SPATIAL RELATION EXTRACTION FROM REMOTELY SENSED IMAGE ON QUADTREE REPRESENTATION

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ABSTRACT

This paper addresses a development of spatial relation extraction from remotely sensed image based on quadtree representation. The input image is first transformed into a hierarchical structure of quadtrees, which is composed of quadtree, segmentation quadtree; homogeneous region quadtree and spatial relation quadtree. With the description of hierarchical quadtrees, appropriate spatial relation can be extracted, which is from local to global as more and more object knowledge is used. The strategy that is called discrimination graphs algorithm for spatial relation extraction in terms of quadtree representation is presented. The result obtained in this paper is clear and can easily be used for remotely sensed image interpretation.

KEY WORDS: Spatial relation extraction, Quadtree representation, Hierarchical quadtree, Object knowledge, Discrimination graphs.

1. INTRODUCTION

The region quadtree has been applied in both raster image and raster map in various forms. Recent advance in the use of quadtrees for computer image processing and computer cartography have made efficient algorithms for conversion between the region quadtree and other image representation. In most published quadtree research, we has seen the space efficency of a quadtree depending on the particular structure used to represent it. However, we also saw that it lack close links with image interpretation.

Most research in region quadtree so far was focussed on developing image encoding, storage, transformation etc. (Jean, 1985). In this paper the term "quadtree representation" we mean here some hierarchical structure, which is composed of quadtree, segmentation quadtree, homogeneous region quadtree and spatial relation quadtree, generally concerning the local properties that stem from spectral and statistical information and the global properties that originate from prior object knowledge.

In many situation, it does not suffice to determine the mapping between region quadtree, which stemming from the low — level quadtree generation, and the associated hige — level quadtree representation. This indeterminate is not only in the meaning, but also in the spatial areas. It must result in indefinite relations between the high — level quadtree representation to convert the indeterminate region quadtree into the high — level quadtree representations. Thus, when we interpret quadtree using relations in terms of spatial knowledge, the result shall still be indeterminate. In our work we have attempted to solve the problems by taking a strategy which has a feedback route to revise the errors under current best representation. As some processes are repeated, more attributes and relations are discovered in the quadtrees, which force each representation to become more specific. This approach is therefore referred to discrimination graphs (Jan, 1988).

