IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 8, Issue 6 (Sep. - Oct. 2013), PP 73-82
www.iosrjournals.org

Using of intelligent communicational devices in controlling road structural weights

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Abstract: *The goal of this paper is to state and evaluate the differences in gap acceptance observations between left lane and right lane change, and experiment overall aggressiveness by the means of right lane change behaviors and use of electrical instruments for reaching this goal, furthermore we use Digital Signal Processing on our controlling cameras to be able to distinguish different behaviours of drivers. Also, in this paper we evaluate the decision making process of drivers, we do this work with use of electrical sensors for accumulating some data and clarifying and processing them and finally with use of cumulative distribution functions of driver lane change behaviours from the observed field data. These experiments are performed for drivers using I-20 in Grand Prairie, Texas with the roadside controlling cameras and some other electronical controlling instruments which were amounted near the intersection of I-20 and Great Southwest Blvd. Our experiments and evaluations demonstrates, that the whole ratio of right lane change observations to left lane change observations was close to 3 to 1.*
Keywords: *Electronic devices, roadside control camera, lane change, digital image processing, electronic control systems.*

I. Introduction:

The impact of lane change maneuvers is fundamental to microscopic traffic flow theory. In microscopic model both the system entities and their interactions are described at a high level of detail. For example, a lane-change maneuver at this level could invoke the car-following law for the subject vehicle with respect to its current leader, then with respect to its putative leader and its putative follower in the target lane, as well as representing other detailed driver decision processes. The duration of the lane-change maneuver can also be calculated (TRAFFIC SIMULATION BY EDWARD LIEBERMAN18 AJAY K. RATHI). There are several lane change algorithms in microscopic simulation models aiming at simulating a series of decision-making processes during lane change movement. The agreement between the simulated and field lane change behaviors is an important factor for simulation models to replicate the real world conditions.

A recent study (Godthelp and Shumann 1994) found errors between speed desired and maintained to vary from -0.3 to -0.8 m/sec in a lane change maneuver; drivers tended to lose velocity when they made such a maneuver.

In an article published by Kouichi Sumida et. al. - Mitsubishi Motors, it is measured the changes of heart rate in order to analyze the drivers' stress while they tried high speed lane-change on the stationary driving simulator. In this paper they concluded that the reasons of the changes were mainly dependent on the following two items. (1) mental pressure caused by the coming task of lane-change, (2) mental disturbance by the task to keep the vehicle inside the lane. By using the mental pressure and disturbance, they could evaluate the stability of the vehicles in lane-change maneuver.

The purpose of this paper is to experiment that there is difference in gap acceptance observations between left lane change and right lane change maneuver, and evaluate the overall aggressiveness of right lane change behaviors. In this paper, the driver's decision-making processes are evaluated using cumulative distribution functions of driver lane change behaviors from the observed field data. These evaluations are performed for drivers using I-20 in Grand Prairie, Texas with the roadside cameras mounted near the intersection of I-20 and Great Southwest Blvd.

It has been widely recognized that the performance of a multi-agent system (MAS) is highly affected by its organization. A large scale MAS may have billions of possible ways of organization, depending on the number of agents, the roles, and the relationships among these agents. These characteristics make it impractical to find an optimal choice of organization using exhaustive search methods.(16)

Data Collection Approach:

Due to the difficulty of tracking many vehicles over time and space, we collected lane change maneuver data recorded from a Texas Department of Transportation roadside camera located near the intersection of I-20 and Great Southwest Blvd. The type camera cannot be mentioned due to the security concerns. This approach eliminates the need for high-resolution maps accurate enough to capture the exact positions of vehicles in individual lanes. Five video segments from two days were analyzed in this project. The time periods analyzed were:

- Monday, October 20, 2008
  - 9:00 am to 9:30 am
  - 4:00 pm to 4:15 pm
  - 4:30 pm to 4:50 pm
- Thursday, October 23, 2008
  - 3:00 pm to 4:00 pm
  - 4:30 pm to 4:50 pm

A combination of data from all five time periods were examined together, and then the segments were segregated according to Peak and Off-peak periods. The 9am and 3pm segments were considered in the off-peak analysis, and the 4pm and 4:30pm segments were included in the peak period analysis. The time periods were segregated in this manner to determine if lane change behavior varies between low volume and high volume traffic conditions.

