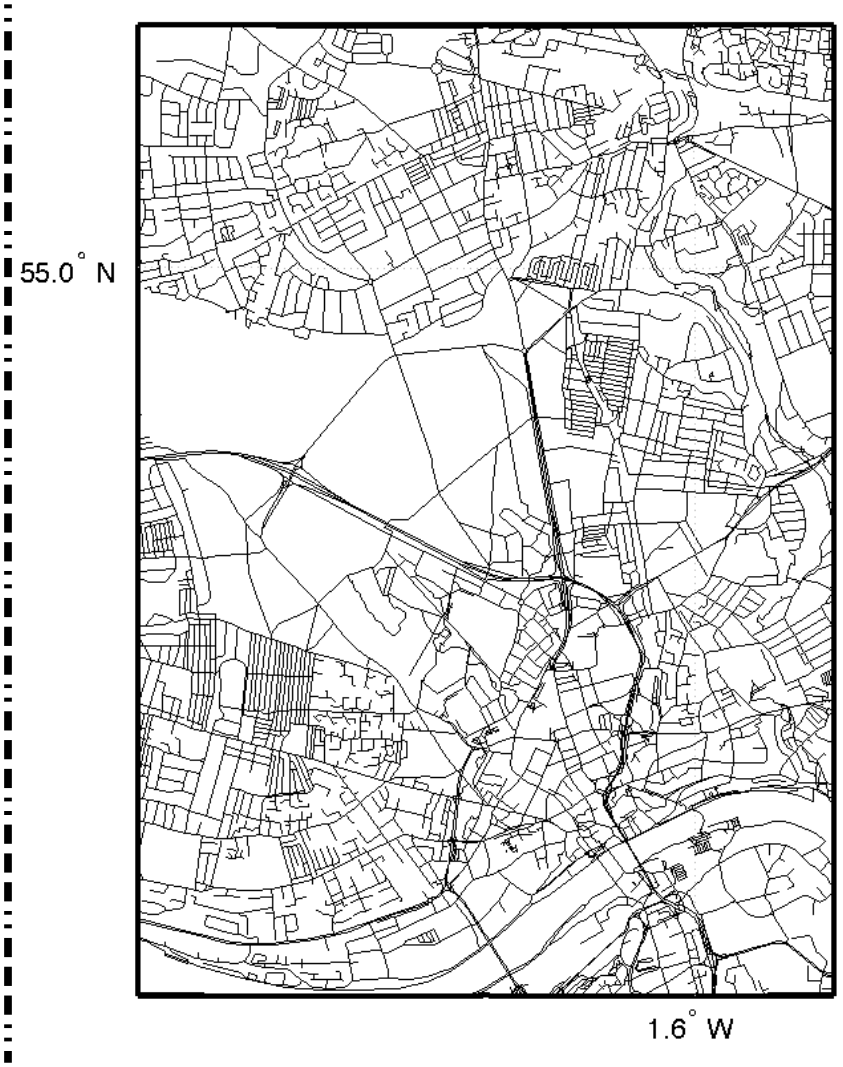
Datasets

OpenStreetMap (OSM): A collaborative mapping data contain many types of GIS data including:

- Road locations and names
- Points of Interest
- Natural Features
- Bodies of Water
- Political boundaries
- ……



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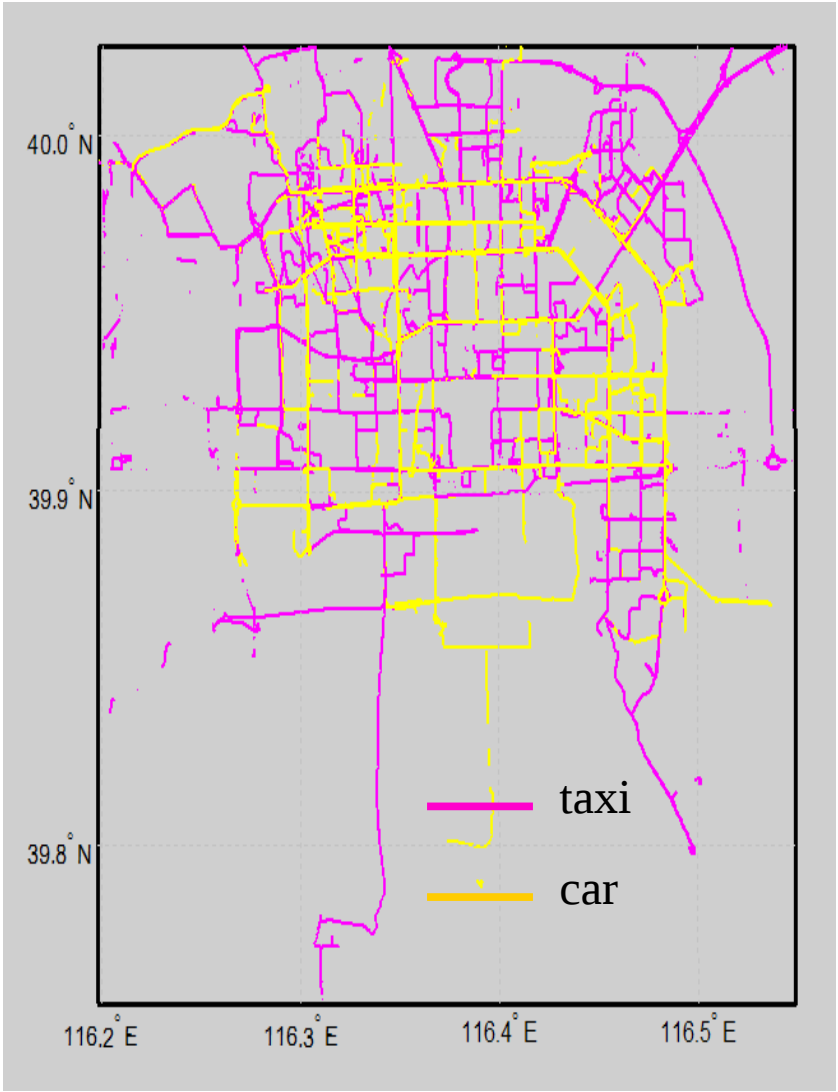
GeoLife Dataset from Microsoft Research Asia:

