The GIS-based Research on Criminal Cases Hotspots Identifying

Liu Lei

Department of Border Controlling, Chinese People’s Armed Police Academy
Langfang City, Hebei Province, China, 065000
liulei_bf@126.com

Abstract

This article is based on geographic information system (GIS) as a platform, from the perspective of criminal cases described hot spots to study the spatial patterns of criminal cases, inspection hot spots counting. This paper designs the algorithm identified hot spots of criminal cases and has developed a tool for identifying set of hot spots, drug cases through the Chinese city case studies, confirmed the proposed theory can identify hot spots of criminal cases to provide effective prevention and control of information support.

© 2011 Published by Elsevier B.V. Selection and/or peer-review under responsibility of National University of Singapore.

Keywords: GIS, criminal case information, identify hotspots

1. Introduction

GIS (Geographic Information System, referred to as GIS) is a spatial data collection, editing, storage, analysis and output of the computer information systems[1]. It is in the computer software and hardware support, spatial data processing and analysis, and graphics, images, charts and data in the form of the output of spatial information systems. GIS as a tool for solving spatial problems, methods and technologies, wide range of applications, including military police, resource survey, almost all areas of transportation[2]. Chinese police the construction of GIS at an early stage, the emphasis on emergency command and dispatch, is the application of GIS in primary and shallow. Such as the construction of police throughout China GIS are: 110 Command System, 119 Fire Police Geographic Information System, traffic management systems and command systems, and marine GPS. Analysis of the GIS information for public security, to meet the decision-making command and carry out the operations of the information
needs of public security is the field of GIS in public security applications and high-end depth. Chinese police GIS analysis of the information is still very weak, only a few papers and monographs. Development in practice, since 2006, Ministry of Public Security and the State Bureau of Surveying and Mapping, American institutions such as GIS software company ESRI GIS police began a co-development projects, the Shanghai Public Security Bureau has also developed a case of space-time analysis system [3]. In order to strengthen the public security police GIS information analysis, information analysis of GIS in public security work in the application of methods and techniques, the paper's location information in criminal cases, elements of the research object, in criminal cases in the spatial pattern of GIS testing and evaluation, and morphological analysis of related issues.

2. criminal case the basic theory of hot spots identified

2.1. The Concept of Hotspots of Criminal Cases

Hot spots of criminal cases (Criminal Cases Hotspot) is the high crime geographic area [4], is often many times the geographical area criminal offense occurred, is a criminal offense gather geographical area. Hot-related criminal cases is more extensive comparisons of the geographical area, through such a comparison can be demonstrated in the high incidence of drug cases in the region (on many occasions, aggregation occurs). So hot in criminal cases is a relative concept, rather than criminal cases is relatively cold (Cold Spots). Criminal cases, criminal cases, cold and hot there is no strict division between the standards described in different ways in different hot region of space, we explore the GIS map of hot spots for the definition of a criminal case. The location of criminal cases can occur in the GIS projection and coordinate system for accurate description, this is the next step based on spatial analysis.

2.2. GIS Coordinate System

GIS GIS is a spatial coordinate system of data location, the amount of calculation, conversion and spatial analysis of the benchmark for precise focus of criminal cases has provided a guarantee. GIS coordinate system is divided into two categories: geographic coordinate system and projection coordinate system. This case study chosen coordinate system: geographic coordinate system GCS_Xian_1980 (1980 national geodetic coordinate system, also known as Xi'an 80 coordinate system), the projector coordinate system Xian_1980_GK_CM_117E (Xi'an 80 coordinate system, projection, longitude 117 ° points with coordinates), projection Methods for the Gauss-Kruger projection. This vector data structure organizations selected hot spots of criminal cases, the instance data.

2.3. GIS Data Structure

GIS surface features or phenomena of space into several basic types of high level of abstraction - points, lines, surfaces and compositions of objects [5]. Point data (entities), said a specific location only, is the zero-dimensional data for the spatial expression of discrete surface features; line data (entity) type is an abstract linear features or phenomena, for the one-dimensional data; surface data (entity) with a specific spatial location of a certain scope and area of spatial entities, spatial coordinates of this data type is a closed chain, said two-dimensional data. Composite object is a point, line, surface features can not express the complexity of the abstract, by point, line, surface expression of a combination. Criminal cases which occurred in the abstract place in space is zero-dimensional point data (entities).

GIS data structure commonly used raster and vector are. In order to facilitate access to data and processing data and GIS software, GIS data on the structural limitations, this selection of vector data
structure organizations, identify hot spots of criminal cases, the instance data. Vector data structure [6] assume that geographical space is continuous manner by recording the coordinates that point as precisely as possible, lines, polygons and other geographical entities, coordinate space is set to Continuous, allowing any position, length and area of a precise definition. For a point entity, Vector structures were recorded only in the specific coordinate system coordinates and attributes of the code; for line entities, the connection with a series of coordinates that; polygon is completely closed the border region of space, with a series of coordinates connection said.

