PAPER ID 4141

Monitoring urban accessibility for freight delivery services from vehicles traces and network modelling

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PURPOSE

The aim of this paper is to develop a method to measure the **city accessibility** for freight distribution by the use of vans **GPS traces**. The accessibility was investigated through the **travel time** estimated along the most frequently used paths and the average speed to connect relevant zones in the city.
The use of GPS data (as Floating Car Data) could improve the knowledge of the **road network** performances to help different **stakeholders** providing them reliable feedbacks according to their specific needs and interests.

A PRIORI NETWORK

DATASET

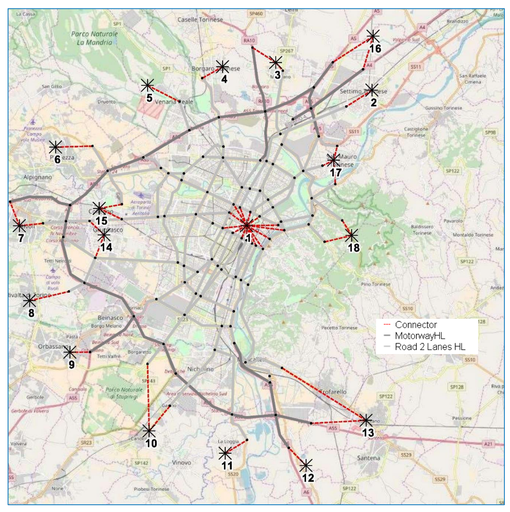
The method is applied to a dataset collecting more than **360,000 GPS** positions in **Turin** related to vehicles (**light vans**) of logistics fleets delivering goods all around the city. Data are collected for 28 different vans in a period going from 29th April to 29th May 2017. Each **recording** includes time and day, latitude and longitude, instantaneous speed and bearing. Only GPS traces collected in **working days** are included in this analysis.

Centroid	Name
1	Turin City Center
2	Settimo Torinese
3	Mappano
4	Borgaro Torinese
5	Venaria Reale
6	Pianezza
7	Rivoli
8	Rivalta di Torino
9	Orbassano-Sito
10	Candiolo
11	La Loggia
12	Highway South (A6)
13	Santena-Trofarello-Cambiano-Moncalieri Chieri
14	Grugliasco
15	Collegno
16	Highway North (A5-A4)
17	San Mauro-Pescarito
18	Chieri

A priori network characteristics		
Links (two-way)	arcs	324
	connectors	84
Nodes	nodes	110
	centroids	18

Road_Type	Speed [km/h]
Motorway	80
Road2lanes	30

A priori network is a **sketch network** model with principal nodes and links built using a traffic modeling tool (Omnitrans) for a high-level representation.



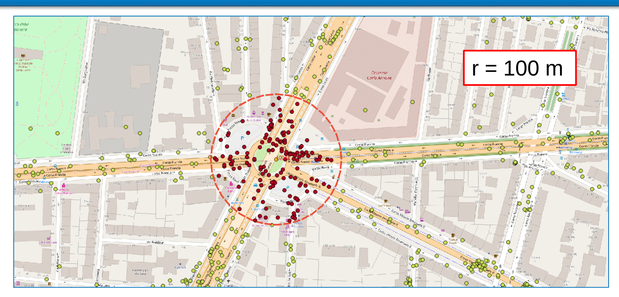
DATA ELABORATION

Each node of the *a priori* network is used to detect the vehicle passage timestamp and the **time** necessary to travel along the selected links is computed.

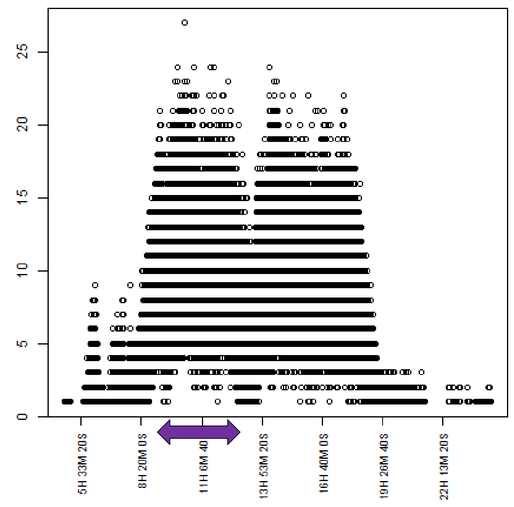
To increase the chance of **vehicle detection,** these nodes are set with different diameter options depending on the link type:

- Intersection of two motorways → r = 200 m
- Intersection of two road2lanes → r = 100 m
- Mixed intersection → r = 200 m.

