EFFECTS OF HIGHWAY GEOMETRIC ELEMENTS ONACCIDENT MODELLING

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ABSTRACT

The traffic growth generally seen in road transportation which has causes to a lot of Not favourable conditions in the term of road accidents both in developed and developing Countries. This observation needs to be paying attention towards the development of a system for the road safety mechanism of rural highway. prediction of Road accident plays an important part in improving the safety of road . An popular techniques FUZZY LOGIC in the broad field of artificial intelligence and fuzzy logic is the ability to improve system performance which is very similar to human reasoning and describe complex systems in semantic terms instead of numerical values. In this thesis, a system was accepted and totally build on Fuzzy Inference System (FIS) in which produced output data is traffic Accident Rate (AR) and produced input data is various highway geometric elements. This study was basically based on two road segments which are plain & rolling terrain highway and also based on two road segments and they are from mountainous & steep terrain highway within the area of the rural Indian Territory. Two Highway Accident Rate Prediction representation (HARPMPRT and HARPMMST) were developed due to the complication of geometric elements of highway in rural area on different terrain conditions which combine and take input variable as horizontal radius, super elevation, K-value, vertical gradient and visibility and output variables as Accident Rate (AR) .

The findings show that the proposed model can be a useful Road Safety tool which is capable of recognize risk factors related to the characteristics of the road and great support in Intelligent Transportation Systems to the decision making of incident management . A study and real life data analysis Model are performed to demonstrate model fitting performances of the proposed model.

KEYWORDS: *AADT, FIS, Fuzzy Logic, FCM, AR, DTM, TIN and SCF*

I. INTRODUCTION

Motor vehicle accidents kill about 1.2 million people a year world-wide and the number will grow day by day if we are not working on this problem then it became more than 2 million in 2020 , a study released by the World Health Organization (WHO) and the World Bank has found.

WHO has disclose in its first Global Status Report on Safety of road in which clearly mention the reason that the maximum deaths in India are occurs due to road accident than anywhere else in the world, Road transport affects economic development, trade and social integration, which depends on the transfer of both people and goods.

Three major factors causing traffic accidents are

1. Human
2. Road
3. Vehicles

The human factor has the most significant effect on accident. However, this factor is governed by an individual thought process and cannot be studied empirically. Moreover, any design solution mitigating this kind of individual human behavior cannot be predicted only some safety rules can been forced.

Also, different mechanical behavior of vehicles factors is not the scope of civil Engineering study. Hence, road factors are only considered as a part of this study. It is very important for the highway to establish a harmony between the all the three factors. With a geometrically good design, it is possible to compensate for the other factors and thus decrease the number of traffic accidents.

Objectives:

To study the causes of road accidents. The present aims is to study and prediction of accident rate through artificial intelligence system modeling and the role of alignment geometric elements on road accident.

II. RELATED WORK

Feng-Bor Lin (1990) studied on flattening of horizontal curve on rural two lane highways and found that horizontal curves on highways are on average more hazardous than tangent sections. As the increase in curvatures, horizontal curves tend to have higher accident rates. He suggests that the differences between the 85th percentile speeds and the safe speeds have no statistically relationships with the accident rates. In contrast, the reduction in magnitudes of speed , whenever vehicle moves from a tangent section to a curve, have a impact on traffic safety. Such these kind of speed reductions on horizontal curve with gentle grades are strongly correlated with the curvatures of the curves. Therefore, curvatures can be used as a safety indicator of the curves

Y. Hassan et al. (2003) studied on effect of vertical alignment on driver perception of horizontal curves that means it directly relate to driver and found that perception of the driver of the road features ahead is an important for human factor and should be mention in road design.

Zhang Yingxue (2009) observed the relation between highway horizontal curve and traffic safety and found that curve radius, super-elevation, widening, transition curve and sight distance have the important reasons of traffic accidents.

Ali Aram (2010) studied on effective safety factors on horizontal curves of two-lane highway and analyzed that several traffic volumes and mix, geometric features of the curve, cross section, roadside hazards, stopping sight distance, curve coordination, pavement friction and traffic control devices affect the safety performance of horizontal curve. He found that degree of horizontal curve length of curve, super elevation, transition length, shoulder width and ADT responses are theImportant independent effective variables. He also suggested that horizontal curves have higher crash rates than straight section of similar length and traffic composition.

Kay Fitzpatrick et al. (2010) studied on horizontal curve accident modification factor with consideration of driveway density on rural four-lane highways in Texas. They developed horizontal curve accident modification factor (AMF) for rural four-lane divided and undivided highways and determined the effect of driveway density is different for horizontal curves as compared to tangent sections. Negative binomial regression models were used to determine the effects of independent variables on crashes.

George Kanellaidis et al. (2011) studied highway geometric design from the perspective of recent safety developments and suggested emphasis on concerns of three-dimensional (3D) highway design to achieve a “safe-by-design”.