The determination of gap sizes were accomplished by recording the elapsed time between a vehicle moving into a particular lane (the "lead vehicle") passing a fixed point on the freeway and the vehicle directly behind the lead vehicle (the "trailing vehicle") in that lane passing the same point. Times were recorded using a hand-held stop watch, and gap values were carried out to tenths of a second. For this project, the west abutment of the Interstate 20 overpass over Great Southwest Blvd. proved to be an ideal fixed point at which to base the measurements. This determination was performed for both right lane and left lane change. The vehicle that made lane change was not tracked after the lane change. Due to the small numbers of lane changes observed by large tractor-trailer trucks and motorcycles during the observation times, the behavior of these vehicles was not considered in this study. Also gap lengths greater than five seconds were not measured to prevent excessive gap lengths from skewing the data.

II. Data Collection and Results:

The gap acceptance observations for this project were analyzed in two parts: As a whole by combining all observations made over all five time periods considered, and individually by segregating the observations into peak and off-peak time periods. To help account for possible error in the data collection procedure stemming from the operation of the stop watch, the observations were grouped into 0.2 second classes for analysis. For each case, the number of observations, average gap size, and standard deviation of the gap size were computed. These same statistics were calculated for the "raw" (ungrouped) observations for comparison purposes. Summary tables of the grouped data are shown in Tables 1 through 3, and the statistics computed from the ungrouped observation data are presented in Table 4.

The number of observed gaps that fell within each class was compiled and tabulated, and histogram plots of the frequencies of observations in each class were drawn for right and left lane change movements. It is interesting to note that the shapes of the histograms, shown in Figures 1 and 2, resemble that of an exponential function that gap acceptance distributions commonly represent. To prove that the observed gaps were exponentially distributed, a Chi-Squared test was performed. The critical gap parameter was estimated for each case by computing the gap length that fell in the middle of the observations. Theoretically, half of the drivers would accept this gap, and half of the drivers would reject it. Not surprisingly, the critical gap for left lane change movements was found to be larger than that for right lane changes. Expected frequencies were calculated by multiplying the total number of observations for each lane change direction by the cumulative probability function, and then compared with the observed frequencies. For both the right and left lane change movements, the error between observed and expected frequencies was found to be within the threshold chi-squared error limits, indicating that the observed gaps were exponentially distributed. Results of the Chi-Squared tests are presented in Table 5. Plots of the observed cumulative frequencies are shown in Figures 3 and 4.

Finally, hypothesis tests were performed to determine if drivers did, indeed, accept shorter gaps for right lane changes than for left lane changes. For the three conditions considered – the Off-peak Periods, Peak Periods, and Combined Observations – a one-sided hypothesis test was run on the combined mean gap lengths and variances of the left and right lane change gap observations. The null (h_0) hypothesis stated that the gap lengths for right lane changes were, on average, about the same or greater than those for the left lane changes, and the alternative (h_1) hypothesis stated that the average gap lengths for right lane changes were less than those for left lane changes. The tests were performed at a 5% level of significance, which is the common significance level used for traffic studies.

Since this study used variances that were estimated from observed data and not "true" or universally accepted variances, the hypothesis tests were performed using the Student's t distribution. A pooled variance was found by taking the weighted average of the observed variances, and this was used to compute the test statistic, t^*. This test statistic was compared with the t-value from the Student's t table at a 5% level of significance and degrees of freedom equal to the sum of both sample sizes minus 2. If the absolute value of t^* was found to be less than that of the tabulated value, the null hypothesis was confirmed. Conversely, if the absolute value of t^* was greater than the tabulated value, the null hypotheses was rejected. For this study, it was concluded that, overall, the average gaps accepted by drivers making right lane changes are statistically less than those making left lane changes. Of the two time periods considered, this was also found to be true during the off-peak conditions. For the peak conditions, however, the average gaps of left-lane changes were found to be statistically equal to or greater than those of right hand maneuvers.

For the periods where the both the right and left lane change sample sizes were large (>30), which was the case for the Combined and Off-peak Periods, hypothesis tests were also conducted as if the variances were known. This is acceptable because, according to the Central Limit Theorem, large sample sizes normally produce estimated variances that are close to the "true" variances. In this case, the test statistic (Z^*) was found using a pooled value of the measured variances, and this was compared with the Z value from the Standard Normal at a 5% level of significance. For both cases in which this method was performed, its conclusion matched that of the assumed variance method. The null hypothesis was rejected, and the average gap lengths of right lane change maneuvers was found to be statistically less than those of left lane change maneuvers. All hypothesis tests are shown in the Appendix to this report.

