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Full Length Research Paper

Spatial analyst methods for urban planning

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In urban planning, the development of the city for the future must be controlled. Therefore, in the city planning phase, it is necessary to plan for all events, from meteorological conditions, weather pollution, and settling to traffic accidents, according to potential future requirements. Road maps produced using statistical methods must be the base products for city planning. This study develops methods to obtain maps to determine traffic hot zones in Konya, Turkey, by applying Spatial Analyst (SA) supported by Geographical Information Systems (GIS). In this study, unlike preceding studies, the aim is to determine new safe routes and zones with the help of GIS. Another, different aim is to map and determine graduated hot or safe zones using different criteria. Accident criteria (AC): AC1 is the number of mortalities criterion, AC2 is the number of injured people criterion, AC3 is the number of accidents with damage only criterion and AC4 is the total number of accidents criterion.

Key words*:* Spatial analyst, kernel density estimation, GIS, density map, traffic accidents.

INTRODUCTION

Sample points to evaluate environmental dataset are generally distributed on irregular positions. Because of the irregular distribution of the points, mapping by traditional interpolation techniques is insufficient to evaluate the dataset. So, firstly SA must be considered before mapping. Some recent developed environmental researches with SA can be seen in the literature.

In this paper, spatial relationships of related points approaches have been used to study traffic accident datasets in a case study of the city of Konya. The paper attempts to examine the characteristics of the spatial distribution of traffic accident data according to the AC using spatial analyst method and to analyse their implications for junction spatial structure.

The numerical analysis of spatial point distributions has interested academics for many years. A very early work that resulted in the famous Moran's I statistic was that by (Moran 1948). An early important collection of work on general spatial analysis is that edited by (Berry and Marble 1968). The development of spatial point analysis theory is illustrated by such later books by (Cliff and Ord, 1973, 1981), more recent papers by (Ord and Getis 1995), (Anselin 1995) and (Gatrell et al., 1996), the overview by (Getis and Ord 1996), leading to large number of recent studies such as (Cho, 2003) using the techniques that have been developed over the last fifty years (McCullagh et al., 2006).

It is not the main purpose of this study to determine the hot spots only. The main aim is to produce useful maps with different AC by the help of density tools of SA. These maps will guide evaluating of existing accidents and future route planning or regulations. Therefore, risk maps are the fundamental products.

This study differs from others in that the mapping is carried out according to the different AC.

STATISTICAL ANALYST AND APPLICATION

Statistical techniques are commonly adopted to analyze traffic accidents. Spatial analysis is difficult to apprehend. With the advance of the GIS technique, it has become easier for even a layman to visually comprehend spatial analytical results. To obtain a clear spatial distribution of accident events, a mapping method is usually adopted to show the locations of the accident events.

Spatial data and its analysis is one of the most important information for traffic accident analysis. GIS aided spatial data and spatial analysis provides a lot of information to analysts about hazardous locations, hot spots, warm spots etc. Using GIS, the analyst can merge accident and highway data, geocode the accident data and locations, calculate frequency and rate of accidents, select a variable for stratification to calculate mean and standard deviation of accident rates (Liang et al., 2005; Erdogan et al., 2008).

Kernel Density Estimation is able to quickly and visually identify Hot Spots from large datasets and thereby provide a statistically and aesthetically satisfactory outcome. The advantage of these surface representations, particularly of road accidents, is that they can provide a more realistic continuous model of accident Hot Spot patterns reflecting the changes in density which are difficult to represent using geographically constrained boundary basin models such as the transport network or census tracts (Sabel et al., 2005).

For the Kernel Distribution with density function $d(x)$, an estimate $\hat{d}(x)$ of the density at *x* can be calculated using;

$$\hat{d}(x) = \frac{1}{n}\sum_{i=1}^{n} S_{\sigma}(x \quad x_i)$$

Where S_{σ} is a "Kernel function" with a bandwidth (scale) σ.

In many previous research studies, multiple linear regression, poisson regressions, and negative binomial regression models were used for developing accident event models that mimic the relationship of accident and contributing factors. Ng et al. (2002) proposes in their study poisson and negative binomial regression models for estimating traffic accident events.

