Full Length Research Paper

Prediction models for conflict rate in unsignalized intersections

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Most conflicts occurring in intersections are related to left turn of vehicles. Therefore, transportation engineers use access management as an effective tool to improve arterial ways safety specifications to solve the problem and minimize conflicts. The goal of this study is offering prediction models for conflicts in unsignalized intersection for direct left turn (DLT). In other words, these models analyze safety and performance of DLT and they help managers to select the most suitable movement. To do so, a model is calibrated and offered by effective variables of safety of intersections like: left turns volume, traffic volume, lanes width, etc., four models for conflict rate are offered for DLT. Synchro simulation software was used to validate final models of this study. Regarding to the results, one can examine safety of DLT from Major Street to Minor Street in unsignalized intersections, and can analyze access management techniques to improve safety.

Key words: Conflict, left turn, intersection, simulation, modeling.

INTRODUCTION

Traffic conflicts are one of the concerns of today's society. This was started from one century ago by production of the first vehicle. Traffic safety problems are increasing because of social and economic costs to remove them. Transportation engineers and metropolitan managers continuously try to gather necessary safety data to characterize traffic safety problems. Traffic conflicts on intersections are one of the indicators. By traffic conflicts we mean a situation in which because of violation of one or more users, other users must do a runaway maneuver to prevent a conflict. This runaway maneuver can be a sudden brake, sudden line change, etc (Mallah, 2009). Most traffic conflicts in unsignalized intersections are due to left turn. Left turn in unsignalized intersections, especially from minor street to major street creates many problems and increases conflicts, which

this is a great factor for accidents (Liu, 2006).

LITERATURE REVIEW

Traffic conflict rate probability method is one of the main methods of measuring conflict potential in highways and intersections without any need for accidents occurrence. This method was first introduced in 1967 by two researches with cooperation of research laboratory of General Motors. These researchers recognized traffic conflict pattern for more than 20 conflict patterns in intersections. Since any traffic conflict probability is defined based on a certain type of similar accidents, this method was considered as a standard for conflict risk potential. In 1985, many researches and studies were launched and indicated that some certain types of traffic conflict probabilities in intersections are related to each other. It means that conflict probabilities may be considered as a proper substitute for conflict statistics in analysis of roads and intersection safety (Pirinccioglu,

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2008).

In 2003 a research was launched in University of Florida for studying traffic conflict in unsignalized intersections. In this study a model was defined for anticipation of number of collisions in unsignalized intersections. This model depends on the traffic volume in the major and minor road. This research indicated that number of left turns and traffic volume has a major role in the number of conflicts (Gluck, 1999). Also in 1992 salesman studied eight unsignalized intersection and indicated that square of approach volume may well define the relation between conflict and traffic volume (Kennedy, 2006).

TYPE OF MEDIANS

Medians are classified based on the geometric design, access level, access or non-access to left turns and etc. In this research three types of medians were applied:

(i) Opened medians
(ii) Closed medians
(iii) Directional medians

TYPES OF DIRECT LEFT TURN (DLT) CONFLICTS

There are many types of conflicts in direct left turn (DLT). movements that their observation is not simple. So, the most significant conflicts were selected. These conflicts are defined as:

(i) DLT with direct route (CON1)
(ii) DLT with left turn from right (CON2)
(iii) DLT with left turn from left (CON3)
(iv) Left turn with upstream route (CON4) (Figure 1).

GATHERING INFORMATION

Data of this research was gathered by field study from seven intersections of Tehran. Also, it was tried that those situations were similar. Therefore, the following conditions were considered:

1. Major street must at least include three lines in each direction
2. Traffic of highway must be relatively high
3. Intersection angle must be 90°
4. Minor street must have two lines in each directions
5. Minimum distance of minor street with another upstream or downstream signed intersection must be 60 m.

CALCULATION OF CONFLICT RATE

Several conflicts rates can be calculated. These conflict rates are useful for conclusion and problem-solving. Two types of conflicts are used in this study. First conflict is calculated from ratio of number of conflicts on number of hours observed. This conflict is used to analyze conflicts on peak, non-peak, and average times. Second conflict is calculated from ration of conflicts number to engaged traffic volumes. This conflict is used to build anticipation model for conflict rate. Relation 1 shows hourly conflict rate and relation 2 shows volume conflict rate (Allen et al., 2000).

$$CR = \frac{\text{Number of conflicts}}{\text{Hours observed}} \qquad (1)$$

$$CR = \frac{\text{Number of conflicts}}{\sqrt{V1 \times V2}} \times 1000 \qquad (2)$$

in which:
V1 = Number of vehicles in DLT
V2 = Number of vehicles on major street
CR = Hourly or volume conflict rate.