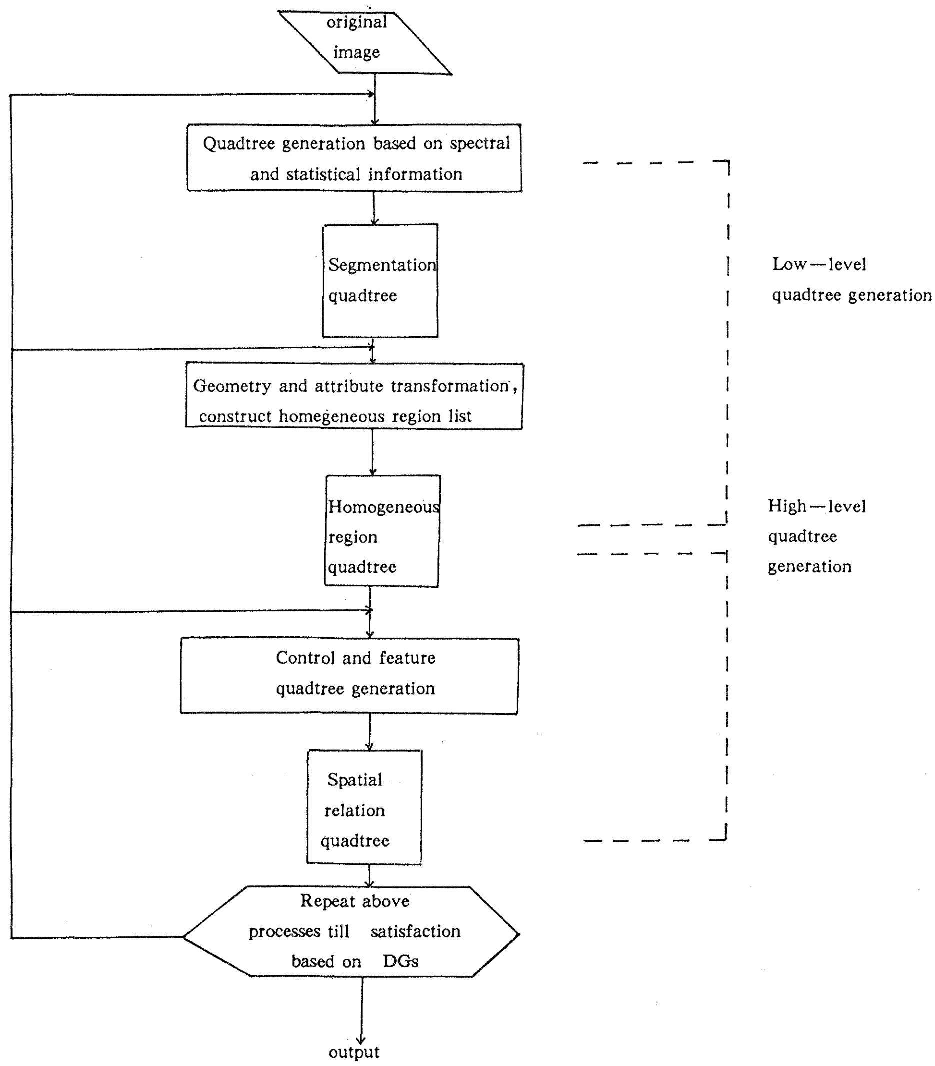


Figure 1. Hierarchical processing for spatial relation extraction based on quadtree.

2. A NEW PROCEDURE FOR SPATIAL RELATION EXTRACTION BASED ON QUADTREE REPRESENTATION

The steps of automatic spatial relation extraction based on quadtree representation by a computer system are as the following and Figure1 shows the hierarchy of the processing in which:

Step1. The image is first segmented by using quadtree generation . The characteristics are detected by only checking the spectral and statistical attributes, and a segmentation quadtree is made.

Step2. A segmentation quadtree is defined as a binding which composed of location code for a quadtree node, attribute values measured during the scanning of a quadtree generation and region number. Then the quadtree segments from step 1 are merged to yield a new quadtree segment by defining the segment descriptive parameters and mergence criterion that relate to the thematic units. At the same time, the spatial configuration characteristics such as shape , size etc. are extracted. Througe step 2 , the segmentation quadtree is transformed into the homegeneous region quadtree.

Step 3. The spatial relations and constraints among the segmentation quadtree are extracted by using control and feature quadtree generation. Thus the region relationship list is formed. As more and more constraints are filled in the list , each spatial relation become more unambiguous by using constraint propagation techniques. Sets of mutually consistent relations, which construct spatial decompositions of the scene, make a spatial relation quadtree.

It must be pointed out that the procedure described in the previous steps , which drives from a local , low—level set of relation to a high — level , more global scene relation, is based on the discrimination graphs. Discrimination graphs (DGs) closely involve a categorization of relation class that belong to a particular image feature category. If this procedure is imperfect, such as some relations is missed , and others is interpreted incorrectly, we may repeat some processes to revise the errors. As more attributes and constraints are discovered in the image by using DGs furtherly , the relations shall be forced to become more specific.

3. HIERARCHICAL QUADTREE

In this section , the problem of how to transform a primary image into a segmentation quadtree, and homogeneous region quadtree is described (see step 1 —2 in Figure 1).

At first, the primary image is segmented by the judgement of the intraparallelism which involves the attributes stemming from the gray level, such as intensity, hue, saturation etc. To each node of the quadtree segment that maybe contains multiple objects, if the attributes are parallel, then give it a corresponding values , otherwise give it a question mark label which is a control label used to indicate where the segments must be continuously subdivided. As a result a quadtree composed of these values is obtained. It is called the segmentation quadtree.

It has been shown in (V. S. Frost, 1985) that pixel intensities of neighboring pixels from the same object can be assumed to be incompletely correlated. For many objects more than one quadtree segment may be obtained. Thus these segments must be conbined into homogeneous regions on the basis of the knowledge of object that determine collections of segments, which form "nutural" components of the scene.

Homogeneous region quadtree formation consists of three facets: location code formation, attribute value description and region numbering . location code for a leaf representing a $(2^m \times 2^m)$ image consists of the m quadrant digits representing the recursive subdivision of the raster into quadrants. Attribute value refer to specific parts of segmentation quadtree and homogeneous region quadtree which satisfy a particular homogeity condition. With region number we associate two list , in the first list each node is represented by two fields, one for the quadrant location code , one for the region number; in the other list the nodes that have same region number are assigned to same attribute value(see Figure 2).

Thus the collection of these elements may be regarded as a binding which consists of location code, attribute value and region number. An example of a binding is shown in Figure 2.

