Travel time prediction for trams in Warsaw

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Motivation

- use big data from urban infrastructure to improve quality of citizens’ life in big cities
- improve passenger travel experience
- tell passengers precisely how long their travel will take and at what time vehicle arrives
- travel time depends on many factors difficult to predict

Warsaw trams infrastructure

Parameter	Value
Stop groups in Warsaw	2204
Stops in Warsaw	6296
Stops groups with trams	237
Stops with trams	568
Tram lines	26
Average number of stops per line	31.84
Maximal number of stops per line	47 (line 11)
Minimal number of stops per line	9 (line 2)
Average line route length	12.999 km
Longest line route length	20.007 km (line 11)
Shortest line route length	5.600 km (line 2)
Average distance between two stops on route	447.2 m
Maximal distance between two stops on route	2203.1 m
Minimal distance between two stops on route	42.5 m
Earliest planned tram departure	03:32 (line 9 on Woronicza)
Latest planned tram on stop arrival	01:31 (line 9 on Zajezdnia Wola)

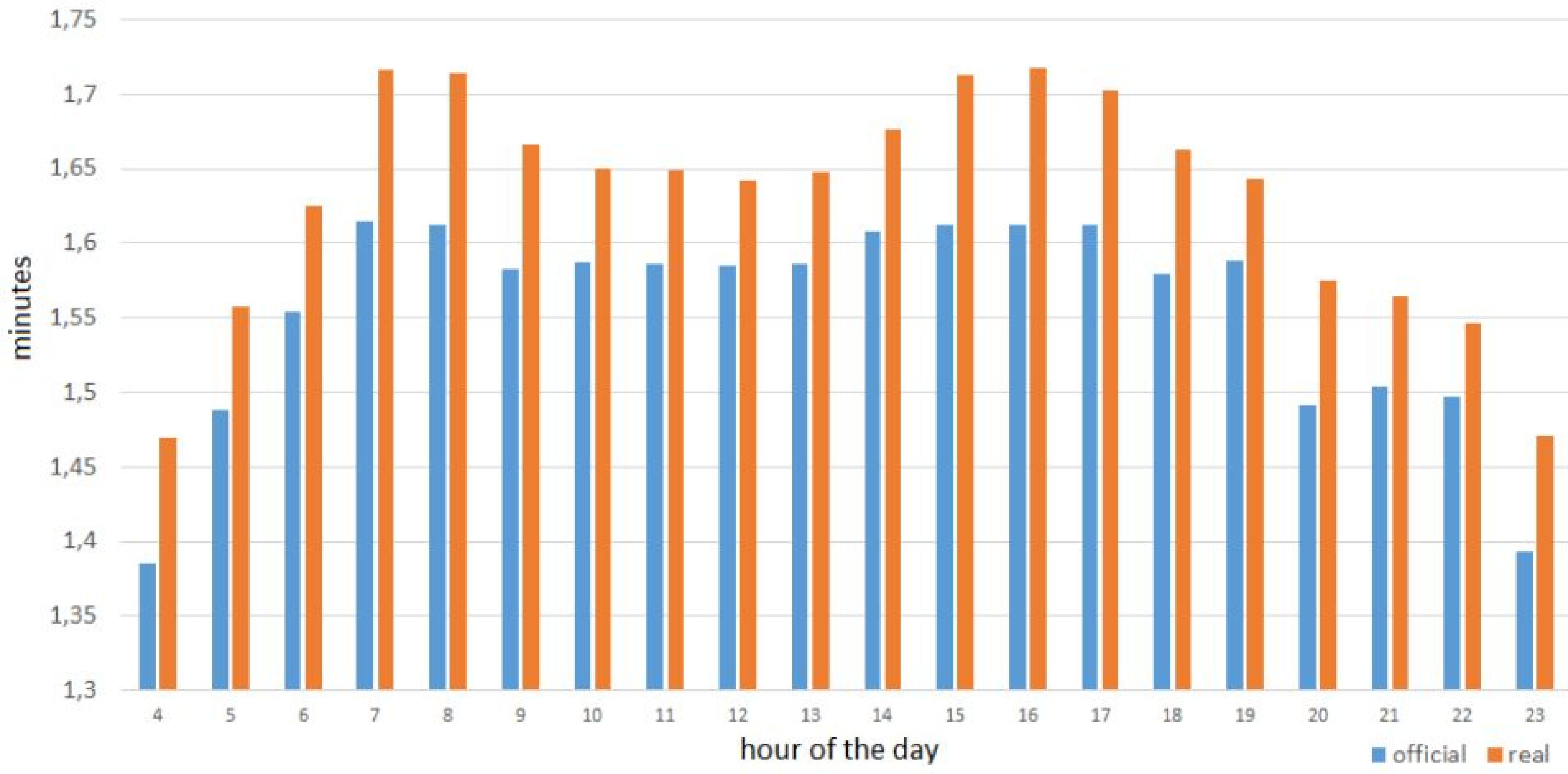
Data sources

- information about the official planned schedules (stops locations, routes and lines on stop planned times)
- real trams' positions from GPS transmitters (coordinates of current position sent every 15 seconds)

GPS data source

Parameter	Value
All logs	993263
Unique logs (unique triples [time, line, brigade])	861054 (86.7%)
Logs from Warsaw territory	991639 (99.84%)
Average time between logs from the same tram	18.2 s
Average distance traveled between logs	71.12 m
Unique pairs: [line, brigade]	305
Unique pairs: [line, brigade] in schedule	375

Travel time vs hour



Comparison between average time between all stops pairs by hour of the days for the official schedule and real travels

Prediction methods

- current delay propagation
- historical average time travel
- artificial neural network model

Available data: historical data from previous days about trams positions and all data from current day until prediction time and current tram position

1. current delay propagation

- finding current vehicle delay and propagate it to next stops on planned route
- does not use any historical data
- weakness: not able to predict future problems or delay changes