	Version 1.3
Time span of the collection	04/2007 – 8/2012
Number of users	182
Number of trajectories	18,670
Number of points	24,876,978
Total distance	1,292,951km
Total duration	50,176hour
Effective days	11,129

Transportation mode	Distance (km)	Duration (hour)
Walk	10,123	5,460
Bike	6,495	2,410
Bus	20,281	1,507
Car & taxi	32,866	2,384
Train	36,253	745
Airplane	24,789	40
Other	9,493	404
Total	14,0304	12,953



Weather information in Beijing from 2007 to 2012

#Year	Day	Solar	T-max	T-min	Humidity	Precipitation	Evaporation
2007	1	8.08	-3.8	-14	67	2.4	0.8
2007	2	7.85	-1.2	-10	86	1.7	0.4
2007	3	4.37	-4.1	-11.4	90	1.6	0.3
2007	4	2.54	-4.9	-10.1	86	2.7	0.4
2007	5	2.56	-6.6	-10.4	92	0.1	0.2
2007	6	2.57	-6.4	-9.8	88	0.7	0.3
2007	7	2.58	-6.6	-10.3	88	0.8	0.3
2007	8	2.6	-6.4	-13	92	1	0.2
2007	9	8.08	-5.8	-17.5	90	1.6	0.2
2007	10	9.23	-6.7	-20.1	68	1.8	0.6
2007	11	10.14	-7.6	-20.2	71	2.7	0.6
2007	12	10.1	-8.2	-20.3	59	2	0.7
…...							

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OpenStreetMap (OSM)

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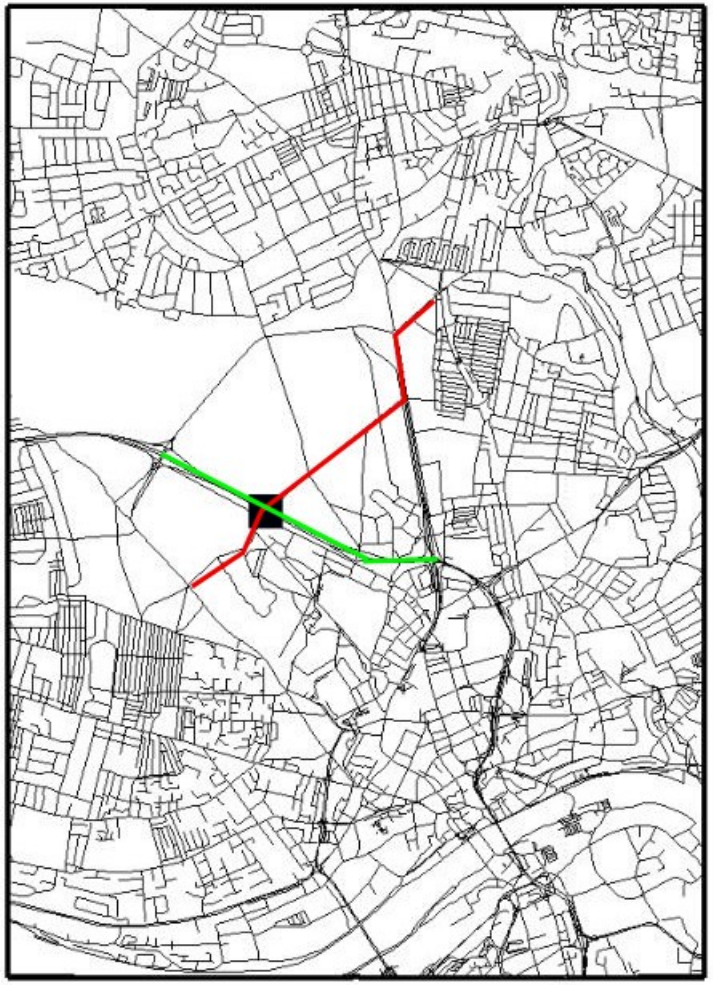
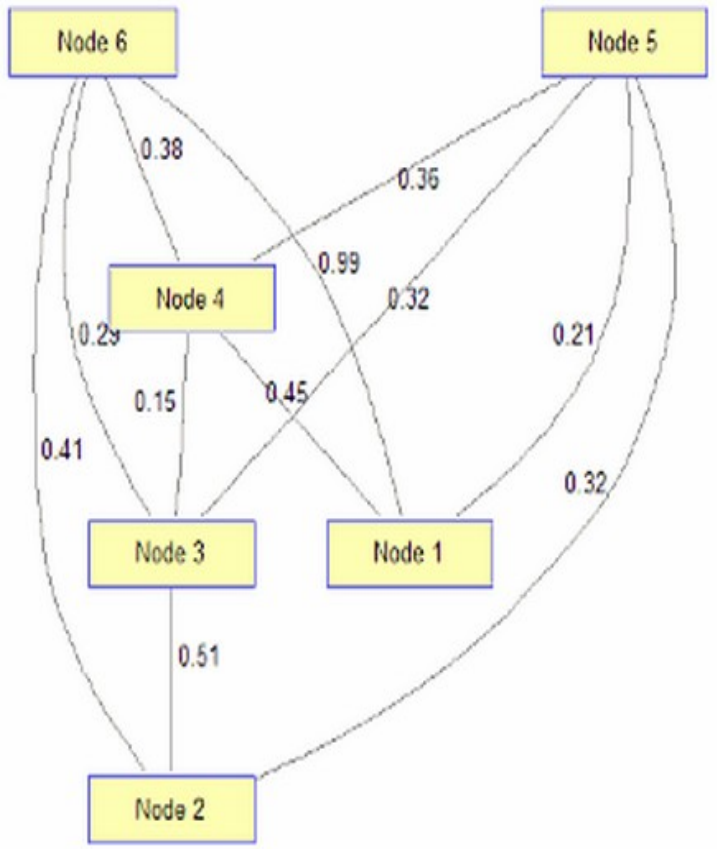
OpenStreetMap (OSM)

Road 1:	Road 2:
Node1	Node5
Node2	Node7
Node3	Node8
Node4	Node9
Node5	Node10
Node6	Node11
……	……



calculate the shortest route based on the connectivity between each pair of nodes, and the distance between them.



