An Finite-Automata and Discrete Wavelet Transform to the Representation of Fractal Images

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ABSTRACT : In this paper, we propose a new approach to represent the features of image objects in order to recognize it. The proposed approach consists of three stages. The first stage includes a segmentation of an image into regions, and then DWT is applied to each of these regions for extracting the statistical properties such as the energy and standard deviation. In the final stage, the FA is constructed to represent the extracted features. The performance of the proposed approach is demonstrated in the domain of fractal images.

Key words: edge-detection, wavelet transform, finite automata.

1. Introduction

Fractal are a geometric patterns that are self similar and can be zoomed infinitely. They are used especially in computer modeling of irregular patterns and structures in nature(Saranathan). The representation of objects in fractal images is necessary for recognizing them, where it refers to significant parts (regions, edges) of which the image is composed. Thus representation requires segmenting the image into such parts, and then to extract and compare the object features in it. There are various kinds of object features: shapes, distribution (of brightness, color,…), texture, etc. (Tomiya and Ageishi 2003). Among them, the shape information must be the most robust and the most effective for the fractal images. All information on the shape of an object is, for example, contained in its boundary pixels. Generally, the edge-detection is applied to get the pixels of the boundaries that form the shape features.

In recent years, wavelet transform(WT) has attracted significant attention in scientific research and engineering applications since it is very powerful for analyzing transient signals/images for its capability of multiresolution analysis with localization in both time and frequency domains. The wavelet-based multiresolution analysis is very efficient in pattern recognition, image compression, and other domains.

In fractal images where the regions or objects are composed of parts arranged in particular ways, and the parts themselves are arrangement of subparts, and so on. There is analogy between this type of representation and the use of finite automata (FA) to define language.

Mindek (2004) describes the method to represent the images by finite automata and application in image recognition. In his method, the image is partitioned into blocks with the same size and give code for each block, then describe this codes by finite automata. This paper present a method to represent the fractal images using FA.

The remainder of the paper is organized as follows. In section 2. and section 3. we introduce edge-detection and wavelet transform respectively. Section 4. present FA. In the next section, we describe the proposed approach. Finally, the experimental results and conclusions will be generated.

2.Edge-detection segmentation

It is possible to segment an image into regions of common attribute by detecting the boundary of each region for which there is a significant change in attribute across the boundary (Pratt 2001). Boundary detection can be accomplished by means of edge detection. There is many detectors, but a better edge detector may be found by first smoothing the image and then applying laplacian filter. This leads to a kind of regularized edge detection and a class of filter called Laplace of Gaussian filter (LoG for short)(Jahne 2001).

The LoG detector proposed by Marr and Hildreth has been widely used. Briefly, this operator has the following properties: It uses the Gaussian filter for noise elimination. A simple detection sheme is used. Since locating the extreme of functions which are flat is not located by detecting zero crossings in laplacian of the intensity function, rather than locating extreme in the first partial derivative. Further, this operator does not require an explicit thresholding, and there is a possibility of extracting edges from different spatial frequency ranges of the images. Finally, the response of the center-surround cells found in biological vision systems (Shah 1997).

3. Discrete Wavelet Transform (DWT)

The practical and fast way of implementing wavelet transform is using a filterbank structure. The link between wavelet transform and filterbank was first discovered by daubechies (Daubechies 1988). An analysis filterbank first decomposes the pixels in all rows of the image into low-pass and high-pass components. These components are then downsampled by a factor of 2 so that the total number of low-pass and high-pass coefficients is the same as the total number of pixels in the input image. After completion of the row-wise operation a similar operation is applied column-wise to both the low-pass and high-pass components the order of operation for rows and columns can be swapped. The final output of the analysis system for $N \times M$ image is a set of four $N/2 \times M/2$ subimages called:LL (low low), LH(low high), HL(high low), and HH(high high) subbands which correspond to different frequency bands in the image. The total number of coefficients in the four subbands is equal to the original number of pixels in the image, $N \times M$. The LL subband is alow resolution(coarse)version of the original image, and the LH, HL, and HH subbands respectively contain details with vertical, horizontal, and diagonal orientations (Danyali 2004).

4. Finite Automata

As a modeling tool, finite automata(FA) have played an important role in various areas of computer science and the related disciplines. Aside from their usefulness in formal languages and complexity theory, it has recently been shown that finite automata can be also play a constructive role in digital image processing (Lin and Yen 2003) .

By exploiting self-similarities within images, it have suggested that finite automata serving as an image description tool. The FA is probably the simplest and most widly computer science model. Intuitively, a FA is a system that can enter a finite set of different states. As a consequence of some input, which may range over a finite set of possible values, the FA operates a transition from one state to another. We assume that the reader is familiar with the elementary facts about finite automata, see e.g.(Rayward-smith 1983).

5. The proposed approach

The block diagram in fig. 1 show the steps of proposed approach.

