

Traffic Conflict Technique to Predict Countermeasure Effectiveness at 3-legs Signalized Intersections

تقنية التعارضات المرورية للتنبؤ بكفاءة المعالجات المضادة على التقاطعات
الثلاثية المسيطر عليها بإشارات ضوئية

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Abstract:

Traffic accident reduction is a measure to evaluate the effectiveness of any proposed countermeasure. A draw back of estimating this reduction is that, traffic accidents involve; rare occurrence, under-reporting, unreliability, and difficult observation. This paper aims at estimating the effectiveness of countermeasures using traffic conflict technique (T.C.T) as alternative.

This paper involves a study of the traffic operations and safety analysis for a sample of three legs signalized intersections in Baghdad City. Traffic and conflict data are collected through observation of the selected sites. Regression analyses are performed to relate hourly traffic conflict and average stopped delay. Some countermeasures of traffic control and geometric design are adopted. Analysis of traffic operation before and after countermeasure is implemented using HCS software.

A developed statistical model indicates that 92.5 % of variation in hourly traffic conflict can be predicted significantly by average stopped delay. A countermeasure can be evaluated due to before and after average stopped delay based on HCS output and accordingly the involved conflicts based on the developed statistical model. The results show that, more than 35 % of potential conflicts can be reduced due to countermeasures and the highest reduction (62.6 %) is introduced due to increase of lane width. This paper maximizes the usefulness of T.C.T as a tool to predict the effectiveness of any proposed countermeasure before its implementation.

الخلاصة :

تقليل حوادث المرور هو مقياس لتقييم كفاءة أي معالجات مضادة مقترحة. من المعوقات لتخمين هذا التقليل، إن حوادث الطرق تكتنفها؛ ندرة الحدوث، قلة التوثيق، عدم الموثوقية، وصعوبة الملاحظة. هذه الورقة تهدف إلى تخمين كفاءة المعالجات المضادة باستخدام تقنية التعارضات المرورية كبديل.

تتضمن الورقة دراسة عمليات المرور وتحليل السلامة لعينة من ثلاثة تقاطعات ثلاثية مسيطر عليها بإشارات ضوئية في مدينة بغداد. تم جمع بيانات عن المرور والتعارضات عبر مشاهدات على المواقع المختارة. أجري تحليل الانحدار لارتباط التعارضات المرورية الساعية مع زمن التأخير. تم اختيار بعض المعالجات المضادة للسيطرة المرورية والتصميم الهندسي. تم إجراء تحليل عمليات المرور لما قبل وبعد المعالجات المضادة باستخدام برنامج دليل السعة المروري (HCS).

أظهر النموذج الإحصائي المستحدث أن 92.5% من التغير في التعارضات المرورية يمكن التنبؤ بها، وبمعنوية إحصائية بدلالة زمن التأخير. يتم تقييم كفاءة المعالجات المضادة المختارة استناداً إلى: زمن التأخير القبلي والبعدي حسب مخرجات برنامج السعة المروري، والتعارضات المرورية المتعلقة استناداً إلى النموذج الإحصائي المستحدث. أظهرت النتائج أن أكثر من 35 % من التعارضات المحتملة يمكن تقليلها بعد إجراء أية معالجة وأعلى تقليل (62.6%) ظهر في معالجة زيادة عرض المسرب. هذه الورقة تعظم فائدة تقنية التعارضات المرورية للتنبؤ بكفاءة المعالجات المضادة قبل تنفيذها.

1. Introduction

According to 2002 data compiled by the National Highway Traffic Safety Administration, 21 percent of crashes and 24 percent of all fatalities and injuries occurred at signalized intersections [1]. This is because, signalized intersections involve traffic movements most

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frequently conflict with one another. Hence, improving road traffic safety at such sites is highly appreciated to save human and properties.

Accident reduction is a measure to evaluate the effectiveness of any proposed countermeasure. A draw back of estimating this reduction is that, traffic accidents involve; rare occurrence, under-reporting, unreliability, and difficult observation. This paper aims at predicting the effectiveness of countermeasures using traffic conflict technique (T.C.T) as alternative before its implementation.

2. Traffic Conflicts and Accidents

Parker and Zegeer (1988) ^[2] define traffic conflict technique as" an event involving two or more road user which the action of one user causes the other user to make an evasive maneuver to avoid collision. Further, traffic conflict technique (TCT) can be considered as an indirect measure of traffic safety. The technique itself is grounded in the ability to register the occurrence of near-accidents directly in real time [3]. Glauz *et al* (1985) ^[4] reported that conflict data is not used to predict crash rates, but rather as a surrogate measure of safety when crash data is insufficient. Also, Svensson 1992 ^[5] stated that serious conflict provides a better estimate of the number of expected accidents involving personal injury.