2.4. Hot Recognition Process in Criminal Cases

GIS-based hot spot identification in criminal cases is to accurately describe the focus of criminal cases, the use of spatial analysis techniques, the use of spatial analysis tools of the criminal case which had occurred to test the spatial model, hot form of calculation process. GIS-based object recognition in criminal cases is the distribution of hot spots in the geographical space of the criminal cases, a single case of form factor is zero-dimensional space points, a number of criminal cases, criminal cases, the formation of the spatial distribution model. GIS-based hot spot identification in criminal cases is the description of hot spots of criminal cases, criminal cases from the test of hot spot distributions of hot spots of criminal cases to the calculation. Its purpose is to enable users to intuitively, aware of the image of criminal cases through the thematic map of the location of hot spots and shape information for the user to indicate areas of high incidence of criminal cases. Identify hot spots of criminal cases flow chart in Figure 1.

![Figure 1 Flow chart of criminal cases hotspots identifying](image)

Shown in Figure 1, the hot spot identification process is divided into criminal cases, criminal cases and criminal cases testing spatial patterns computation hot form of two parts. Hot recognition process in criminal cases, in criminal cases were clustered spatial pattern distribution of the premise, according to different forms of the characteristics of hot spots of criminal cases, criminal cases, the order of calculated hot spots: hot spots, front surface area calculation of hot spot calculations point and oval shape Hot calculation form.
3. The algorithm of criminal cases hotspots identifying

3.1. The Algorithm of Criminal Cases Spatial Patterns

Criminal cases, the performance space for the spatial point pattern model, tested on spatial point pattern is to identify the distribution of the main types are aggregated distribution, random distribution or uniform distribution. Spatial point pattern analysis of two main types of tests. Aggregation of a class is based on density-based method, it uses the rules defined by the point area density or frequency distribution of the various features of the spatial point pattern, the main plot counting methods and nuclear function French. The other is a dispersion-based distance-based method, which is the nearest neighbor by a distance measure point of the spatial distribution pattern analysis methods, the main methods are nearest neighbor index (Nearest Neighbor Index, referred to as the NNI), G-function, F-function, K-function method. The nearest neighbor index method can not only be a good test of spatial point pattern, and its method is easy to calculate and use, so this choice nearest neighbor index (NNI) on spatial patterns of criminal cases tested.

Nearest neighbor index (NNI) points using the nearest neighbor distance between the spatial point pattern described in [7]. Calculation as follows: first calculate the nearest point on the average distance between, and then compare the observed patterns and random patterns (Complete Spatial Randomness, referred to as CSR) similarity between. If the observed pattern is larger than the nearest distance from the nearest neighbor random pattern, then the observation model tends to uniformity, if the observed pattern of nearest neighbor random distribution model is less than the closest distance, you tend to be aggregated. Nearest neighbor index (NNI) to calculate the amount of mainly the average closest distance observed pattern, random pattern, the average closest distance, nearest neighbor index (NNI) and the nearest neighbor index values of significance tests. There were significant differences in the premise, if the average nearest neighbor index greater than 1, then the observation model, the average distance is more than the recent average of recent CSR distance, the spatial pattern of criminal cases tend to spread evenly; if the average nearest neighbor index is less than 1, then the observation model is less than the average CSR most recent average closest distance, the spatial pattern of criminal cases tend to aggregated distribution, or spatial patterns in criminal cases tend to randomly distributed.

3.2. The Calculation of Criminal Cases Hotspots

Hot spots of criminal cases is the calculation of the criminal cases to solve the problem of distributions of hot spots, making the hot concrete way through the thematic map presented to the user. Different distribution patterns of criminal cases is the key hot spots hot spots of different calculation methods. This paper studies the form of three hot spots of criminal cases: point form of hot, hot area, surface morphology, oval form of hot spots.

1) Calculation Method of Hot Point Form

Point calculations used to find the same form of hot spots located in criminal cases on many occasions the formation of hot spots, using the point size of the geometry of the intensity of hot spots of criminal cases that a hot form of performance methods. Point form the calculation principles for the sake of hot frequency principle, criminal cases are located in the geographic coordinates of space. In the two-dimensional space, find the frequency of point coordinates, you need to abscissa and ordinate respectively calculated, which is calculated the same two-dimensional coordinates of the points appear in the frequency, the frequency determines the number of criminal cases, the intensity of hot spots. Frequency can effectively use knowledge of criminal cases the distribution of spatial point patterns, direct
knowledge of where it occurs more often in criminal cases, especially for a fixed place for hot spots caused by the identification of criminal cases.

2) Calculation Area Hot Surface Morphology

Surface area of criminal cases through the area polygon form factor hot spots of criminal cases within the criminal cases to calculate the density of hot spots. Surface area form the main focus in the region is the actual existence of various polygon domain, such as administrative divisions, such as surface-like elements of law enforcement jurisdictions. The performance of its real hot for each region, the incidence per unit area by unit area to the performance of high and low incidence of hot spots of criminal cases. According to Chinese law, different departments responsible for different districts, the jurisdiction of different cases. Under the jurisdiction of the area, you can build in the GIS polygon element of jurisdiction, the jurisdiction of each polygon by calculating the number of criminal cases occur, in each region can be calculated to the Criminal Cases density. Higher density region polygon surface morphology of region is hot. As criminal cases are not evenly distributed in each area, so there is inaccurate in criminal cases the expression of the shortcomings of hot spots.