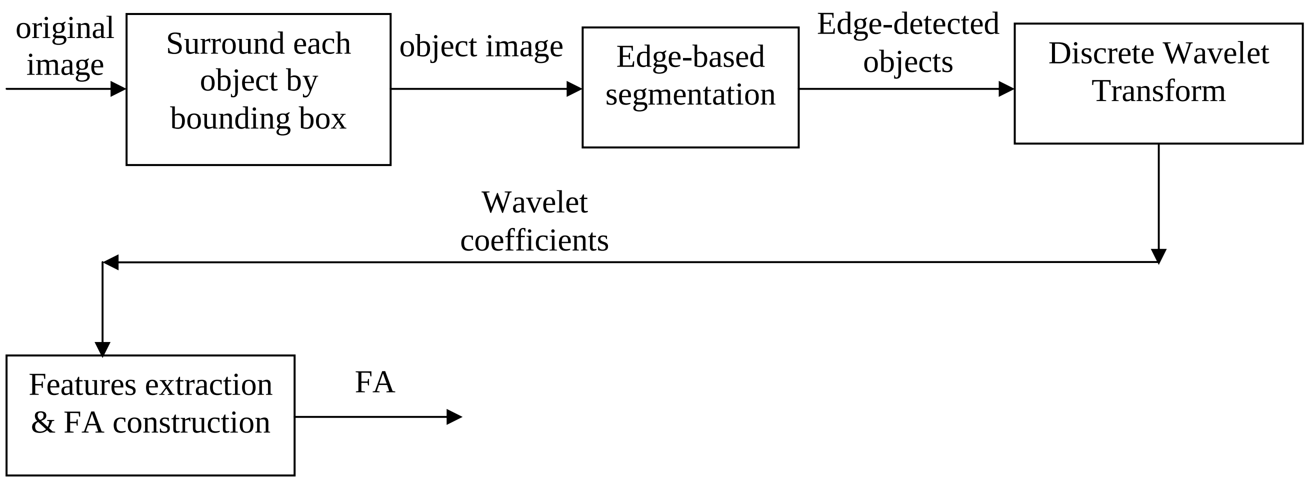

Fig.1.The outline of the proposed approach.

Given an input image corresponding to an fractal image, the first step is to segment the individual objects from the image resulting in a collection of object subimages, each containing a single object and surrounding by bounding box which represent the smallest rectangle that contains that object. In the next step, we perform edge-detection for each subimage using LoG operator. Edge-detection is used because we care with shape of object and not the greyscale or color.

The features extraction is important step where that the goal of which is to take amount of image data and retain only that information which is necessary to distinguish objects. DWT with db4 family is applied on subimages for performing features extraction. One-level decomposition of image objects is performed, and then features(energy, std. deviation) is calculated. We found this level of decomposition is sufficient because we treat with objects alone and not the image overall. The final step in your method is representation the image depending on features extracted. The model used for this is FA where each node in which represents state and the arcs represent the transition from state to another when input value is given. The value associated with the arcs represent the value of properties. The constructing FA depends on scanning the image in left-to-right top-to-bottom fashion with respect to its objects.

6. Experimental Results and Conclusions

We presented in this paper an approach of description the fractal images. It involves using of edge-detection and DWT for features extraction of image objects. After that FA is constructed to describe the image. Our approach is tested by using sierp-triangle image and as shown in fig.2.

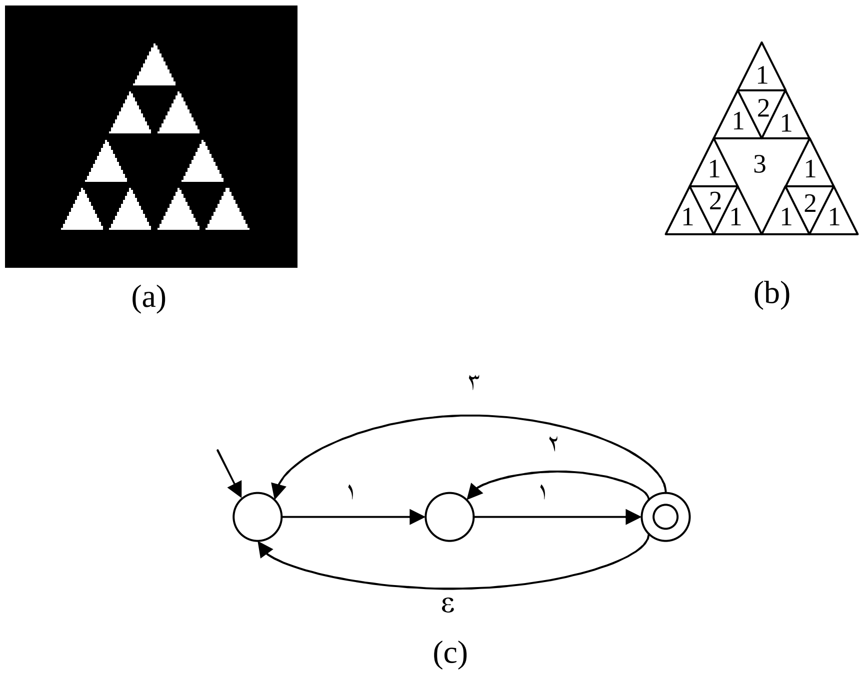

Fig.2. (a) The original image and (b) the codes given for each object; (c) the corresponding FA.

The codes illustrated in fig.2(b) resemble to some energy and std. dev. Value and as shown in table1, for example, the code "1" indicates to all triangles with the same shape and size, and so the same thing for the other codes.

Table1. The codes and equivalence energy and std. dev. values.

Codes	1	2	3
Energy	32.30	38.09	74.73
Std. dev.	0.2852	0.2986	0.2624

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