Elements of Traffic Conflict Techniques in Czech Republic

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1 Abstract summary

This paper presents methodology for application of traffic conflicts techniques in Czech Republic. This issue is part of safety analysis. Based on traffic survey in pilot locality relative index of traffic conflicts was calculated. The hypothesis of problematic geometric characteristics in pilot locality was specified. The safety of selected roundabout was tested by Bayesian approach to model hypotheses and result is index of risk.

2 Extended abstract

2.1 Introduction

In most road safety studies, analysts use the information contained on accident reports to identify and understand failures of the road system and then propose appropriate corrective actions. While these analyses are essential, it is well recognized that accident data suffer from a number of shortcomings and need to be complemented by field observations in order to improve the accuracy of safety diagnoses. Over the years, different tools have been proposed to assist safety analysts in making these field observations and formalized techniques have been developed (e.g. traffic conflict techniques, road safety audits …). In a traffic conflict study, trained observers watch the traffic and note the frequency and types of conflicts that occur at a specific location. Traffic conflict studies are primarily conducted at urban intersections, where these events are more frequent. Since conflict studies imply direct observations of road user's behavior, they help in identifying maneuvers that are particularly hazardous and in finding improvements that could alleviate these problems. It should be noted that the introduction of traffic conflict techniques initiated a long-standing debate concerning their validity as an accident estimator. A clear answer to this question has yet to be found but research has shed some interesting light on the topic [1].

The research is focused on traffic conflicts as an alternative to accident data. Conflicts occur far more frequently in traffic and can include the whole range of incidences where the actual accident is just at one end of the scale. Techniques range from subjective to the more objective where conflicts are rated by measurements such as time to collision or post encroachment time. This research follows the dissertation work [5] and the research of Mr. Folprecht [6].

2.2 Traffic conflict Techniques

The main advantage of conflict studies over accident studies is that it is not necessary to wait several years before gathering sufficient data to complete the evaluation. A conflict study can be conducted soon after work has been completed and negative can be made quickly if anticipated benefits have not been achieved (or if unexpected side effects have been created). In these studies, traffic conflicts need to be observed before and after the implementation of the treatment. A well-accepted definition of traffic conflict is: *"an observable situation in which two or more road users approach each other in space and time to such an extent that there is a risk of collision if their movements remain unchanged"* [2].

For traffic conflict techniques is necessary to define the 5 basic questions:

a) Why to analyze traffic conflicts

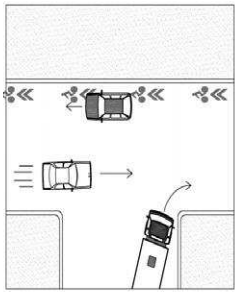
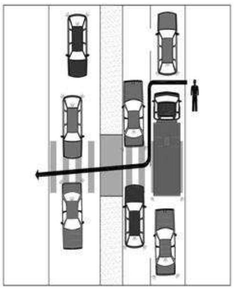
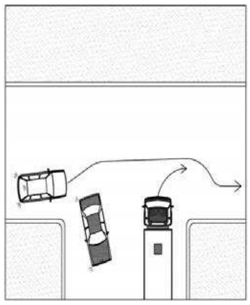
A traffic conflict study can be used:

- to make progress in a safety diagnosis (to evaluate the effectiveness of a safety treatment);
- to compare the safety performance of different road features or traffic rules.

b) Conflict severity

Most traffic conflict techniques (TCTs) categorize conflicts based on their severity (e.g. serious or non-serious). Some TCTs use subjective criteria to determine conflict severity.

For the TCTs purposes three levels of conflicts have been defined. For the complex analysis of the studied locality even so called level 0 and level 4 can be monitored. Thus there are 5 levels altogether (Figure 1). We will describe the constituent levels of conflict severity now.

