Analysis of Destination Lane Choice at Urban Intersections

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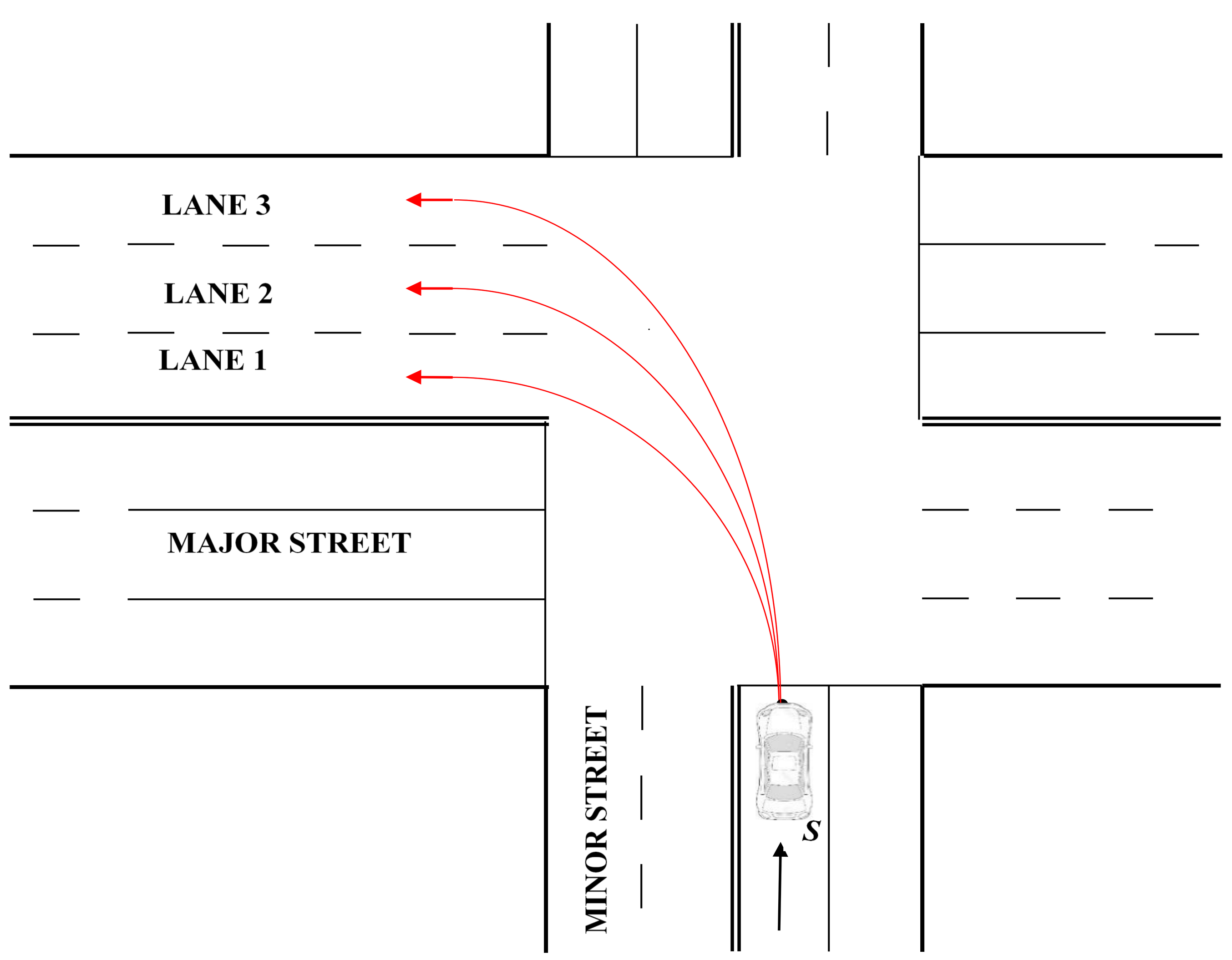
Objective: To perform statistical comparisons of driver's left-turn behavior, and predict the destination lane choice of left-turns at urban intersections

Introduction

- Turning movements are one of the most important considerations related to intersections. Left turning movements, in particular, are more critical due to the severity of collisions with opposing through traffic and near-side through traffic.
- When a driver makes a turn at an intersection, he/she has the opportunity to select a downstream destination lane.
- In some states in the U.S., it is required by law that drivers use a designated destination lane at intersections so as to avoid a potential collision with another concurrent turning movement.



- The destination lane choice is assumed to be chosen based on different driver behaviors, including the speed of the subject vehicle when entering the intersection, among others.
- With the advent of connected and automated vehicles, a good understanding of drivers' turning behavior and the ability to model it under different conditions has critical impacts on the safety and capacity of urban intersections and arterial streets.