III. Conclusions and Discussion:

The first thing that was noticed when collecting the data for this paper was the disproportionate number of right lane change movements observed compared to left lane change movements. The overall ratio of right lane change observations to left lane change observations was close to 3 to 1, and the disparity was more than 4 to 1 during the Peak Period observations. This is likely due, in part, to the location of the camera from which the video was taken for this project. As stated previously, the camera is located alongside westbound Interstate 20 at its interchange with Great Southwest Parkway, which is less than a mile upstream of the Interstate 20 / State Highway 360 interchange. It is reasonable to think that a large number of vehicles would access the right lane in this location in preparation to exit to SH 360, and the observations reflected this. The disparity may also stem from the idea that left lane changes are mainly "convenience movements" made for speed of travel purposes, while right lane changes are "necessity movements" made, in large part, for navigational purposes to access exit ramps. The increase in vehicle volume during peak periods results in a lower availability of comfortable gaps in which to change lanes, and this condition would likely reduce the number of "convenience" lane change movements more than it would the "necessity" lane change movements.

The second item that stood out in the findings was that the difference in gap lengths in the two lane change movements was most prevalent in the Off-peak Period, and not so much in the Peak Period. The average gap length observed for right lane changes was shorter than that for left lane changes during all periods considered. Interestingly, however, this difference was almost one half second in the off-peak times, and it reduced to less than a quarter second during the peak times. The overall results indicated that, overall, there is a statistical difference between the gap acceptance lengths for right and left lane changes, but most of the discrepancy appears to occur during periods of lighter traffic. This may be due to the fact that, since there are fewer vehicles on the road during the off-peak, there are a greater number of long gaps for drivers to choose from. What then occurs is the reverse of what happens during the peak times and described in the previous paragraph. The lighter volume allows a greater amount of freedom for vehicles to move within the freeway, which results in a greater number of "convenience" (i.e. left) lane change movements, and these movements occur with longer gap lengths. Meanwhile, the "necessity" (i.e. right) lane changes continue to occur at relatively high rates and with shorter gap lengths.

While the scope of this study was rather limited by its use of one camera to collect data from a single location, we believe that it does shed some light on driver behavior regarding lane change maneuvers during varying traffic conditions. It would be interesting to expand the scope of this study to other locations throughout the Metroplex and even to other metropolitan locations to determine if the behavior patterns described herein translate to other locations as well.

Tables and Figures

Table 1

STATISTICS FROM GROUPED OBSERVATIONS
Combined Periods

Gap Interval (seconds)	Mark M_i	M_i^2	Left Lane Changes Frequency f_i	f_iM_i	$f_iM_i^2$	Right Lane Changes Frequency f_i	f_iM_i	$f_iM_i^2$
< 0.20	0.10	0.010	0	0.000	0.000	0	0.000	0.000
0.20 - 0.40	0.30	0.090	0	0.000	0.000	1	0.300	0.090
0.40 - 0.60	0.50	0.250	2	1.000	0.500	7	3.500	1.750
0.60 - 0.80	0.70	0.490	5	3.500	2.450	15	10.500	7.350
0.80 - 1.00	0.90	0.810	7	6.300	5.670	18	16.200	14.580
1.00 - 1.20	1.10	1.210	6	6.600	7.260	27	29.700	32.670
1.20 - 1.40	1.30	1.690	7	9.100	11.830	20	26.000	33.800
1.40 - 1.60	1.50	2.250	4	6.000	9.000	13	19.500	29.250
1.60 - 1.80	1.70	2.890	3	5.100	8.670	9	15.300	26.010
1.80 - 2.00	1.90	3.610	5	9.500	18.050	12	22.800	43.320
2.00 - 2.20	2.10	4.410	1	2.100	4.410	7	14.700	30.870
2.20 - 2.40	2.30	5.290	1	2.300	5.290	3	6.900	15.870
2.40 - 2.60	2.50	6.250	1	2.500	6.250	6	15.000	37.500
2.60 - 2.80	2.70	7.290	1	2.700	7.290	4	10.800	29.160
2.80 - 3.00	2.90	8.410	2	5.800	16.820	6	17.400	50.460
3.00 - 3.20	3.10	9.610	3	9.300	28.830	2	6.200	19.220
3.20 - 3.40	3.30	10.890	2	6.600	21.780	3	9.900	32.670
3.40 - 3.60	3.50	12.250	1	3.500	12.250	2	7.000	24.500
3.60 - 3.80	3.70	13.690	1	3.700	13.690	1	3.700	13.690
3.80 - 4.00	3.90	15.210	1	3.900	15.210	3	11.700	45.630
4.00 - 4.20	4.10	16.810	2	8.200	33.620	2	8.200	33.620
4.20 - 4.40	4.30	18.490	2	8.600	36.980	1	4.300	18.490
4.40 - 4.60	4.50	20.250	4	18.000	81.000	3	13.500	60.750
4.60 - 4.80	4.70	22.090	0	0.000	0.000	1	4.700	22.090
≥ 4.80	4.90	24.010	0	0.000	0.000	2	9.800	48.020
		Σ:	**61**	**124.300**	**346.850**	**168**	**287.600**	**671.360**
		μ:	**2.04**			**1.71**		
		σ:	**1.249**			**1.035**		

