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Applying linear analysis methods to GIS-supported procedures for preventing traffic accidents: Case study of Konya

Ismail Bulent Gundogdu *

Department of Geomatic Engineering, Selcuk University, Konya, Turkey

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ABSTRACT

This study develops methods to obtain maps to determine traffic Hot Spots in Konya, Turkey, by applying linear analysis supported by Geographical Information Systems (GIS).

Hot Spot analysis is known method but the study differs from former researches at the point of determining of risky zones, classification and illustration of them on the maps with the different accident parameters. The aim is not to contribute another Hot Spot analysis using a number of statistical methods, but to determine the Highest Potential Hot Spots (HPHS), which are inter-sectional clusters, and to use different parameters, such as number of accidents, number of fatalities and injured, and number of accidents with only financial loss.

In addition, apart from classical illustrational techniques, Hot Pieces (HPCS) on roads divided into 1 km segments are shown by their grading according to their numerical values. Hence, thematic illustration distinguishes them from others.

Another aspect of this study is that, besides investigation of Hot Spots by means of data of accidents of previous years', Probable Hot Spots (PRHS) were illustrated and highly potential Hot Spots were determined. These latter are candidates for Hot Spots in the near future. Thus, premature accidents can be anticipated easily.

The main intention of this study is to emphasize the importance of using criteria, other than total accident number, to illustrate intersection Hot Spots and to constitute a model of accident severity and variety. It is anticipated that the results obtained from highway accidents data will guide improvement of the route segments.

1. Introduction

Traffic accidents have been recognized as one of the major causes of human and economic losses, both in developed and developing countries. This problem is of great concern in developing countries, because of its seriousness and the limited resources available to develop feasible countermeasures for reducing this ever-growing challenge (Berhanu, 2004).

A report from the World Health Organization and the World Bank (2004) on road traffic accidents and injuries estimated that 1.2 million people are killed in road crashes each year and as many as 50 million are injured worldwide (Rathinam et al., 2007; Rutter and Quine, 1996; Hilakivi et al., 1989). According to estimations of the World Bank, traffic accidents will be the third most frequent cause of deaths in 2020.

Statistics from the Turkish Statistical Institute (TUIK) reveal that, in 2006, there were 665, 618 traffic accidents in Turkey, 2629 of which resulted in mortality, 77,644 resulted in injuries and 585,345 in economical damage. The damage was estimated as $870 million.

According to a questionnaire from Arslan (2007) among 800 people whose relatives lost their lives in traffic accidents in European countries revealed that 37% of those had a tendency to commit suicide and 64% of those had depression in the subsequent 3 years. Another questionnaire applied in Turkey revealed that 50% of 240 people whose relatives lost their lives in traffic accidents suffered from insomnia and 39.2% suffered from hysteria, in addition to depression.

Several precautionary procedures have been conducted to prevent or minimise the destructive problem of traffic accidents. Plotting, which needs to be conducted by analysing causes of accidents through a large amount of data, is one of the major precautionary measures that might prevent accidents.

According to a report from the Turkish Ministry of Public Works and Settlement (2007), there was, between 2003 and 2005, a 64% decrease in the number of accidents, a 94% decrease in road fatalities and a 65% decrease in the number of people injured on rehabilitated segments of roads.

* Tel.: +90 555 7214769; fax: +90 332 2410635.
E-mail address: bgundogdu@selcuk.edu.tr

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The most frequent method in defining a Hot Spot is how they are determined. A Hot Spot can be defined as a point where there is a particularly frequent recurrence of an event. These spots are determined statistically and have various visual methods and usage fields that can be described as follows (Eck and Weisburd, 1995). Areas of concentrated crime are often referred to as Hot Spots. Researchers and police use the term in many different ways. Some refer to Hot Spot addresses (Eck and Weisburd, 1995; Sherman et al., 1989), others refer to Hot Spot blocks (Weisburd and Green, 1994; Taylor et al., 1984), and others examine clusters of blocks (Block and Block, 1995).

The number of accidents on a given road section during a certain period of time is probabilistic in nature and is a non-negative integer. Despite the fact that accidents are random and unpredictable at micro-level, statistical models can predict reliable estimates of expected accidents by relating aggregates of accidents to various explanatory measures of flow, site characteristics, and road geometry at macro-level. Numerous empirical relationships between vehicle accidents and these explanatory variables have been established in several previous studies (e.g. Maher and Summersgill, 1996; Miaou, 1994; Miaou and Lum, 1993). Such accident predicting models are useful in identifying the most critical variables of safety, assessing design and management alternatives, and improving safety standards for new roads.