Gledec 1996 [6] recommended applying the traffic conflict technique because it has a good correlation with the accidents and that these techniques are (mainly) evaluated in a satisfying way as a procedure used for establishing the risk in road traffic.

3. Traffic safety and Countermeasures

The most desirable improvement alternative is specified according to the expected project costs and accident benefits for each alternative. Accident benefits include accident costs, interest rates, project service life, accident reduction, and traffic growth factors [7].

There are 11 variables significantly affected the safety at intersections , the total approach volume , the number of phases per cycle , the uncontrolled left – turn lane are among the variables that are the highly significant [8] . Experience has shown that low cost changes at urban signalized intersections can lead to significant safety improvements.

The process of countermeasure development should aim to obtain measures that have; high effectiveness (ability to reduce number and/or severity of accidents), and reasonable cost effectiveness (high benefit-cost ratio). Table (1) shows a review summary of some countermeasures adopted to reduce percent of traffic accidents. In reference to the correlation found between traffic accidents and conflicts, it can be concluded that there is an expected relation between the effectiveness of countermeasures to reduce accidents and already conflicts.

4. Site selection

Three 3– leg signalized intersections in Baghdad city in 2003 are selected for analysis according to the guidelines recommended by FHWA ^[2], where the specific intersections has no pedestrian facilities, no appreciable grades and had entering traffic volume more than 1000 vehicle per day. Three signalized 3-legs intersections are selected to conduct the study; Adu-Talib, Ras Al-Hawash, and Al-Emam Al-Adham intersections.

5. Data collection

According to the definition of FHWA the data are collect by using a Sony video digital, 700x/ zoom, high quality USB streaming. A four weekday (4 hour minimum at each day), traffic conflict study was conducted at each of the intersections selected. Data was collected between the hours of 7:00 A.M. and 6:00 P.M. The data collection procedure included a 10

minute set – up period before the start of the conflict study followed by data collection for 20 minutes, and then changes the place of set – up the video camera. Video tapes are played back in the laboratory to process and extract conflict data and for supplementary observations of traffic volume, geometric design, and cycle time.

6. Conflict type

Traffic conflicts are generally categorized by type of maneuver [16]. Four types of conflicts are observed at 3– legs signalized intersections:

- **Slow vehicle:** A slow vehicle conflict occurs when the first vehicle slows while approaching or passing through the intersection, placing a second, following vehicle in danger of a rear – end collision.
- **Lane change:** Lane change conflict occurs when the first vehicle changes from one lane to another, thus placing a second, following vehicle in the new lane in danger of a rear – end or sideswipe collision.
- **Right turn same direction:** A right turn same direction conflict occurs when the first vehicle slows to make a right turn, thus placing a second, following vehicle in danger of a rear – end collision.
- **Left turn same direction:** A left turn same direction conflict occurs when the first vehicle slows to make a left turn, thus placing a second, following vehicle in danger of a rear – end collision.

7. Traffic Operation and Conflict Analysis

Average stopped delay at each approach is a measure used to represent the traffic operation at the study intersections. Before analysis is performed on all study intersections using; existing traffic control, lane configuration, and traffic volumes as input. Software of HCM 2000 is used to determine the average stopped delay for all approaches in the study intersections. On the other hand, traffic conflicts at each approach are obtained due to different type of conflict. It is intended to conduct the study for the total traffic conflict rather than for each type of conflict. However, the extension of the concept and methodology presented in this study may be easily extendable to each type of conflicts and other types of intersections and traffic control as well. The relation between the average stopped delay at each approach due to the output of HCS and the involved hourly traffic conflicts is detected through a linear regression analysis. Figure (1) shows that a linear relation explains increasing variation (92.5 %) of hourly traffic conflict in relation with average stopped delay according to the following statistical model:

$$C = 1.605 * D - 67.57 \quad (R^2 = 0.925) \dots\dots\dots 61 \leq D \leq 96$$

Where:

C = hourly traffic conflict at approach

D = Average stopped delay at approach

Parameters of the statistical model are summarized as follows:

R	R ²	F sig.	Stand. Error	P-value Intercept	P-value Delay (D)
0.962	0.925	3.46E-05	6.24026	0.001734	3.46E-05

8. Selection of Proposed Countermeasures

According to the criteria in article 3 and in reference to Table (1), five countermeasures are selected to demonstrate the procedure of predicting any proposed one:

- Optimization of cycle length from 80 sec to 110.
- Use of a Permitted Left Turn Treatment.
- Use of a Protected Left Turn Treatment.