		
Level 0	Level 1	Level 2

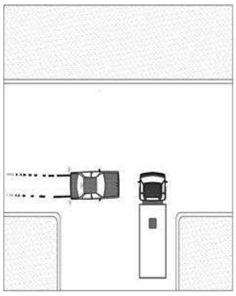
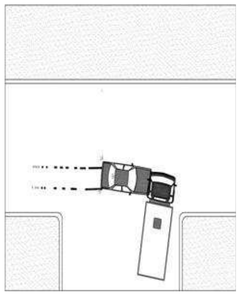
	
Level 3	Level 4

Figure 1: Example of traffic conflict severity

The first level (level 0) is used for the record of mere breaking road traffic rules of the isolated vehicle. The level 1 is assigned to the controlled maneuver without any limitation or just with minor limitation. The difference between level 1 and level 2 is minor. In spite of that, it is necessary to realize, that in some specific situations (the example with pedestrians - see above) it is necessary to sort out this kind of conflict into less severe and more severe (level 2). The conflict level 3 is assigned to such situations, when the road users are threatened and sharp maneuver (loud breaking supplemented for example with beeping) is necessary to avert traffic accident. Level 4 is accident. Example of traffic conflict record is illustrated in Figure 2.

Traffic conflict record		**O / B – 1**	
		Problem creator / respond – conflict severity	
Comment:			
O	personal vehicle	B	bus
N	small largo vehicle	T	tramway
NT	long largo vehicle	Ch / C	pedestrian / cyclist

Figure 2: Example of traffic conflict record

c) Types of traffic conflicts

As in the case of accident analyses, it is quite useful to subdivide traffic conflicts into different categories, based on their type. This allows the preparation of summary tables, graphs and diagrams that facilitate the interpretation of results (comparisons with sites having similar characteristics and detection of deviant types of traffic conflicts). Our research defined 14 types of conflicts between 2 vehicles and 1 example of secondary conflict.

However, some of these conflicts have very low rates of occurrences, which reduce their usefulness. The number of conflict types rises quickly when those that may occur between motorized and non-motorized road users are added to the list (pedestrians, cyclists, others). The list of conflict types that may be observed at a site depends upon its prevailing traffic rules and geometric characteristics; this list should be determined prior to initiating the study. It is not necessary to observe all traffic conflicts that may occur at a site in all conflict studies. If, for example, the objective is to compare the performance of two left-turn treatments at intersections, it might very well be sufficient to collect conflicts that are related to this maneuver.

d) How to conduct a traffic conflict study

A number of elements need to be considered in the planning of a traffic conflict study:

- personnel training;
- observation technique;
- observation period.

e) Traffic conflict summary - presentation

Before initiating the analysis, the observer must complete all the information on the traffic form heading to ensure that the location and observation conditions will be readily recognized in the future: municipality, intersection, approach, date, time, weather conditions and other comments.

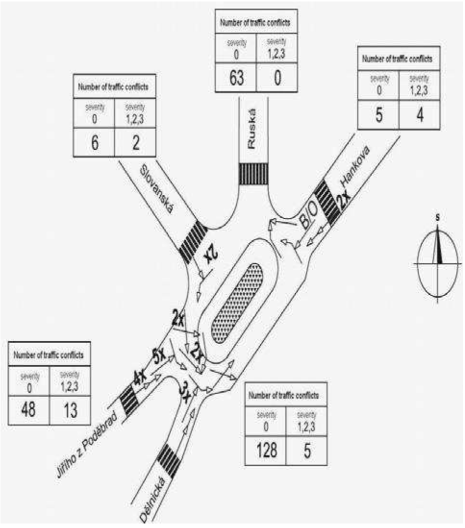
Once observations have been completed, data must be reduced and summaries prepared. Results are presented either in summary tables or in traffic conflict diagrams (Figure 3). Summary tables allow comparisons of conflict rates between the site being analysed and sites with similar characteristics, which is useful in detecting deviant patterns. The logic behind these analyses is similar to that of the accident pattern analysis. Traffic conflict diagrams are quite similar to the collision diagrams. They facilitate the identification of repetitive conflict patterns that are concentrated in some travel directions and intersection areas. As a result of traffic conflicts survey has been chosen simple relative index $\mathbf{k_R}$.