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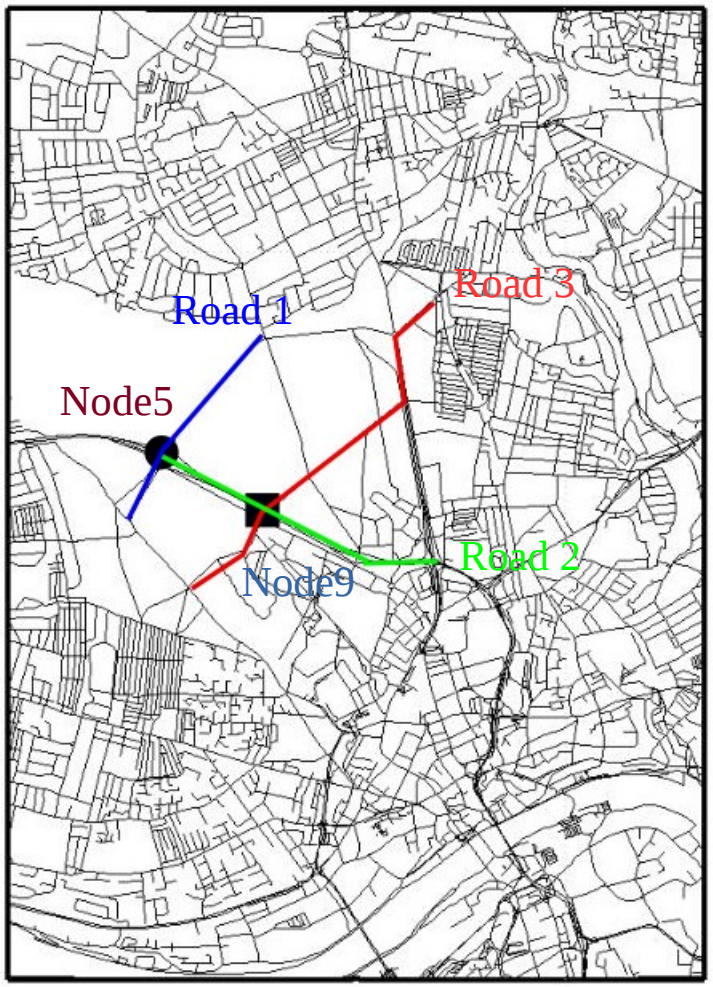
OpenStreetMap (OSM)

Road 1:	Road 2:	Road 3:
Node1	Node5	Node78
Node2	Node7	Node89
Node3	Node8	Node45
Node4	Node9	Node9
Node5	Node10	Node20
Node6	Node11	Node21
……	……	……

sum



Connectivity matrix

	Node1	Node2	Node3	Node4	Node5	Node6	……
Node1	0	1	0	0	1	0	
Node2	1	0	1	1	0	0	
Node3	0	1	0		0	0	
Node4	0	1	0	0	0	1	
Node5	1	0	0	0	0	0	
Node6	0	0	0	1		0	
……							

Distance matrix

	Node1	Node2	Node3	Node4	Node5	Node6	……
Node1	0	500m	0	0	70m	0	
Node2	500m	0	4500m	230m	0	0	
Node3	0	4500m	0	0	0	0	
Node4	0	230m	0	0	0	100m	
Node5	70m	0	0	0	0	0	
Node6	0	0	0	100m	0	0	
……							

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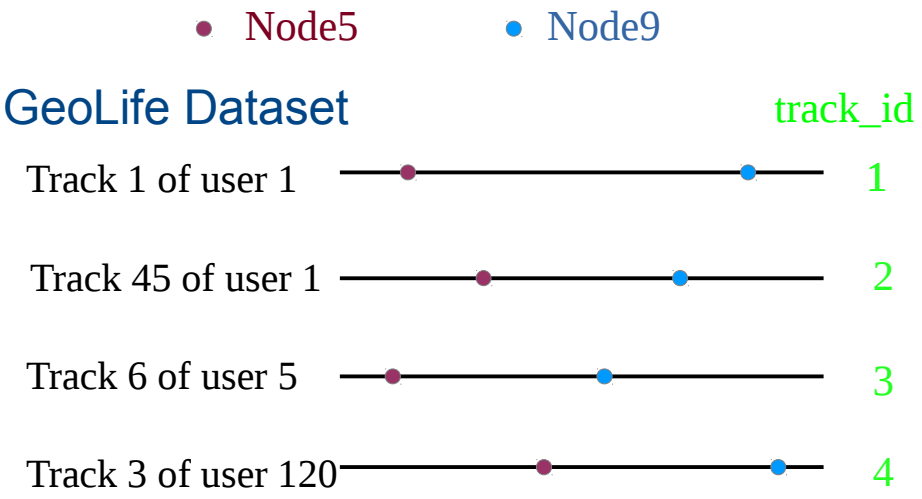
GeoLife Dataset

Features for each pair of connected nodes:

- average of the speeds
- standard deviation of the speeds
- the confidence of the Geolife trajectory data matching the openstreetmap data



	ave_speed	var_speed	confidence of map matching	Precipitation
track_id =1				
track_id =2				
track_id =3				
track_id =4				