Table 2

STATISTICS FROM GROUPED OBSERVATIONS
Off-Peak Period
10/20/2008 - 0900-0930
10/23/2008 - 1500-1600

Gap Interval (seconds)	Mark M_i	M_i^2	Left Lane Changes Frequency f_i	f_iM_i	$f_iM_i^2$	Right Lane Changes Frequency f_i	f_iM_i	$f_iM_i^2$
< 0.20	0.10	0.010	0	0.000	0.000	0	0.000	0.000
0.20 - 0.40	0.30	0.090	0	0.000	0.000	0	0.000	0.000
0.40 - 0.60	0.50	0.250	1	0.500	0.250	5	2.500	1.250
0.60 - 0.80	0.70	0.490	4	2.800	1.960	12	8.400	5.880
0.80 - 1.00	0.90	0.810	6	5.400	4.860	14	12.600	11.340
1.00 - 1.20	1.10	1.210	5	5.500	6.050	15	16.500	18.150
1.20 - 1.40	1.30	1.690	5	6.500	8.450	7	9.100	11.830
1.40 - 1.60	1.50	2.250	3	4.500	6.750	5	7.500	11.250
1.60 - 1.80	1.70	2.890	1	1.700	2.890	4	6.800	11.560
1.80 - 2.00	1.90	3.610	2	3.800	7.220	9	17.100	32.490
2.00 - 2.20	2.10	4.410	1	2.100	4.410	2	4.200	8.820

2.20	-	2.40	2.30	5.290	0	0.000	0.000	2	4.600	10.580
2.40	-	2.60	2.50	6.250	1	2.500	6.250	3	7.500	18.750
2.60	-	2.80	2.70	7.290	0	0.000	0.000	1	2.700	7.290
2.80	-	3.00	2.90	8.410	1	2.900	8.410	4	11.600	33.640
3.00	-	3.20	3.10	9.610	2	6.200	19.220	1	3.100	9.610
3.20	-	3.40	3.30	10.890	1	3.300	10.890	2	6.600	21.780
3.40	-	3.60	3.50	12.250	1	3.500	12.250	0	0.000	0.000
3.60	-	3.80	3.70	13.690	1	3.700	13.690	1	3.700	13.690
3.80	-	4.00	3.90	15.210	1	3.900	15.210	1	3.900	15.210
4.00	-	4.20	4.10	16.810	2	8.200	33.620	2	8.200	33.620
4.20	-	4.40	4.30	18.490	2	8.600	36.980	0	0.000	0.000
4.40	-	4.60	4.50	20.250	3	13.500	60.750	2	9.000	40.500
4.60	-	4.80	4.70	22.090	0	0.000	0.000	1	4.700	22.090
	≥	4.80	4.90	24.010	0	0.000	0.000	1	4.900	24.010
				Σ:	**43**	**89.100**	**260.110**	**94**	**155.200**	**363.340**
				μ:	**2.07**			**1.65**		
				σ:	**1.341**			**1.073**		