A.F. Iyinam et al. (1997) studied relationship between highway safety and road geometric design elements and observed that the relationship between safety and road geometric has meaningful relationships through regression analysis. They suggested that the control of the road factor is much easier than the human factor and by making a geometrically good design, it was even possible to compensate for the other factors and thus decrease the number of traffic accidents through a regression analysis is made between the geometric parameters and accident rates.

III. METHODOLOGY

In order to have the accurate topographical survey work, a network of horizontal control has established using differential GPS techniques and levelling network using Digital Auto Levels. The fixing of major control stations, the station points are embedded in the ground, in pair with inter visibility with a distance of around 200m. The horizontal control coordinates were observed and worked out by use of GPS instrument for each pair and the elevation were provided by an independent levelling survey by Digital Auto Level. These Major Control Stations were kept at a distance of 500m at a safe location.

The control traverse is the base framework for all the further survey work. This provides a coordinated horizontal grid and a level reference system to ensure accuracy. Thus the measured coordinates of these survey grids (Northing and Easting) and the levels are to be tied to GTS benchmark wherever available, to verify the accuracy of survey. The GPS/ Benchmark points and Reference Benchmark points established acted as both horizontal and vertical control points.

Levels along center line of the existing road are taken at every 10m interval and at all intermediate breaks in ground using Total Station. The said spacing has suitably reduced at horizontal curves to 5m. Cross sections are taken at every 20 m intervals and at each cross section the survey normally extends beyond 20m on each side of the existing road center line with survey points at

5-10 m apart and at all variations in the natural ground or breaks in level. The topographic survey thus carried out contains the details of all physical and topographical features within the survey corridor. The survey data were processed and converted to graphic files using Highway Design software called "MX Road".

IV. EXPERIMENTAL SETUPS

Experimental setup is n approach of considering the essential set of experiments suitable and useful for the creation of new highway and roads in rural or in urban area. Accident records have been collected from concerned police station from their accident record books. All these accident points have been verified with policemen as well as local villagers at the site.

The testing methodology will consist of the following step:

a. Collection of data

b. Accident records

c. Traffic volume

d. Average Daily Traffic

e. Average Annual Daily Traffic

V. EXPERIMENTS & RESULTS

Statistical Analysis of Variance

Statistical process or methods can summarize or describe a collection of data. Analysis of variance (ANOVA) is a collection of statistical models used to analyze the differences between group means and their association. In ANOVA setting, the observed variance in a particular variable is partitioned into components attributable to different sources of variation. ANOVAs are useful in comparing for statistical significance.

All geometric elements has been analysed independently with accident rate of the highway as previously shown and the details are illustrated in Appendix-4.1 to Appendix-4.9. MicrosoftOffice Excel has been used in the regression analysis and the result of ANOVA has been furnished

Table a: Summary of Analysis of Variance of NH-200

Variables	**R^2**	**Adjusted R^2**	**Standard Error**	***SS***	***MS***	***F***
Radius	**0.83**	**0.80**	**0.78**	**17.74**	**17.74**	**28.96**
Deflection Angle	**0.10**	**-0.02**	**1.50**	**1.92**	**1.92**	**0.86**
Arc Length	**0.61**	**0.54**	**1.48**	**20.23**	**20.23**	**9.28**

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Superelevation	0.90	0.85	1.94	65.44	65.44	17.40
Rate of Change of Superelevation	0.12	0.04	1.19	2.01	2.01	1.43
Vertical Gradient	0.02	-0.14	4.16	2.50	2.50	0.14
Vertical Curve Length	0.15	-0.13	5.11	14.08	14.08	0.54
K-value	0.78	0.71	1.16	14.68	14.68	10.91
Visibility	0.87	0.85	0.77	34.67	34.67	58.31

SS=Sum of Square, MS= Mean of Square

Table b: Summary of Analysis of Variance of NH-87

Variables	R^2	Adjusted R^2	Standard Error	*SS*	*MS*	*F*
Radius	0.86	0.84	1.06	42.05	42.05	37.66
Deflection Angle	0.00	-0.09	1.45	0.00	0.00	0.00
Arc Length	0.03	-0.13	3.68	2.77	2.77	0.20

Superelevation	**0.93**	**0.92**	**1.22**	**101.54**	**101.54**	**67.76**
Rate of Change of Superelevation	**0.32**	**0.19**	**4.77**	**54.55**	**54.55**	**2.40**
Vertical Gradient	**0.86**	**0.84**	**1.08**	**43.09**	**43.09**	**37.25**
Vertical Curve Length	**0.01**	**-0.49**	**3.77**	**0.26**	**0.26**	**0.02**
K-value	**0.04**	**-0.44**	**3.71**	**1.11**	**1.11**	**0.08**
Visibility	**0.83**	**0.77**	**1.94**	**54.09**	**54.09**	**14.37**