- Increase lane width (existing lane width is ranged between 2.8m to 3.6m and increased to 3.65m)
 - Increase number of lane (existing number of lane is three and proposed increase to four)
- However, this selection should not preclude the possibility of addressing the traffic safety issues at the study intersections by mean of other countermeasures of traffic operations and geometric design.

9. Prediction of Countermeasure Effectiveness

Traffic operation analysis is conducted for the condition of the proposed countermeasures. HCS outputs are reduced and summarized for the average stopped delay each approach. Table (3) shows that average stopped delay is decreased due to the entire proposed countermeasure. Furthermore, LOS is enhanced from F to E in many approaches and the most effective countermeasures are; cycle time optimization and increase in number of lanes. Based on the developed statistical model in equation (1), the potential conflict (after a proposed countermeasure) is predicted at each approach. Percentages of reduction in conflicts (C.R.) can be determined by the following equation:

$$C.R. = (C_{\text{before}} - C_{\text{after}}) / C_{\text{before}} \dots\dots\dots(2)$$

Figure (2) shows that a percentage of reduction; more than 69 % in average stopped delay as well as more than 35 % hourly conflicts, are achieved. It can be seen that the percentages of reduction in traffic conflicts predicted in case of each proposed countermeasure, goes with that ones reviewed in Table (2).

10. Conclusions

- A developed statistical model indicates that 97 % of variation in hourly traffic conflict can be predicted significantly by average stopped delay.
- A countermeasure can be evaluated due to before and after average stopped delay based on HCS output and accordingly the involved conflicts based on the developed statistical model.
- A percentage of reduction; more than 69 % in average stopped delay is achieved due to each proposed countermeasure. Furthermore, LOS is enhanced from F to E in many approaches and the most effective countermeasures are; cycle time optimization and increase in number of lanes.
- The results show that, more than 35 % of potential conflicts can be reduced due to each countermeasure of; signal optimization, use of permitted or protected left-turn, increase of number or width of lanes. This result goes with the percentage reductions reported in Table (1). The highest reduction (62.6 %) is introduced due to increase of lane width because the existing lane width is out of the standard and result in unsafe movements of road users.
- This paper maximizes the usefulness of T.C.T as a tool to predict the effectiveness of any proposed countermeasure before its implementation.
- The proposed countermeasures strategies show that :
- Optimization of cycle length from 80 sec to 110 sec reduces average stopped delay 73.21 % while it reduces hourly traffic conflict 42.27 %.
- Use of a Permitted Left Turn countermeasure reduces average stopped delay 71.23 % while it reduces hourly traffic conflict 39.62 %.
- Use of a Protected Left Turn countermeasure reduces average stopped delay 79.26 % while it reduces hourly traffic conflict 53.39 %.
- Increase lane width countermeasure reduces average stopped delay 82.37 % while it reduces hourly traffic conflict 62.64 %.
- Increase number of lane countermeasure reduces average stopped delay 69.40 % while it reduces hourly traffic conflict 35.85 %.

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Table (1) Review Summary of Adopted Countermeasures at Signalized Intersections

Author	Type of countermeasures	Reduction in accident %
Ogden, K.W. 1997 [9]	Modified traffic signal	30-80
Institute of transportation Engineers 1999 [10]	Provide left turn lane	25-36
Thomas ,Gary B. & Daniel J.2001 [11]	Add left turn phasing	46-69
Polanis , Stanley F. 2003 [12]	Add protected / permitted LT phase	4-10
NCHRP 2003 [13]	Add left turn phasing	23-48
Jone 2005 [1]	Displaced left turn lane	48-85
Agent , Kenneth 1996 [14]	Additional lane	5-56
Gluck et al. 1999 [15]	Installation of left-turn lane	54

Table (2) Summary of HCS Output for Average Stopped Delay Due to The Proposed Countermeasures