In recent studies on the modelling of crashes, accident prediction models for urban roads were studied by Greibe (2003). Ng et al. (2002) worked on evaluating different methods. Soares and Pereira (2007) studied risk maps and Liu et al. (2008) studied geostatistical models for solving the cartographic problems.

Using Geostatistical Analyst by Kriging interpolation techniques have proved to be popular in many areas such as agriculture, mining, geology, environmental science, building, cartography, risk management, and so on. For example, they have been used for modelling the spatial variability of tropical rainforest soils (Yemefack et al., 2005), soil mapping (Leopold et al., 2005; Lopez-Granados et al., 2005), modelling the spatial distribution of human diseases (Pleydell et al., 2004), Finke et al., 2004), mapping the abundance of fish in the ocean (Rivoirard, 2002), rainfall mapping (Lloyd, 2005), and for detailed mathematical approaches (Hengl, 2007). Instead of evaluating risky zones caused trafiic accidents by Probability map, it has been produced for the only aim of risk illustration in this study.

PROVINCE OF KONYA AND TRAFFIC ACCIDENT DATA

Konya is not only the largest province of Turkey in the context of territorial size but also has the longest road network, with a 2957 km state road in a country with a total of just 61 939 km of roads. It lies eighth in the context of accident rates, third in the context of mortality rates and fifth in the context of numbers of injuries, according to statistics for 2006.

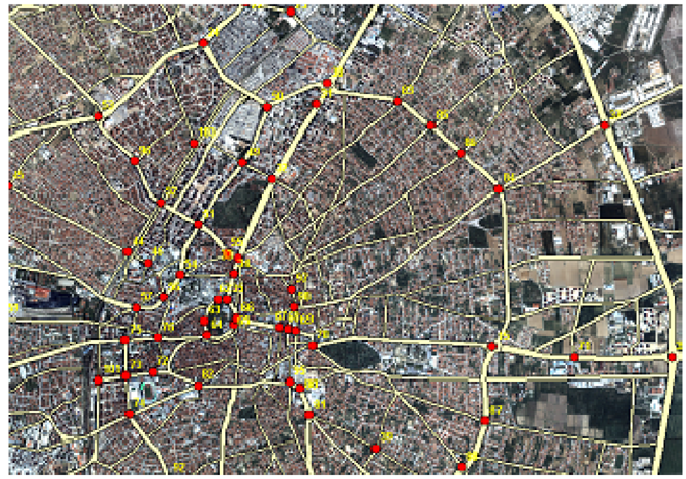

Figure 1. 103 junction points in the city centre.

Accident records for six years have been obtained from Konya Police Department and input into the database using MS Access to set up the GIS-based application. In this period, a total of 2078 accidents occurred; there were 13 accidents with mortalities, 314 accidents with injuries, and 1751 accidents with only damage. Figure 1 shows digitized routes and junctions on satellite image.

PRODUCING OF MAPS

It is essential to understand and real evaluate informations correctly from maps. So, sometimes it may be necessary to use different visualisation methods to produce different presentation. Figure 2 shows different AC4 maps presentation techniques produced by SA and Figure 3 shows that distributions of AC by kernel.

RESULTS AND CONCLUSION

When route maps producing different criteria are investtigated (Figure 3a - c) different Hot Points degree appear at different points on the same routes. For instance, Hot Spots determined by mortality criteria are seen on straight routes because of the high speed on those sections. If there were an accident on this route, someone would normally be killed.

With the analysing and mapping the following tasks must be undertaken:

- Determining the locations where an increased number

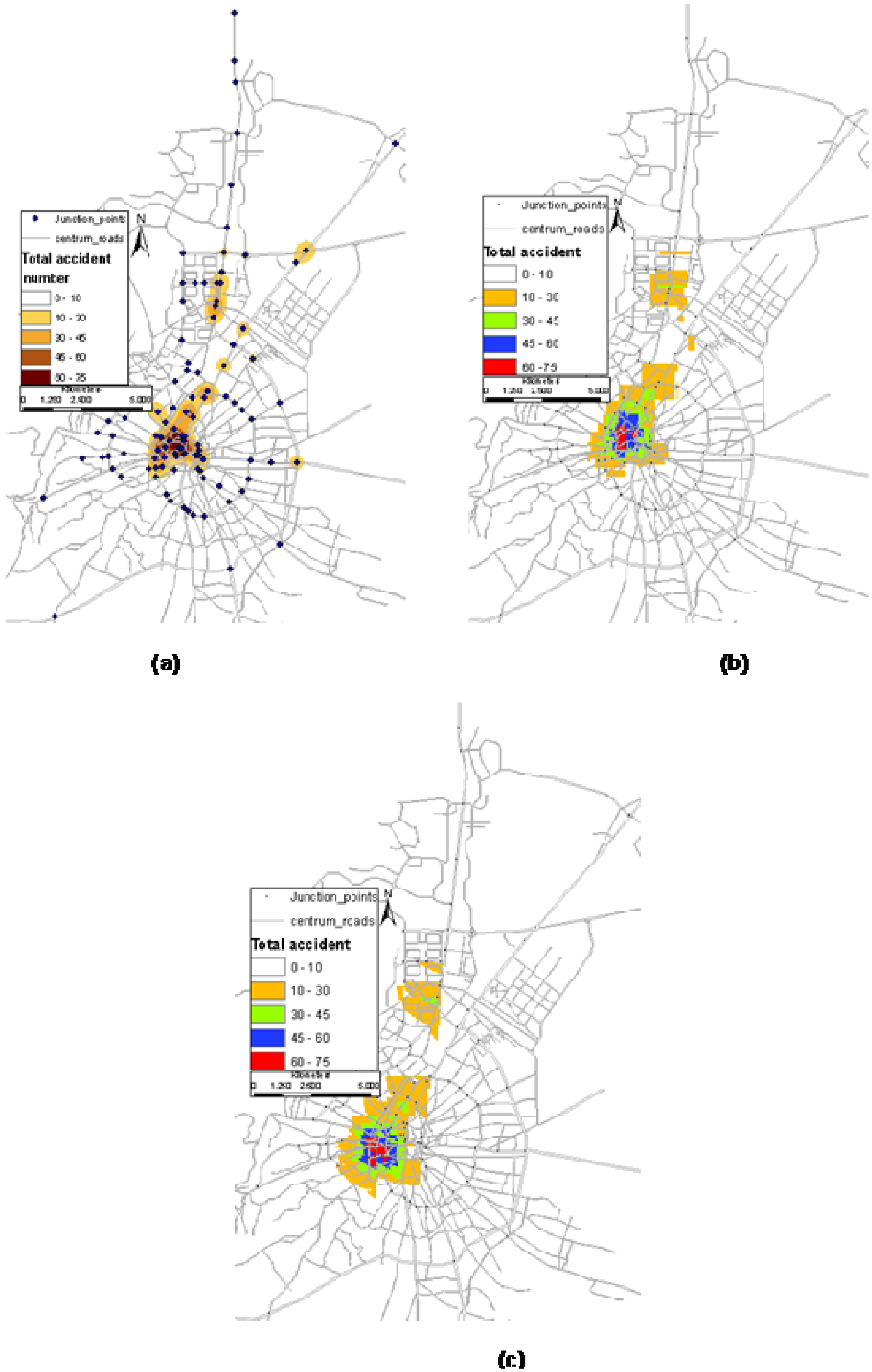

Figure 2. Different presentations with total traffic accident number. **(a)** Kernel- radius: 500 m., **(b)** Point density- Neighborhood: rectangle, radius: 500 m, **(c)** Point density- Neighborhood: wedge, radius: 500 m. Angel: 90°.