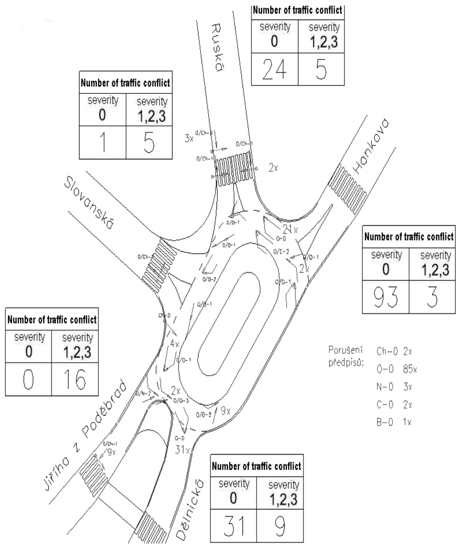
$$\mathbf{k_R = (P_{ks}/I) \times 100} \text{ [conflict situations /100 reduction vehicles]}$$

P_{ks} ... conflict situations per hour (only conflicts of levels 1 – 3)

I ... traffic volume rv/h (reduction vehicle per hour)

Pilot survey was realized in Děčín (roundabout "Dělnická – Hankova – Ruská") by students of the CTU FTS. Result is illustrated in Figure 3.





2007				2009			
conflict situations according to conflict severity				conflict situations according to conflict severity			
0	1	2	3	0	1	2	3
250	12	7	5	149	24	12	2
relative index of traffic conflicts k_R [conflict situations /100 rv]							
k_R =(24/1417)×100 = **1,69**				**k_R** = (38/1233)×100 = **3,08**			

Figure 3: Traffic conflicts survey at the roundabout in Děčín

2.3 Bayesian approach to model hypotheses

The hypotheses were defined according to particular parts of the intersection on the basis of described safe status on roundabouts in Děčín (see above). We will demonstrate the hypothesis „too much wide ring road belt" on a problematic intersection in Děčín.

We are trying to find out, if monitored character V („too much wide ring road belt") is bigger than allowed per cent traffic conflict (TC). Let's define index of risk.

a) Model of data

We think over model for character V in the shape of:

$$f(y_t|\vec{\alpha}) = \alpha_{y_t} \qquad \text{(eq. 1)}$$

where

- y_t is the traffic conflict ($y_t = 1 \rightarrow$ traffic conflict of level 1 – 3; $y_t = 2 \rightarrow$ the safe crossing–over);
- $\alpha = [\alpha_1, \alpha_2]$ is the vector of probability ($\alpha_1 > 0$, $\alpha_2 > 0$, $\alpha_1 + \alpha_2 = 1$);
- $f(\cdot|\cdot)$ is the plausibility probability function.

It is better to express the model in the following form:

$$f(y_t|\alpha) = \alpha_1^{\delta(y_t,1)}(1-\alpha_1)^{\delta(y_t,2)} \quad \text{(eq. 2)}$$

where: $\delta(i, j) = 1 \rightarrow i = j$; $\delta(i, j) = 0 \rightarrow i \neq j$.

b) The model of parameters

We will find the recursive form of a prior density in adjoint shape:

$$f(\alpha|A_P) \propto \alpha_1^{S_{1,0}}(1-\alpha_1)^{S_{2,t}} \quad \text{(eq. 3)}$$

where normative constant si beta function B ($S_{1,0}$, $S_{2,0}$). That is why the posterior density of probability will be in this shape:

$$f(\alpha|y(t)A_P) \propto \alpha_1^{S_{1,t}}(1-\alpha_1)^{S_{2,t}} \quad \text{(eq. 4)}$$

where

- A_P is a prior knowledge of model of parameter;
- **B** $(S_{1,t}, S_{2,t}) = \int \alpha_1^{S_{1,t}}(1-\alpha_1)^{S_{2,t}} d\alpha$ is the normative index.