MODELING

There are various modeling methods used for gathering data (Table 1). Linear regression and stepwise variable entrance is used for modeling conflict rate by SPSS software. Conflict rate is dependent variable and geometrical and traffic parameters are independent variables. Relations 3 to 6 show final models of each defined conflict.

CR1 = 5.61 + 0.007 V1 + 0.107 DLT + 4.609 LANE (3)
CR2 = 1.87 + 0.042 V3 + 0.068 DLT (4)
CR3 = 0.52 + 0.081 V4 + 0.023 DLT (5)
CR4 = 2.45 + 0.005 V2 + 0.115 DLT + 3.462 LANE (6)

in which
V1 = Traffic volume in major street downstream
V2 = Traffic volume in major street upstream
V3 = Left turn volume to minor street from right
V4 = Left turn volume to minor street from left
DLT = Direct left turn volume from minor street to major street.

Table 2 shows briefly final results of modeling dependent and independent variables. R1 and Sig in this table show that all independent variables are confirmed by reliability of 95%. Regarding conflict rate model, it is clear that increment of defined vehicles increases DLT conflict rate. Also, increment of major street lanes width increases conflict rate in DLT. Theoretically, increment of major street lanes width causes DLT travel time to increase. Thus, drivers intending to turn left need more gap between vehicles in major streets. Obtaining this gap complicates DLT and consequently increases number of
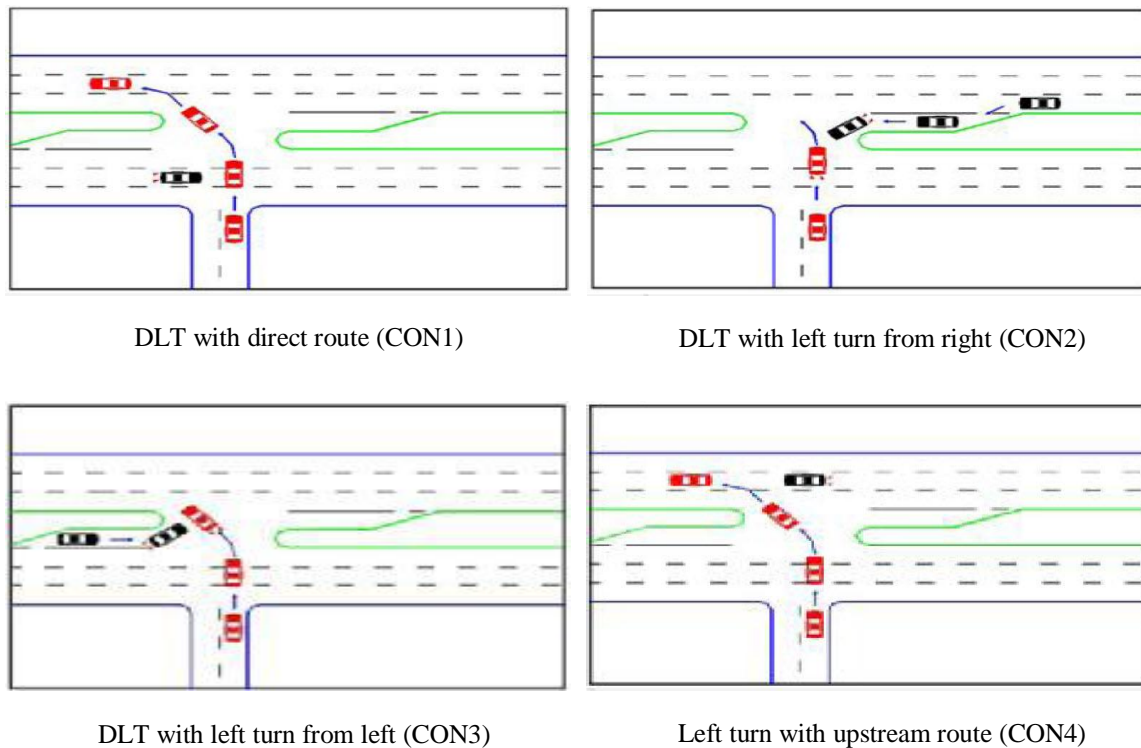
DLT with direct route (CON1)

DLT with left turn from right (CON2)

DLT with left turn from left (CON3)

Left turn with upstream route (CON4)

Figure 1. Types of DLT conflicts.

