

EFFECT OF GEOMETRIC ELEMENTS ON ACCIDENTS RATES
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ABSTRACT

Road accident prediction plays an important role in accessing and improving the road safety. Fuzzy logic is one of the popular techniques in the broad field of artificial intelligence and ability to improve performance similar to human reasoning and describe complex systems in linguistic terms instead of numerical values. In this study, a system was established based on Fuzzy Inference System (FIS) in which output data such as traffic Accident Rate (AR) and input data such as various highway geometric parameters. The study was conducted on two road segment from plain and rolling terrain highway and two road segments from hilly and mountainous terrain highway within the rural area of the Indian Territory. Two Highway Accident Rate Prediction Models (HARPMPT and HARPMHMT) were developed due to the complexity of geometric parameters of rural highway on different terrain conditions which takes horizontal radius, superelevation, K-value, vertical grade and visibility as input variables and Accident Rate (AR) as output variables. The findings show that the proposed model can be effectively applied as a useful Road Safety tool capable of identifying risk factors related to the characteristics of the road and great support to the decision making of incident management in Intelligent Transportation Systems.

INTRODUCTION

Motor vehicle accidents kill about 1.2 million people in a year world-wide and the number will grow to more than 2 million in 2020 unless steps are taken; a study released by the World Health Organization (WHO) and the World Bank. [Washington: Article-Traffic accidents becoming one of world's great killers, By Matthew Wald, April 8, 2004]. Any design solution mitigating this kind of individual human behavior cannot be predicted, only some safety rules can be enforced. Also, vehicle factors, related to mechanical behavior of vehicles are not the scope of civil engineering study. Hence, road factors are only considered as part of this study. It is very important for the highway to establish a harmony between all the three factors at the design stage of a highway. With a geometrically good design, it is possible to compensate for the other factors and thus decrease the number of traffic accidents.

Basic Parameters of Highway Geometric

• **Speed**

Speed is defined as the distance covered per unit time. Since speed of every vehicle is impossible to track on a roadway; therefore, in practice,

average speed is based on the sampling of vehicles over a period of time on a particular section of road. Speed is one of the most important factors considered by travellers in selecting alternative routes. The speed of a vehicle on a road depends upon five conditions: physical characteristics of the highway, amount of roadside interference, weather, presence of other vehicles, and the speed limitations in addition to the capabilities of the driver and their vehicles. It is the basic parameter which determines all other geometric features of the highway

• **Cross Section**

Cross section is defined as the number of lanes and lane width including cross fall, shoulder, sidewalk, earth slope and drainage features in the transverse direction of the roadway. The cross section shows the total formation of the road.

• **Super elevation**

Super elevation is tilting or banking the roadway to counteract the centripetal force developed as the vehicle moves around the horizontal curve. When a vehicle moves in circular path, it undergoes a centripetal acceleration that acts towards the center of curvature. This

acceleration is sustained by a component of the vehicle's weight related to the roadway super elevation, by the side friction developed between the vehicle's tires and or the pavement surface.

- **Sight Distance**

Sight distance is the distance along the road surface at which a driver has visibility of object at a specified height above the carriageway. This is the adequate length along the highway in the different situations to permit drivers enough time and distance to control their vehicles so as to avoid unforeseen accidents.

- **Terrain/Topography**

The classification of the terrain is done by means of cross slope of the country, i.e., slope approximately perpendicular to the center line of the highway location. To characterize variations in topography, engineers separate it into four classifications,

- **Horizontal Alignment**

The horizontal alignment is the route of the highway, defined as a series of horizontal tangents and curves. Horizontal curve is the curve in plan to change the direction of the center line of the highway. The geometries of horizontal alignment are based on an appropriate relationship between design speed and curvature and on their joint relationship with super elevation and side friction.

- **Vertical Alignment**

Vertical alignment is the longitudinal section of a roadway to provide easy and safe change of Gradient. It is defined as a series of gradients and vertical curves. Gradient is the rate of rise or fall with respect to the horizontal along the length of a road expressed as a percentage or as a ratio or in degrees. Vertical curves to effect gradual changes between gradients with any one of the crest or sag types and result is safe and comfortable in operation, pleasing in appearance, and adequate for drainage.

OBJECTIVES

The high socio-economic cost of the injuries and fatalities, occurring due to road accidents, and the need for effective policies for curbing road accidents make it imperative to study the causes of road accidents. The present study aims to detect and identify the role of alignment geometric parameters on accident and prediction

of accident rate through artificial intelligence system modeling.

EMPIRICAL DATA COLLECTION AND EXTRACTION

For this study, two roads in plain and rolling terrain-- National Highway (NH) 23 and 200 -- and two roads in hilly terrain -- National Highway 22 and 87 were selected. Various field data such as 3D Topographic features, Accident records and Traffic volume were collected for these roads. Careful observation and collection of such data with accuracy was carried out.