The letter $S_{j,t}$ where j = 1, 2 is statistic of parameter estimation α for the data sample y(t). $S_{j,0}$ is a prior statistic for estimation α. From the Bayes formula it is possible to express recount of statistic according to the following relationship:

if $y_t = i$, than

$$S_{j,t} = \begin{cases} S_{j,t-1} + 1 & \text{for } i = j \\ S_{j,t-1} & \text{for } i \neq j \end{cases} \quad \text{(eq. 5)}$$

c) Test of the model

Our aim is to test parameter of the model α.

Null hypothesis H_1: $\alpha < \alpha_h$, correspond to the case, when traffic conflict probability is as low, that we can accept it → intersection is safe.
Alternative hypothesis H_2: $\alpha \geq \alpha_h$, it is inconsistent with null hypothesis and so → intersection is not safe.

Number α_h is marginal probability for traffic conflict, we are willing to accept. Choice of this number count among a prior expert knowledge of traffic specialist.

By Bayes test of hypotheses about character V we count probability of particular hypotheses according to the formula:

$$\frac{P(H_1 | y(t), A_H, A_P)}{P(H_2 | y(t), A_H, A_P)} = \frac{I_{1,t}(y(t), A_P)}{I_{2,t}(y(t), A_P)} \frac{P(H_1 | A_H)}{P(H_2 | A_H)} \qquad \text{(eq. 6)}$$

where

- $\mathbf{y_t}$ is data (monitored quantites traffic conflicts);
- $\mathbf{A_H}$ is next a prior knowledge, related to the probability of particular hypotheses acceptance;
- $\mathbf{I_{k,t}}$ integral is set by the formula $I_{k,t} = \int L_t f(\alpha | A_P) d\alpha$ where O_k indicate subject of non–null parameter α according to k–hypothesis and L_t is the plausibility function $L_t = \prod f(y(t)|\alpha)$.

d) Algorithm of the testing

1) Input data

- Marginal probability of the traffic conflict α_h is [α ‹0,1›];
- A prior probability of particular hypotheses → $p_1 = f(H_1|A_H)$, $p_2 = f(H_2|A_H)$ is [$p_1, p_2 > 0$, $p_1 + p_2 = 1$];
- A prior data or another piece of information about supposed traffic conflict or accident index → $S_{1,0}$, $S_{2,0}$ *[whole, non negative numbers];*
- Measured data $y(t) = \{y_1, y_2, ..., y_n\}$ *measured traffic conflicts ($y_i = 1$ for TC, other wise $y_i = 2$).*

2) Calculation

- statistic of the estimation

$$S_{1,t} = S_{1,0} + \sum \delta(y_\tau, 1) \quad , \quad S_{2,t} = S_{2,0} + \sum \delta(y_\tau, 2) \qquad \text{(eq. 7)}$$

- integrals

$$I = betainc(\alpha_h, S_{1,t}, S_{2,t}) \quad , \quad I_{k,0} = I \quad , \quad I_{k,t} = 1 - I \qquad \text{(eq. 8)}$$

- probability of the hypotheses rate

$$P = \frac{I_{1,t}}{I_{2,t}} \frac{p_1}{p_2} \qquad \text{(eq. 9)}$$

- probability of the hypotheses

$$P_1=(H_1|y(t),A_P,A_H)=\frac{P}{P+1} \quad \text{(eq. 10)}$$

$$P_2=(H_2|y(t),A_P,A_H)=\frac{1}{P+1} \quad \text{(eq. 11)}$$

3) Result

We will accept the hypothesis with the highest probability.

