A STUDY ON THE REPRESENTATION AND INTERPRETATION OF REMOTELY SENSED IMAGERY

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ABSTRACT

For past many years, many researchers have devoted considerable effort to the problem of image representation. However, no recent study has been undertaken for an interpretation of remotely sensed image based on the combination of multiform representations under conditions where a computer system can interpret an image by incorporating multi — information overlap analysis in the traditional representation of image understanding. In this paper, we describe an multilevel representation tree composed of synthetic land unit map ,land unit relatability list, complexes labeling, correlation list and region relation graphs. This representation tree allows one to interpret image in terms of remotely sensed image and non — remotely sensed digital maps that may provide geometric, topological, overlapping and attributive information in a form suitable for image interpretation. We present an interpretation for remotely sensed image by using multilevel representation tree and give also a number of experimental results.

KEY WORDS: Representation, Interpretation, Multilevel representation tree, Synthetic land unit map, Complexes labeling, Correlation list.

1. INTRODUCTION

The problem addressed in this paper is that of how effectively to interpret an object in an image based on the combining of remotely sensed images and non — remotely sensed digital maps that are in multiform representations.

For many years, much of the research on image recognition has involved various representatations such as boundary representations, constructive solid geometry representations, sweep representations, and decomposition representations etc.. Most of these methods are feasible for acquiring the geometric information from the object image(Andrew, 1989).

We submit that the above — mentioned representations provided for image recognition all have two grave defects. The first defect is that some information, such as the relationships between objects and their environmental factors, which is very usuful for remotely sensed image interpretation hasn' t been reflected. The second defect is that it is impossible to obtain a suitable correspondence between different data that may be remotely sensed images or digital maps. This is because the representations are aimed at representing regular geometric form.

It has been shown that geographic information is important to remotely sensed image interpretation, because the data Provide information on the spatial distribution of important factors such as rivers, roads, towns etc.. To use the geographic information and overcome the shortcomings as stated above, in this paper we describe a multilevel representation tree that have two principal branches. One of them is composed of various digital maps, synthetic land unit map and land unit relatability list etc. , which originate from multi — information overlap analysis. The other is associated with complexes labeling, correlation list and region relation graph which stem from image understanding.

The main contribution of this paper is the introduction of incorporating the synthetic land unit representation in the traditional representations of image understanding (Guan, 1990). Synthetic land unit representation can adequately convey the relations that exist between the image regions or mapping units. Spatial relations may be easily found by examing the synthetic land unit map, so it is useful for image interpretation.

In subsequent sections we first recall a practical example of remotely sensed image interpretation and some procedure for image analysis. Next, the problems of how to transform the input image and digital map into synthetic land unit map is described. We then present an interpretation for remotely sensed image by using multilevel representation tree and we give also a mumber of experimental results.

2. MULTILEVEL REPRESENTATION TREE WITH MULTI—INFORMATION FUSION

There is a difference between the interpretation of remotely sensed image and recognition of 3—D objects in CAD/CAM. The latter usually only involve geometric, topological and some attributive information. But, of course, these informations are useful, not sufficient for remotely sensed image interpretation, which is possible needing more information (see Table1).

The information as shown on Table 1 contains not only spectral, geometric features of objects, but also their spatial positions, relationships between objects and other attributes. Part of them cann't be extracted from remotely sensed image, but they are useful for image interpretation.

Table 1
Information for Image Interpretation

1. Image density and color 1. 1 Hue 1. 2 Saturation 1. 3 Intensity 1. 4 Grey tone 2. Form or relief 2. 1 Shape 2. 2 Shadow 2. 3 Stereoscopy 2. 4 Size	3. Location and spatial relation 3. 1 Situation 3. 2 Distance 3. 3 Direction 3. 4 Adjacency etc. 4. Environmental factors 4. 1 Vegetation 4. 2 Soil 4. 3 Hydrologic factor 4. 4 Geologic factor etc.

There exist many representations that may indicate the information on Table 1, but some representation is usually only suitable to some information. For example, it is convenient to determine spatial position in a raster image (see Figure 1a), however, it is difficult to find the correspondence between region R_1 in image A and region G_1 in image B (see Figure 1b).

