



Providing a Method for Accident Severity Analysis Using Geospatial Clustering Functions and Decision Tree, Case Study: Qazvin-Loshan Freeway

H. Behbahani¹, M. Effati^{2*}, S. Mortezaei¹

¹ Department of Road and Transportation, Faculty of Civil Engineering, the University Of Elmo-Sanat, Tehran, Iran

² Department of Civil Engineering (Road and Transportation), Faculty of Engineering, The University of Guilan, Iran

ABSTRACT: Spatial analysis of accidents occurred in freeways and identifying effective parameters can help researchers and authorities to improve road safety by reducing the severity of accidents. The purpose of this study is to provide a method to analyze the accident severity and determine related effective parameters in freeways based on spatial clustering functions and regression and classification tree data mining method. Proposed method was assessed in Qazvin-Loshan freeway. In this study, to study the spatial distribution of the accidents in the aforementioned axis during the period from 2011 to 2016, the spatial functions such as Getis-Ord G^* autocorrelation and Kernel Density Functions were Used. The results of spatial analysis showed that the spatial gathering of accidents in most of horizontal curves was greater. According to this achievement, in the next phase of the study, in order to study the factors affecting the severity of accidents, the Regression and Classification Tree was used on accidents that occurred in the whole axis and specifically the crashes which occurred in the horizontal curves. Results of this part of the study showed that the type of accidents (overturning and falling, exit from the road, multi-vehicle collisions, etc.) and human factors are the most important factors in the severity of accidents in this axis. Relative importance coefficients for these two independent variables are 100 and 39.7 percent for the whole axis and 100 and 65.9 percent for horizontal curves. The study of the relative importance of other variables used in the proposed model showed that the geometric design, type and date of crashes are among the most effective factors in increasing the property damage only crashes in Qazvin-Loshan Freeway. This study showed that the integration of GIS functions with non-parametric data mining algorithms such as decision tree, which is capable of simultaneous modeling of quantitative and qualitative data, is an effective approach to determine the factors affecting the severity of accidents and to analyze the spatial patterns of accidents in freeways.

Review History:

Received: 2018-12-02

Revised: 2019-02-03

Accepted: 2019-05-12

Available Online: 2019-07-04

Keywords:

Road Safety

Accidents Severity

Getis-Ord G^* Autocorrelation

kernel Density Functions

Classification and Regression Tree

1. INTRODUCTION

The effective treatment of road accidents and thus the enhancement of road safety is a major concern to societies due to the losses in human lives and the economic and social costs. Tremendous efforts have been dedicated by transportation researchers and practitioners to improve road safety.

Spatial analysis of accidents occurred in freeways and identifying effective parameters can help researchers and authorities to improve road safety by reducing the severity of accidents. Traffic safety of freeways has attracted major concerns, especially for a mountainous freeway affected by adverse terrain conditions, constrained roadway geometry and complicated driving environments. On the basis of a comprehensive dataset collected from a freeway with a length of 85 km but gathering 2 tunnels.

Since injury severity of freeway crashes is the result of the combination of multiple factors, no single factor can likely be identified to provide a complete explanation for the high risk

*Corresponding author's email: meysameffati@guilan.ac.ir

of severe crashes in freeways. At mountainous freeways, the sophisticated interaction of the adverse terrain, road facilities, environmental factors and driving behaviors, may greatly elevate the likelihood of crash occurrence and injury severity [1].

This study seeks to examine the interactive effects of freeway alignment, driving behaviors, vehicle characteristics, and environmental factors on crash severity. A classification and regression tree (CART) model is employed as it can deal with high-order interactions between explanatory variables. Classification and Regression Trees (CART) method, as a commonly used data mining technique, can capture non-additive behaviors, which provides the ability to highlight sophisticated relationships that are difficult to discover. When CART analysis is applied, variable correlation problems are not problematic [2]. Also, CART model can boost efficiency when it deals with large-scale data containing a large number of explanatory variables and produces useful results using only a few essential variables



with a brief graphic display [3, 4].

Identifying the effective parameters on the increase of the severity of the accident in freeways and also the spatial analysis of the accidents occurring in them could lead to the reduction of road accidents. In this regard, the present paper seeks to identify the high crash locations, in addition to the factors affecting the severity of accidents. The probability of accident occurrence, and its severity, can often be reduced by the systematic analysis of the incident scenarios and by resorting to appropriate solutions involving the application of proper traffic control devices, suitable roadway design practices and effective traffic police activities. However, the task of making effective solutions warrants analysis of spatial and temporal patterns in the zone of traffic accidents, which can be achieved through the application of geospatial technology [5].

