

# Using Image Contour Recognition In GIS Navigation

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## Abstract

*This paper presents an approach of using image contour recognition in the navigation for enterprise geographic information systems (GIS). The extraction of object mark images is based on some morphological structural patterns which are described by morphological structural points, contour property, and other geometrical data in a binary image of enterprise geographic information map. Some preprocessing methods, contour smooth following, linearization and extraction patterns of structural points, are introduced. If a focus point of a map is selected, based on the extracted object mark image, a dynamic layout and navigation diagram is constructed, which consists of three underlying views: a graph navigation view, an image layout view, and an enterprise information view. In the diagram each object mark image is represented by a node, the relation information between two nodes is represented by an edge. If a node is selected, the new dynamic layout and navigation diagram is found based on the extracted object mark images around the selected node, which contains the relation with the previous diagram. Therefore a dynamic layout adjustment and navigation for enterprise GIS is determined.*

## 1. Introduction

There are lots of Geographic Information Systems (GIS) that do provide facilities for viewing and navigating GIS images [1, 2] and there are also some systems that support enterprise information browsing. But there are a few systems for conveniently navigating and viewing both kinds of information. One of critical problems is how to develop effective interfaces for users to conveniently navigate and view both geographic images and enterprise information together. Also, to view GIS images/maps, current approach of using scrolling bars, windows (i.e. multi-

views), zoom-in and zoom-out operations to show a huge GIS image is not convenient for the user's navigation, because it is difficult to obtain whole and detailed views of a huge image.

This paper presents an approach of using image contour recognition in the navigation for enterprise geographic information systems (GIS). In the following section a method of image contour recognition is introduced. Section 3 describes how to apply our image contour recognition in GIS

## 2. Image Contour Recognition Method

In order to know if an enterprise should be established in a suitable site, the decision makers have to research all related information which concerns Geographic Information Systems (GIS). Especially all the same enterprises around the selected site in any area size. If there are many object mark images in a huge geographic map, we can find how many object mark images in any given region of a huge geographic map based on the pattern recognition of image processing. Our approach is a new method of structure recognition, that is, the description of shape is based on some morphological structural points. Some preprocessing methods are used to extract a binary image of geographic map. Let the starting point of image be the upper-left corner. The  $k$ -th contour of a binary image is represented as:

$$C_k = \{c_0, c_1 \dots c_i \dots c_{n-1}, c_n\} \quad (1)$$

where  $C_k$  is the direction chain code set of contour  $k$ , and  $i$  is the index of the contour pixels. The difference code is defined as:

$$d_i = c_{i+1} - c_i \quad (2)$$

In the smoothed contour,  $d_i$  equals 0 or 1 [6].

The smoothed contour can be converted to a set of line which consist of ordered pixels. Suppose that the direction chain code set of the smoothed contour is

$$c^l[i] \quad (i = 0, \dots, (n^l-1)), \quad (3)$$

where  $l$  is the  $l$ -th line of a smoothed contour and  $n^l$  is the number of points of the  $l$ -th line.

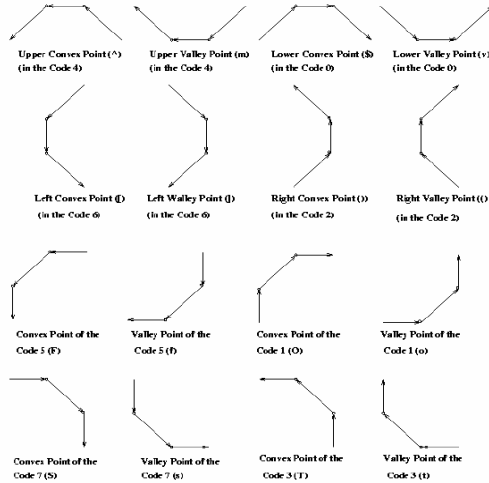


Figure 1: The pattern models of structural points.