Features of {node5, node9}

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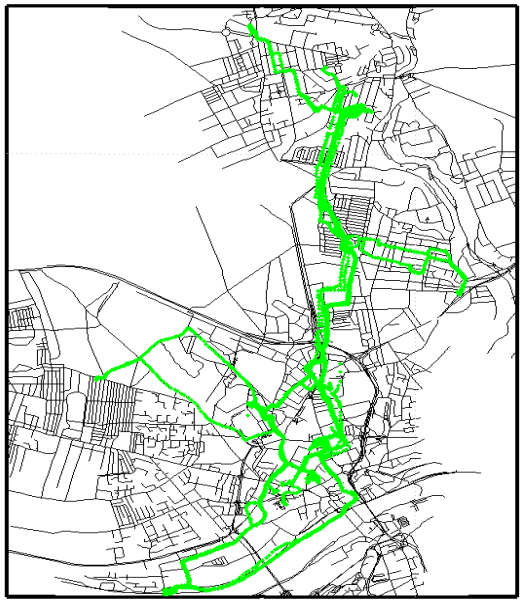
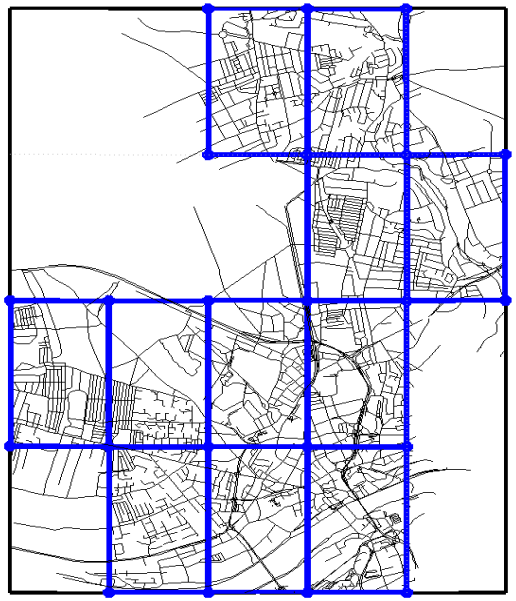
GeoLife Dataset



OpenStreetMap (OSM)



confidence of map matching

ave_dist

One segment

node i
node i+1
node i+2
...

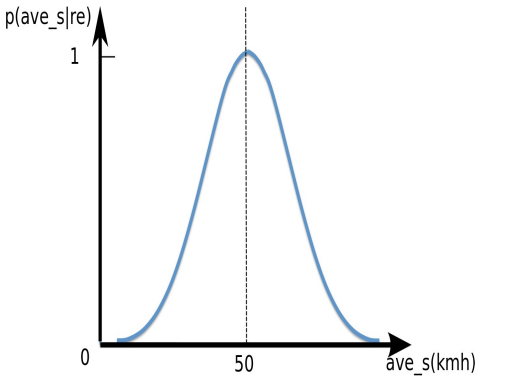
dist0
dist1
dist2
.....

The corresponding segment

node j
node j+1
node j+2
...

Variables:

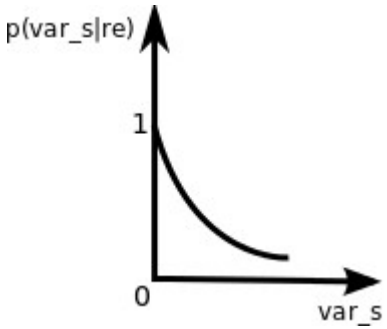
ave_s: average of speeds
re: road evaluation



$$p_n(ave\_s_n|re) = e^{-\frac{(ave\_s_n - 50)^2}{2\sigma^2}}$$

Variables:

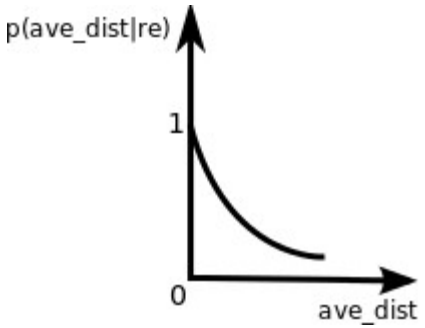
var_s: variance of speeds
re: road evaluation



$$p_n(var\_s_n|re) = \alpha^{var\_s_n}$$

Variables:

ave_dist: map matching
re: road evaluation



$$p_n(ave\_dist_n|re) = \beta^{ave\_dist_n}$$

Bayesian theory:

$$p_n(re|ave\_s_n) = \gamma * p_n(ave\_s_n|re)p_{n-1}(re) \qquad p_n(re|var\_s_n) = \gamma * p_n(var\_s_n|re)p_{n-1}(re) \qquad p_n(re|ave\_dist_n) = \gamma * p_n(ave\_dist_n|re)p_{n-1}(re)$$

$$p_n(re) = \lambda_1 * p_n(re|ave\_dist_n) + \lambda_2 * p_n(re|var\_s_n) + \lambda_3 * p_n(re|ave\_s_n)$$

	prob(re)	Precipitation
track_id =1		
track_id =2		
track_id =3		
track_id =4		

corr(road condition, humidity)

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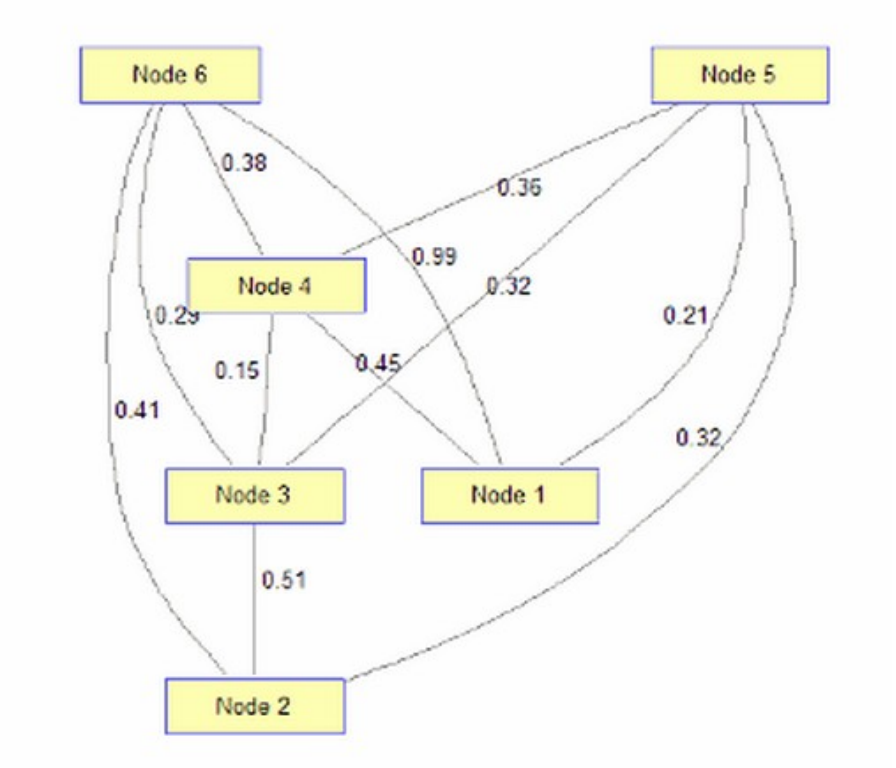
- Road evaluation and the impactor of Precipitation are used to adjust the distance between each pair of connected nodes
- Calculate the shortest route using the connectivity matrix and new distance matrix