Table 1. Required data for modeling.

Location	Intersection	Median width (m)	Lane width (m)	C1	C2	C3	C4
1	T-Intersection	4.5	3.30	33	4	-	26
2	T-Intersection	3.5	3	26	4	-	28
3	T-Intersection	3.5	3.6	6	3	-	6
4	X-Intersection	5.5	2.70	22	1	1	22
5	X-Intersection	3.3	3.20	5	3	3	4
6	X-Intersection	3.4	3	6	2	3	2
7	X-Intersection	4.5	3	18	1	0	17

Table 2. Summary of modeling results.

Dependent variable		Independent variable							R^2
		V1	V2	V3	V4	DLT	LANE	Constant factor	
CR1	Factor value	0.007	---	---	---	0.107	4.609	5.61	0.85
	Sig.	0.0045	---	---	---	0.036	0.048	0.012	
CR2	Factor value	---	---	0.042	---	0.067	---	1.87	0.77
	Sig.	---	---	0.049	---	0.050	---	0.022	
CR3	Factor value	---	---	---	0.081	0.023	---	0.52	0.83
	Sig.	---	---	---	0.033	0.042	---	0.048	
CR4	Factor value	---	0.005	---		0.115	3.462	2.45	0.84
	Sig.	---	0.47	---		0.036	0.050	0.027	

Figure 2. Synchro simulation software for confirming final models.

■ Means of simulation conflict rates in one day
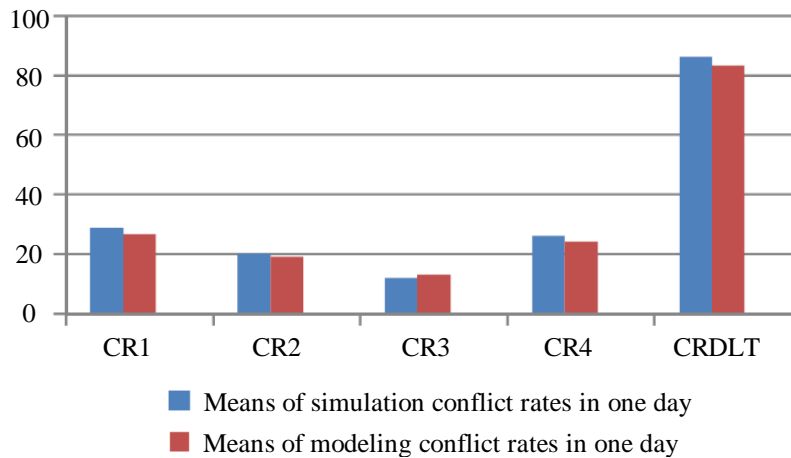■ Means of modeling conflict rates in one day

Figure 3. Means of modeling and simulation conflict rates for direct left turn.

conflicts and conflict rate. However, it seems that conflict rate decreases by increment of major street lanes width, and conflict rate increases by decrement of major street lanes width. In other words, by increment of this gap, drivers have more time to select suitable position to change lane. Rest conflict rate models are distributed around $y = x$ axis. This suggests that error points are random and their distribution is normal.

MODEL CONFIRMATION

Synchro simulation software was used to confirm final models. At first, geometrical and traffic parameters of selected intersections were fed to the software. Then, number of conflicts can be estimated. A simulated intersection sample is shown in Figure 2. Figure 3 show conflict rate obtained from situations simulation and conflict rate from proposed models for DLT. Regarding

these figures, difference between conflict rates from simulation and modeling for DLT is 8.3%. This small difference is due to error of observer. Therefore, regarding to small error percentage, final proposed model is confirmed.

DATA ANALYSIS

Total number of conflicts in DLT movement per day is equal to 864 and conflict rate is 86.44. Among the conflict defined in DLT movement, C1 with an average of 34.49 contributes 32.24% of total conflict rates and C3 with an average of 4.61, contributes 14.09% of total conflict rates. Therefore, in DLT movement conflict between left turn and direct movement in downstream and right turn from the left are the most and least collisions, respectfully.

