Geospatial Patterns Analysis of Traffic Accidents in Jinju, Korea

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Abstract: Traffic accidents account for the highest proportion of artificial disasters occurred in urban areas along with the fire in Korea, which have a close relation with the structures of urban space such as land using zoning, population density, and road network in accordance with the urban development. Therefore, this study analyzed the changes in the types of traffic accidents according to the plans of land use zoning by making an analysis on the patterns of the occurrence causes of traffic accidents by using the GIS geospatial patterns. As a result, it came to demonstrate that the patterns of land use are closely related to the types of land use zoning. Therefore, it is expected that the study results will be utilized for establishing the measures to prevent traffic accidents according to the urban development.

1. Introduction

1.1 Research Background and Purpose

Rapid economic development has caused all sorts of disasters and accidents such as social conflicts, crime, environmental pollution, and traffic accidents as well as positive results in terms of the development of a nation and improvement in the quality of life. While disasters are referred to as the damages caused by natural phenomena such as hurricanes, floods, hail, and heavy snow, accidents represent artificial disasters like accidents that damage people's life and properties such as fire, collapse, and traffic accidents. Among disasters, traffic accidents account for the highest proportion of artificial disasters in urban areas, which have generated many casualties every year, so that more efficient solutions and preventive measures need to be established. Investigating the statistics of traffic accidents in Korea, total cases have repeated an increase and decrease over the last several years with 211,662 in 2007, 215,822 in 2008, 231,990 in 2009, 226,878 in 2010, 221,711 in 2011, and 223,656 in 2012. To prevent such traffic accidents, many measures have been formulated through a variety of studies, but there was little change in effect by showing a high incidence and mortality.
Therefore, this study puts its purpose in establishing preventive measures by analyzing the changes in accident types according to the land use by using the function of GIS spatial analysis in comparison of data of 2013 with data of 2009 with the target of Jinju-si which is the small and medium-sized city in Korea.

1.2 Research Target Area

Jinju-si, which is the target area, located in the southern province of korea, holds the approximately 340,000 in population. This small and medium-sized city includes total 21 dongs and 16 myeons and the analysis was conducted by selecting central areas (12 dongs) which are high in the traffic passage.

Figure 1. Location in Jinju-si

2. The Analysis Technique of Traffic Accident

The location is expressed by using the position coordinates (X, Y) for the occurrence spot of traffic accidents. An analysis on the pattern of GIS-based space was conducted by using the marked points. The analysis of spot pattern is largely divided into two: The first method is to measure the interaction of spots through the nearest neighbor analysis with the standard of distance between spots, and the second method is the kernel analysis, as a way of pattern analysis through the point density.

Since the nearest neighbor analysis compares distances at an arbitrary pattern by calculating the average distance to the nearest neighbor spot from each spot, the distance of all spots should be calculated and the relationships with neighboring spots are important. In comparing distances, the formula like $d_{\min}/E(d)$ is utilized, where $\overline{d_{\min}}$ is the average distance from each spot to the nearest spot, and $E(d)$ is the expected distance of spots in the case of arbitrary distribution.

As the value of R is smaller, it is closer to the clustered pattern, while as the value of R is bigger, it is closer to the dispersal pattern. The Kernel analysis as a way of identifying the density estimates the space density across the entire target areas based on the distribution of spots in the target area.

Since the localized spatial density is expressed visually, and conceptual understanding is easy, available for the intuitive interpretation, this analysis is widely utilized for visualizing the distribution pattern of point data. In particular, in case of analyzing the distribution pattern of spots, the spots which represent the particular phenomenon in a clustering are indicated with hot spots (Lee et al., 2013).

3. The Analysis of the Study Results

3.1 The Setting-up of Traffic Accident Data

The traffic accident data of Jinju-si, which occurred in 2009 and 2013, were acquired by using the TAAS presented by the Road Traffic Authority, and the location of traffic accidents was marked on the map after conducting the coordinate transformation through GIS. The analysis on the traffic accident pattern between 2009 and 2013 was targeted at 12 dongs which are central areas in Jinju-si and hold the largest resident population and floating population (Table 1).