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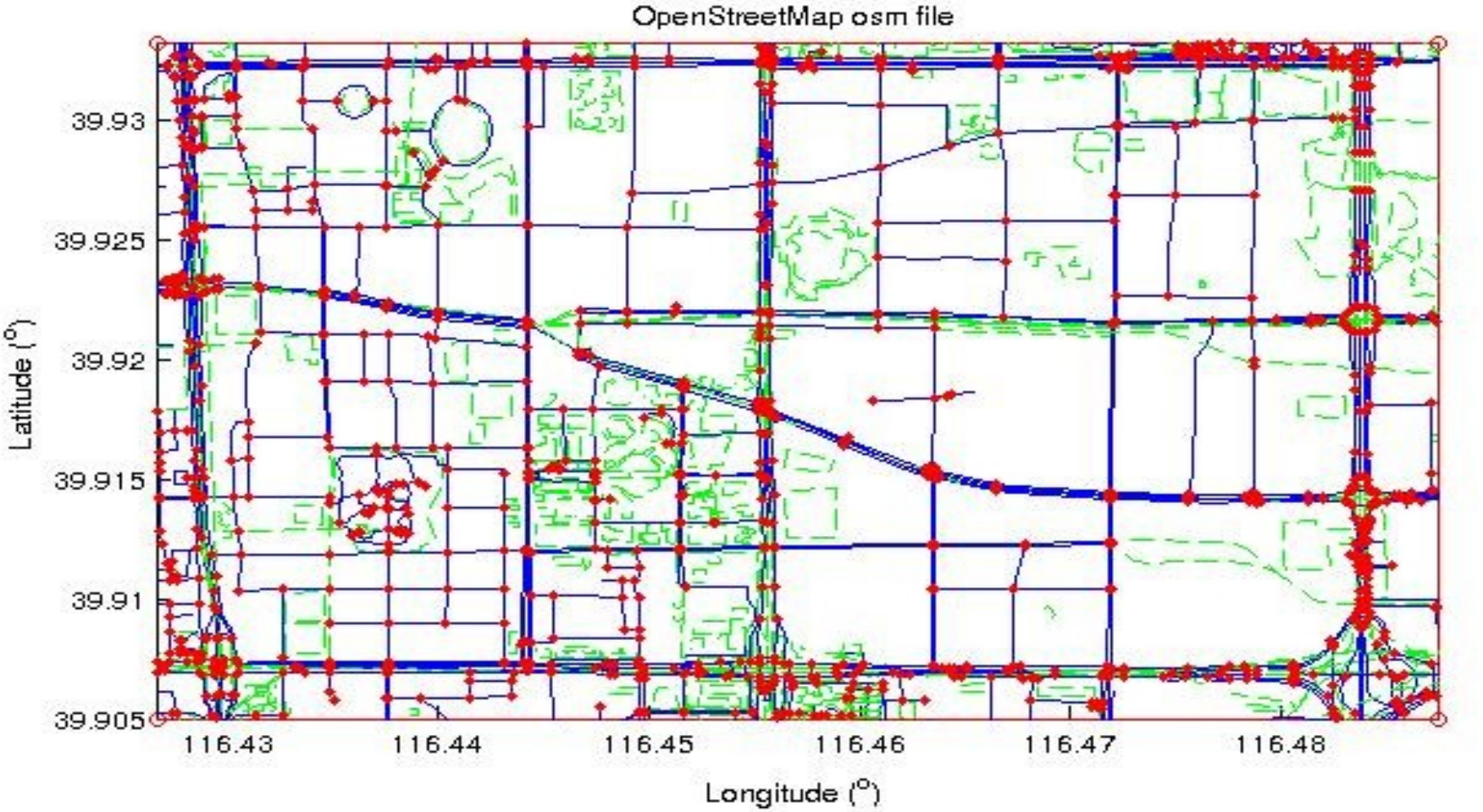
intersections



