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Identification and Prioritization of Accident-prone Segments Based on Wavelet Theory and Cause-oriented Method

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ABSTRACT: Accident-prone segments have a significant role in the occurrence and the number of road accidents. They impose negatively social and environmental effects on the performance of the transport system. Thus, identification and prioritization of these segments play positively a role in reducing accidents, costs, and improvement of safety level on roads. Due to the importance of determining the accident-prone segments, the aim of this study is to use dynamic segmentation and prioritization methods including wavelet theory and cause-oriented methods. Therefore, results from the segmentation and wavelet signal theory on the Kermanshah-West Islamabad Road indicated that accident-prone segments are classified as main and local segments. Then, the cause-oriented prioritization method based on the analytical hierarchy process method for main and local segments showed that the S2 section, which ranges from about 2.5 km to 11.5 km from the beginning of the road is in the higher priority. However, the S3 section which ranges from about 7.5 km to 10.5 km from the beginning of the road is the lower priority of the improvement of road safety. In the future, this paper may help researchers in order to examine a combination of arithmetic functions with artificial intelligence methods, logical reason methods, and SVM (Support Vector Machines) algorithm for segmentation accident-prone segments as dynamic segmentation methods.

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1. INTRODUCTION

An accident is defined as an incidence between a vehicle and other vehicles or animals, humans or collision of vehicles that cause casualties [1]. Accidents have negatively imposed social, and environmental effects on the transport system. They are relatively jointed to other factors such as road, human, and environmental factors [2-4]. There are locations that accidents frequently occur which are called accident-prone segments [5, 6]. Identification and segmentation of hazardous locations are used to prevent and reduce their consequences. Therefore, for reducing accident numbers, and increasing safety levels on roads, many methods have been used to identify the locations of accidents occurrence. Therefore, the aim of this study is to propose a new segmentation method based on the dynamic segmentation method as wavelet signal theory on the Kermanshah-Eslamabade Gharb road and prioritize accident-prone segments by using cause-oriented method for helping experts to allocate budgets in order to improve safety level on road.

2. RESEARCH BACKGROUND

Studies have shown that accident-prone locations are fixed and annually they become changed after road making operations, road geometric modification and changing traffic load and these locations are changed [7]. Alian et al. [8] examined that the road accident casualties in arterial highways. They used a static segmentation method and measured the length of the road between 500 m and 7 km according to the geometric properties. They found black spots. Troche [9] segmented intersection near highways in Puerto Rico into 0.2 miles per section to identify hazardous locations. In another study, Luis et al. [10] used the technique of visual Analytics to combine data analysis with interactive visualizations for identifying the displacement of black spots on sliding windows of 12 months. Promothes and Ksaibati [11] proposed an optimization model for identifying the best combination of safety improvement projects and maximizing the safety benefits in terms of reducing overall crash frequency. Their model was as a function of annual safety budget, roadway inventory, roadway functional classification, historical crashes, safety improvement countermeasures, cost, and crash reduction factors (CRFs) associated with safety improvement countermeasures, and average daily traffics (ADTs). In addition, Liu et al. [12] proposed the methodology of integrating a moving average (MA) model with a stationary wavelet decomposition for automatic incident detection. They yielded the incidents were identified locations more accurately.

3. RESEARCH METHODOLOGY

In order to implement this research, the first dynamic

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segmentation methods and wavelet theory were examined. Then, the cause-oriented method was proposed to prioritize critical accident-prone segments and help experts for an appropriate budget in their improvement that is explained as follows:

3.1. Dynamic segmentation

There are two ways to segment accident-prone segmentations. These are classified as static and dynamic segmentation. In the static segmentation method, identification and segmentation of accident-prone segments are not determined accurately because data may not be available and are scattered. However, in the dynamic segmentation method, identification and segmentation of these segments are complete and accurate. Agarwal et al. [13] introduced the methodology for ranking road safety hazardous locations using the analytical hierarchy process (AHP). They calculated the eigenvalues of the Relative Weight Matrix (RWM) and determined the relative weights. Behzadi and Rouhi [14] proposed a new method based on accident frequent data, accident density, and accident ratio and effective factors contribution to accident occurrence and the AHP model. Shirmohammadi et al. [15] focused on investigating hazardous locations and segments by using dynamic segmentation method as wavelet theory and multi-criteria decision making. They found lower and higher safe segments for road improvement.