A full—scale interpretation of remotely sensed image will normally not be restricted to features directly visible in the image, but will also encompass the Linkage of these visible to other, invisible environmental factors such as soil, vegetation ect..

So it is necessary to allow one to interpret image in terms of remotely sensed image and non—remotely sensed digital maps that may privide geometric, topological, overlapping and attributive information in a form suitable for image interpretation.

In view of the above, we propose a representation series for image interpretation, termed multilevel representation tree (see Figure 2). It includes two fundamental aspects. The first aspect is composed of vairious disital maps, synthtic land unit map and land unit relatability list ect•, which originates from multi—information overlap analysis. The purpose of this aspect is to form or reflect an operable relation which exist within the environmental factors if it is useful. The other is associated with complex labeling, correlation list, region relation graphs and attribute list, which stems from image understanding and is aimed at organizing the geometric , topological, attributive etc • information extracted from the image into a form suitable for image interpretation.

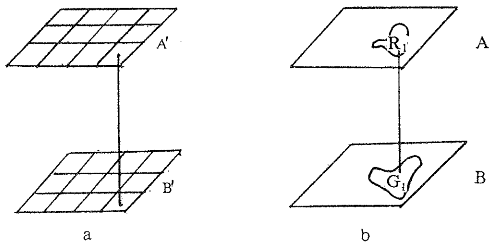


Figure 1. An example of image representation

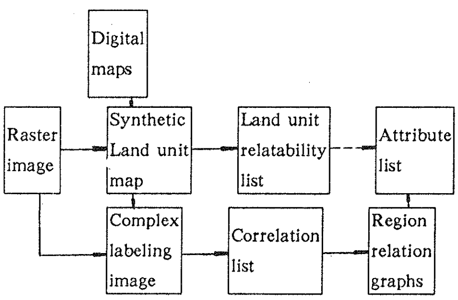
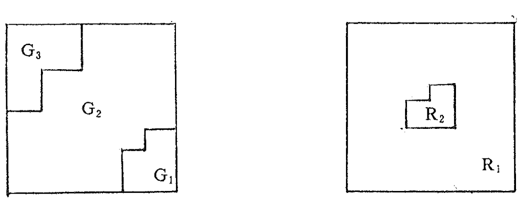


Figure 2. Multilevel representation tree

3. IMAGE INTERPRETATION BASED ON MULTILEVEL REPRESENTATION TREE

As shown in Figure 3, let us assume that we have a segmentation image (Li, 1992), and a digital land use map. R_2 is the segment of the segmentation



a Digital landuse map b segmentation image

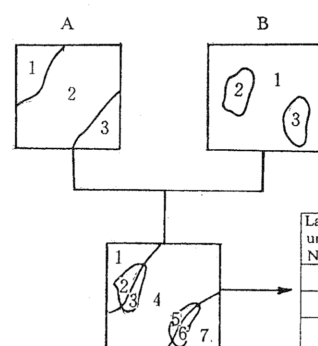
Figure 3.

image . Its interpretation class may be grass land or tree land in accordance with the attributes of the region R_2 extracted from the image. How can we exclude the ambiguity of the image interpretation? In visual interpretation, we may find that region R_2 surrounded by region G_2 (see Figure 3) by overlapping segmentation image with degital land use map, we, then may interpret the region R_2 as swamp meadow by using the knowledge: vegetation in a swamp is swamp meadow.

In this section we will give a description of how to use a computer system to interpret region R_2 in the segmentation image based on multilevel representation tree.

3. 1 Synthetic land unit map and relatability list

Suppose that we have some single element maps which are compiled by using remotely sensed image or other data. In accordance with the multi — information overlap method , we transfer all information in single element maps onto a blank map and a new polygon map is made , we name it synthetic land unit map (see Figure 4 a). Next, the polygons (land units) on the map are numbered. A land unit



Land unin No.	A	B
1	1	1
2	1	2
⋮	⋮	⋮
7	3	1

a Synthetic land unit map

b land unit relatability list

Figure 4.

indicates the correspondence between all single element maps. Thus we can constitute a list, which is called land unit relatability list, to represent the relationships between single element maps associated with land unit number (see Figure 4 b). Synthetic land unit map and relatability list fairly good solve the problem of fusing multi — information by linking up the mapping units of all single element maps, so it is very useful for remotely sensed image.