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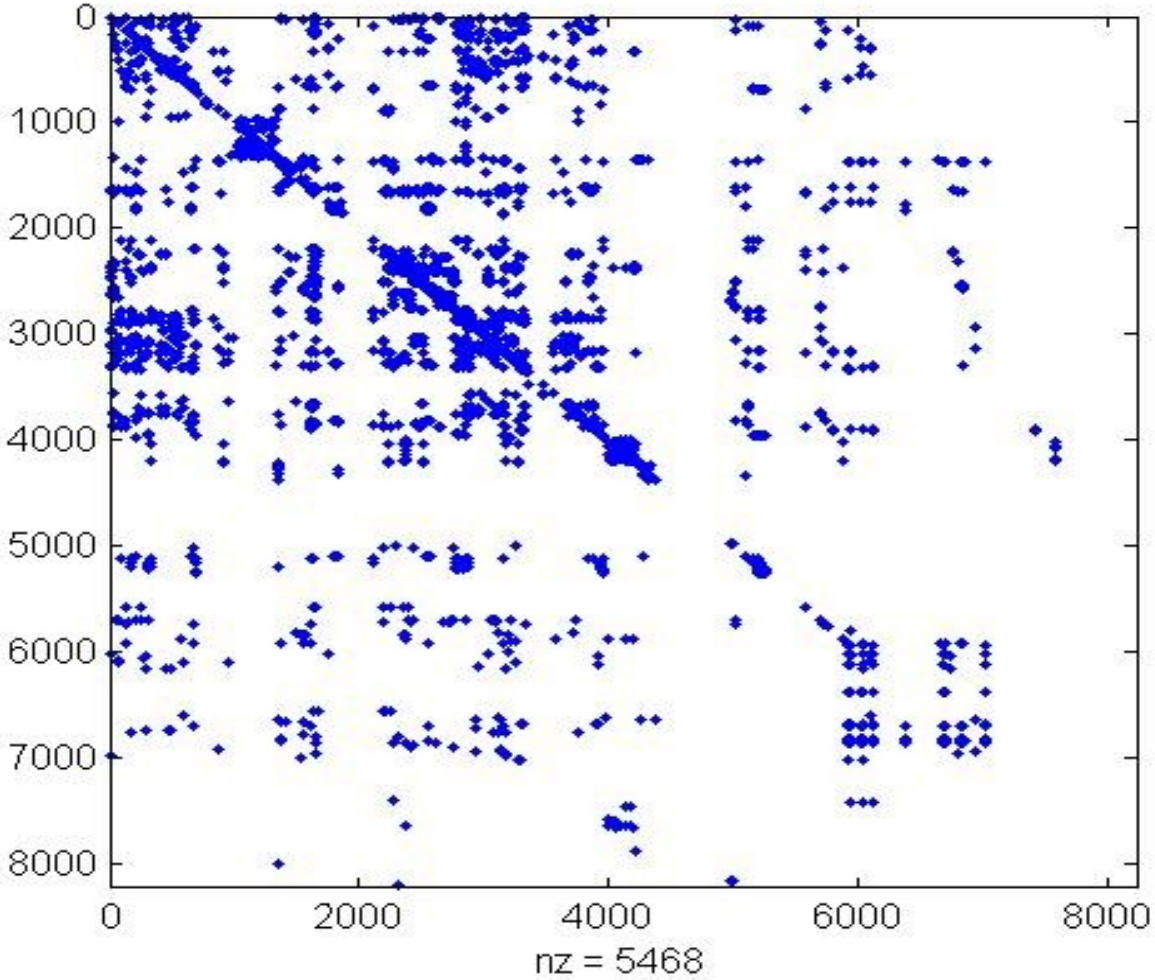
Connectivity matrix



