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Proceedings of the International Conference on Computing in Civil and Building Engineering
W Tizani (Editor)

A study on traffic accident measures in municipal roads by using GIS

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Abstract

Traffic Accidents are serious problems in all countries. In Japan, thousands of people are killed due to traffic accidents every year. Therefore, the Government of Japan has submitted and put into operation many measures to reduce traffic accidents. However, choosing effective measures is difficult because it involves many hazardous levels, various locations of accidents, various traffic volumes, etc. In case of municipal roads, the problem is more difficult than arterial roads because of their wide ranges of accident circumstances, lower traffic volumes, and unknown hazardous levels. Therefore, this study focused on submitting indices of hazardous spots and hazardous meshes as a methodology to choose measures appropriately for the scope of municipal roads. To investigate the method, GIS is used to analyze traffic accidents, and Utsunomiya City was chosen as a case study area. The Microcomputer Accident Analysis Package (MAAP) was used as a tool to do cluster analysis and density analysis. Cluster analysis is a function to determine hazardous accident spots, and density analysis is for determining hazardous accident meshes. As the result, many hazardous meshes are concentrated in the city centre. Furthermore, the important thing is that we classified hazardous levels of traffic accidents and divided the measures into two groups called spot measures and mesh measures for reducing traffic accidents on municipal roads.

Keywords: traffic accident, municipal road, measure, GIS, microcomputer accident analysis package

1 Introduction

1.1 Background and Purpose

Traffic accidents are serious problems in all countries because it causes many deaths and injuries every year. Although governments take various measures to solve the problem, traffic accidents are still persistent problems. This situation is the same in many countries including Japan.
In Japan, according to the data taken from 1965 to 2007, the number of traffic accidents, deaths and injuries increased sharply from 1965 to 1971 due to the insufficiency of traffic safety measures. In 2008, the number of traffic accident deaths is reduced to 5,155 which are the lowest in half a century. However, the number of injured people exceeded one million for 7 years since 1999.

Besides, traffic accident measures implemented by the government are almost concentrated on solving problems at the accident-prone places such as intersections of national roads or prefectural roads, and little attention was paid to municipal roads because of their infrequent occurrences of accidents. However, although there were fewer accidents occurred on municipal roads, they were widely scattered everywhere on a large scale. Therefore, if all accidents on municipal roads are summed up, the number of traffic accidents is not a small one at all. In order to reduce traffic accidents on municipal roads, the measures applied for national roads maybe inappropriate due to the difference between the environment of the national road and the municipal road. Therefore, the purpose of this study is to find out hazardous position of traffic accident and submit a method to choose measure appropriately and effectively for the scope of municipal road.

1.2 Review of related studies

Hideki's study (Hideki et al., 2000) made an analysis on traffic accident for municipal roads from the viewpoint of sight distance of intersection. The author also defined causes of accidents by using variation tree method).

Besides, The Road Administration Management of Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan has defined accident-prone places, and measures are chosen with the indicator called casualty rate calculated by the number of accidents in a year and traffic volume (See Equation 1).

$$\text{Casualty rate} = \frac{\text{Number of deaths and injures}}{\text{Number of cars in one km}} \quad \text{(case/cars)}$$

However, the traffic accidents on municipal road have a characteristic that the occurrence rate is low, and gathering traffic volume data on all municipal roads is very difficult. Therefore, we think that new indices for analyzing traffic accident on municipal road as proposed in this study are very necessary.