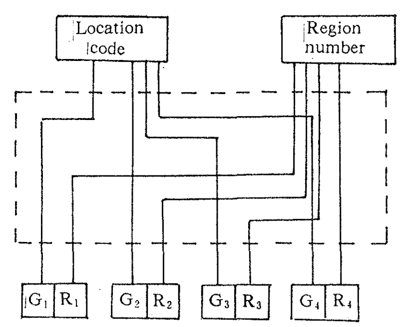
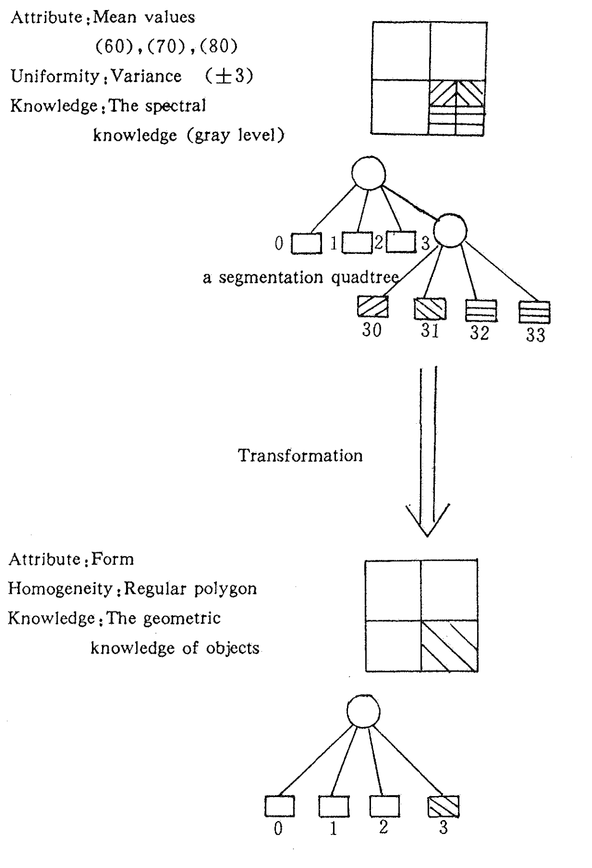


Figure 2. An example of a binding for homogeneous region quadtree.

Figure 3 illustrates the elements of segmentation quadtree and homogeneous region quadtree, and their transformation. The attribute and uniformity of segments, which are mainly based on statistical properties and sensor dependent; while the attribute and homogeneity of homogeneous regeions mainly refer to the knowledge of objects and theme , which include the geometric characteristics. For example, segments 30, 31, 32, 33 in Figure 3a indicate three rice lands with different water depth. Because all of them have the same attribute, regular polygon, they should be merged into a single homogeneous region by using form attribute and discrimination graphs.



b Homogeneous region quadtree

Figure 3. The elements of segmentation quadtree and homogeneous region quadtree ,and their transformation.

4. QUADTREE INTERPRETATION AND SPATIAL RELATION EXTRACTION BASED ON DG

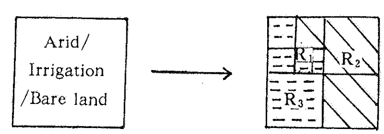
After a homogeneous region quadtree is formed by using the above technique the correspondence between objects and the regions quadtree shall be determined based on DGs , and a class interpretation quadtree shall be obtained

For this purpose, the spatial relations and constraints among the class interpretation quadtree are extracted. Sets of mutually consistent interpretation that share similar function or are spatial decompositions of the scene are formed, which may further help us to interpret the quadtrees based on DGs.

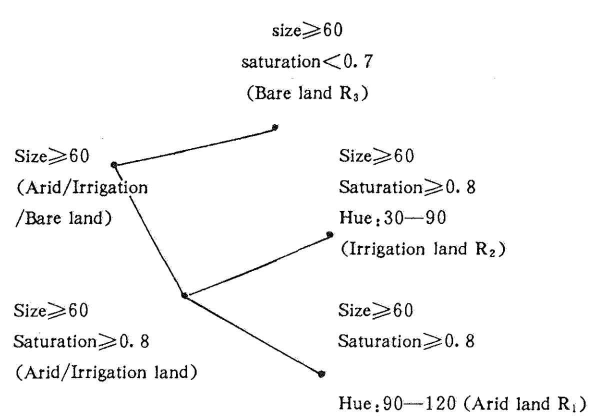
If, after the above processes, some interpretation class is still ambiguous , the previous processes may be repeated by using the current best interpretation. At each repetition, the regions quadtree and the projected objects may be put into a more accurate correspondence in the discrimination graphs way.

4.1 Interpretation of homogeneous region quadtree

Assuming that we can obtain different image attributes and the result of each attribute is a finite number of categories; as well as there is only a finite number of scene objects whose image appearance falls in a particular category . In accordance with these assume, we introduce the quadtree interpretation based on discrimination graphs (DGs), i.e. we may assign the quadtrees to same interpretation if they belong to same the categories of the image attributes. The interpretation may be an abstract objects class, or be an elementary object class (see Figure 4).



a Homogeneous region quadtree intepretation from abstract to specific one based on DGs.



(b) DGs

Figure 4. An example of discrimination graphs and homogeneous region quadtree.

