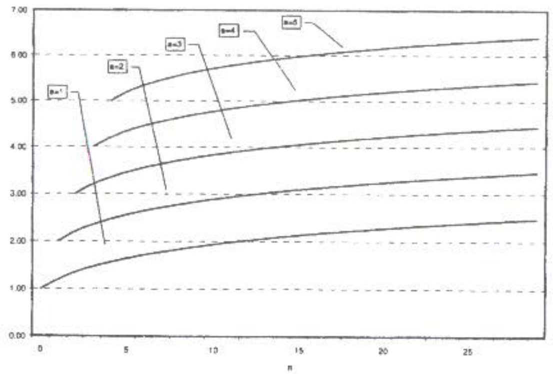

Fig. 8 R – n Relationships in terms of a

From this development, it is seen that guideway link volumes q increase as the length of trip n increases. This increase is most pronounced for small values of x. In this formulation, x is a measure of the importance of proximity to the traveler and is a function of trip purpose. Historically, $x < 1$ has been used for work trips; $1 < x < 2$ for school and shopping trips; and $x > 2$ for social and recreational trips, in transportation planning. From a practical point of view, $x \geq 2$ is a requirement for convergence in the above formulation.

Summary and Conclusions

If ITS is to be the new transportation paradigm, as suggested in the "Introduction," it must have its own "strategic vision." Assume that by the middle of the next century, the guideway-freeway system described in this paper will be implemented throughout the present Interstate Highway System. The population of the U.S. will have increased by at least 100 million persons. The new transportation paradigm requires that the new system be used as a structuring device for rebuilding and reorganizing existing cities, rationalizing suburban growth, and building new cities, so as to form a one-dimensional linear megalopolis consisting of population modules located around the system interchanges.

Interchanges and population modules would be planned together so as to load the guideway-freeway system without overloading it. The allocation of industrial and residential activity would be tied to trip generation and trip distribution explicitly. Since cars are separated from trucks and buses, modal split is performed between the respective roadways. Network assignment is based on allocating traffic between the guideway and the freeway for each link defined by interchange nodes.

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COMPARISON OF NEURAL NETWORK AND DISCRETE CHOICE MODELLING METHODS FOR INCIDENT DETECTION

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ABSTRACT

Many analytical efforts in the field of Transportation focus on modeling discrete phenomena. Different methods are available for modeling such phenomena. This paper aims at comparing two different methodologies, namely, neural network and discrete choice modeling methods. The major objective of this paper is to compare the discrete choice model and the neural network model in terms of various evaluation criteria such as ease of estimation, ability to incorporate many influencing factors, and false alarm rates.

In this paper, the phenomenon of freeway incident detection is considered to perform the comparison. The data used in this effort was obtained from Sanfrancisco, California. The data consists of information about the speed of vehicles, flow characteristics, and the filter occupancy at different points of time in a day. This data is used to develop a logit model that predicts the probability of incident occurrence. A neural network model is calibrated using a multi-layer feedforward network on the same data. The results of the study show that both of these methodologies have the ability to detect incident occurrence efficiently.

INTRODUCTION

Background

An incident is an accident, breakdown, spilled load, or other random event that reduces the capacity of the roadway. When traffic demand approaching the scene of an incident exceeds the reduced capacity, traffic congestion will result. Freeway incident management is the coordinated, preplanned use of human, institutional and mechanical resources to reduce the duration and thus the impact of incidents. Incident management involves a systematic approach to reduce the time it takes to detect and verify an incident has occurred, mount the appropriate response, clear the incident and manage traffic until full capacity is restored. An essential component of incident management is detecting an incident. The objective of the detection element is to detect that an incident has occurred. Examples of detection or surveillance options include electronic detection, police patrols, courtesy or service vehicles, closed circuit television, call boxes, media and cellular telephone. Most freeway incident management programs in the U. S. that include a detection element, rely on some combination of detection measures that enhance each other and also provide information on the nature of the incident when it is detected.

Problem Statement

Freeway incident congestion is viewed as a major problem in urban travel. In the short-term, incident congestion causes delay to travelers, wastage of fuel, secondary accidents, wear and tear of vehicles and roadways, and environmental pollution. In the long-term, congestion adversely affects the economic competitiveness of a region. National statistics indicate that more than 60% of urban freeway congestion is related to incidents. Nearly everyone can cite a horror story about being caught in a massive traffic backup that resulted from a fiery multicar accident overturned truck or spilled load. Because the time and location of these incidents occur randomly, few of us had to suffer through such experiences on a regular or recurring basis.