3. 2 Region relation formation

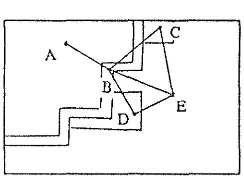
On the synthetic land unit map, each region is the structure of a matrix or a rectangular raster and the relations between regions cann't easily be judged, so we introduce the region relation representation.

At first, we defined an image or digital map as complex with a label assigned to each complex element . The label originate from the gray values measured during the scanning of an image. The region then is formed in accordance with the corresponding notion of the subcomplex (V • A • Kovalevsky, 1988).

Because the complex labing image is still represented in raster form , to obtain topological information, we transform the complex into a data structure called the correlation list . It consists of o — dimensional, 1 — dimensional, and 2 — dimensional topological sublists (Guan, 1990).

With the description of correlation list, appropriate region relation graph (see Figure 5a) and region relation list (see Figure 5 b) can be made to represent the relations between regions.

In the relation list , a_1, a_2 are the labels, identifying the relations between regions such as adjacency , parallel etc • .



a Region relation graph

	A	B	C	D	…
A	1	a_1	0	0	…
B	a_1	1	a_1	a_1	…
C	0	a_1	1	0	…
D	0	a_1	0	1	…
⋮	⋮	⋮	⋮	⋮	…

b Region relation list

Figure 5. Region relation representation

3. 3 Image interpretation

The organization flowchart in Figure 6 gives an overview of the procedure to use a computer system to interpret an image based on multlevel representation tree. Reference to Figure 7, the object interpretation precedure is briefly described as follows.

1) Form segmentation image and digital maps.
2) Construct synthetic land unit map.
3) Construct correlation list, region relation list , land unit relatability list and attribute list.
4) Construct a knowledge base which consists of different types of knowledge such as geometric, topologic, spatial related knowledge etc.
5) If only one interpretation is found by matching the image features and rule hypotheses, the interpretation will be assigned to the image region, or the knowledge base is revised or more information extracted from image and auxiliary data must be acquired.
6) If there is no information and knowledge to specify the interpretation further, assign the image a ambiguous interpretation class.

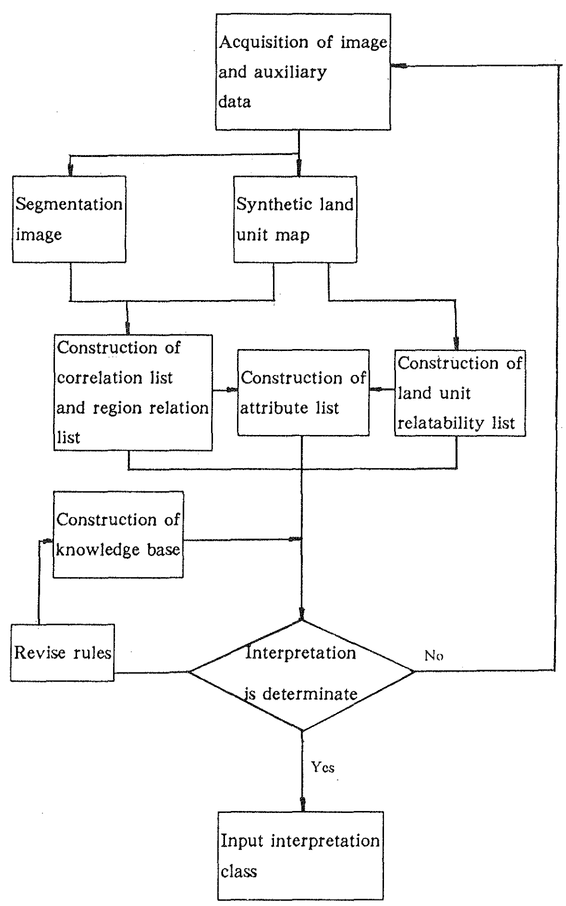
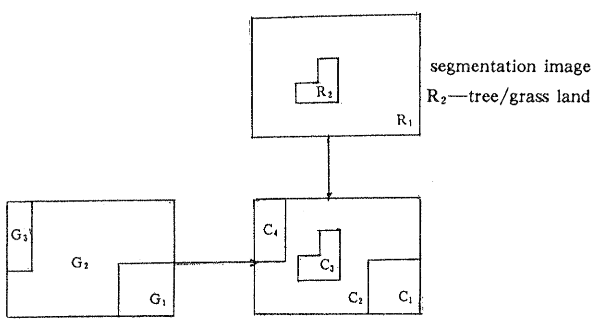


Figure 6. A procedure to interpret an image based on multilevel representation tree.