e) Significance of the a prior parameters and the example of the model usage

First of all it is necessary to set some a prior constant, which express the traffic knowledge of the expert, who set the test. There are the following constants:

- α_h is the marginal probability for tolerated traffic conflict*;*
- A_P is a prior knowledge of the parameter α. It stands:
  - $\hat{\alpha}_0 = S_{1,0} S_{1,0} + S_{2,0}$, where $S_{1,0}$ and $S_{2,0}$ are a prior statistics;
  - the bigger the a prior statistics are, the more is the value of a prior
  - parameter estimate enforced against measured data;
  - the summary: A prior statistic relationship set promoted estimate value
  - α and the size of a prior statistic set the force with which a prior values
  - are enforced.
- A_H is a prior knowledge about hypotheses is represented by two numbers p_1 and p_2 with the characters of the probability which express the degree of expert's assurance in particular hypotheses.

You can find example of the result from tested roundabouts in Děčín in figure 4. The combination of empirical Bayesian methods and multivariate statistical models are now seen as a more accurate method of identification of road safety problems (than traditional methods) as it reduces selection biases related to the random nature of accidents. While this increased sophistication might not be necessary when problems are obvious, which is likely to be the case in the early stages of road safety interventions, the application of these methods can be greatly facilitated by making a proper use of inexpensive computer technologies.

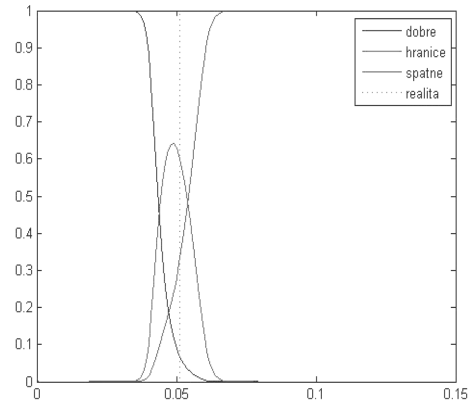
Number of measured data intensity (ndat)	1233	
Rate (ai) traffic conflicts / intensity	3	
Weight of the a prior information α (na)	100	
Real a prior α (α0)	0,02%	
Marginal probability of the hypotheses (thH)	0,05%	
Numbers after setting norms of a prior hypotheses probability – expert has no opinion (p0H)	[1,1.5]	
Result of risk index: Roundabouts is not good enough.		The density is 0,32. The result for tested hypothesis („too much wide ring road belt") is „**incorrect**"

Figure 4: Roundabout in Děčín (2009) – the algorithm

2.4 Conclusion

The article deals mainly with defining the way of monitoring traffic conflicts. This issue is part of safety analysis. The results of traffic conflict observations are used to diagnose safety and operational problems and to evaluate the effectiveness of treatments. I applied traffic conflict technique to estimate the traffic safety at non–signalized intersections (roundabouts). Based on traffic survey in pilot locality relative index of traffic conflicts was calculated. At this stage, it is not possible to set the overall risk result of the monitored intersection yet. The hypothesis of problematic geometric characteristics in pilot locality was specified. The safety of selected roundabout was tested by Bayesian approach to model hypotheses. As a result, the crossing either passes or fails (the index of risk is either good or bad).

There are many possibilities, depending on the available information. If accident data, traffic conflict data, road data and traffic data can be linked, queries that integrate these various types of information can be made (e.g. a search for urban intersections with a high proportion of right-angle accidents and heavy conflicting traffic flows at peak hours, that may be potential candidates for traffic signals). Moreover, when the cost of a treatment and the cost of accidents it could eliminate are also known, the identification can go one step further and include a preliminary estimate of the cost-effectiveness of a given type of action. With current technologies and knowledge, identification procedures can now be much more sophisticated than a few decades ago. Analysts should make good use of these possibilities in order to improve the efficiency of their work, rather than relying only on traditional identification methods.

2.5 Acknowledgment

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