Accident Analysis and Prevention 73 (2014) 274–287

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

A model to identify high crash road segments with the dynamic segmentation method

Amin Mirza Boroujerdian [a,*], Mahmoud Saffarzadeh [a], Hassan Yousefi [b,c], Hassan Ghassemian [d]

[a] Faculty of Civil & Environmental Engineering, Tarbiat Modares University, Tehran, Iran
[b] School of Civil Engineering, Faculty of Engineering, Tehran University, Tehran, Iran
[c] Institute of Structural Mechanics (ISM), Bauhaus-University Weimar, 1599423 Weimar, Germany
[d] Faculty of Electrical & Computer Engineering, Tarbiat Modares University, Tehran, Iran

ARTICLE INFO

Article history:
Received 20 November 2013
Received in revised form 6 September 2014
Accepted 11 September 2014
Available online xxx

Keyword:
High crash road segment
Segmentation
Prioritization
Wavelet theory
Multiple resolutions

ABSTRACT

Currently, high social and economic costs in addition to physical and mental consequences put road safety among most important issues. This paper aims at presenting a novel approach, capable of identifying the location as well as the length of high crash road segments. It focuses on the location of accidents occurred along the road and their effective regions. In other words, due to applicability and budget limitations in improving safety of road segments, it is not possible to recognize all high crash road segments. Therefore, it is of utmost importance to identify high crash road segments and their real length to be able to prioritize the safety improvement in roads. In this paper, after evaluating deficiencies of the current road segmentation models, different kinds of errors caused by these methods are addressed. One of the main deficiencies of these models is that they can not identify the length of high crash road segments. In this paper, identifying the length of high crash road segments (corresponding to the arrangement of accidents along the road) is achieved by converting accident data to the road response signal of through traffic with a dynamic model based on the wavelet theory. The significant advantage of the presented method is multi-scale segmentation. In other words, this model identifies high crash road segments with different lengths and also it can recognize small segments within long segments. Applying the presented model into a real case for identifying 10–20 percent of high crash road segment showed an improvement of 25–38 percent in relative to the existing methods.

1. Introduction

Accident prevention is the most effective method to improve the safety of road networks. Due to wide-spread and complex nature of accident causes, identifying high crash road segments and proposing countermeasures are difficult to analyze. In order to evaluate the high accident-proneness of a road, it is required to divide this road into certain segments and then predict the accident risk probability by collecting and studying physical and traffic characteristics of the road. The process of safety assessment gets more costly and time consuming as the number of segments increase. Additionally, it is probable that inaccurate evaluation arises as the number of segments increases. In the literature review, some of the current segmentation methods are as the following:

2. Current segmentation methods

Identifying high crash road segments is a very critical stage in road safety studies. Using segmentation, one can assign accidents to specific road segments and identify high crash road segments.

The previous researches in segmentation show that for identifying high crash road segments in many countries the first step involves dividing the road of interest into equal length segments and then studying the accidents in each segment using one of the identification methods of high crash road segments. Although, the segment lengths are defined differently in different countries, the length for evaluating a specific road is unique.

Kononov and Allery (2003) studied the level of road safety service. In their study after separating some parts of the road, they divided the road into 2 mile segments to identify high crash road segments (Kononov and Allery, 2003). According to Federal

* Corresponding author. Tel.: +98 21 82884367; fax: +98 21 82884915.
E-mail addresses: ambrouj@yahoo.com, boroujerdian@modares.ac.ir (A.M. Boroujerdian), saffar_m@modares.ac.ir (M. Saffarzadeh), hyosefi@ut.ac.ir (H. Yousefi), ghassemi@modares.ac.ir (H. Ghassemian).

http://dx.doi.org/10.1016/j.aap.2014.09.014
0001-4575/

Highway Administration report, the length of high crash road segments is equal to 0.3 miles in road segmentation (Federal Highway Administration, 1981). According to Texas Transportation Institution the length of high crash road segments should be at least 0.1 miles (Bonneson and Zimmerman, 2006). In Ohio, Segmentation method is applied differently. According to this method, segmentation is a procedure in which a road is divided into segments with the same characteristics. In this research, the length of road segments is equal to 0.25 miles. Also, each segment should not be too long or too short. Depending on conditions, the segments of less than 0.25 miles and 0.25–0.5 miles are defined in the list of segments (Pant et al., 2003). A different method for road segmentation is proposed by Torke. According to this method, the road is divided into 0.2 km segments which may be continued along the highway or included in the other segments or intersections (Troche, 2007).