Table 3

STATISTICS FROM GROUPED OBSERVATIONS
Peak Period
10/20/2008 - 1600-1615
10/20/2008 - 1630-1650
10/23/2008 - 1630-1650

Gap Interval (seconds)			Mark		Left Lane Changes			Right Lane Changes		
					Frequency			Frequency		
			M_i	M_i^2	f_i	f_iM_i	$f_iM_i^2$	f_i	f_iM_i	$f_iM_i^2$
	<	0.20	0.10	0.010	0	0.000	0.000	0	0.000	0.000
0.20	-	0.40	0.30	0.090	0	0.000	0.000	1	0.300	0.090
0.40	-	0.60	0.50	0.250	1	0.500	0.250	2	1.000	0.500
0.60	-	0.80	0.70	0.490	1	0.700	0.490	3	2.100	1.470
0.80	-	1.00	0.90	0.810	1	0.900	0.810	4	3.600	3.240
1.00	-	1.20	1.10	1.210	1	1.100	1.210	12	13.200	14.520
1.20	-	1.40	1.30	1.690	2	2.600	3.380	13	16.900	21.970
1.40	-	1.60	1.50	2.250	1	1.500	2.250	8	12.000	18.000
1.60	-	1.80	1.70	2.890	2	3.400	5.780	5	8.500	14.450
1.80	-	2.00	1.90	3.610	3	5.700	10.830	3	5.700	10.830
2.00	-	2.20	2.10	4.410	0	0.000	0.000	5	10.500	22.050
2.20	-	2.40	2.30	5.290	1	2.300	5.290	1	2.300	5.290
2.40	-	2.60	2.50	6.250	0	0.000	0.000	3	7.500	18.750
2.60	-	2.80	2.70	7.290	1	2.700	7.290	3	8.100	21.870
2.80	-	3.00	2.90	8.410	1	2.900	8.410	2	5.800	16.820
3.00	-	3.20	3.10	9.610	1	3.100	9.610	1	3.100	9.610
3.20	-	3.40	3.30	10.890	1	3.300	10.890	1	3.300	10.890
3.40	-	3.60	3.50	12.250	0	0.000	0.000	2	7.000	24.500
3.60	-	3.80	3.70	13.690	0	0.000	0.000	0	0.000	0.000
3.80	-	4.00	3.90	15.210	0	0.000	0.000	2	7.800	30.420
4.00	-	4.20	4.10	16.810	0	0.000	0.000	0	0.000	0.000
4.20	-	4.40	4.30	18.490	0	0.000	0.000	1	4.300	18.490
4.40	-	4.60	4.50	20.250	1	4.500	20.250	1	4.500	20.250
4.60	-	4.80	4.70	22.090	0	0.000	0.000	0	0.000	0.000
	≥	4.80	4.90	24.010	0	0.000	0.000	1	4.900	24.010
				Σ:	**18**	**35.200**	**86.740**	**74**	**132.400**	**308.020**
				μ:	**1.96**			**1.79**		
				σ:	**1.026**			**0.987**		

Table 4

STATISTICS FROM RAW OBSERVATIONS

Combined Periods						
Lane Change Direction:		**Left**			**Right**	
Sample Size:	n_L:	61		n_R:	168	
Avarage Gap Size:	μ_L:	2.02	sec.	μ_R:	1.71	sec.
Standard Deviation:	σ_L:	1.242	sec.	σ_R:	1.032	sec.

Off-Peak Period *10/20/2008 - 0900-0930* *10/23/2008 - 1500-1600*						
Lane Change Direction:		**Left**			**Right**	
Sample Size:	n_L:	43		n_R:	94	
Avarage Gap Size:	μ_L:	2.05	sec.	μ_R:	1.64	sec.
Standard Deviation:	σ_L:	1.329	sec.	σ_R:	1.063	sec.

Peak Period *10/20/2008 - 1600-1615* *10/20/2008 - 1630-1650* *10/23/2008 - 1630-1650*						
Lane Change Direction:		**Left**			**Right**	
Sample Size:	n_L:	18		n_R:	74	
Avarage Gap Size:	μ_L:	1.94	sec.	μ_R:	1.79	sec.
Standard Deviation:	σ_L:	1.033	sec.	σ_R:	0.993	sec.

Table 5 - Chi Squared Test Results

Gap Length	Left Lane Change Maneuvers				Right Lane Change Maneuvers			
Ti (sec)	Observed Frequencies Oi	Expected Probability $p(g \le Ti) = 1-e^{-Ti/\beta}$	Expected Frequencies $Ei = p(g \le Ti)N$	Error Index $(Ei-Oi)^2/Ei$	Observed Frequencies Oi	Expected Probability $p(g \le Ti) = 1-e^{-Ti/\beta}$	Expected Frequencies $Ei = p(g \le Ti)N$	Error Index $(Ei-Oi)^2/Ei$
≤ 0.20	0	0.119	7	7.274	0	0.137	23	22.975
≤ 0.40	0	0.224	14	13.681	1	0.255	43	40.832
≤ 0.60	2	0.317	19	15.531	8	0.357	60	44.997
≤ 0.80	7	0.398	24	12.311	23	0.445	75	35.789
≤ 1.00	14	0.470	29	7.507	41	0.521	87	24.685
≤ 1.20	20	0.533	33	4.824	68	0.586	98	9.434
≤ 1.40	27	0.589	36	2.216	88	0.643	108	3.700
≤ 1.60	31	0.638	39	1.609	101	0.692	116	1.987
≤ 1.80	34	0.681	42	1.371	110	0.734	123	1.430
≤ 2.00	39	0.719	44	0.540	122	0.770	129	0.423
≤ 2.20	40	0.753	46	0.761	129	0.802	135	0.239
≤ 2.40	41	0.782	48	0.944	132	0.829	139	0.376
≤ 2.60	42	0.808	49	1.079	138	0.852	143	0.186
≤ 2.80	43	0.831	51	1.167	142	0.872	147	0.142
≤ 3.00	45	0.851	52	0.922	148	0.890	149	0.015
≤ 3.20	48	0.869	53	0.472	150	0.905	152	0.027
≤ 3.40	50	0.885	54	0.290	153	0.918	154	0.009
≤ 3.60	51	0.898	55	0.263	155	0.929	156	0.008
≤ 3.80	52	0.910	56	0.225	156	0.939	158	0.019
≤ 4.00	53	0.921	56	0.181	159	0.947	159	0.000
≤ 4.20	55	0.931	57	0.055	161	0.954	160	0.003
≤ 4.40	57	0.939	57	0.001	162	0.961	161	0.002
≤ 4.60	61	0.946	58	0.187	165	0.966	162	0.045
≤ 4.80	61	0.953	58	0.144	166	0.971	163	0.053
≤ 5.00	61	0.958	58	0.111	168	0.975	164	0.110
			X^2(hat)	73.668			X^2(hat)	187.486
			X^2(table)	77.931			X^2(table)	197.064