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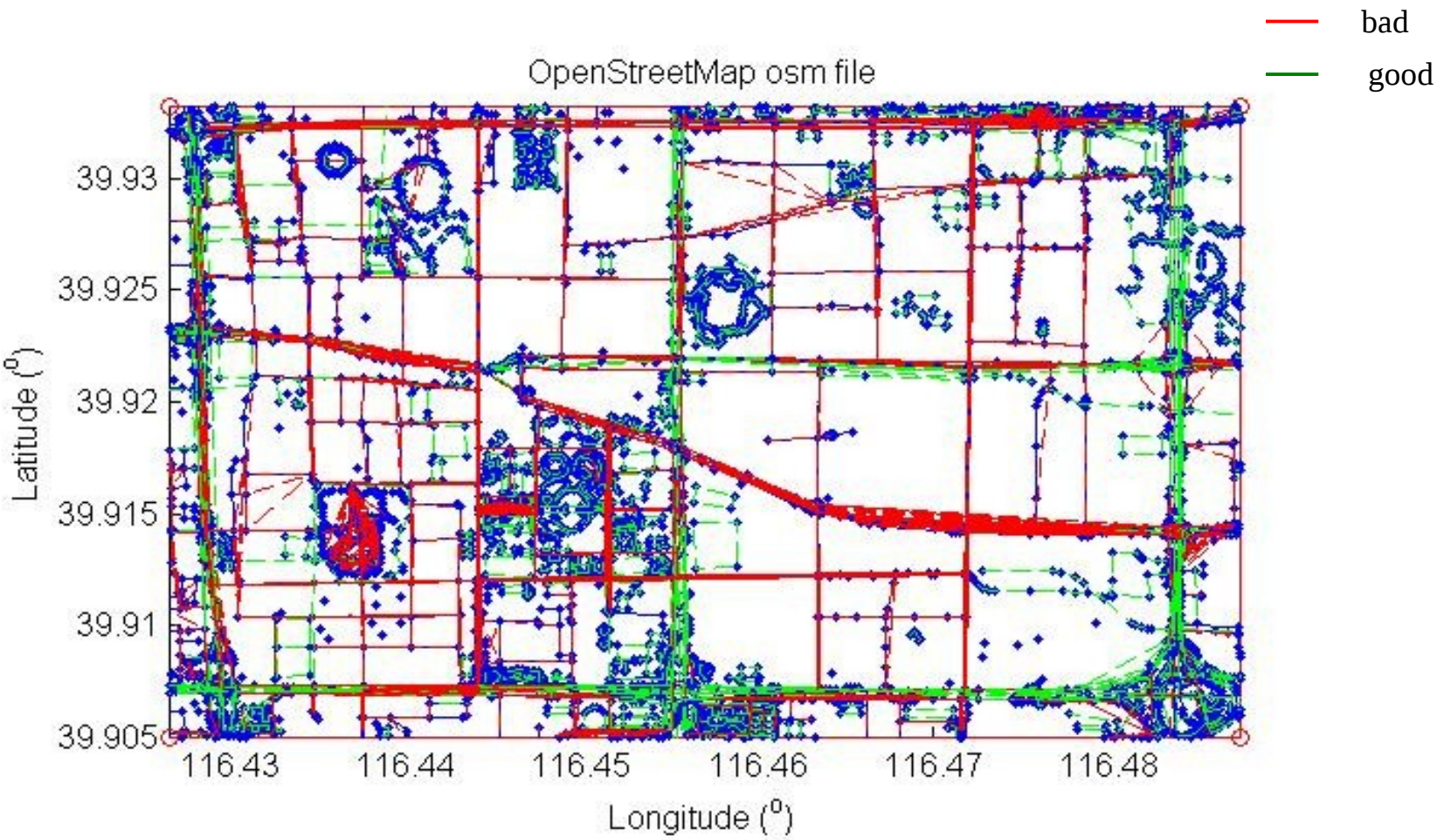
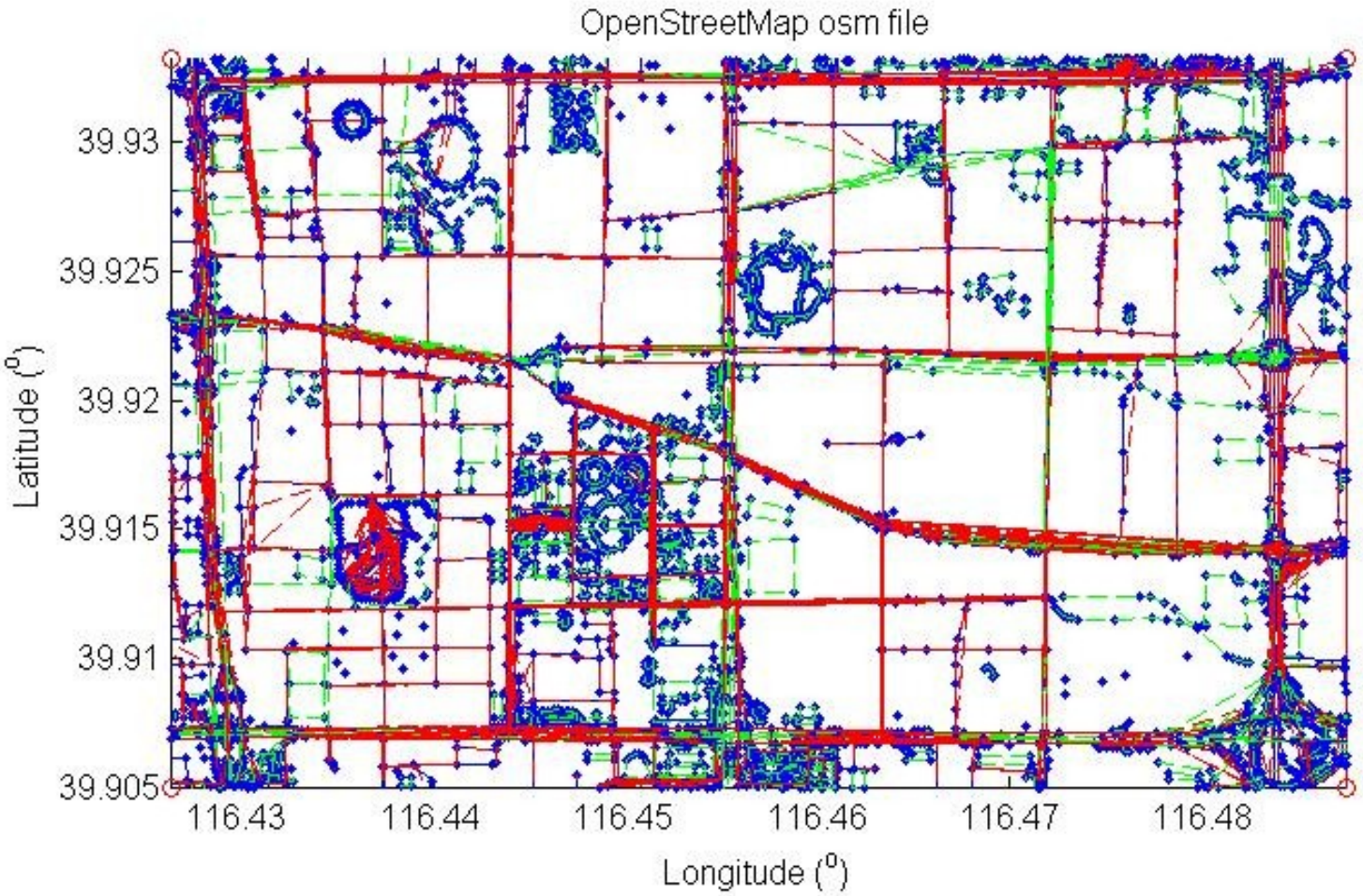
Road evaluation