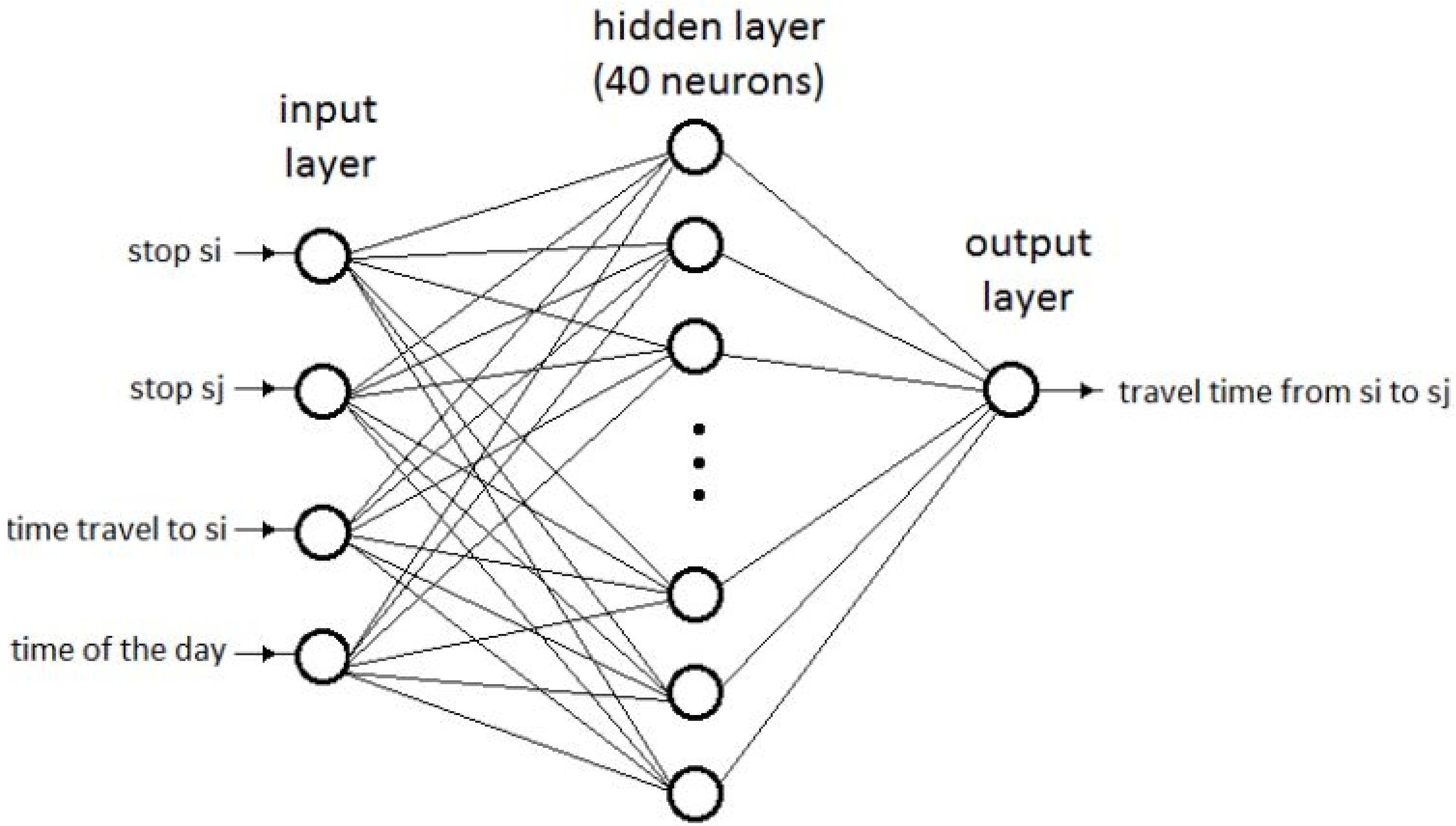
2. historical average time travel

- use average time travel from previous couple of days as an estimator for current day times
- take into consideration historical time travels or usual road fraction traffic conditions

3. artificial neural network model

- multilayer perceptron with backpropagation learning method
- output value: predicted tram's time travel from stop s_i to another stop s_j
- input:
  - order number of stop s_i in route,
  - order number of destination stop s_j in route,
  - travel time from route's start to stop s_i
  - time of the day.

3. artificial neural network model



Learning data set contains information from all travels on given route in last 30 days

Experimental setup

- simulates passenger view: how long trip form particular stop to another chosen stop takes
- 1000 random tram stop pairs
- four different hours: 8:00, 12:00, 16:00 and 20:00
- measure: difference between the real travel time and predicted travel time

Experimental results

	08:00		12:00		16:00		20:00		All	
	Diff	Best	Diff	Best	Diff	Best	Diff	Best	Diff	Best
Official timetables	180.53	36%	172.30	29%	203.61	25%	166.75	29%	180.79	30%
Current delay prop	178.41	30%	118.94	34%	172.99	27%	98.33	33%	142.17	31%
Historical avg travel	**159.70**	37%	**104.80**	**41%**	**137.83**	40%	**89.25**	**49%**	**122.89**	**42%**
Neural network	161.70	**42%**	138.40	38%	149.92	**44%**	143.01	40%	148.25	41%

- average planned time travel was 45 minutes
- average absolute prediction error: ~2 minutes
- official timetables error: 3 minutes
- worst results were obtained in rush hours

Experimental results

	Shorter	Longer
Official timetables	57.9%	31.1%
Current delay prop	57,7%	30.1%
Historical avg travel	48.5%	39.1%
Neural network	41.0%	38.7%

Conclusions

- all proposed methods outperform prediction based on the official timetables
- the best method - historical average time travel reduced prediction error from 3 minutes (for the official schedule) to 2 minutes
- time travels are longer in rush hours and more difficult to predict

Future work

- make similar researches for buses and compare them with trams
- do comparison between delays and prediction methods during holiday week and normal week
- apply results to mobile application for passengers or improve official schedules

Thank you