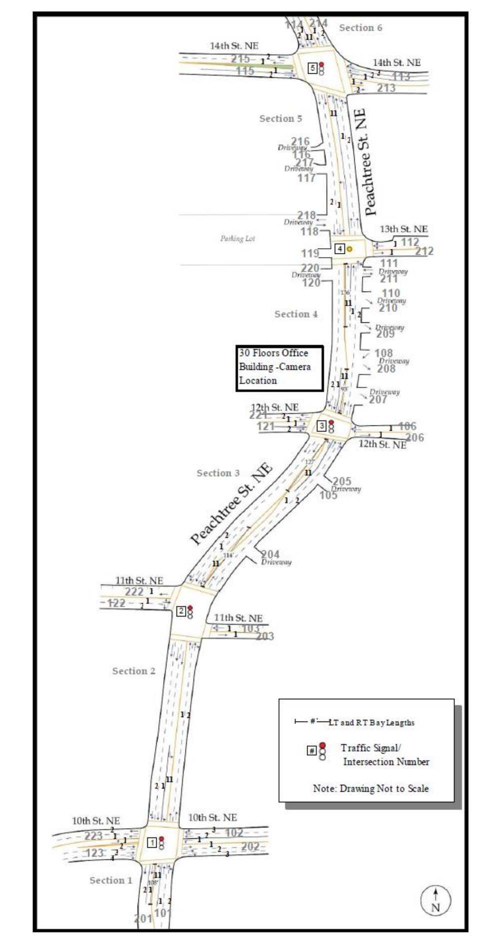
Literature Review

- Microscopic traffic simulation tools (i.e. software) commonly used in the industry were first reviewed to determine if any consider the downstream destination lane:
  - CORSIM (FHWA, 1995)
  - VISSIM (PTV, 2007)
  - PARAMICS (Quadstone, 2009)
  - AIMSUN (TSS, 2002)

  None consider the destination lane
- Zhixia et al. (2000) considered the rising relevance of automated vehicles, and investigated traffic congestion, especially in urban areas.
- Shabihkhani and Gonzales (2013) developed an analytical model based on the kinematic wave theory to compute the number of stops and the proportion of time spent idling and cruising based on the arrival flows at an isolated signalized intersection.
  - They utilized **NGSIM** data (i.e., the same data sets as this research).
- None of the reviewed literature attempted to predict drivers' turning-movement destination lanes using numerical evidence or field data.

Data Collection

- The data used for this research was from the Next Generation Simulation (NGSIM) vehicle trajectory data sets, both of which were along Peachtree St., an urban arterial, located in Atlanta, GA.
- All vehicle types were considered.
- Any vehicle that made a left-turn movement in any of the five intersections was first selected.
- For each identified subject vehicle, the **speed of the vehicle** was recorded as the vehicle was approaching (i.e. entering) the intersection. The **vehicle type** was also recorded, as well as **whether the vehicle was turning onto the major or minor street**.



Cambridge Systematics, Inc. (2007)

Dataset	A	B
Source	Peachtree Street November 8, 2006 4:00 – 4:15 p.m.	Peachtree Street November 8, 2006 12:45 – 1:00 p.m.
Total no. of vehicles (veh/15-minute)	1,222 (Cambridge, 2007a)	1,115 (Cambridge, 2007b)
Space mean speed (km/hr)	35.51 (Cambridge, 2007a)	41.37 (Cambridge, 2007b)
No. of left-turning movements (cars as subject vehicles)	247	228
No. of subject vehicles turning to lane 1	225	209
No. of subject vehicles turning to lane 2 or 3	22	19

Dataset A				
Decision Parameter	*Speed*	*Vehicle Type*	*Major Road*	*Destination Lane*
Sample size	247	247	247	247
Unit	km/hr	1 if car, 0 otherwise	1 if turned onto major road, 0 otherwise	0 for Lane 1, 1 otherwise
Min	0.14	0	0	0
Max	37.98	1	1	1
Mean	18.26	0.98	0.36	0.09
Std. deviation	7.99	0.15	0.48	0.29
Skewness	-0.24	-6.22	0.57	2.90

Dataset B				
Decision Parameter	*Speed*	*Vehicle Type*	*Major Road*	*Destination Lane*
Unit	ft/s	1 if car, 0 otherwise	1 if turned onto major road, 0 otherwise	0 for Lane 1, 1 otherwise
Sample size	228	228	228	228
Min	0	0	0	0
Max	45.67	1	1	1
Mean	15.29	0.98	0.48	0.08
Std. deviation	7.34	0.13	0.50	0.28
Skewness	-0.20	-7.40	0.07	3.04

Hypothesis Test Based on Time of Day

- The results indicate that the population means of the left-turning movement destination lane **are not significantly different** at $\frac{\alpha}{2} = 0.025$.
- Based on the hypothesis test results, **time-of-day does not** play a major role in drivers' left turning behavior at urban intersections.
- Therefore, **time-of-day will not be used** as a decision parameter when predicting left- turning destination lanes.