Hot surface area calculation principles for the shape distribution density of principle. Feature by using spatial point and area features on spatial relationship to calculate the midpoint of each face-like surface features like the number of surface features, divided by the corresponding area of the polygon surface elements, be the case density, sorting through the density Polygon can be obtained in different hot spots of criminal cases within the region. Each jurisdiction of the competent authorities according to their production area area feature, by calculating the Area Feature in each place the number of criminal cases, that the number of point-like surface features, draw the number of criminal cases in various jurisdictions relationship.

3) Calculation Oval Shape Hot

Hot spot is the oval shape of criminal cases through the spatial point pattern clustering, hot spots of criminal cases to reach the standard for the type of cluster theory to calculate the through space space ellipse, the ellipse to show hotspots of criminal cases. Elliptical form of criminal cases, hot hot can not form a specific location point of the restrictions and area hot surface morphology of fixed polygon restrictions, through the use of spatial clustering method to the short distance of the point designated as a class, to reflect more accurate Criminal Cases of hot spots.

Hot elliptical shape for the calculation of the principle of cohesion of the cluster spatial distribution of the cluster of criminal cases. Clustering algorithm using the system focus on spatial patterns of criminal cases, the purpose of cluster analysis is to space out together, said a criminal case, not to form a complete cluster tree is a cluster analysis method for practical use. Cluster analysis method used at the same time, not only to consider the calculation of the distance between classes, clustering tree by cluster analysis methods and other common difficulties, but also the division of the class after what is in oval shape hot
computational requirements of the class. Ultimately boils down to three algorithms, namely clustering method of choice, the determination of the classification criteria, type of filtration problems.

This method compares each clustering method can automatically generate the cluster tree and the corresponding distance matrix of the correlation coefficient, the correlation coefficient closest to 1, as the clustering method clustering. Because single-link method, fully connected, average connection law clustering method the distance between the class size is not uniform, and because intuitive judgments class number is very difficult, so I chose the criteria for classification of inconsistent coefficients to solve the class Number of issues identified. Filtering problem on the class, the tool provides a parameter interface, users can customize, but also provides a default value as the default setting, this would resolve the three difficult problems.

4. hotspot identification tool in criminal cases

Spatial patterns of criminal cases testing tools Points Pattern Test, the tool to the nearest neighbor index method as a basic principle. Points Pattern Test tool in the development process, the main use of graphical modeling tool Model Builder, combined with the dynamic Python scripting language was developed. Development process in which spatial processing tools used in the average nearest neighbor spatial processing tools (Average Nearest Neighbor) and the calculation of polygon area of space processing tools (Calculation Polygons Area). ArcGIS Spatial Processing and because there is no element of area of polygons and calculating tools, so calculations using python script development tools and the polygon area of the Calculation Polygons Area. By Calculation Polygons Area tool to calculate the exact area of the study area after the input to the Average Nearest Neighbor tool for spatial patterns in criminal cases, the nearest neighbor index calculation. After the use of space modeling tools will Calculation Polygons Area tools and ArcGIS Spatial Processing Toolbox provides tools for graphical Average Nearest Neighbor model.

Spatial patterns of criminal cases the processing of test tools are: First of all elements of the input point of the criminal case file and the corresponding elements of the polygon file, using polygon area and tools (Calculation Polygons Area) area of the elements of Polygons (Polygons Area), and input point feature File (Input Feature Class) two parameters input to the mean nearest neighbor spatial processing tools (Average Nearest Neighbor), mean nearest neighbor spatial processing tools (Average Nearest Neighbor) Finally, calculate the nearest neighbor index (NNRatio) and a significant quantity of Z value test (NNZScore), and to visualize the results window in the form of output.

5. Conclusion

In this paper, GIS-based hot spot identification in criminal cases, mainly for the testing spatial patterns of criminal cases, criminal cases and case studies focus calculation. Spatial patterns of criminal cases developed test tools, point form of hot computational tools, surface area calculation tool and oval shape hot hot form computational tools. Finally, the Chinese city in 2010, drug cases, identify hot spots of criminal cases were demonstrated. Through case studies concluded that: the process of identifying hot spots of criminal cases, in criminal cases, the distribution of spatial patterns are clustered under the premise of different forms according to the characteristics of hot spots of criminal cases should be followed by complete surface area calculated form of hot, hot point calculations and forms Hot oval shape calculation. Hot spots in the clear area on the basis of surface morphology can be a particular hot spot area for further calculation of points and elliptical shape hot hot form calculated to get more accurate information on hot spots of criminal cases.
6. Acknowledgment

The author would like to thank Professor Zhou Feng and Lecturer Li Chiyuan for useful feedback. Professor Zhou Feng in particular was a major contributor to border information analysis research. The author also thanks the reviewers for suggesting numerous improvements.

References