A linearized line has the following property [6]: if

$$d_{ij} = c^l[i] - c^l[j] \quad (i = 0, \dots, n^l-1), (j = 0, \dots, n^l-1), \quad (4)$$

then

$$|d_{ij}| \leq 1 \quad (i = 0, \dots, n^l-1), (j = 0, \dots, n^l-1). \quad (5)$$

Therefore a linearized line contains only two elements whose chain codes meet Equation (5). These linearized line need to be merged or split, and new linearized lines and their critical starting points are extracted based on their linearity, length and curvature. Furthermore, the morphological structural points (critical points) are extracted based on extending Freeman codes and their difference codes. The extending Freeman codes are defined as the average code of a linearized line, and it is represented as  $C_e^l$ :

$$C_e^l = \sum_{i=0}^{i=n^l-1} c^l[i]. \quad (6)$$

The definition of different structural points is based on pattern models (as shown in Figure 1) and extending Freeman codes between two neighbouring

linearized lines, and sixteen different characters in these figures are used to represent these structural points [6].

These structural points are the points ``^'', ``m'', ``\$'', ``v'', ``[\", ``]\", ``(\", ``)\", ``F\", ``f\", ``O\", ``o\", ``T\", ``t\", ``S\", and ``s\" [6]. The structural points describe the convex or concave change in different chain code directions along the contour [6]. For example, points ``^'' and ``m'' represent the convex and concave changes in the chain code 2 for the linearized lines respectively (see Figure 1). They can therefore be used to represent the morphological structure of a contour region [6, 7, 8]. For example the extracted structural points are shown in Figures 2 and 3. Some shape structural rules can be got based on the structural points of shape contours.

- **Rule1:** Octagon

1. It consists of eight convex structural points, no concave structural points and eight convex structural are two "F", two "s", two "o" and two "T" in the series of structural points.
2. It has no inter contour.
3. Different octagons are defined based on different group together of lengths between two neighboring structural points.

- **Rule2:** Octagon loop

1. It consists of two octagons. That is it has an inter contour.
2. Different octagon loops are defined based on different group together of two octagons.

- **Rule3:** Digit 1

1. It is an octagon.
2. The lengths between structural points "F" and "s" and between structural points "o" and "T" are greater than that between other two neighboring structural points.

We can construct many rules to recognize different shape with their structural points based on priori knowledge and their morphological structure. Based on the above rules the example 1 is an equal octagon. The shape of example 2 in Figure 3 consists of three polygons, and there are three concave structural points ("f", "s" and "(").

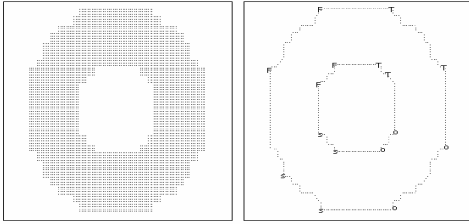


Figure 2: The original image mark and its structural points of example 1.

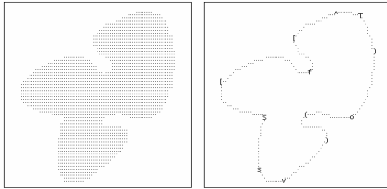


Figure 3: The original image mark and its structural points of example 2.

### 3. Layout and Navigation for GIS

The effective interfaces are developed to support GIS image navigation, detailed local image/map viewing, and enterprise information browsing. If any special object is selected to make a decision in a GIS map, the all information around it should be obtained. Especially all related mark images should be searched in any special region and some relations are set up. For example, we want to set up an object enterprise by selecting a place. We use this place as a central point to find a sub-GIS map shown in Figure 4. We need to investigate similar object enterprises around selected region to analyse whether it is necessary for establishing the object enterprise at that place.

To search similar object enterprises around selected region, we need to use the related mark image as a pattern. In this example we use the mark image shown in Figure 3 as a pattern for scanning this map, six mark images have been found. We use arrows for pointing these six mark images in Figure 4. In our prototype system, these mark images are flashed with red colour.

We use a graph for GIS image navigation. It is shown in Figure 5. Each node in the graph represents a mark image. Each edge between two nodes represents a relationship between two nodes; it is represented as a neighborhood relation. Each node is also related to the enterprise information in a region. The intention of using the graph for GIS image navigation is to give the user a global view of a huge GIS image and whole enterprise information.

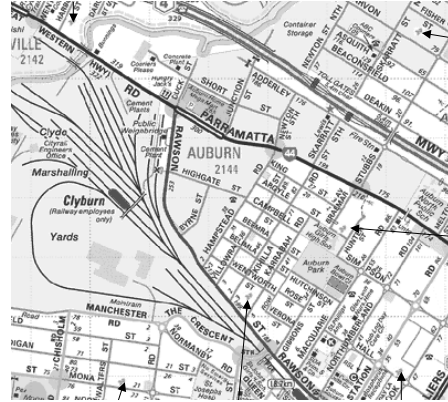


Figure 4: A GIS map and its mark image.