Minor accidents, on the other hand, do occur very regularly, but are generally thought of as mostly just a nuisance. Often times when people are caught in congestion caused by a minor incident, they do not know what caused the backup because it's gone by the time they actually pass the point where it has occurred. There are no definitive studies to reflect how many accidents or fatalities are directly the results of freeway incidents. The evidence however suggests that incidents and traffic congestion resulting from incidents have a significant adverse effect on freeway safety.

Literature Review

This section describes past research in the area of incident detection and prediction. There is an extensive amount of information related to this subject, as such, the literature review is not intended to be comprehensive, but merely illustrative of the efforts undertaken in the past.

Over the past decade, freeway demand has exceeded capacity in many areas. Constantly increasing travel demand generated by the population and economic growth

has been met with an essentially fixed infrastructure, as prohibitive cost and environmental concerns brought the highway building boom to an end. In some areas, the congestion has reached critical proportions and rush hour conditions may prevail eight or more hours every weekday.

Cohen and Ketsidou (1991) developed a general method for the calibration of Automatic Incident Detection algorithms. The other objective of this is to present a simple structure of real data well adapted to the calibration process. Practical results showing the efficiency and the simplicity of the approach were also illustrated in this project of the case in Paris where it was implemented. The authors also compare the results with the various types of algorithms including Double exponential smoothing algorithm, Payne algorithm and the California algorithm. It was found that the Double exponential algorithm was found to be more efficient than the simple one. Payne algorithm produces allowed number of false alarm rate for the same detection level.

An extensive literature search revealed that surprisingly little data on incident characteristics is available (Guiliano, 1989). Aggregate information accidents is available in federal and state records, studies on incident characteristics and impacts, however, are scarce. Moreover, project results vary due to differences in project approach, data collection methods, project environment, and incident categorization. Incident rates vary widely from one location to another.

Goolsby and Smith (1971) collected duration data from police logs for weekdays only, over a two-year period. A mean duration time of 45 minutes for noninjury accidents and 18 minutes for vehicle stalls was reported. Also, the research report by (Juge, et. al, 1074) showed that the mean reported duration of all incidents was 42 minutes. The impact of incident on facility capacity depends on facility characteristics, as well as the characteristics and location of the incident itself (Kelleway and Tucker, 1981; Lari, et. al.1982; Urbanek and Rogers, 1078). These studies indicated that the impact is independent of the nature of the incident. Lane-blocking incidents have a more than proportional impact.

Golob, et al (1987) analyzed the relationships between type of collision and accident characteristics using log-liner models. The results point to significant differences in several immediate consequences of truck related freeway accidents according to collision type. The studies over the years have developed automatic incident detection systems for freeways that monitor traffic flow information from a highway facility and automatically detect such incidents (Solomon, et. al., 1979) for freeway incident detection algorithms.

Previous studies in this field have developed various models to detect incidents on a freeway. Most of these studies have concentrated in developing a neural network model for incident detection. Ritchie and Cheu (1994) have presented a Multi-layer feed forward neural network model for automated detection of lane-blocking incidents on urban freeways. In this project, the authors perform a comparative evaluation with the recently developed algorithms, namely, McMaster and Minnesota incident detection algorithms. The results of this project show the neural network model has shown improvements over existing techniques in detecting lane-blocking urban freeway incidents.

Nathanail and Zografos (1993) present a methodology for evaluating the effectiveness of freeway incident management systems. The authors developed a simulation model that focuses on the operations of the freeway emergency response units (FERU) for the estimation of the measures of effectiveness of incident management systems. First, an analysis of the arrival rates of mobile servers, the area in which these servers provide service to emergency calls is divided into divided into smaller districts and the mobile servers are assigned to each one of these districts.

Specification and estimation of Neural Network model

Freeway loop detector data from highway I-880 in San Francisco, California was used to develop the neural network model. Traffic speed and occupancy data from the loop detectors were used as explanatory variables. These traffic data were first filtered out to give smooth variation using the following low-pass filter. Model training includes selecting a better value for the learning rate zero, or the constant of proportionality. This determines the amount of change in the weight after presentation of each input array. Typically, the value must be between zero and one; higher values cause the network to learn quicker. But with high learning rates, the error function will oscillate as the cumulative effect of the weight changes may become chaotic.

