The review of spatial objects recognition models and algorithms

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Abstract

The article considers the problem of spatial objects recognition in geographic information systems. The solutions for this problem are given, a classification of the methods and algorithms already available is executed and the ways of development in search of the optimum decision on the matter are offered. Firstly, it is the improvement in the quality of recognition. Secondly, it is the creation of general rules of sufficient accuracy rating to prevent erratic classification of objects of a certain type. Thirdly, it is the establishment of rules defining correlations of spatial objects of different classes.

Models and algorithms of spatially distributed objects recognition can be classified based on the following directions: with using external and internal topological relations, with application of neural network approach and mixed methods. Not only the issue of object recognition importance, but also the importance of accounting of their relative positioning and determination of spatial characteristics in relation to each other is considered.

Keywords: algorithms of recognition; allocation of spatial objects; processing of images; separation of contours; spatial distributed objects; topology.

1. Introduction

The person can perceive information visually therefore he studies considerable part of information by means of sight, considering pictures, drawings, maps and diagrams [6]. Recognition of spatial objects is one of the most complex and interesting challenges in digital image processing. Therefore separation of required objects in pictures of the district remains the actual task which requires the optimum decision.

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Recognition of spatial objects in a topographical or space picture is a task of separation significant for the user of part of the image from a background, that is classification of copies of some type (class). There is a set of algorithms of separation of objects on the image. The number of the proposed solutions for recognition of objects is also great, but, as a rule, the decision is applicable to the separate task. Purpose of this article is to make the review of the existing methods and algorithms for recognition of objects on raster maps.

2. Recognitions of objects on the topology basis

One of fundamental tasks in topological data analysis consists in that to treat information on the spatial distributed objects in topological space. In operation [3] some sets are represented and reviews of the discrete theory of the Morse and its generalization are given. The sets of closeness considered in a method have the equivalent double determination which are used in this operation. Delaunay set is often used in case of topological data analysis. The algorithm is generalized by the following methods: settings of parameter; settings of scales which influence “importance” of points, and also operation in the Euclidean space of any fixed dimensionality.

In work [10] the task of automated recognition on images of topographical plans of contours of buildings is considered. In this method signs of spatial object like “building” are specified. The algorithm includes the following stages. These are creation of “skeleton” of the source binary or halftone image and creation on it linear and nodal structure in the form of a graph, and also preliminary processing of “skeleton”. Also the method includes such operations as creation on the basis of a skeleton of closed polygons, finding in potential contours of buildings of texts and receiving a final set of contours of buildings and creation of vectorial objects in geographic information systems with record of semantic data from the recognized text. Results of recognition shall possess the following signs. These are isolation, saving right angles, absence of excess points of “fracture” of a contour, false contours, coincidence of boundaries of adjacent objects, and also requirement for the maximum error of a rejection of rather initial raster original.

In work [1] approach to application of the topological relations is considered in the group spatial analysis of cartographical objects. The task of algorithm of topological selection - fast execution of spatial request of the user. It is possible on the basis of determination of the spatial relations prior to processing of request, besides information on them shall be placed in a random access memory for fast processing. The concept of an array from matrixes of the topological relations storing correlations between objects that allows to make their selection according to the given rules is entered. Three classes of the topological relations are selected. These are intraobject, conceptual and interobject. The interobject relations can be such types as isolation, intersection, an enclosure, the neighbourhood, closeness, remoteness. This method is based on preliminary formation of matrixes on number of the basic interobject topological relations. Binary matrix elements show existence or absence of the topological relation. The method allows to organize fast data sampling by topological rules and simplifies operation of the user in case of object search which advantages of use are especially visible in case of execution of a set of procedures of selection of data on different rules.