Statistics indicate that the conflict rate in peak and non-peak hours compared to medium peak hours increases
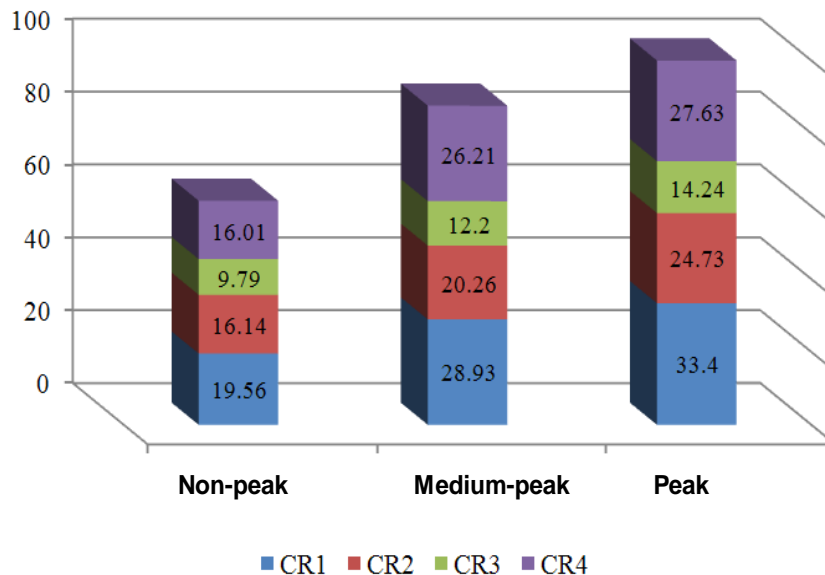
Figure 4. The collision rate of DLT movement in peak, non-peak and medium peak hours.

Table 3. Recommendations for controlling left turns in unsignalized intersections.

Major street volume in one direction (v/h)	Left turn; major street to minor street (v/h)	Direct left turn; major street to minor street (v/h)	Proposed median	
			Close	Directional
	>90	>70	Y	N
1500-200	>90	<20	N	Y
	<20	>70	N	Y
	>80	>60	Y	N
2000-2500	>80	<20	N	Y
	<20	>60	N	Y
	>70	>50	Y	N
2500-3000	>70	<20	N	Y
	<20	>50	N	Y

* Y: Yes, N: No.

and decreases, respectfully. It means as the traffic volume decrease, the number and rate of conflict decreases and as the traffic increases, the number and rate of conflict increase. Figure 4 shows the collision rate of DLT movement in peak, non-peak and medium peak hours.

Conclusion

By using these conflict rate models, some recommendations have been proposed in Table 3 for controlling left turns in unsignalized intersections. These recommendations are based on the least number of conflicts.

The significant results based on the model are represented as follow:

(i) Conflict numbers and rates increase and decrease respectively on peak and non-peak hours than average hours.
(ii) If DLT volume from minor street to major street is high (more than 70 vehicles in hour) and left turn volume from major street to minor street is low (less than 20 vehicles in hour), it is better to use median for enter.
(iii) If left turn volume from major street to minor street is high (more than 90 vehicles in hour) and DLT volume from minor street to major street is low (less than 20 vehicles in hour), it is better to use median for exit.
(iv) If DLT volume from minor street to major street and

from major street to minor street is high (more than 70 vehicles in hour), it is better to use a closed median. In other words, a left turn is converted to a right turn plus a U-turn.

REFERENCES

Allen BL, Cooper PJ (2000). "Analysis of Traffic Conflict and Collisions". Transportation Research Record, N.R.C., Washington D.C.

Gluck J (1999). "Impacts of Access Management Techniques", NCHRP Report 420, Washington, D.C, Transportation Research Board.

Kennedy H (2006). "Unsignalized Intersection Collisions". NCHRP Report 500, Washington, D.C, Transportation Research Board, Spring.

Liu P (2006). "Evaluation of the Operational Effects of U-Turn Movement". University of South Florida.

Mallah M (2009). "Development of A Conflict Rate Prediction Model at Unsignalized Intersection". University of South Florida.

Pirinccioglu F (2008). "Safety Impacts of Right Turns Followed by U-Turns". University of South Florida