2 Concept of traffic accident measure in case of municipal road.

2.1 Current traffic accident situation of Utsunomiya city and data used

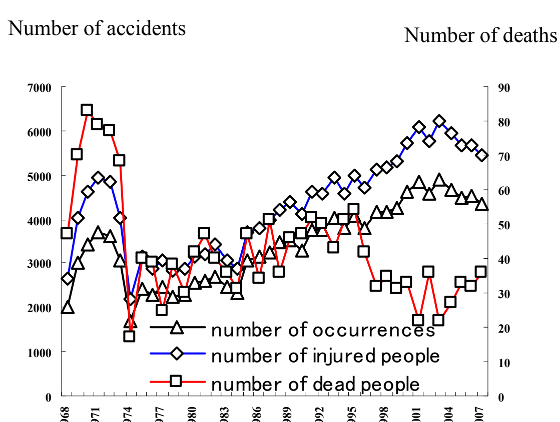


Fig.1 Process of traffic accident in Utsunomiya

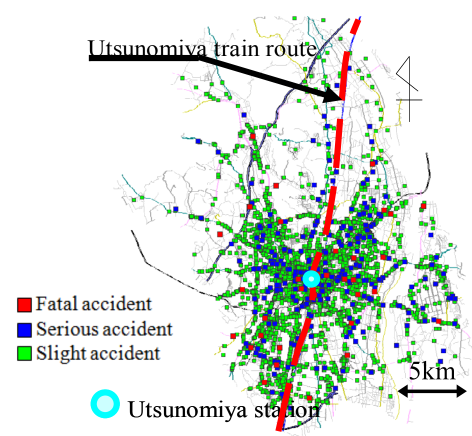


Fig.2 Traffic accidents displayed on GIS

There were 4,332 traffic accidents with 36 people dead and 5,461 people injured occurred in Utsunomiya city in 2007. If comparing with the data of 2006, number of traffic accidents decreased by 178 (3.9%), and number of injured people decreased by 197 (3.5%). But, number of deaths increased by 4 (12.5%). So, it may be said that traffic accident becomes a serious problem in Utsunomiya city (See Figure 1).

Data used in this study is of the year 2006 with 2,088 traffic accidents occurred on municipal roads in Utsunomiya city. These accidents were displayed on GIS as Figure 2.

2.2 *The trend of traffic accident distribution in zones*

In Utsunomiya city, occurrence density of traffic accidents in zones which was calculated shows that occurrence situations of traffic accidents are different by the land use. Moreover, occurrence density of traffic accidents in residential zone is very high. In order to know distribution of accidents in detail, the entire Utsunomiya city area was divided into meshes with size lengths of 500m. And in these meshes, variance was used to determine the distribution types such as concentration type, scatter type, and mix of both types.

Each mesh was set up with x axis and y axis (See Figure 3). Coordinate of accidents in each mesh was examined. Then, variance σ_x^2 and σ_y^2 of x axis and y axis correlatively were calculated (See Equation 2).

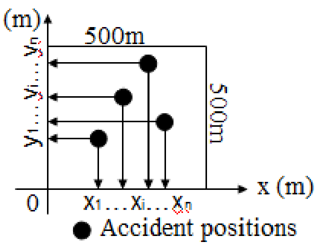


Fig.3 Calculation of variance in meshes

$$\sigma_x^2 = \frac{\sum_1^n (x_i - \bar{x})^2}{n}, \qquad \sigma_y^2 = \frac{\sum_1^n (y_i - \bar{y})^2}{n} \tag{2}$$

Then, scatter graph was created by calculated variances and probability concentration ellipse (PCE) (90% confident limit). (See Figure 4)

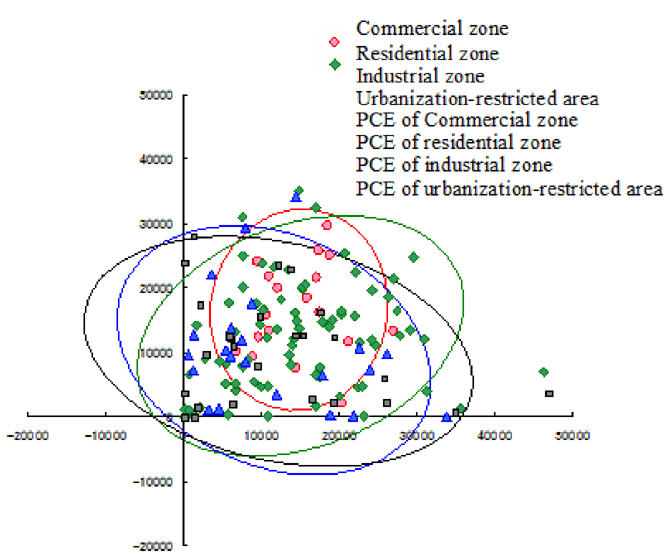


Fig.4 Distribution graph

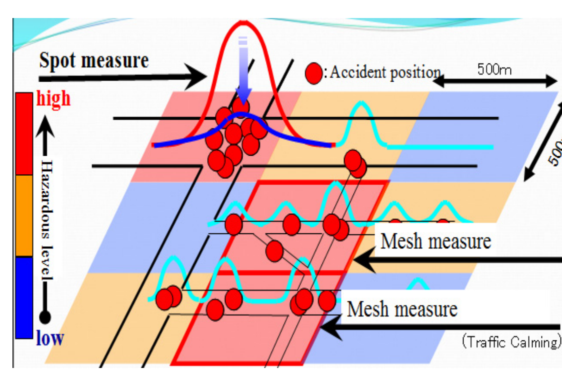


Fig.5 Concept of traffic accident measures in Municipal road

2.3 *Concept of traffic accident measures for Municipal Roads*

According to figure 4, traffic accidents on municipal roads have different distributions in each mesh. So, it was thought that understanding of distribution types of traffic accidents occurred on municipal road is very essential. In fact, in case of concentration type, safety will increase higher if spot accident measure is used. But in case of large scale with random accidents, it was thought that mesh measure will become more effective. In summary, if distribution types of accidents are determined, either spot measure or mesh measure will be chosen to implement to reduce traffic accidents effectively (See Figure 5).