In operation [2] algorithms of separation of such objects as buildings, the land plots and reservoirs are offered. Spatial characteristics for these classes of objects are set. This technology assumes existence of the input image with which preliminary processing is made. It includes such operations as binarization and a skeletization. The technology assumes the minimum set of settings in which the object type and color of separation for visual display of search results are set. This algorithm includes the following stages. These are search algorithm of closed objects; algorithm of separation of the object containing other object; the search algorithm of distinctions in closed objects. These algorithms assume operation with a bit image matrix. The search algorithm of closed objects consists in finding of offset of originating point to adjacent, applying a mask 3x3. Thus, if the contour is shorted, there is a resetting in originating point. If the contour isn't shorted, at some point it is found out that adjacent points aren't present at all. The algorithm of separation of the object containing other object consists in the following. A certain contour undertakes and in it the point is considered. From this point the straight line to an opposite point is drawn. If this straight line crosses any contour, so the object contains in itself other object or objects. If the straight line doesn't cross a contour, the following point undertakes and so to the middle of this contour. In case the object doesn't contain other objects in itself, it is classified either as the building, or as a reservoir.
The algorithm of search of distinctions in the closed objects assumes classification of objects on two types: “buildings” and “reservoirs”. The algorithm consists in consideration of all points of the classified object. Calculation of quantity of points of turn is made (such points that in them the contour starts appearing in other direction). On the drawn interest of such points the conclusion about object belonging to this or that class is drawn. It is supposed that the objects having required percent higher than 30, possess more roundish form, that is are reservoirs.

Shortcoming of this algorithm is reference of object to a certain type on the sign revealed in the empirical way. For an exception of errors in recognition it is required to support experiment with new signs or provision of the mathematical description of this phenomenon.

Shortcomings of this group of methods are need of creation of more exact signs of spatial objects to exclude their erratic classification [10], large volume for data storage [1], need of confirmation of experiment by mathematical rules [2].

3. Neural networks using

In this group of methods the database of images is applied to training of a neural network. So, for example, in [4] the problem of the automatic analysis of satellite pictures for determination of level of marshiness of terrain is solved. The algorithm of segmentation of satellite images of the territory, on covered and uncovered by water area is developed. It consists of the following stages: formation of collections of satellite pictures on which there can be a water space; compilation of learning selection; implementation of methods of processing and the analysis of images for computation of local and global signs; machine training; implementation of results of training in system together with other methods of computation of signs.

Signs of images which are used in this method are defined, and also the description of the neural network qualifier of points which is its cornerstone is provided. Results of the automatic analysis of real satellite images are given.

Shortcomings of this group of methods is need of training of a neural network which can take the long time for obtaining the acceptable accuracy of recognition of objects. And only the limited circle of tasks can be solved.

4. Mixed methods

The methods considered in this group assume using of several algorithms of image processing for receiving better results.

4.1. Analysis of images of moving objects

One of the principal problems of synthesis of the color image of certain RGB canals is the impossibility of automatic combination of moving objects. As a result, on the image, synthesized in the color, there are three RGB copies of each moving object (red, blue and green) which correspond to different timepoints.

In case of detection of RGB copies of objects there can be following difficulties: the small size of objects concerning permission of space pictures, imposing of RGB copies of the friend on the friend, non-uniformity of brightness of objects in one color copy, distinction in the linear size of objects of one type.

The offered algorithm of normalization of images of the moving objects [9] received as a result of sequential registration of RGB channels allows to integrate multi-colored copies of moving objects and to calculate their characteristics. The method is based on use of correlation of coordinates, sizes and orientation of multi-colored copies of objects. High quality of work of this method can be seen at normalization of red and blue copies of objects.
4.2. The search algorithm of objects in high-precision pictures

In operation [5] the analysis of the existing methods on separation of spatial objects on the bitmap image is made. The search algorithm of vehicles in high-precision pictures in tasks of the analysis of emergency situations is offered. The transformed high-precision picture with the spatial objects selected on it like “vehicles” is given as result of implementation of a method. Images' recognition happens automatically then layout of spatial object of the interesting user of type is defined.

The algorithm includes such steps as binarization of the image, application of the Canny method, sifting of contours, using the removed mathematical formulas.

4.3. Methods of the unified processing procedure of images

The idea of this method [7] consists that the author offers practical implementation of the unified processing procedure of images which will allow to replace application of a set of methods for receiving the same results. It is supposed that there is some hypothetical “reference” conversion of the ideal image to the required day off. By reviewing enough the coordinated couples of input and output images as learning selection it is possible to make procedure of training of the qualifier which puts in compliance to a vector of the signs calculated according to the input image, the output image. In operation use of some limited two-dimensional areas is offered. After the recursive computation of the generalized moments is considered. The main task in case of this approach is algorithm elaboration and methods of formation of local signs of images in the sliding window. As signs local “the generalized moments” - the linear signs which are calculated by means of the discrete convolutions of the image are offered. Classification of counting of the image is given. In operation the qualifier which is realized in the treelike (hierarchical) form in case of the simplest piecewise constant approximation of function of decisions is used. Also process of synthesis of such qualifier is given. This unified processing procedure showed qualitative results in such tasks as separation of contours, recovery of the binary (two-graded) image like the printing text, filtering the halftone (fuel-gray-scale) image, detection of local two-dimensional objects, recognition of spatial objects on raster maps.