3.2. Converting accident data to signal processing data

Signals processing by means of wavelet theory is implemented to determine frequencies and occurrence time, the elimination of disturbances in data, and converting energy process to density. Different theories have been used. But, the most popular one is wavelet theory to process signals [16].

3.3. Cause-oriented model

In this method, accident-prone segments are prioritized in terms of effective factors and causes in the occurrence of accidents. This model basically prioritizes segments in seven steps which are defined as follow:

1- Investigating road and collecting data
2-Segmenting the studied area
3- Classifying accident data
4- Weighting criteria
5- Making a decision matrix
6- Making probable matrix
7- Prioritizing matrix

4. RESULTS AND DISCUSSION

After collecting data on the Kermanshah-Eslamabade Gharb road, dynamic segmentation method was simulated by Matlab and accident-prone segments were obtained and classified based on accident density index as main and local segments as shown in Figure 1. The results of this segmentation are presented in the following as:

$$S_7 \prec S_{13} \prec S_8 \prec S_{10} \prec S_1 \prec S_{14} \prec S_4 \prec S_{11} \prec S_{12} \prec S_9 \prec S_6 \prec S_5 \prec S_2 \prec S_3$$

Hence, according to the cause-oriented method, these segments were prioritized by means of the cause of accidents

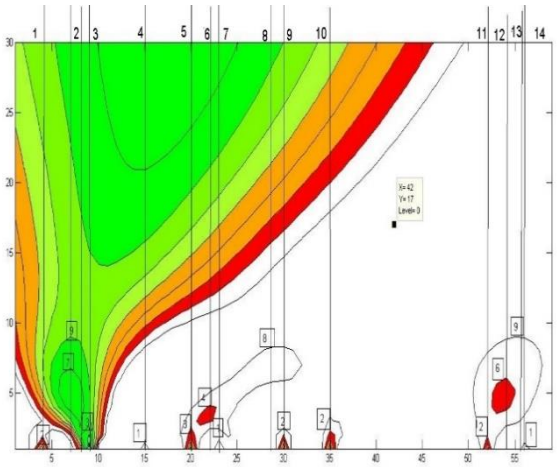

Fig. 1. Dynamic segmentation on ermanshah-Eslamabade Gharb road

and results were indicated in the following as:

$$S_2 > S_1 > S_6 > S_4 > S_5 > S_7 > S_{11} > S_{12} > S_3$$

5. CONCLUSIONS

The main conclusions are presented as follows:

- A dynamic segmentation method is an important tool in the segmentation of accident-prone segments.
- In the dynamic segmentation method, wavelet theory is used.
- In the prioritizing process, the cause-oriented method considers the causes of accidents and arranges accident-prone segments in ascending and descending order.
- Dynamic segmentation method was implanted as a case study on the Kermanshah-Eslamabade Gharb road, results indicated that the S2 section, which ranges from about 2.5 km to 11.5 km from the beginning of the road is in the higher priority. However, the S3 section which ranges from about 7.5 km to 10.5 km from the beginning of the road was the lower priority of the improvement of road safety.
- By comparison of this study with other studies, we can understand that accident-prone segments are identified accurately. And subsequently, engineers can improve safety levels on roads based on budgets by accurate segments.
- This paper may be used as a case study in internal city roads and it may help researchers in order to examine the combination of arithmetic's functions with artificial intelligence methods, logical reason methods, and SVM (Support Vector Machines) algorithm for segmentation accident-prone segments as dynamic segmentation methods.

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