These first analysis concentrate on the traces registered in the **time range** 9.00 - 12.30 a.m. to capture a larger number of vehicles circulating.



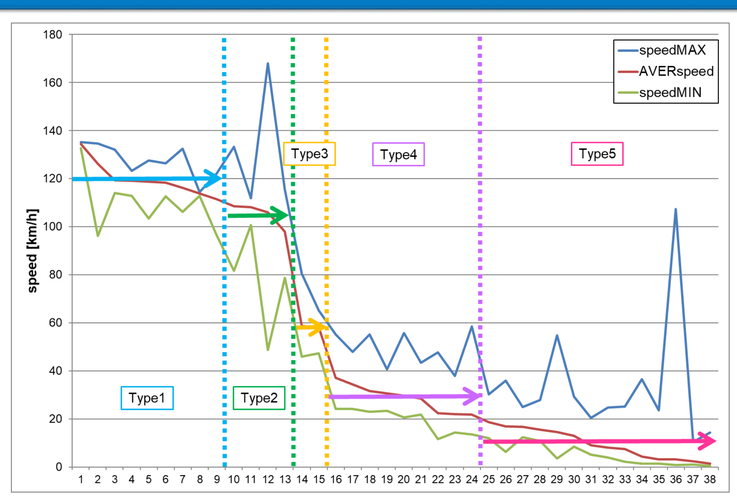
9.00 - 12.30 a.m.
Recordings distribution according to the time of the day



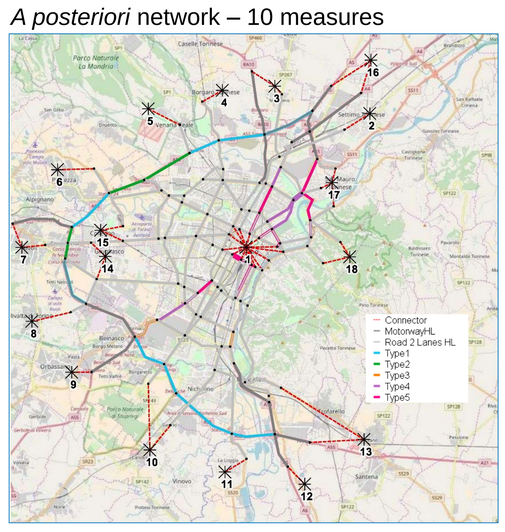
A POSTERIORI NETWORK

The final network, called *a posteriori*, is derived from the **refinement** of *a priori* one thanks to the GPS traces dataset that allow a better definition of the links characteristics previously defined.

Road_Type	Criteria [km/h]	Average [km/h]	# arcs 10 meas	# arcs 5 meas
Type1	s > 110	120	9	12
Type2	110 ≤ s < 80	105	4	5
Type3	80 ≤ s < 40	58	2	3
Type4	40 ≤ s < 20	29	9	13
Type5	s ≤ 20	10	14	44



A posteriori network – 10 measures



RESULTS

Time difference between the *a posteriori* (> 10 measures) and the *a priori* network

Travel time [min]																		
Centroids	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0	0	0	0	0	0	0	-1	-1	-1	-2	-1	-1	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	7
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	6
4	0	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	-2	-2	6
5	-1	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	-2	-2	5
6	0	-2	-2	-1	-1	0	0	0	0	0	0	0	0	0	0	-3	-3	4
7	-1	-3	-3	-2	-2	-1	0	0	0	0	0	0	0	0	-1	-4	-4	3
8	-1	-4	-4	-3	-3	-2	-1	0	0	0	0	0	0	0	-2	-5	-5	2
9	-1	-4	-4	-3	-3	-2	-1	0	0	0	0	0	0	0	-2	-5	-5	-1
10	0	-5	-5	-4	-3	-3	-2	-1	-1	0	0	0	0	-1	-2	-5	-5	0
11	-1	-6	-6	-5	-5	-4	-3	-2	-2	-2	0	0	0	-2	-4	-7	-7	0
12	0	-7	-7	-6	-6	-5	-4	-3	-3	-2	-1	0	0	-3	-4	-8	-7	0
13	0	-7	-7	-6	-6	-5	-4	-3	-3	-2	-1	0	0	-3	-4	-8	-7	0
14	0	-3	-3	-2	-2	-1	0	0	0	0	0	0	0	0	0	-4	-4	2
15	0	-2	-2	-1	-1	0	0	0	0	0	0	0	0	0	0	-3	-3	0
16	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	-1	-2	-1	-1	0	0	3	0	0