Left		Right	
Critical Gap = β = 1.58 n = 61 l = 1 v = 59 α = 5%	**Since χ2(hat) is less than the threashold error χ2(table), exponential distribution accurately models the observed gap acceptances for left-handed lane change maneuvers.**	Critical Gap = β = 1.36 n = 168 l = 1 v = 166 α = 5%	**Since χ2(hat) is less than the threashold error χ2(table), exponential distribution accurately models the observed gap acceptances for right-handed lane change maneuvers.**

Figure 1- Typical View from TxDOT Video Camera

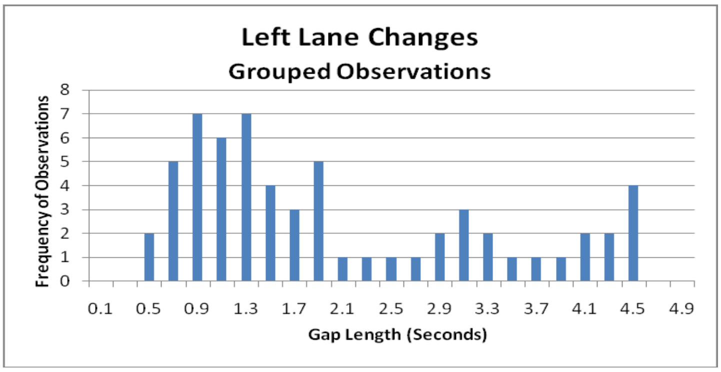

Figure 2

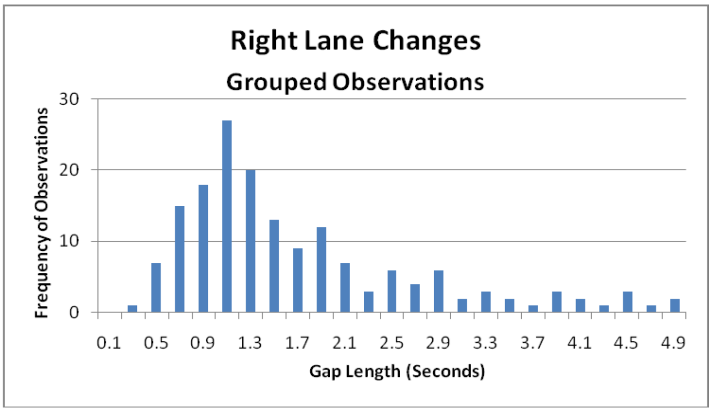

Figure 3

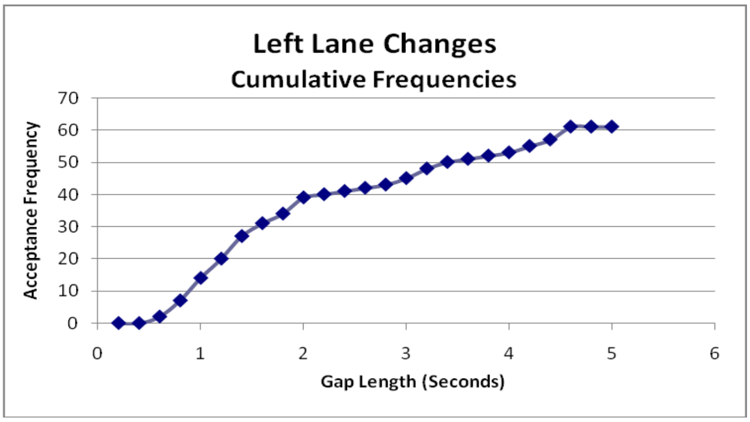

Figure 4

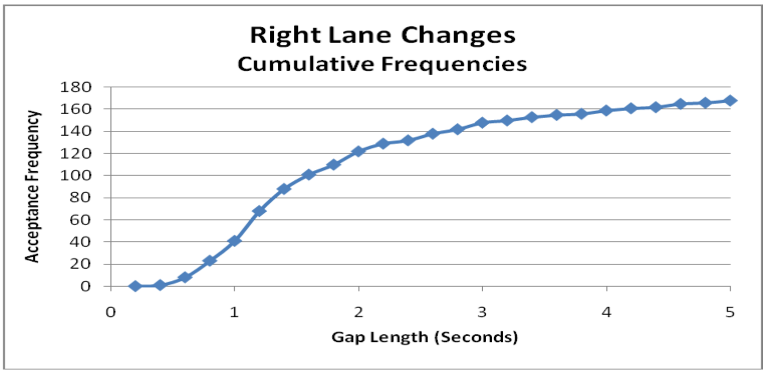

Figure 5

Combined Periods

Lane Change Direction:	Left	Right
Sample Size:	n_L: 61	n_R: 168
Avarage Gap Size:	μ_L: 2.038 sec.	μ_R: 1.712 sec.
Standard Deviation:	σ_L: 1.249 sec.	σ_R: 1.035 sec.

Hypothesis Statement: At a 5% level of significance, freeway drivers accept, on the average, lower gaps to make right-handed lane change maneuvers than they do for left-handed lane change maneuvers.

H_0: μ_R ? μ_L
H_1: $\mu_R < \mu_L$
α: 5%

Alternative 1: Assume variances are known.
(valid since $n_L > 30$ and $n_R > 30$)

$$Z^* = \frac{\mu_R - \mu_L}{\sqrt{\frac{\sigma_R^2}{n_R} + \frac{\sigma_L^2}{n_L}}} = -1.823$$

$Z_{\alpha=5\%} = 1.645$

$|Z^*| >$ 1.645 Therefore, reject H_0.

Conclusion: There is no evidence to suggest that freeway drivers accept the same or larger gaps for right-hand lane change manuevers than they do for left-hand lane changes, therefore we conclude that they accpet shorter gaps for right-hand lane changes.

