Estimating Freeway Level-of-Service (LOS) Using Crowdsourced Data

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Introduction

- Highway Capacity Manual (HCM) defines six Level-of-Service (LOS).
- Traditionally, traffic data are collected by fixed location sensors.
- Problem with RDS data and fixed location sensors:
  - Limited Coverage
  - Data Collection Problems: power outage, severe weather, etc.
  - Installation and Maintenance costs
- Crowdsourcing refers to obtaining data from a group of users who contribute their information via smartphone, social media, or the internet.
- Crowdsourcing is an emerging low-cost solution to improving safety and operation.

"This study proposes a method that exploits features from crowdsourced data and speed/travel time deviation to assess LOS on freeways."

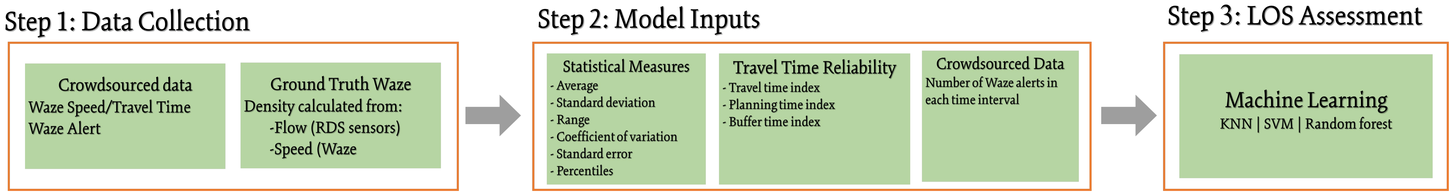
Data & study site

Crowdsourced Data:
- Waze Speed Data
- Waze User Alert (accident, jam, hazard, construction, etc.)

Location:
- MM385, I-40 Westbound, Knoxville, TN

Date:
- October 2019 for training the method
- March, April, August 2020 for testing the method

Methodology

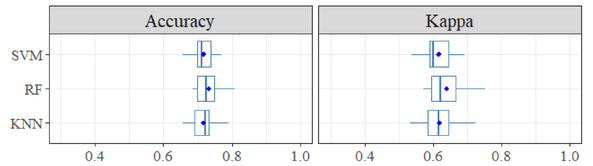


Model Inputs

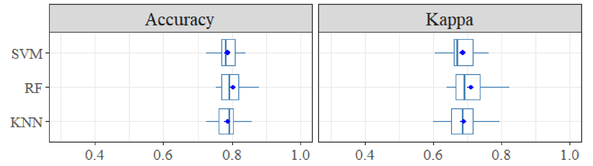
Model Inputs	Measure	Equation
Basic statistical measures of speed	Average Speed	$\bar{v} = \frac{\sum_1^n v_i}{n}$ Where v_i is speed and n is number of observations in each time interval
	Standard Deviation (SD)	$\sigma = \sqrt{\frac{\sum_1^n (v_i - \bar{v})^2}{n}}$
	Range	$Range(v_i) = \max_{1 \le i \le n} v_i - \min_{1 \le i \le n} v_i$
	Coefficient of Variation (CoV)	$CoV = \frac{\sigma}{\bar{v}}$
	Standard Error (SE)	$SE = \frac{\sigma}{\sqrt{n}}$
	Percentiles (5^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th})	$k^{th}\ percentile = rank(\frac{k}{100}(n+1))$ Where $k = 5, 25, 50, 75, 90$
	Interquartile Range (IQR)	$IQR = Q_3 - Q_1$ Where Q_3 is 75^{th} percentile and Q_1 is 25^{th} percentile of v_i
Travel time performance	Travel Time Index (TTI)	$TTI = \frac{TT_{Avg}}{TT_{free-flow}}$ where TT_{Avg} is average travel time and $TT_{free-flow}$ is free flow travel time
	Buffer Time Index (BTI)	$BTI = \frac{TT_{95th} - TT_{Avg}}{TT_{Avg}}$ Where TT_{95th} is 95th percentile of travel time
	Planning Time Index (PTI)	$PTI = \frac{TT_{95th}}{TT_{free-flow}}$
Crowdsourced data	Hourly Number of Alerts	$Count(Waze\ Alert_t^s)$ Where s is the study segment and t is the time interval (hour of day)

Model Selection

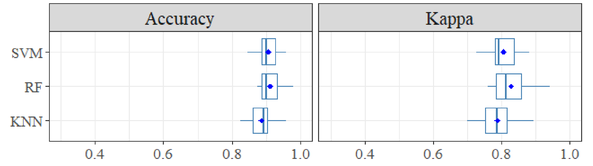
Model I — Inputs: Travel Time Performance



Model II — Inputs: Travel Time Performance, Statistical Measures



Model III — Inputs: Travel Time Performance, Statistical Measures, Crowdsourced Data



Results

Training Result:

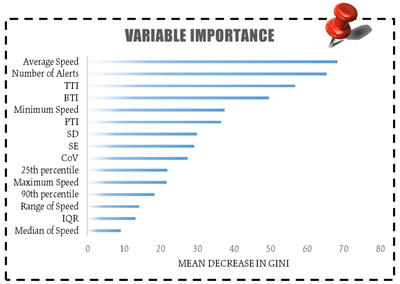
Summary of classification methods with 3, 5, 10-fold cross validations

Classifier	3-fold cross validation		5-fold cross validation		10-fold cross validation	
	Accuracy	Kappa	Accuracy	Kappa	Accuracy	Kappa
SVM	0.91	0.81	0.91	0.81	0.90	0.79
RF	0.91	0.82	0.93	0.83	0.92	0.83
KNN	0.88	0.77	0.89	0.79	0.88	0.76

Test with after COVID19 Data:

Date	Random Forest test result	
	Accuracy	Kappa
03/15/2020 to 04/15/2020	0.95	0.86
08/01/2020 to 08/31/2020	0.92	0.83

Most important variables
- Average speed
- Number of reports
- Travel time index (TTI)
- Buffer time index (BTI)
- Minimum speed
- Planning time index (PTI)
- Standard deviation



Conclusions

- The proposed method used crowdsourced data, travel time variability, and speed statistics measures to estimate LOS.
- Waze crowdsourced alerts can improve LOS estimation accuracy by about 10%.
- The results of this research provide transportation agencies a LOS method based on crowdsourced data on different freeways segment (urban or rural) regardless of the availability of traditional fixed location sensors.

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