	Dataset A	Dataset B
Destination Lane		
Sample mean	0.09	0.08
Sample std. dev.	0.29	0.28
Sample size	247	228
t-value	0.052	
Conclusion	**Fail to reject H_0**	

Hypothesis Test Based on Road Classification

- The results indicate that the population means of the left-turning movement destination lane **are significantly different** at $\frac{\alpha}{2} = 0.025$.
- Statistically, this is evidence that drivers have **different left-turning behavior** when turning from a major street to a minor street and vice-versa. Drivers tend to choose **lane 1** when turning onto a minor street more than when turning onto a major street.
- Therefore, whether drivers turn from a major or minor street **will be used** as a decision parameter when predicting left turning destination lanes.

	Major Street to Minor Street	Minor Street to Major Street
Destination Lane		
Sample mean	0.06	0.13
Sample std. dev.	0.26	0.33
Sample size	275	200
t-value	-2.26	
Conclusion	**Reject H_0**	

Binary Logit Model

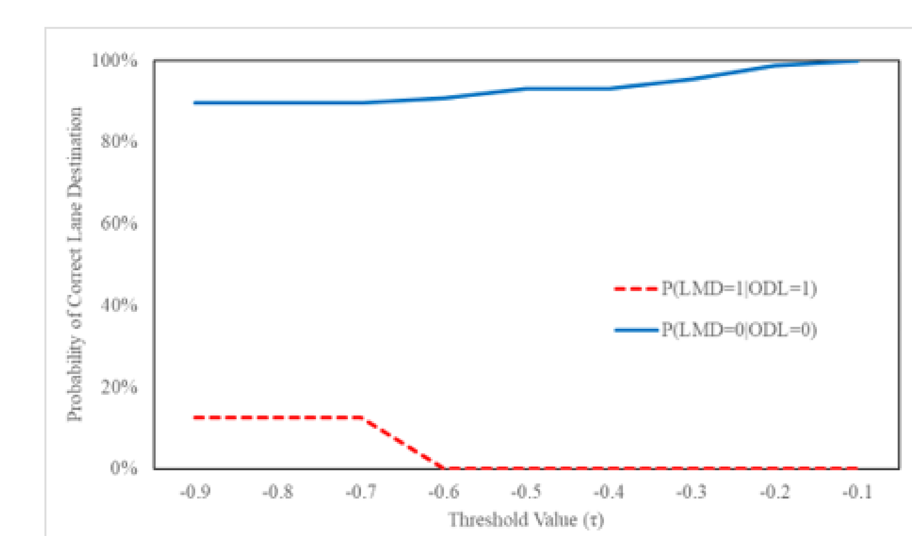
- All data was compiled from both data sets into one table.
- Then, a stratified 80/20 split was made to separate the data into a training and test data set.
- A binary logit model was developed using the training data set.
- The coefficients provide insights on drivers' left turning behavior when selecting a destination lane.

Overall data set (Datasets A and B combined)	
No. of left-turning movements or subject vehicles	475
No. of subject vehicles with output of 0 (chose lane 1 as destination lane)	434
No. of subject vehicles with output of 1 (chose lane 2 or 3 as destination lane)	41
Training data set	
No. of left-turning movements or subject vehicles	380
No. of subject vehicles with output of 0 (chose lane 1 as destination lane)	347
No. of subject vehicles with output of 1 (chose lane 2 or 3 as destination lane)	33
Test data set	
No. of left-turning movements or subject vehicles	95
No. of subject vehicles with output of 0 (chose lane 1 as destination lane)	87
No. of subject vehicles with output of 1 (chose lane 2 or 3 as destination lane)	8

Decision Parameter	Coefficient	*t*-statistic	95% Conf. Interval	
Constant	-0.538	-0.47	-2.801	1.725
Speed (ft/s)	-0.083	-3.23	-0.133	-0.033
Vehicle Type (1 if car, 0 otherwise)	-1.177	-1.03	-3.418	1.063
Major Street (1 if turned onto major street, 0 otherwise)	0.937	2.38	0.164	1.710
Log likelihood	-103.5823			
Prob > chi2	0.0007			
McFadden R^2	0.0765			

Accuracy of Logit Model

- A threshold (τ) is used to separate the binary logit model output to predict lane 1 as the destination lane, or lanes 2 and 3 as the destination lane.
- The best τ-value is **-0.7**.
- The binary logit model can **accurately** predict left-turning movements into **destination lane 1 (at 89.7%)**; however, it performs **poorly** when predicting **destination lanes 2 or 3 (at only 12.5%)**.



Conclusions

- The test on the difference between two means **based on time-of-day** has shown **no significant difference** between the two data sets.
- The test of the difference between two means of drivers' choosing different left turn destination lanes **based on whether they turned from a major street to a minor street or from a minor street to a major street** has shown a **significant difference**.
- A **binary logit regression model** has been developed to predict the left turn destination lanes based on the input decision variables. The model can **accurately predict** left turning movements into destination lane 1; however, it **performs poorly** when predicting destination lanes 2 or 3.
- An overwhelming majority of drivers use **destination lane 1** when executing a left-turning movement, **at all times** during the day.