2. METHODOLOGY

In this study, the accidents of Qazvin-Loshan Freeway during the period from 2011 to 2016 were initially investigated, using the clustering and spatial distribution methods. The employed spatial functions included Getis-Ord G^* Autocorrelation and kernel density functions.

In the next stage, the Classification and Regression Tree models were used to evaluate the factors affecting the severity of accidents occurring in the whole axis and specifically in the high crash horizontal curves. The Classification and Regression Tree (CART) is a non-parametric modeling approach, which uses a decision tree to solve classification and regression problems using both categorical and continuous variables. When the value of the target variable is categorical, CART produces a classification tree, whereas a regression tree is developed for the continuous variables. Relationships between risk factors and injury severity can be identified by splitting a large dataset into more homogenous subsets during the classification process. The classification tree begins from the topmost node using a binary split procedure, where statistical tests are run against every attribute in the dataset [1].

3. RESULT AND DISCUSSION

The preliminary results of spatial analysis showed that the number of accidents was greater in horizontal curves. According to this achievement, in the next phase of the study, in order to study the factors affecting the severity of accidents, the Classification and Regression Tree was used on accidents occurring in the whole axis and specifically in most horizontal curves with high crashes. The results of this part of the study show that the type of accidents (overturning and falling, exit from the road, Multi-vehicle collisions, etc.)

and human factors with the respective independent variables importance coefficients of 100 and 39.7 percent for the whole axis and 100 and 65.9 percent for horizontal curves, are the most important factors in the severity of accidents of this axis.

The study of the relative importance of other variables in the proposed model shows that the geometric design, type of crashes, and date of the accident are the effective factors in increasing the accident severity at the Qazvin-Loshan Freeway. Also, the results of modeling of crashes occurred in horizontal curves showed that the accident location, especially the shoulder, as well as the time of the accident, cause serious accidents.

4. CONCLUSIONS

Safety interventions to prevent severe crashes at the freeway include hierarchical supervision in terms of hazardous driving events, enhanced enforcement for speeding and fatigue driving, deployment of advanced driving assistance systems for fatigue driving warning, and cumulative driving time monitoring for long-distance-travel freight vehicles.

This study showed that the integration of GIS functions with non-parametric data mining analysis based on decision tree, which is capable of simultaneous modeling of quantitative and qualitative data, is an effective approach to determine the factors affecting the severity of accidents and to analyze the spatial patterns of accidents in freeways.

The results of the study can be proved useful for enhancing road safety in Iran. Further research could focus on examining additional parameters such as geometrical road characteristics, traffic parameters such as flows, speeds and so on. Furthermore, different areas and regions in Iran could be explored. In this case, other statistical methods could be explored as well, for example, multilevel models.

REFERENCES

- [1] H. Huang, Y. Peng, J. Wang, Q. Luo, X. Li, Interactive risk analysis on crash injury severity at a mountainous freeway with tunnel groups in China, *Accident Analysis and Prevention*, 111 (2018) 56-62.
- [2] L. Breiman, J. Friedman, R. A. Olshen, C. J. Stone, *Classification and Regression Trees*. CRC press, (1984).
- [3] L. Y. Chang, J. T. Chien, Analysis of driver injury severity in truck-involved accidents using a non-parametric classification tree model, *Safety Science*, 51 (1) (2013) 17-22.
- [4] S. Jung, X. Qin, C. Oh, Improving strategic policies for pedestrian safety enhancement using classification tree modeling, *Transportation Research Part A: Policy & Practice*, 85(2016) 53-64.
- [5] W. Cheng, S. Washington, New criteria for evaluating methods of identifying hotspots. *Transportation Research Record* 2083 (2008) 76-85.

HOW TO CITE THIS ARTICLE

H. Behbahani, M. Effati, S. Mortezaei, *Providing a Method for Accident Severity Analysis Using Geospatial Clustering Functions and Decision Tree, Case Study: Qazvin-Loshan Freeway*, *Amirkabir J. Civil Eng.*, 52(6) (2020) 353-354.

DOI: 10.22060/ceej.2019.15376.5903