3 Investigation of the classified method base on spot hazardousness and mesh hazardousness.

3.1 Evaluation of spot hazardousness and mesh hazardousness.

As discussed above, we knew that traffic accidents occurred and distributed everywhere on municipal roads. And, we think that accidents with near distances will become hazardous if they are grouped together.
Therefore, in order to investigate the methods classified as in Section 2.3, we focused on evaluation of spot hazardous level and mesh hazardous level.

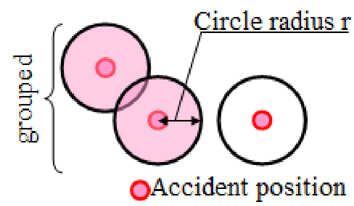


Fig.6 Grouped traffic accidents

About the evaluation of spot hazardousness, the accidents was grouped as figure 6 by circles with radius r = 16.32m that was calculated by using the concept of nearest neighbour distance. According to this, we can find out accident-prone places and define them as "Accident Hazardous Spot" (AHS).

Next is about the evaluation of mesh hazardousness. We divided area into equal size meshes in which the weighting of accident will be calculated, and hazardous level of mesh will be evaluated according to the accident weighting. So, meshes which have high hazardous levels will require immediate attention to implement counter-measures. We defined the mesh as "Accident Hazardous Mesh" (AHM).

3.2 Weighting of traffic accident

In order to evaluate hazardous level in each spot and mesh, weighting of traffic accident was used. It is also called as Accident Score (AS) in this study. Its equation is shown as follows (See Equation 3).

$$\alpha_1 \times A + \alpha_2 \times B + \alpha_3 \times C = \text{Accident score} \tag{3}$$

A: Number of fatal accidents
B: Number of seriously injured accidents
C: Number of slightly injured accidents
$\alpha_1, \alpha_2, \alpha_3$: Parameters (α_1=0.76, α_2=0.22, α_3=0.02)

Parameters $\alpha_1, \alpha_2, \alpha_3$ were determined by the rates after counting amount of loss of each person according to various cases such as death, after effect, injury based on car insurance data (General Insurance Association of Japan, 2007).

3.3 Priority of measure inside the hazardous mesh

After determining AS for meshes and spots as above, priority measures will be chosen to implement effectively based on distribution ratio (DR) of hazardous level counted as Equation 5.

$$\begin{matrix}\text{Distribution ratio}\\ \text{of hazardous level}\end{matrix} = \frac{\text{AS of each spot}}{\text{AS of total of mesh}} \tag{4}$$

The process of choosing measure is shown in the chart below.

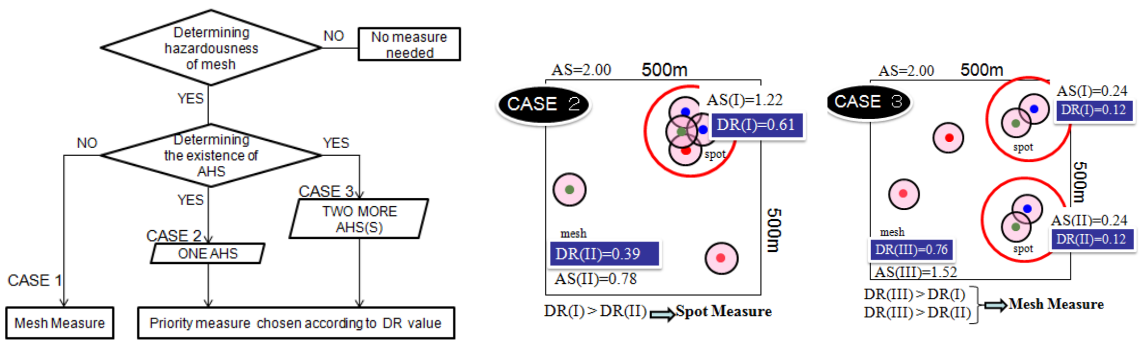


Fig.7 Proces

In case 1 with no AHS in the mesh, the necessary measure will obviously be the mesh measure. But, in case 2 with one AHS, and case 3 with two or more AHS, spot measure or mesh measure will be prioritized according to the value of distribution ratio (DR) (Figure 8).