In a project undertaken by the European researchers, the current methods of high crash road segment management and road network safety analysis are evaluated (Elvik, 2008). In Austria, a fixed segment of 2.5 km moves along the road as a template. The segments which are defined along this template and meet the specific criteria of high accident-proneness level are defined as high crash road segments (Troche, 2007). High crash road segment in Denmark is defined by dividing road systems into different kinds of road segments and intersections (Vistisen, 2002). A test based on the Poisson distribution is done to identify high crash road segments. The minimum number of accidents that is considered for a high crash road segment is 4 accidents in a period of 5 years. Accordingly, segmentation is achieved to identify high crash road segments using the defined template. The length of this template depends on the number of normal accidents in each segment (Vistisen, 2002). In Belgium, based on police report, every segment in which three or more accidents occur during 3 years is defined as a high crash road segment. In this method, a 100 miles template is used to identify high crash road segments. Therefore, the segments with the maximum length of 100 miles and 3 accidents are recorded (Geurts, 2006). In Romania, there are two definitions to identify high crash road segments: (1) with the exclusion of the residential areas, a high crash road segment is a location in which at least 4 accidents occur in 3 years in a length of less than 1000 m (2) in residential areas, a segment is identified as a high crash road segment if at least 4 accidents occur in 3 years in a length of less than 100 m. In this method, the template (100 m or 1000 m) is used for segmentation (Elvik, 2008).

In Iran, the road is divided into 1 km segments and then the accidents in each year are counted. Table 1 summarizes the common definition of high crash road segments in each country (Elvik, 2008).

However, in addition to various lengths of high crash road segments in different methods, another difference between the segmentation methods is the definition of starting point. There are basically three starting point definition: (1) some fixed and successive segments are defined from the beginning of the road (2) the segments are moved in half of the length of fixed segments and then the accidents in the new segments are studied so that analysis errors in this method may be reduced (3) high crash road segments are identified by floating the fixed template segment along the road. The last definition is the most accurate.

3. Evaluation of current segmentation methods

The current segmentation methods fall into two categories: static and dynamic segmentation methods. In static segmentation methods the length of each segment is fixed; high crash road segments are identified by dividing the road into segments with specific lengths, and by counting the accidents in these segments according to the definition of high crash road segments. Then the segments with high priority are identified in terms of high accident-proneness. With regards to accident distribution along the road and their causes, it can be concluded that the risk index or probability of accident occurrence along the road may vary due to interaction between safety factors of the road, vehicles, and humans. For example, the friction coefficient may not be suitable along the road and lead to an accident occurrence at time intervals in a year or the accidents may occur in part of a road due to inadequate sight distance such as in a road curve. Considering the aforementioned examples, it is concluded that the length of high crash road segments may vary along the road depending on the extent of accident causes. Also, using the static segmentation methods may lead to some errors in results analysis and high crash road segment identification or may even fail to identify some high crash road segments. Three main deficiencies of static segmentation methods are as follows:

Table 1
Definition of high crash road segments in some countries (Elvik, 2008).

Country	Definition
Germany	- 300 m road segments - More than 3 accidents during 1 year and more than 5 accidents during 3 years
United Kingdom	- 300 meters road segments - The location in which the total number of accidents is more than 12 during 3 years.
Portugal	- The segments with the length of 200 m - More than 5 accidents during one year
Spain	- 1 km segments - More than 5 injury accidents or 2 fatal accidents during 1 year - More than 10 injury accidents or 5 fatal accidents during 3 years
Norway	- 100 meter road segments and more than 4 fatal accidents during one year
Czech Republic	- A road segment of 250 meters - At least 3 injury accidents during one year or 3 similar injury accidents during 3 years - At least 5 similar accidents during 1 year
Netherland	- At least 10 total accidents or at least 5 accidents with certain specifications