The interpretation of a homogeneous region quadtree is done by assigning the quadtrees to a class based on how closely the observed set of the region attributes matches the set of the attributes for the particular object class. This work has to be done under the guidance of DGs. For example, if the image shown in Figure 4 is of an agricultural area containing a number of fields and there are three categories, such as arid land, irrigation land, and bare land, which have the same attributes size$\geqslant$60 in the image, the quadtrees may be related with the same abstract object class: Arid/Irrigation/Bare land. As more attributes are discorved in the image, each interpretation class may become more specific. R_1 in Figure 4, for instance, can be interpreted as an Arid land according to the attributes:

Size$\geqslant$60 and

90$\leqslant$Hue$<$120 and

Saturation$\geqslant$0.8

4.2 Spatial relation extraction based on quadtree

In the last process, we see that quadtrees interpretation and image processing are mainly concerned with statistical and geometric attributes of the image, and classifying shapes that appear in the image. However, it is not always unambiguous to interpret quadtrees using these attributes. As a continuation of the interpretation, we consider further solution by using some spatial relations in the homegeneous region quadtree.

An simple example in Figure 5 will illustrate the use of spatial relations. In accordance with the attributes of the regions R_1, R_2, we can not discern if they are willow lands or poplar lands. If we consider the relation between river(R_3) and willow lands(R_1 and R_2), the region R_1 and R_2 may be interpreted as willow lands. So the relations between objects is important to exclude the ambiguity of the image interpretations.

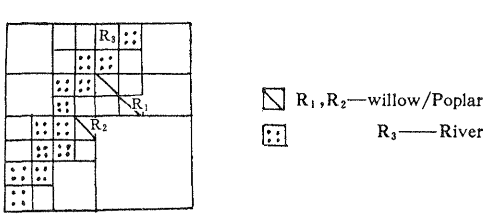


Figure 5. An example of spatial relation

In this paper, spatial relation extraction is perform on the control quadtree and feature quadtree.

Control quadtree is a enclosure quadtree that is applied for testing the relation between homegenous region quadtrees or class interpretation quadtrees. Detecting the relation between quad rant c and b can be simplified to shrinking and expanding a enclose polygon (see Figure 6 a).

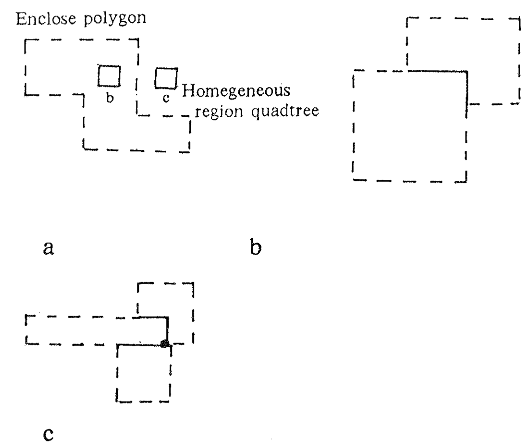


Figure 6. An example of spatial relation extraction base on quadtree.

Feature quadtree is a specific quadtree which extract two kinds of essential components of control quadtree: (a) feature node, which is used as label to represent the intersecting node caused by the meeting of several line quadtrees of a control quadtree (see Figure 6 c). (b) feature line quadtree, which is a part of control quadtree used for representing the relations between homogeneous region quadtrees (see Figure 6b). Thus the spatial relation extraction is performed as the following:

1) Construct control quadtree by shrinking and expanding enclosure polygon.

2) Quadtree node that is a part of a control quadtree is labeled in terms of the relation between homogeneous region quadtrees.

3) Extract feature node and feature line quadtree.

4) Extract spatial relation between homogeneous region quadtrees by using feature node and feature line quadtree, and a spatial relation quadtree is made.

5. CONCLUSIONS

A novel method for spatial relation extraction based quadtree has been present. The method is applicable for remotely sensed image interpretation.

The main contributions of this paper are: (1) representing a hierarchical structure of quadtrees, which is composed of quadtree, segmentation quadtree , homogeneous region quadtree and spatial relation quadtree. (2) describing a quadtree structure called binding that contains three parts, location code, region number and attribute value. (3) introducing the notions of control quadtree, feature quadtree, feature node and feature line quadtree into the spatial relation extraction.

In addition, A comparetively normalized way of repre senting image and interpreting image based on quadtree are described in this paper. It can exclude the ambiguity of spatial relation extraction and interpretation even when some objects spectrum are very approximate. Because the problems of segmentation and interpretation errors involve edges and inperfect interpretation etc. in the low — level phase, which are difficult to be detected in the high — level phase. some interpretation errors can still be found from results . We have tried to solve them by repeating some proper steps to revise the errors under current best interpretation based on DGs. But the further improvement of this method is being done by authors.

6. ACKNOWLEDGEMENT

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