Data Collection

The topographic survey has been carried out with Total Station survey equipment at accident locations. Total Station is a high precision surveying equipment to carry out 3-dimensional feature of the existing road. This survey equipment can measure distance, angle, and coordinates with relative to the known position and calculates using coordinate geometry and triangulation. All the measurements are controlled by an internal program and interfaced via computer. The captured digital data can be downloaded into a CAD program (AutoCAD) to visualize the surveying data as vector entities. Finally, this data has been analyzed later with the design application software (MX Road) which is extensively used for highway design.

Data Extraction

To find out the geometric parameters of the existing road, topographic survey points (X, Y and Z / Easting, Northing and Elevation), road center line, carriageway edge and shoulder edge line have been imported to MX Road software and a 3-dimensional digital terrain model (DTM) was developed. Then Triangulation Integrated Network (TIN) was modeled as 3-dimensional surface. After this, geometric parameters such as horizontal curve radius and Horizontal curve length, deflection angle, super elevation / cross fall, vertical grade, vertical curve length and sight distance have been extracted.

Analysis of Empirical Data and Results

Accident analysis has been carried out in order to determine the effects of different geometric elements of the highway with accident rate of the same highway. These geometric elements are horizontal radius, deflection angle, horizontal arc length, super elevation, rate of change of super elevation, vertical gradient, vertical curve length, *K*-value and visibility/sight distance. Finally, these geometric elements are statistically analyzed and considered for model development.

PROPOSED MODEL

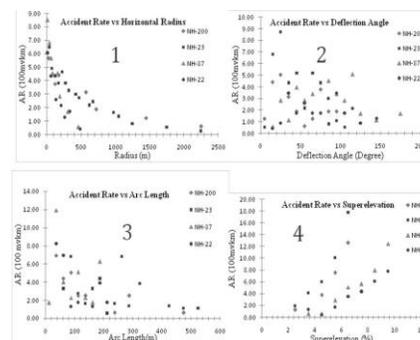
In the literature studies, generally the traffic accident models were developed as statistical prediction model with limited parameters. The nature of the traffic accidents required a flexible model that can accept imprecise data. For the more complex issues, fuzzy logic is very convenient in explaining traffic accidents, in which uncertainty is principal.

Here in this proposed fuzzy logic model (shown in Figure 2), an attempt has been made to predict the Accident Rate (AR) with respect to the various highway geometric parameters. Two models have been developed due to the complexity of geometric parameters of rural highway on different terrain conditions. First one is Highway Accident Rate Prediction Model for Plain and Rolling Terrain (HARPMPT), and second one is Highway Accident Rate Prediction Model for Hill and Mountainous Terrain (HARPMHMT).

The HARPMPT which has been proposed provide the accident rate of the highway as output variables considering radius, super elevation, *K*-value and visibility as input variables. The HARPMHMT which has been proposed provide the accident rate of the highway as output variables considering radius, super elevation, vertical gradient and visibility as input variables.

The Proposed model quantifies the accident rate considering various geometric parameters of alignment of the highway as premise variables. As mentioned earlier, two types of model (HARPMPT and HARPMHMT) are proposed for different magnitude of parameters of

highway alignment geometrics considering terrain condition. For the complexity of the formulation, fuzzy logic has been applied in the model.



VALIDATION

Here set of input data of validation set group has been entered to the Fuzzy Inference System (FIS) and each crisp output result has been taken using both Highway Accident Rate Prediction Model (HARPMPT and HARPMHMT). Also, simulation results using the proposed model are presented.

- a) The Validation of HARPMPT and HARPMHMT: Comparison with Observation Results: the Simulation results are produced corresponding with each set of input data of validation set group and compared with the combined linear regression analysis results.
- b) Model Results and Discussions: when the model results were examined in details, it was observed that as far as the simulation results are concerned, the Accident Rate (AR) value obtained from statistical analysis and obtained.

from the model are almost same. Hence, HARPMPT models can be applied to predict the Accident Rate of plain and rolling terrain highway and, also, HARPMHMT model can be applied to predict the Accident Rate of hilly and mountainous terrain highway.

CONCLUSIONS

In view of complexity of highway geometric parameters, Fuzzy Inference System (FIS) based

traffic accident prediction algorithm for rural highway was proposed. Comparing to the traditional algorithms, the proposed algorithm has many advantages such as use of linguistic data set variables and apply of the expertise decisions. Two accident models were proposed which provide the accident rate of the existing highway such as HARMPRT (Highway Accident Rate Prediction Model for plain and rolling terrain highway) and HARPMHMT (Highway Accident Rate Prediction Model for hilly and mountainous terrain highway). Simulation test shows that the detection results of the algorithm are encouraging and thus get the whole picture of traffic safety improvement based on the condition of the contributing factors. Many developed nations have started a campaign with the motto of "vision zero" that predicted zero deaths on roads. Thus, there is so much research made on traffic accidents in developed countries. However, in India there is not enough research or study on this issue. It is suggested that more importance should be given to the Road Safety issue considering all accident causing factors and a highway safety system should be developed.

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