Table 1. Traffic Accident in Jinju-si (2009, 2013)

	Occurrence(cases)	Death (Person)	Serious injury (Person)	Slight injury (Person)	Injury (Person)
2009	1,092	39	834	560	51
2013	976	25	688	586	42

Figure. 2 shows the land use zones in Jinju-si, which was utilized for analyzing the relationships between traffic accidents and land use zoning. A area is the central commercial area in Jinju-si, where commercial facilities are condensed, B area, is the apartment-condensed residential area, and C area is the area around colleges and universities where commercial area and residential area are intermingled. D area is the area where residential area and industrial area are intermingled. Lastly, E area is the area around colleges and universities like C. Figure 3 and Figure 4 express the entire data of 2009 and 2013 traffic accidents according to the locations on the map.

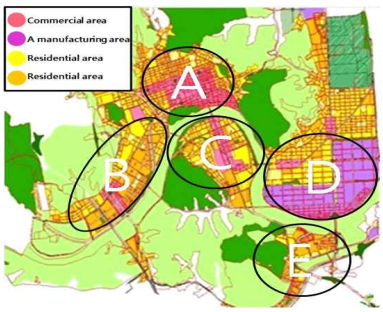

Figure 2. Land Use Map

Figure 3. Traffic Accidents Map(2009)

Figure 4. Traffic Accidents Map(2013)

3.2 The Analysis of the Traffic Accident Pattern

Table 2 is the result of the nearest neighbor index analysis by dividing the traffic accident types of 2013, which is the latest year into five types; accident type, damage type, weather condition, road types, and road condition with a view to identifying the pattern change of traffic accidents. This organized the most clustered distribution type and the highest dispersed distribution pattern.

As the value of the nearest neighbor index is closer to 0, it appears a clustered type. While the value of the nearest neighbor index is closer to 1, it shows an arbitrary distribution type, as the value is bigger than 1, it shows a dispersed distribution type. Some factors were excluded in the nearest neighbor analysis

Table 2. Nearest Neighbor Indexes of Traffic Accidents in Jinju(2013)

Type	Nearest neighbor indexes	Type	Nearest neighbor indexes
Accident type - Front collision	0.98	Weather condition - Clear	0.41
Accident type - The side right-angle collisions	0.55	Weather condition - Cloudy	0.96
Accident type - The roadside zone during the passing	1.30	Road street - Dry	0.41
Accident type - During the crossing	0.57	Road street- Humid	0.65
Damage condition - Personal injury	0.43	Road type - Three way intersection	0.48
Damage condition - Damage of oneself	0.86	Road type - Direct route	0.68

because accident which is subject to these five types did not occur or numbers of accidents were not sufficient to analyze. The nearest index analysis about remaining factors was conducted.

The study results reveal that the side right-angle collisions showed the highest clustered distribution with

the value of 0.55 in a car versus car accident type, and the front collision showed the highest dispersed distribution with the value of 0.98. In the accident type of car versus person, the traffic accident during the crossing showed the highest clustered distribution with 0.57, and the traffic accidents during the passing were the highest dispersed distribution with 1.30.

In traffic accidents that correspond to the damage conditions, personal injuries showed the highest clustered distribution type with the nearest neighbor index value of 0.43, and the damage of oneself showed a dispersed distribution type with 0.86. In addition, the traffic accidents in a clear day, cloudy day, and dry condition in the road condition were 041, 0.96, and 0.41 respectively. The traffic accidents in the three-way intersection and direct route in terms of the road types were 0.48 and 0.68 respectively, showing a clustered type and dispersed type. To analyze the traffic accident types and changes in the occurrence spot in time series, the traffic accident data of 2009 (four years earlier than 2013) were utilized for the nearest neighbor analysis(Table 3).

Table 3 shows the analysis result of 2009 data in which the highest clustered case and highest dispersed case were selected. In the comparative analysis of 2009 and 2013 data, the side right-angle collisions showed the highest clustered distribution in the case of the car versus car traffic accident type, while front collision showed the highest dispersed distribution. This shows the same characteristics without a great change in a flow of time over the last 4 years. In the accident type of car versus man, traffic accident that occurred during the crossing, and clear day in the weather condition, and dry condition in the road condition showed the highest clustering without a significant change between 2009 and 2013.