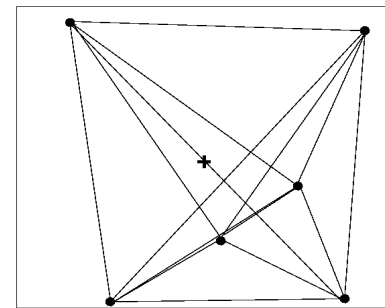


Figure 5: The diagram of linked nodes based on the extracted mark images.

The GIS user interface has three underlying views: a graph navigation view, an image layout view, and an enterprise information view. The graph navigation view shows a sub-graph corresponding to the current user's focused image displayed in the image layout view. The crossing line mark in Figure 5 indicates our initial intention at that place to establishing an object enterprise.

The enterprise information can be shown with those information such populations, sales records, distance between this node and other nodes, and so on. This can help us to make a decision. For example, if we click a node in Figure 5 in the enterprise information mode, the relevant enterprise information will be shown up. That is, we can know whether the selected place is suitable for establishing an enterprise.

To further explore similar object enterprises around this region, we can navigate this graph by select a node in this graph to changing the focus point. For example, if we select the node on the left-bottom of the graph, a new sub-GIS map is displayed (see Figure 6). The navigation graph is shown on the upper right to help the user track back to the original focus. After searching all surrounding areas by selecting the nodes in the graph, we can obtain the information of

surrounding enterprises. In the mode of EnterpriseInfoShow, we can get enterprise information for each surrounding enterprise by selecting the corresponding node in the graph.

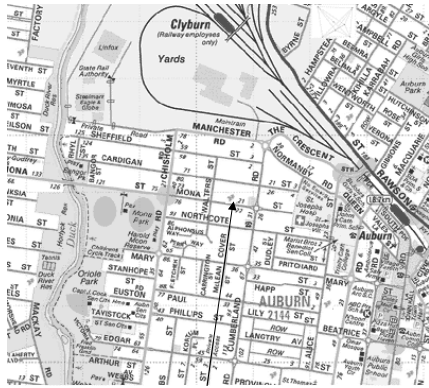


Figure 6: The dynamic layout and navigation of decision processing.

Three kinds of modes are provided in the graph navigation view: Navigation, ImageShow, and EnterpriseInfoShow. In the mode Navigation, if the user selects a node, a new sub-graph with this node as its central node is displayed. In the mode ImageShow, when the user selects a node, the corresponding GIS image is shown in the image layout view. In the mode EnterpriseInfoShow, after the user clicks a node, the corresponding enterprise information of an organisation's branches in this region is shown in the enterprise information view, and the locations of the branches are highlighted in the image layout view. Thus, a decision may be made based on the above information. Also, each view has its own layout and layout adjustment operations. For example, the image layout view should provide some functions operating on its displayed image, such as zoom-in and zoom-out operations for image viewing.

The graph navigation view maintains the user's orientation for GIS image and enterprise information exploration and it also reduces the cognitive effort required to recognize the change of views. This is done by connecting successive displays of the subset of the graph and by smoothly swapping the displays via animation. In other words, a sub-graph is changed smoothly to another sub-graph during the user's navigation. This change from one subset to another should preserve the user's mental map [3, 4] for GIS image navigation. The navigation graph is based on the link direction between the selected node and the central node. We have developed a dynamic method on

extending the CIGRAPH model [5] for GIS image navigation and giving a formal specification for the graph structure. The dynamic linkage mechanism can be set up among the logical part of the model, GIS abstract mark image areas and their connections, and enterprise information.

#### 4. Conclusion

A new algorithm is developed to extract mark images in GIS map based on some morphological structural points. We have developed dynamic methods for the communications among sub-graphs, GIS image views and enterprise information for a specific application. A site and its surrounding region size can be selected and changed in terms of enterprise strategy. A dynamic layout and navigation for Enterprise Geographic Information System is given based on the navigation graph which consists of mark images and three underlying views (a graph navigation view, an image layout view, and an enterprise information view). The method can be used for any special object decision which is related to GIS system if there are mark images in GIS map..

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