In [8] the correlation method of detection of objects on the image is considered. It is based on computation of values of cross correlation between analysable function of brightness and a standard. Shortcoming of a method is that required coordinates of objects not always manage to be determined with the set accuracy. Therefore for elimination of this shortcoming two modifications of algorithm of correlation which increase the accuracy of calculation of coordinates of objects at recognition are offered.

One of the offered modifications: “A peak filtration of a correlation field”. It allows to simplify procedure of detection of objects and to increase the accuracy of determination of coordinates. The peak filter belongs to the class the rank methods of processing of images. In them each output value is calculated on the basis of the analysis of the variation row constructed of counting of some vicinity which corresponds to a point of an entrance field. If entrance counting has the highest rank in set, he is sent on an exit without change, otherwise receives zero value.

After such processing on a correlation field nonzero points are only local maxima the distance between which exceeds window “radius”. For reduction of number of false detection the area of a window has to be as much as possible.

One more modification of a correlation method consists in transition to the adaptive indication of the purposes. At it for each provision of a window the calculated value of correlation can be referred to any point of the screen. Receiving narrower correlation peak that leads to improvement of a standard method is result of this modification. The given experiments show good operability of the offered modifications of algorithm of correlation. For practical tasks modification with the adaptive indication of the purposes provides higher quality of detection of objects with big noise level and smoothness that can be used at detection and allocation of spatial objects on raster images.

4.4. Methods of recognition of objects in space pictures

In a method [11] the question of recognition of objects of a road network is considered. This task is complicated by that the road network belongs to difficult spatial objects with various extent, geometrical and brightness
characteristics. Besides, complicates detection overlapping of a road network various objects of other classes. In work signs of a road network, in particular, the considerable extent of straight sections, identical width on an extent area, uniform distribution of brightness within object, accurate contours of a roadbed are created.

Mathematical formulas which are applied at selection of objects are given. The filter with the final pulse characteristic which applications to the initial image are result of using: the map of average quadratic deviations for points with a nonzero response of function and the map of the directions of angles of rotation of a window of the filter.

In a method [12] information technology for recognition of pictures of buildings in topographic maps of the cities is considered. It is based on combinatory and geometrical approaches.

Shortcomings of this group are false detection of green component of RGB channels and lack of automatic calculation of characteristics of moving objects [9]; need of improvement of quality of recognition of objects [5]; lack of special selection of signs with which efficiency of this group of algorithms would be higher [7]; loss of part of points of spatial objects therefore additional data processing is made [11]. It consists in use of the map of angles of rotation of a window of the filter containing information on the direction of a road network concerning image abscissa axis.

5. Conclusion

In work the question of detection and allocation of spatial objects on raster maps in geographic information systems is considered. Versions of solutions of this problem are given, classification of already available methods is executed. Algorithms and methods of such groups as are presented: based on topology and various topological rules, on the basis of a neural network, the combined methods in which solutions of questions on the basis of using of several methods and algorithms are proposed. Most often the combined methods are directed on the solution of certain practical tasks. For example, methods and algorithms of this group are used at the solution of such tasks as recognition of spatial objects, in particular, of buildings [10], vehicles [5, 9], an assessment of marshiness of territories [4], recovery of the binary (two-graded) image [7]. Ways of development in search of the optimum decision on the matter are offered. Firstly, this improvement of quality of recognition. Secondly, creation of the general rules possessing sufficient accuracy rating for an exception of erratic classification of objects of a certain type. Thirdly, creation of the rules defining correlations of spatial objects of different classes. In particular, without reducing importance of process of improvement of recognition of spatial objects, it is worth paying attention to a question of the accounting of interposition of these objects and other spatial characteristics. The partial solution is proposed in the form of algorithm [5], but this technology, firstly, demands improvement of quality of recognition; secondly, it is directed on a certain type of spatial objects that, certainly, doesn't resolve an issue in general. Therefore in parallel with a question of recognition of spatial objects it is necessary to pay attention to generalization of topological regularities and creation of mathematical rules. The topology will give the chance to leave from comparing of standards, and to determine an object type by a set of its characteristics.

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