The significantly different areas detected by the applied statistics (usually termed LISA: Local Indicators of Spatial Autocorrelation) are, traditionally, termed Hot Spots, hotpoints or, occasionally, hotbeds (Ratcliffe and McCullagh, 1999). The statistics used to define the hotbed coverage may result in circular, elliptical or amoeboid shapes depending on the method or application used. There is a wide choice of approaches available (Mccullagh, 2006). The numerical analysis of spatial point distributions has interested academics for many years. A very early work that resulted is the famous Moran's I statistic 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 later works by Cliff and Ord (1973, 1981), Ord and Getis (1995), Anselin (1995) and Gatrell et al. (1996). The overview by Getis and Ord (1996) has led to large number of recent studies, such as Cho (2003), using the techniques that have been developed over the last 50 years (Mccullagh, 2006).

The Linear Referencing Model (LRM) was used to determine Hot Spots in this study.

An LRM can be defined as a mechanism for finding and stating the location of an unknown point along a network by referring it to a known point (Vonderohe and Chou, 1997). More specifically, an LRM is a process for determining a previously unknown location based on a defined path along the underlying transportation network; a distance along that path measured from a known datum location; and, optionally, an offset from the path. There are several types of LRMs, which differ based on the parts of the network used for referencing and the ways in which measures and offsets are calculated (Nyerges, 1990).

The following tasks must be undertaken in a study which has the same aim:

- Determining the locations where an increased number 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.
- Inferring the effect of physical features of a road such as curve, pavement material, and turning directions on accident occurrence.

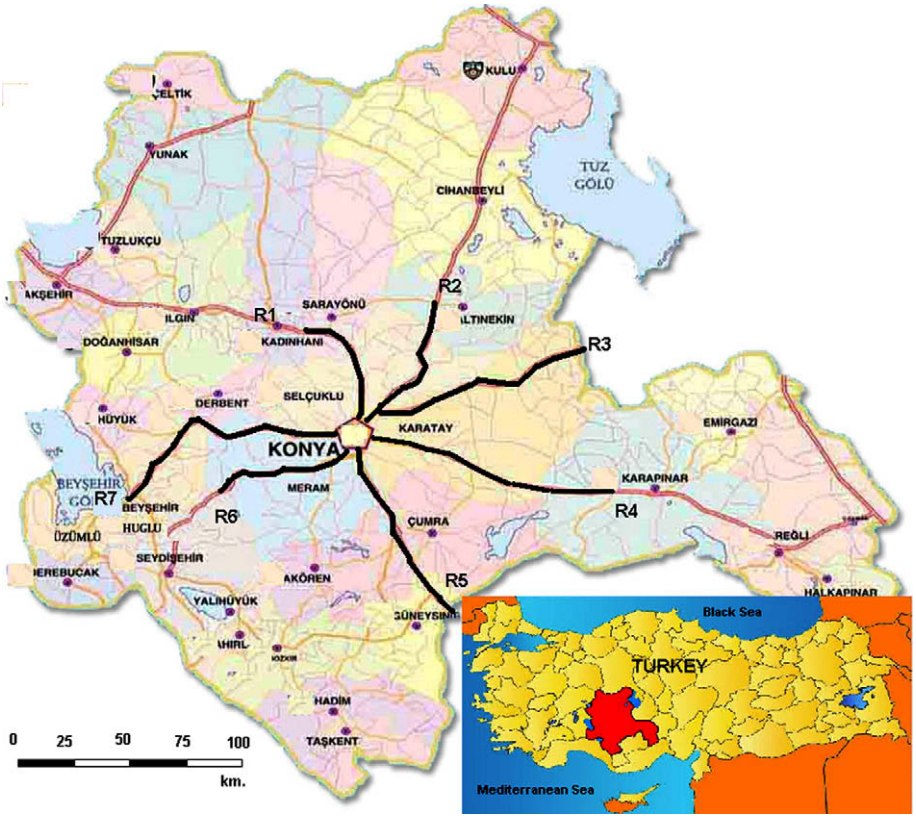

Fig. 1. General map of roads in Konya Province and location of the related highways.