Alternative 2: Assume variances are estimated.

$$S_P = \frac{(n_L - 1)\sigma_L^2 + (n_R - 1)\sigma_R^2}{n_L + n_R - 2} = 1.096$$

$$t^* = \frac{\mu_R - \mu_L}{S_P\sqrt{\frac{1}{n_R} + \frac{1}{n_L}}} = -1.989$$

$$\nu = n_R + n_L - 2 = 227$$

$t_{\alpha=5\%,\nu=227} = 1.652$

$|t^*| >$ 1.652 Therefore, reject H_0.

Conclusion: There is no evidence to suggest that freeway drivers accept the same or larger gaps for right-hand lane change manuevers than they do for left-hand lane changes, therefore we conclude that they accpet shorter gaps for right-hand lane changes.

Off-Peak Periods

10/20/2008 - 0900-0930
10/23/2008 - 1500-1600

Lane Change Direction:	Left	Right
Sample Size:	n_L: 43	n_R: 94
Avarage Gap Size:	μ_L: 2.072 sec.	μ_R: 1.651 sec.
Standard Deviation:	σ_L: 1.341 sec.	σ_R: 1.073 sec.

Hypothesis Statement: At a 5% level of significance, freeway drivers accept, on the average, lower gaps to make right-handed lane change maneuvers than they do for left-handed lane change maneuvers during off-peak periods.

H_0: $\mu_R \geq \mu_L$
H_1: $\mu_R < \mu_L$
α: 5%

Alternative 1: Assume variances are known.
(valid since $n_L > 30$ and $n_R > 30$)

$$Z^* = \frac{\mu_R - \mu_L}{\sqrt{\frac{\sigma_R^2}{n_R} + \frac{\sigma_L^2}{n_L}}} = -1.811$$

$Z_{\alpha=5\%} = 1.645$

$|Z^*| >$ 1.645 Therefore, reject H_0.

Conclusion: There is no evidence to suggest that freeway drivers accept the same or larger gaps for right-hand lane change manuevers than they do for left-hand lane changes during off-peak periods, therefore we conclude that they accpet shorter gaps for right-hand lane changes.