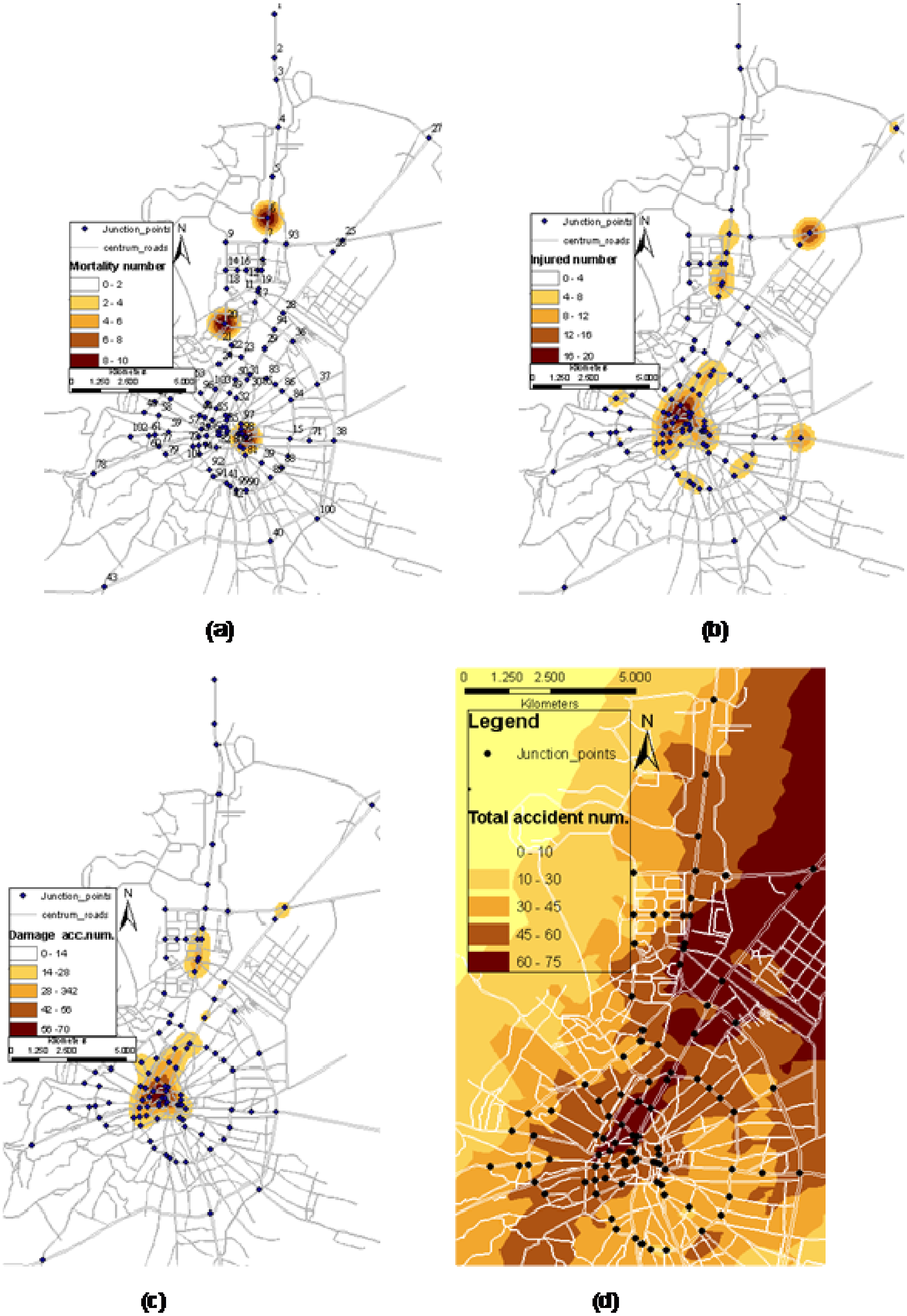

Figure 3. Result maps: **(a)** density map for number of mortalities (with junction numbers), **(b)** density map for number of injured persons, **(c)** density map for number of accidents with damage only, **(d)** probability map with no more than 10 (mean value) accidents

of accidents occur.

- Detailed functional analysis of a location where an accident has occurred for the purpose of determining the factors causing accidents.
- Developing methods used for determining elements such as traffic notices, and lights controlling traffic flow that cause danger.

According to the resulting values, there are important problematic junctions: three junctions (6, 20, 70) arising from AC1, three junctions (25, 38, 51) arising from AC2, three junctions (30, 49, 51) arising from AC3, and four junctions (25, 30, 49, 51) arising from AC4.

Three junctions (30, 49 and 51) which meet four criteria, of a total of nine problematic junctions, must be improved urgently.

The most straight and longest north artery with high traffic speed triggering the all AC. Precautions about reducing the speed must be put on the agenda urgently.

As a result, in the light of calculated values, result maps were produced with the aim of helping to create new city models. Maps which have statistical value and can be visualised will be a better help to city planners.

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