For example , in Figure 7 region R_2 of segmentation image may be intepreted as tree land or grass land in terms of the features extracted from image (see Figure 7)and some rules. When the land use map is used, we may find that the indeterminate region is surround by region G_2 of digital land use map, so it may further be interpreted as a swamp meadow by using the knowledge: vegetation in a swamp is swamp meadow.



Digital land use map Synthetic land unit map
G_2—swamp
Figure 7. An example of image interpretation

4. EXAMPLES AND CONCLUSIONS

Following the thought of this paper , we have developed a set of computer programs for automatically converting and interpreting remotely sensed imagery. These programs have been used in real projects including the vegetation classification of shuang Yang county in Jilin province of China using TM image, satisfactory results have been obtained.

The TM image used in the experiment is a 512×512 pixel image of an agricutural scene . Figure 8 is a segmentation image obtained by a maximum likelihood classifier based on ARIES image processing system . Because the classification is only based on spactral and statistical information of each pixel , and ignore the imterrelation between adjacent pixes, the corresponding between segments and objects is indeterminate. For example, in Figure 8 the willow land may be mixed with poplar land.

Figure 9 is a synthetic land unit map composed of the segmentation image and digital land use map that is acquired by non — remotely sensed way . We may obtain some relations which are difficulty found in remotely sensed image. In Figure 9, rivers, roads, resident lands etc • are provided from the land use map. The relation may be used for image interpretation.

Figure 10 is the region labeling in the complexes. It shows the enclosed region with the aim of forming correlation list, region relation list and attribute list. By making use of the complex labeling, correlation list, land unit relatability list etc • a class interpretation image is made. Based on the spatial parsing of the class interpretation image, the relation between willow land and irrigation land is used for the interpretation of willow land . As a result, the mixture of willow lands with poplar lands is reduced at least about 25%.

5. ACKNOWLEDGEMENT

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Figure 8. Segmentation image

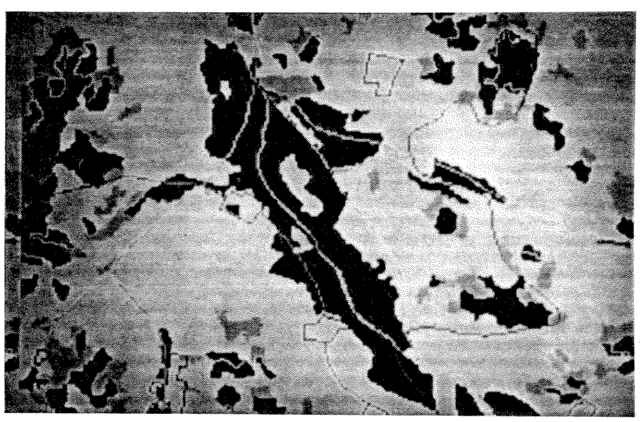

Figure 9. Synthitic land unit map

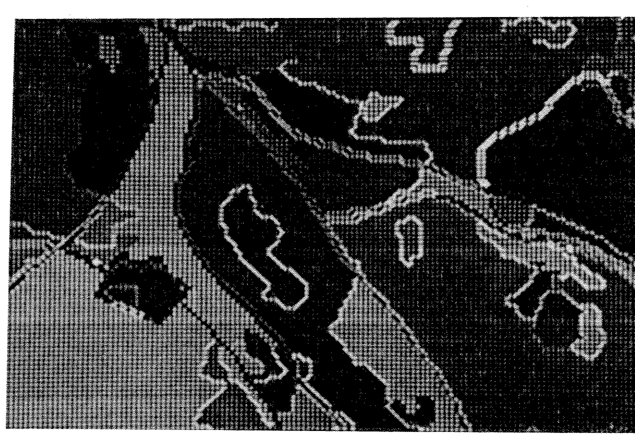

Figure 10. The region labeling in the complexes