Alternative 2: Assume variances are estimated.
($n_L < 30$ and $n_R < 30$)

$$S_P = \frac{(n_L - 1)\sigma_L^2 + (n_R - 1)\sigma_R^2}{n_L + n_R - 2} = 1.163$$

$$t^* = \frac{\mu_R - \mu_L}{S_P\sqrt{\frac{1}{n_R} + \frac{1}{n_L}}} = -1.966$$

$$\nu = n_R + n_L - 2 = 135$$

$t_{\alpha=5\%,\nu=31} = 1.656$

$|t^*| >$ 1.656 Therefore, reject H_0.

Conclusion: There is no evidence to suggest that freeway drivers accept the same or larger gaps for right-hand lane change manuevers than they do for left-hand lane changes during off-peak periods, therefore we conclude that they accpet shorter gaps for right-hand lane changes.

Peak Periods

10/20/2008 - 1600-1615
10/20/2008 - 1630-1650
10/23/2008 - 1630-1650

Lane Change Direction:	**Left**	**Right**
Sample Size:	n_L: 18	n_R: 74
Avarage Gap Size:	μ_L: 1.956 sec.	μ_R: 1.789 sec.
Standard Deviation:	σ_L: 1.026 sec.	σ_R: 0.987 sec.

Hypothesis Statement: At a 5% level of significance, freeway drivers accept, on the average, lower gaps to make right-handed lane change maneuvers than they do for left-handed lane change maneuvers during peak periods.

H_0: $\mu_R \geq \mu_L$
H_1: $\mu_R < \mu_L$
α: 5%

Alternative 2: Assume variances are estimated.
($n_L < 30$)

$$S_P = \frac{(n_L - 1)\sigma_L^2 + (n_R - 1)\sigma_R^2}{n_L + n_R - 2} = 0.995$$

$$t^* = \frac{\mu_R - \mu_L}{S_P\sqrt{\frac{1}{n_R} + \frac{1}{n_L}}} = -0.636$$

$$\nu = n_R + n_L - 2 = 90$$

$t_{\alpha=5\%,\nu=72} = 1.662$

$|t^*| <$ 1.662 Therefore, reject H_0.

Conclusion: There is no evidence to suggest that freeway drivers accept shorter gaps for right-hand lane change manuevers than they do for left-hand lane changes during peak periods.

References:

[1]. Henry Lieu (January/February 1999·). "Traffic-Flow Theory". *Public Roads* (US Dept of Transportation) (Vol. 62· No. 4).
[2]. Highway Capacity Manual 2000.
[3]. SATURN ITS Transport Software Site.
[4]. UK Department for Transport's WebTag guidance on the conduct of transport studies.
[5]. Cassidy, M.J. and R.L. Bertini. "Some Traffic Features at Freeway Bottlenecks." *Transportation Research Part B: Methodological* 33.1 (1999) : 25-42.
[6]. Pitstick, Mark E. "Measuring Delay and Simulating Performance at Isolated Signalized Intersections Using Cumulative Curves." *Transportation Research Record 1287* (1990).
[7]. N. Bellomo, V. Coscia, M. Delitala, On the Mathematical Theory of Vehicular Traffic Flow I. Fluid Dynamic and Kinetic Modelling, *Math. Mod. Meth. App. Sc.*, Vol. 12, No. 12 (2002) 1801–1843.
[8]. S. Maerivoet, *Modelling Traffic on Motorways: State-of-the-Art, Numerical Data Analysis, and Dynamic Traffic Assignment*, Katholieke Universiteit Leuven, 2006.
[9]. M. Garavello and B. Piccoli, Traffic Flow on Networks, American Institute of Mathematical Sciences (AIMS), Springfield, MO, 2006. pp xvi+243 ISBN 978-1-60133-000-0.
[10]. Carlos F.Daganzo, "Fundamentals of Transportation and Traffic Operations.",Pergamon-Elsevier, Oxford, U.K. (1997).
[11]. B.S. Kerner, *Introduction to Modern Traffic Flow Theory and Control: The Long Road to Three-Phase Traffic Theory*, Springer, Berlin, New York 2009.
[12]. Cassidy, M.J. and R.L. Bertini. "Observations at a Freeway Bottleneck." *Transportation and Traffic Theory* (1999).
[13]. Daganzo, Carlos F. "A Simple Traffic Analysis Procedure." *Networks and Spatial Economics* 1.i (2001) : 77-101.
[14]. Lindgren, Robert V.R. "Analysis of Flow Features in Queued Traffic on a German Freeway." *Portland State University* (2005).
[15]. Ni, B. and J.D. Leonard. "Direct Methods of Determining Traffic Stream Characteristics by Definition." *Transportation Research Record* (2006).
[16]. N.Taghizadieh,M.Jalilian."New Application Of Genetic Algorithm in Optimization Of Structural Weights"IOSR-JMCE.Jul-Aug.(2013).