Regression Analysis

Analysis of Variance (ANOVA) shows that the highway alignment geometric elements like, radius, superelevation, K-value and visibility are significant to cause accident on NH-200 & NH-23 in plain & rolling terrain and geometric elements like, radius, superelevation, vertical gradient and visibility are significant to cause accident on NH-87 & NH-22 in mountainous & steep terrain. The group effect of highway geometric element on accident rate has been calculated through regression model as below and same has been furnished

Accident Rate (NH-200) = -0.002(RA) + 2.7349(SE) - 0.0279(K) - 0.0476(VB) + 10.7396

Accident Rate (NH-23) = -0.0022(RA) + 3.7610(SE) - 0.0249(K) - 0.0600(VB) + 9.4498

Accident Rate (NH-87) = -0.0159(RA) + 1.9043(SE) + 1.0129(G) - 0.2326(VB) + 15.1894

Accident Rate (NH-22) = -0.0122(RA) + 1.1914(SE) + 1.2687(G) - 0.4072(VB) + 21.8108

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 more complex issues, fuzzy logic is very convenient in explaining traffic accidents, in which uncertainty is principal.
the proposed fuzzy logic model, in which an attempt has been done to predict the Accident Rate (AR) with respect to the various highway geometric elements mentioned in chapter 4. There are Two models have been developed due to the complexity of the geometric parameters of rural highway on different terrain conditions.

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First one is Prediction Model for Highway Accident Rate for Plain & Rolling Terrain (HARPMPRT) and second one is

Highway Accident Rate Prediction Model for Mountainous & Steep Terrain (HARPMMST). HARPMPRT has been proposed which provide the accident rate of the highway as output variables considering radius, superelevation, K-value and visibility as input variables

Lotfi A. Zadeh (1965)introduced the mathematical expression of an infinite-valued logic by his Fuzzy Sets and defined the concept of Fuzzy Sets as "A fuzzy set is a class of objects with a continuum of grades of membership. Such a set is characterized by a membership function which assigns to each object a grade of membership ranging between zero and one. The notions of inclusion, union, intersection, complement, relation, convexity, etc., are extended to such sets and various properties of these notions in the context of fuzzy sets are established. In particular, a separation theorem for convex fuzzy sets is proved without requiring that fuzzy sets to be disjoint".

Table a: Summary of Fuzzy Clustering of NH200 (HARPMPRT)

Input Variables	**Fuzzy Clustering**		
	Group	**Group Center**	**Group Range**
Radius	1	152	27 – 330
	2	531	350 - 750
	3	1055	970 – 1475
	4	1963	1890 - 2150
Superelevation	1	4	2.6 - 4.4
	2	5	4.6 - 6.0
	3	7	6.1 - 7.0
K-value	1	14	5 -23
	2	41	30 - 60

	3	142	125 - 167
Visibility	1	51	32 - 67
	2	84	68 – 109
	3	137	113 - 180

Table b: Summary of Fuzzy Clustering of NH87 ($HARPM_{MST}$)

Input Variables	**Fuzzy Clustering**		
	Group	**Group Center**	**Group Range**
Radius	1	25	7.5 – 48
	2	73	58- 100
	3	178	130 - 220
	4	339	260 - 480
Superelevation	1	5	3.1 - 6.4
	2	8	7.0 - 8.7
	3	10	8.8 - 10.0
Gradient	1	2	1.0 - 3.5
	2	5	3.9 - 6.1

	3	7	6.3 - 8.0
Visibility	1	19	15 - 25
	2	32	28 -39
	3	47	40 - 60

VI. SUMMARY AND CONCLUSION

The goal of the research was to present an expression of a model that can be used to predict accident rate on existing highway and motivation to implement on highway safety projects in throughout Indian territory. On the other hand, this study produced traffic accident prediction model for the road safety mechanism of rural highway. In this model, a system was established in which output data such as traffic accident rate (AR) and input data such as various highway geometric elements i.e., horizontal radius, superelevation, K-value, vertical gradient and visibility.

In view of complexity of highway geometric elements, 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 HARPMPRT (HighwayAccident Rate Prediction Model for plain & rolling terrain highway) and HARPMMST (Highway Accident Rate Prediction Model for mountainous & steep 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.Statistical analysis indicated that, several highway geometric parameters are very significant to cause accident in the highway. Highway alignment geometric elements such as radius,superelevation, K-value, vertical gradient and sight distance/visibility are very significant in causing accident both in plain & rolling and mountainous & steep terrain highway. However, deflection angle, horizontal arc length, rate of change of superelevation and vertical curve length are insignificant to cause accident in both plain & rolling and mountainous & steep terrain highway.

Sensitivity analysis demonstrate that superelevation and visibility have greater impact on accident rate in plain and rolling terrain highways; whereas, superelevation and vertical gradient have greater impact on accident rate in mountainous and steep terrain highways.

Many developed nations started a campaign with the motto of “vision zero” that was predicted zero deaths on roads. Thus, there is so much research made on traffic accidents in developed countries. Moreover, developing countries like India need to give emphasis to research on traffic accidents. 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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