Weather impactor



correlation

low

high

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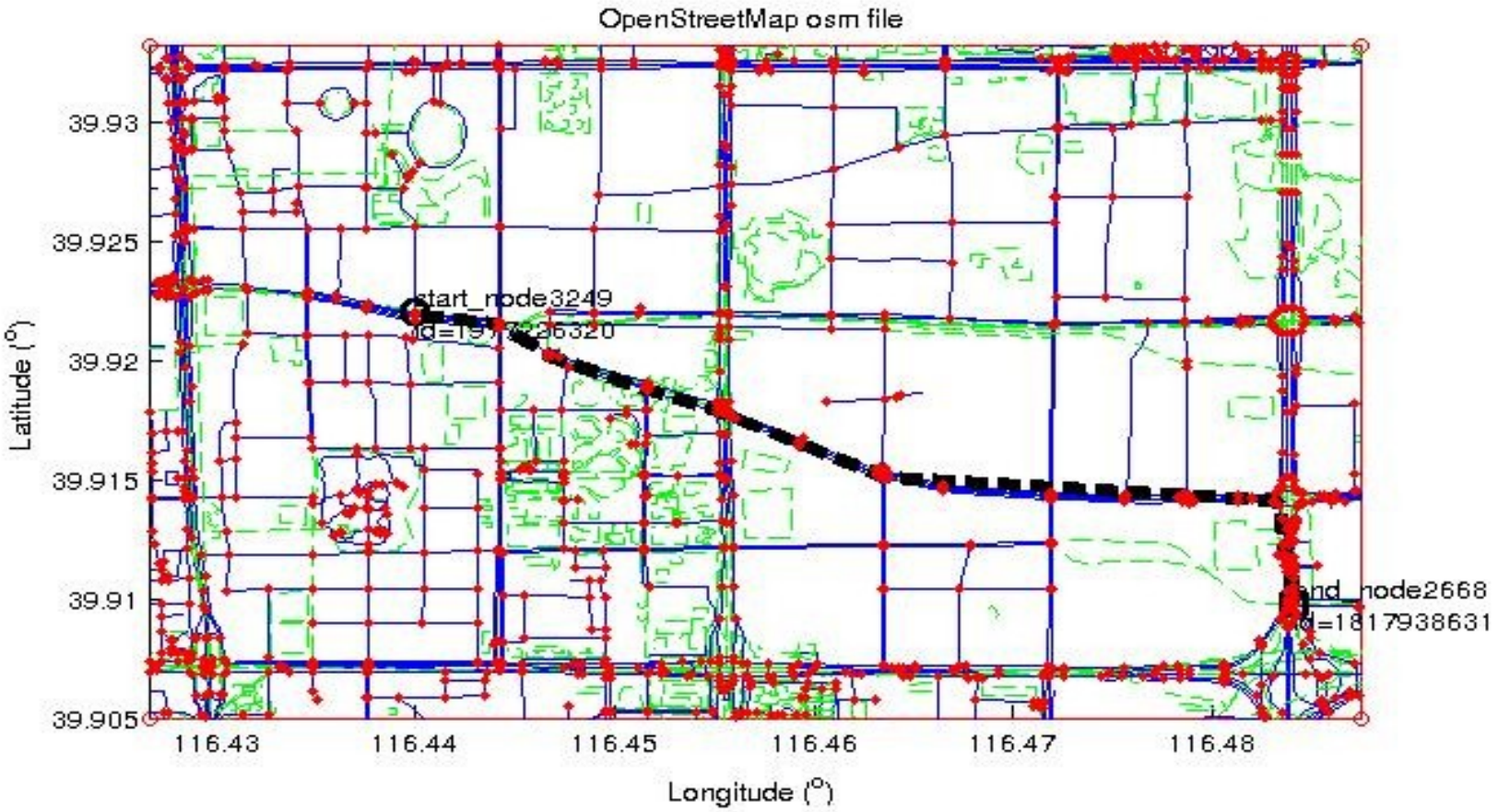
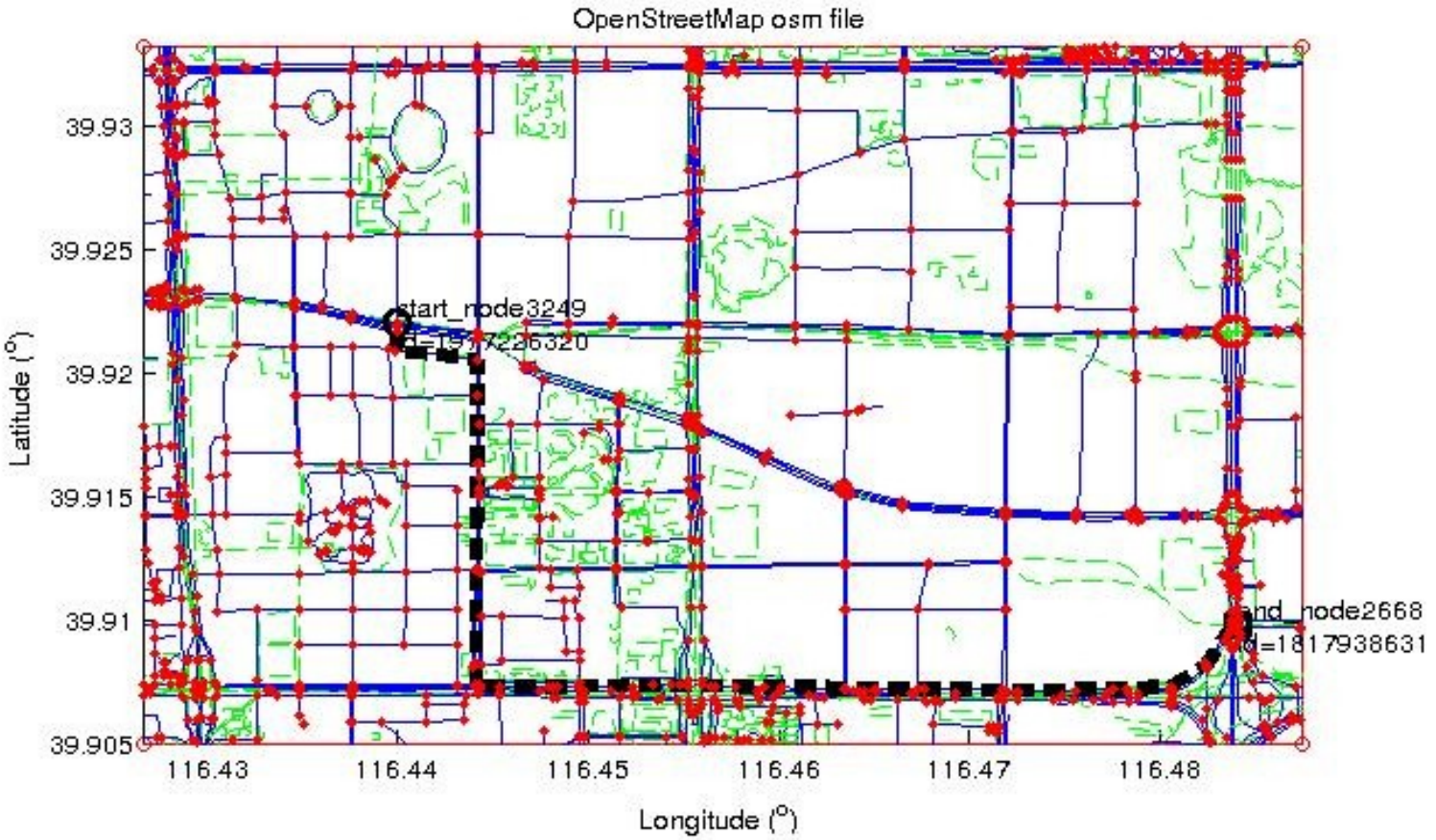
Route planner (traditional method)



Route planner (our method)



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THANKS FOR YOUR ATTENTION!
QUESTIONS?

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