4 Determining accident distribution in Utsunomiya city

4.1 Determination of accident distribution type by using Accident Analysis Software

Utsunomiya city was used as a case study for the analysis. Traffic accident distribution in Utsunomiya city will be determined by using Microcomputer Accident Analysis Package (MAAP). The accident analysis software was provided by TRL Company in England. It helps analyzing accident causes and submitting measures for reducing accident by displaying hazardous levels optically.

As an analysis method, density analysis (mesh analysis) and cluster analysis (spot analysis) will be focused on. Density analysis divides a pre-defined geographical area into equally dimensioned squares. MAAP will then count the number of accidents in each square and thematically colour the map correspondingly. A list of the worst squares, i.e. the squares with the highest accident counts are produced and the accidents contained with-in the square can be analyzed with MAAP’s other analysis tools (TRL, 2001)

Cluster analysis searches for collections of geographically related accidents within a defined geographical area. MAAP defines geographically related accidents as lying within a user defined distance of each other. Accidents belong to the same cluster as all other accidents geographically related to it, and to all accidents geographically related these nearest neighbours. Therefore it is possible to ‘move’ from any accident in a cluster site to any other accident in a cluster site, moving accident–to-accident whilst never moving more than the resolution distance. MAAP counts the number of accidents in each site. This information is then thematically represented on the map and a list of the sites with the highest accident counts produced (TRL, 2001).

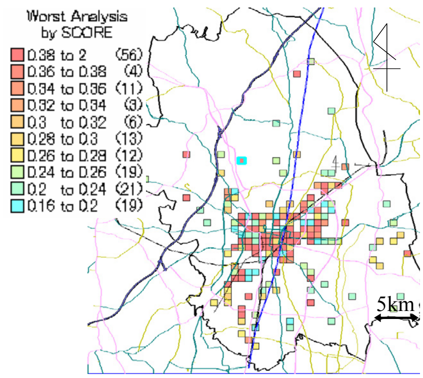
Generally speaking, cluster analysis is used to evaluate spot accident hazardousness, and density analysis is used to evaluate mesh accident hazardousness.

4.2 Density analysis result

As the result of density analysis, traffic accident hazardous meshes are concentrated and distributed in the city centre. Hazardous level of central area is also higher compared with suburban area (See Figure 9).

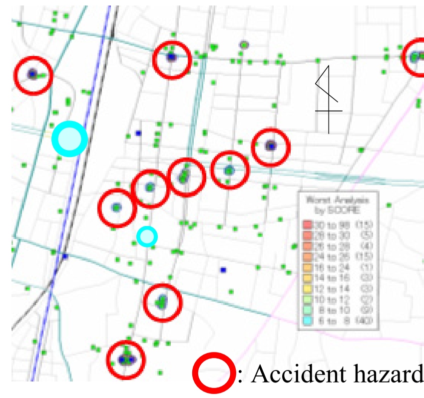
4.3 Cluster analysis result

As the result of cluster analysis, 97 spots of 230 grouped spots are hazardous and displayed on GIS map as in Figure 10 which shows that almost all accident hazardous spots are concentrated in intersection areas.



: Utsunomiya station

Fig.9 Distribution of accident hazardous mesh



: Accident hazardous spot

: Utsunomiya station

Fig.10 Distribution of accident hazardous spot in the east side of Utsunomiya station

4.3 Choosing accident measures for each mesh

In order to choose an appropriate measure for each mesh, we applied the steps shown in figure 7, and used the eastern area of Utsunomiya station as a case for analysis.

Density and cluster analysis results of the area were displayed on GIS map as Figure 11. Then, the distribution ratio was computed and shown as in the Table 1. According to the table, the meshes of No.3 and No.7 which have high distribution ratio of spot will need spot measure on a priority basis. Besides, the other meshes which have high distribution ratio of mesh will be asked for mesh measure to be implemented effectively.

5 Conclusion

The purpose of this study is to find out traffic accident hazardous places and propose the method of choosing effective accident counter-measure in the scope of municipal roads. Therefore, the indices of spot and mesh hazardousness to choose and implement measure effectively have been submitted. According to the indices, spot measure and mesh measure have also been submitted in this study. Furthermore, in practice, MAAP software was used to analyze traffic accident in Utsunomiya city. As the analysis result displayed on GIS, the city centre was known as the hazardous area due to the concentration of traffic accidents. So, the determination of appropriate counter-measures for reducing accidents has been called for.

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