Table 3. Nearest Neighbor Indexes of Traffic Accidents in Jinju(2009)

Type	Nearest neighbor indexes	Type	Nearest neighbor indexes
Accident type - Front collision	0.91	Weather condition - Clear	0.42
Accident type - The side right-angle collisions	0.45	Weather condition - Cloudy	1.08
Accident type - The roadside zone during the passing	1.29	Road condition - Dry	0.42
Accident type - During the crossing	0.55	Road condition - Humid	0.63
Damage condition - Personal injury	0.44	Road type - Three way intersection	0.50
Damage condition - Damage of oneself	1.19	Road type - Curved road	1.11

However, while traffic accidents, in which material damage and personal injuries are combined in the condition of traffic accident, demonstrated the highest clustered distribution in 2009, personal injuries were the highest clustered distribution in 2013. This indicates that the condition of damage would change according to the lapse of time. In addition, the accident that occurred in the three-way intersection was the highest clustered, the highest dispersed accident type appeared in the curve section in 2009, and in the straight section in 2013.

Meanwhile, the relationships of clustered degree in the traffic accident point and the land use were analyzed for the analysis of traffic accidents and land use. First of all, the hot spot of the accident spots was conducted by the GIS kernel analysis and the land use zoning in related areas was investigated. The side right-angle collisions(Fig. 5, 6) which showed the highest clustered distribution in a car versus car accident type, a total of 471 accidents occurred in 2009, which were distributed in A area, shop concentration area, B area, residential area, and D area where industrial complex and residential complex are intermingled. However, in 2013, traffic accidents were reduced to 280 cases, which showed a decline on the whole, and in A area where traffic accidents were the highest, hot spot showed a change in comparison with 2009.

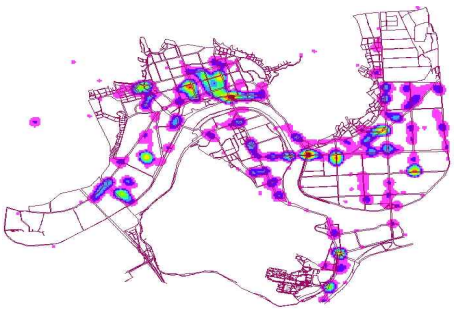

Figure 5. Accident Distribution Map by the Accident Type (the side right-angle collisions)-2009

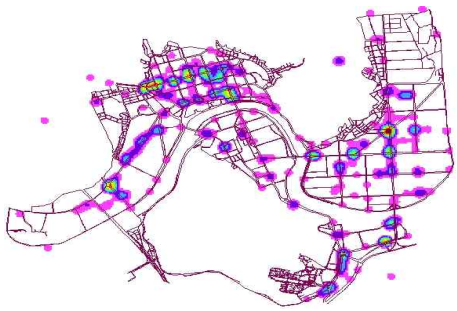

Figure 6. Accident Distribution Map by the Accident Type (the side right-angle collisions)-2013

In the case of traffic accidents according to the damage circumstances, traffic accidents in which the combination of material damage and personal injuries occurred in 649 cases in 2009. The combined damage occurred in 550 cases and personal injuries occurred in 397 cases in 2013.

Besides, when the weather condition was clear, the road condition was dry, and the road type was a three-way intersection, clustered traffic accident pattern appeared. This pattern was condensed in A area (central business area), B area (residential area), and D area where industrial complex and residential facilities were intermingled.

4. Conclusion

In this study, the spatial pattern analysis of spots were conducted with a view to classifying the causes of traffic accidents by utilizing the data of 2009 and 2013 traffic accidents with the target of jinju-si, a small and medium-sized local city. As a result of the analysis on the correlation of urban development and the spatial distribution of traffic accidents, the conclusions are obtained as follows:

First, the side right-angle collisions in the case of car versus car among the traffic accident types, accidents during the crossing in the case of car versus person accident type, clear day in the weather condition, and dry condition in the road condition showed the highest clustered distribution between 2009 and 2013 without a significant change. However, in terms of the damage condition of traffic accidents, the combination of material damage and personal injuries was the highest clustered distribution in 2009 and personal injuries showed the highest clustered distribution in 2013. This demonstrates that the damage conditions have changed according to the lapse of time.

Second, the analysis result of finding the hot spot through the GIS kernel analysis in regard to the density of accident spots and analyzing the land use of related areas reveal that the side right-angle collisions which showed the highest clustered distribution in the car versus car accident types appeared to be concentrated in central commercial areas and residential areas, while the location of the hot spot showed a slight change.

As described above, this study analyzed the correlation between the clustering of traffic accident types and land use to examine the changes of traffic accident types according to the urban development. It is judged that the transition analysis of traffic accidents will be usefully utilized for establishing the measures which can develop urban areas and manage traffic accidents.

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