A neural network is composed of several neurons, which are connected to one or more neurons by links. These links are characterized by a weight of their own. Training of a neural network involves presenting a series of input arrays to the network along with the corresponding target output values for each input array. Processing of each input array consists of two distinct steps, a feed-forward (forward pass) and a back-propagation (backward pass). The network adjusts connection weights over a series of many iterations so that it can reproduce the desired output values. Each input pattern is processed independently. When all patterns have been processed, the network returns to the first pattern.

A four-layer feed-forward neural network with back-propagation capabilities was developed by trial and error method. The model with five and two neurons in the first and second hidden layers respectively performed better than other hidden layer combinations. The number of model inputs determines the number of neurons in the input layer. The type of output expected determines the number of neurons in the output layer.

The input traffic data was divided into two sets. The first data set was used to train the neural network model and the second data set was used to evaluate the final model. The model training procedures were implemented using algorithms available in MATLAB software.

Results from the Neural Network Model

The neural network model with two-hidden layers provided the following evaluation assessments with the test data set.

Total number of incidents present = 289
Total number of incident presence detected = 277
Total false alarms = 1
Total number of incident presence undetected = 12
Therefore, the detection rate of the neural network model = 277/289 = 95.85%
Similarly, the false alarm rate = 1/289 = 0.35%

Estimation of Discrete Choice Model

The data obtained from the loop detector and the incident detection are assembled in a single data set to perform the analysis and formulate the model. The two data segments from the loop and the incident detection are assembled based upon their timings. This data is imported in the Statistical Analysis Software (SAS) to perform the analysis.

The parameters of the utility functions of the logit model are estimated using Statistical Analysis Software (SAS). The intercepts and the covariates are calculated for the filter speed, filter occupancy, and volume data using the Logistic procedure in SAS. Then, the utility functions are calibrated for both incidents and non-incidents, and these functions are used to develop a logit model, which predicts the probability of incidents at a point of time.

The equation of the logit model is expressed as:

$$p(k) = \frac{e^{U_k}}{\sum_{j=1}^{n} e^{U_j}}$$

p(k) - Probability of occurring an incident,
U_I - Utility function of incident,
U_{NI} - Utility function of non-incident.

Results from the Discrete choice Model

The following are the summary of the results obtained from the discrete choice model. Further details of the model coefficients are furnished in the tables next page.
Number of incidents detected = 289
Number of non incidents = 191
Intercept in the model (a_0)= -8.538
Coefficient of Speed (a_1) = 0.526
Coefficient of occupancy (a_2) = -2.4033
Average predicted probabilities and observed responses concordant = 99.8%
Average predicted probabilities and observed responses discordant = 0.2%

The following tables summarize the results from the Statistical Analysis Software:

Descriptive statistics of the data from the loop detector during the Freeway Service Patrol study on I-880 Southbound

Variable	Sample Size	Minimum	Maximum	Mean	Variance	Std Dev
Time	480	21600.00	35970.00	28785	17316000	4161.25
Speed	480	10.55	63.22	36.13	497.19	22.29
Filter occupancy	480	4.42	38.95	20.49	154.12	12.41
Incident	480	0	1	0.60	0.24	0.49

The Logistic Procedure

Variable	Intercept	Speed	Occupancy
Intercept	916.16	-9.72	-39.86
Speed	-9.72	0.11	0.34
Occupancy	-39.86	0.34	2.25

Analysis of Maximum Likelihood Estimates

Variable	DF	Parameter estimate	Standard Error	Wald Chi-square
Intercept	1	-8.53	30.26	0.07
Speed	1	0.52	0.33	2.37
Occupancy	1	-2.40	1.50	2.56

CONCLUSIONS

The following are the conclusions that are drawn from the results of the study. The probability of occurring an incident increased gradually when an incident is detected at the point of time. The filter speed is reduced when an incident is detected. The filter occupancy is increased when an incident is detected. The results indicate that the logit model is capable of detecting incidents accurately. The number of incidents detected by both the models was found to be 289. The predicted probabilities and responses for this study was found to be 99.8%. Applicability of neural networks in freeway incident detection was discussed. A four-layer feed-forward neural network with back-propagation capability is developed. The conventional volume-occupancy input combination was replaced by a new input combination in the current study. Filtered real-time speed and occupancy data from loop detectors were used as the model inputs. The model was trained and tested using loop detector data collected on I-880. Results of the study indicate an excellent detection rate of lane-blocking incidents on freeways. This paper has presented the preliminary results, as further investigation is ongoing.

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