Time difference between the *a posteriori* (> 5 measures) and the *a priori* network

Travel time [min]																		
Centroids	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0	0	0	0	-1	1	1	-2	-1	3	1	5	5	0	0	0	0	6
2	8	0	0	7	7	7	7	7	7	7	7	7	7	7	7	7	9	18
3	0	0	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	8
4	0	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	-2	-2	8
5	-1	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	-2	-2	7
6	0	-2	-2	-1	-1	0	0	0	0	0	0	0	0	0	0	-3	-3	6
7	-1	-3	-3	-2	-2	-1	0	0	0	0	0	0	0	0	-1	-4	-4	6
8	0	-4	-4	-3	-3	-2	-1	0	0	0	0	0	0	0	-2	-5	-5	4
9	0	-5	-5	-4	-4	-3	-2	-1	0	0	0	0	0	-1	-2	-6	-6	5
10	1	-6	-6	-5	-4	-3	-3	-2	-1	0	0	0	0	-2	-3	-6	-6	9
11	0	-7	-7	-6	-6	-5	-4	-3	-2	-2	0	0	0	-3	-5	-8	-8	9
12	1	-8	-8	-7	-7	-6	-5	-4	-3	-2	-1	0	0	-4	-5	-8	-8	9
13	1	-8	-8	-7	-6	-6	-5	-4	-3	-2	-1	0	0	-4	-5	-8	-8	9
14	0	-3	-3	-2	-2	-1	0	0	0	0	0	0	0	0	0	-4	-4	5
15	0	-2	-2	-1	-1	0	0	0	0	0	0	0	0	0	0	-3	-3	6
16	0	-1	-1	-1	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	0	8
17	0	0	3	2	2	2	2	2	2	2	2	3	3	3	2	2	5	0	0
18	0	6	6	5	5	5	5	3	0	7	3	3	3	5	5	11	0	0

Travel time [min]																		
Centroids	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0	29	22	25	28	32	31	33	27	37	33	32	39	26	23	27	16	25
2	38	0	25	42	44	48	47	54	52	66	61	61	68	47	46	43	39	54
3	23	25	0	21	24	28	27	33	32	45	41	40	47	26	25	23	19	38
4	26	34	21	0	23	28	27	33	32	45	40	40	47	26	25	25	22	41
5	28	36	23	23	0	28	27	33	32	45	41	40	47	26	26	28	24	43
6	31	40	27	27	27	0	23	30	28	41	37	36	44	22	22	31	27	46
7	29	38	25	25	25	22	0	23	21	35	30	30	37	16	20	29	25	45
8	34	43	30	30	31	28	22	0	21	35	30	30	37	20	25	34	31	50
9	28	41	28	28	28	25	19	21	0	28	23	23	30	18	23	32	28	48
10	35	53	40	40	41	38	32	33	27	0	33	32	39	31	36	45	41	55
11	32	48	35	35	35	32	26	27	21	31	0	19	26	25	30	39	35	53
12	28	46	33	33	34	31	25	26	20	30	18	0	22	24	29	38	34	48
13	35	53	41	41	41	38	32	33	27	37	25	22	0	31	36	45	41	55
14	26	37	24	24	24	21	16	20	19	32	28	27	34	0	14	28	25	44
15	23	37	24	24	25	22	21	27	25	39	34	34	41	14	0	29	25	44
16	27	36	23	26	28	32	31	37	36	49	45	44	51	30	30	0	18	37
17	17	30	23	26	28	32	31	37	36	49	45	44	51	30	30	24	0	17
18	19	43	36	39	41	45	44	49	43	53	47	43	50	43	43	40	17	0

The main results underline the influence of FCD integration on the travel time matrices. The third matrix represents a possible accessibility matrix in terms of travel time between main zones of the city (the shortest path is selected on the basis of the travel time).

Acknowledgements

The methodology studied in this paper is partially developed in the SUITS (Supporting Urban Integrated Transport Systems: Transferable tools for authorities) project, which has received funding from the European Union's Horizon 2020 Framework programme for research and innovation under grant agreement no 690650.

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