App. No.	Delay (sec / stopped veh.)- (L.O.S)					
	Type of Countermeasure*					
	before	(1)	(2)	(3)	(4)	(5)
1	61(F)	55 (E)	48 (E)	58 (E)	47 (E)	50 (E)
2	82(F)	57 (E)	50 (E)	64 (F)	75 (F)	54 (E)
3	96(F)	58 (E)	72 (F)	66 (F)	80 (F)	57 (E)
4	66(F)	46 (E)	47 (E)	62 (F)	54 (E)	48 (E)
5	85(F)	60 (E)	60 (E)	65 (F)	72 (F)	58 (E)
6	88(F)	53 (E)	52 (E)	56 (E)	76 (F)	50 (E)
7	93(F)	84 (F)	77 (F)	82 (F)	67 (F)	76 (F)
8	70(F)	56 (E)	53 (E)	57 (E)	58 (E)	52 (E)
9	68(F)	50 (E)	46 (E)	52 (E)	55 (E)	47 (E)

* (1): optimization of cycle length from 80 sec to 110 sec. *

(2) Use of A permitted Left Turn Treatment.

(3) Use of A protected Left Turn Treatment.

(4) Increase lane width.

(5) Increase number of lane.

Table (3) Predicted Traffic Conflicts Based on the Developed Statistical Model Due to The Proposed Countermeasures

App. No.	Traffic Conflicts /hr					
	Type of Countermeasure*					
	before	(1)	(2)	(3)	(4)	(5)
1	34	19	12	26	11	13
2	54	25	13	33	57	17
3	89	26	47	37	60	25
4	34	8	11	30	17	12
5	61	28	28	35	47	26
6	78	17	16	20	57	13
7	87	68	58	61	38	57
8	47	20	17	25	26	16
9	46	13	8	16	19	11

* (1): optimization of cycle length from 80 sec to 110 sec. *

(2) Use of A permitted Left Turn Treatment.

(3) Use of A protected Left Turn Treatment.

(4) Increase lane width.

(5) Increase number of lane.

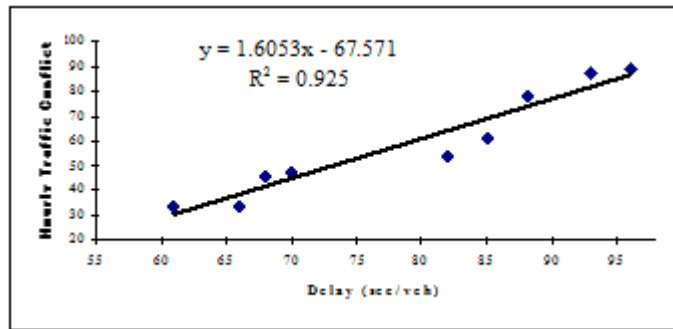
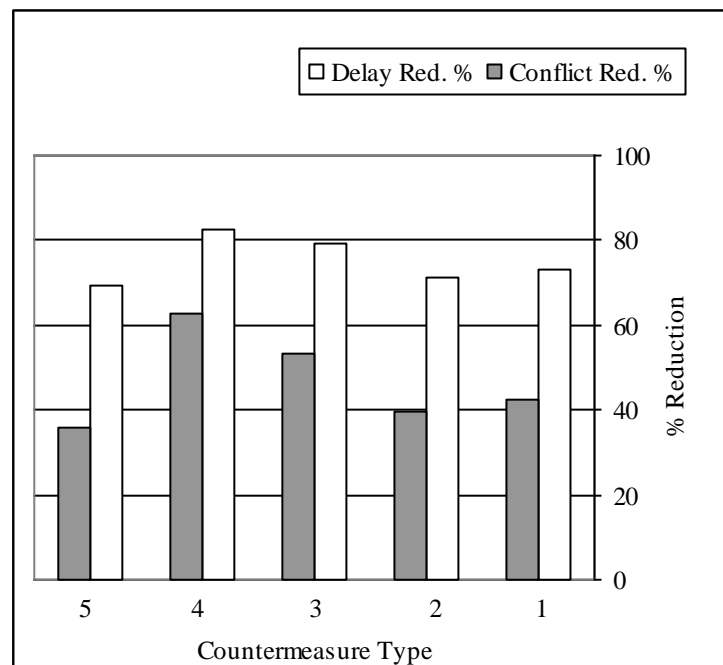


Figure (1) Linear Relationship between Hourly Traffic Conflict & Average Stopped Delay



- 1- optimization of cycle length from 80 sec to 110 sec
- 2- use of a Permitted Left Turn Treatment.
- 3- use of a Protected Left Turn Treatment.
- 4- increase lane width.
- 5- increase number of lanes.

Figure (2) Percent of Reduction in Hourly Traffic Conflicts & Average Stopped Delay after adopting the Proposed Countermeasures