Texture Analysis: Algorithm for Texture Teatures Computation

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***Abstract*— Textures are one of the most important features in computer vision for many applications. Texture feature extraction has been an active topic for years. There are a lot of feature extraction methods for texture analysis. In this paper the features were constructed using novel algorithm. Beside the other methods the computational simplicity is the main advantage of this algorithm.**

Keywords*— *image processing; texture; texture analysis; feature extraction

I. Introduction

At present digital image processing and pattern recognition technologies have been extensively explored and widely applied in many areas. Texture analysis is a fundamental problem in image processing, machine vision, object recognition, image reconstruction, etc. It is possible to define texture areas in a whole series of different images. A lot of original, natural surfaces are presented by textures (Fig. 1). Texture is a characteristic features for image classification. Texture is usually described as a combination of features and has a large number of different constructions and properties. However there is no universally accepted definition of visual texture. Therefore, texture analysis plays an important role in image processing and image recognition (many industrial, biomedical and remote sensing applications) [1].

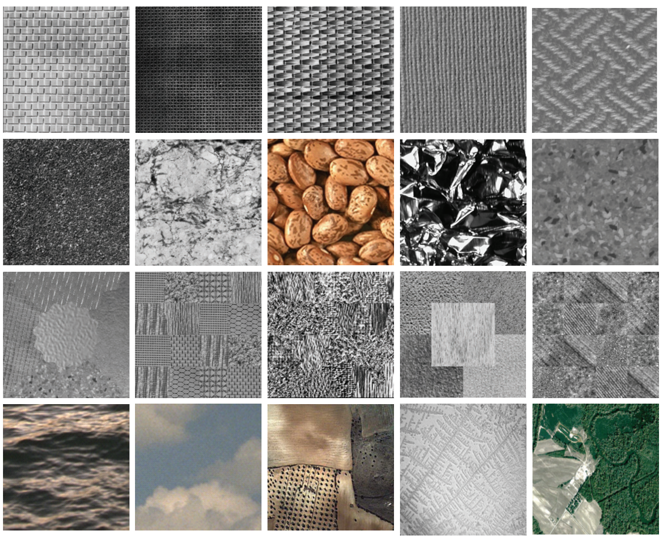

Figure 1. Texture images

We can define textured surface of an object as grained, rough, smooth and repetitive. But it is very difficult to associate such characteristics with mathematical tools. Person can define a texture presence for an object. However it is a complicated question to give a definition of texture.

There are no formal approach and strong domain of texture. We can define two approaches in definition formulation [2]:

Structural approach: texture is characterized by *texture primitives* or texture elements, and the spatial arrangement of these primitives.

Statistical approach: texture is characterized by the spatial distribution of pixel values.

The best definition of the concept of "texture" is a synthesis of two approaches in the case described above. The texture should be considered as two-level structure, which is a spatial organization (high level) the basic primitives, which themselves have a random aspect (lower level).

II. Texture Analysis Scheme

In general, the process of texture analysis and image segmentation can be represented as a sequence of the following stages (Fig. 2).

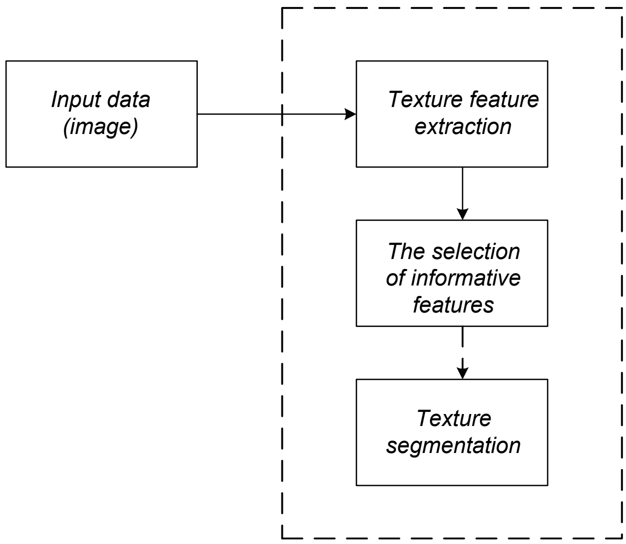

Figure 2. Stages of texture analysis and image segmentation

A. Input data

The input data are images (color, grayscale). In the texture analysis process significant texture information can be lost in the preprocessing phase. So now, most researchers do not consider this part as part of texture analysis problem. Although at present there are algorithmic solutions, which allow to perform preprocessing stage with preservation of texture information.

B. Texture feature extraction

The first step is the texture features extraction. To solve this problem prompted a large number of approaches and algorithms. The main efforts of researchers are concentrated on the creation of efficient algorithms for computing the texture features.

C. The selection of informative features

The second step is the selection of informative (important, significant) texture features. It is necessary to reduce the redundancy of features which were obtained in the previous step. This allows us to construct an optimal classification model.

D. Texture segmentation

Segmentation problem is the third stage. At this stage there is a need to choose an algorithm for image segmentation.

III. MAIN APPROACHES

Approaches to texture analysis are usually categorized into[2-7]:

1) *Statistical methods;*
2) *Geometrical methods;*
3) *Model-based methods;*
4) *Signal processing methods.*

The use of statistical features is therefore one of the early methods proposed in machine vision literature. They are well rooted in the computer vision world have been applied to various tasks. Statistical texture analysis methods measure the spatial distribution of pixel values. A large number of texture features have been proposed (first-order statistics, second-order statistics, high-order statistics).

In geometrical approaches texture is characterized by texture primitives or texture elements, and spatial arrangement of these primitives. There are two goals of geometrical approaches: to extract texture primitives and to generalize the spatial placement rules.

Model based texture methods are based on the construction of an image model that can be used not only to describe texture, but also to synthesize it. The model parameters capture the essential perceived qualities of texture. Markov random fields (MRFs) and Fractals are very useful and have become popular in modeling these properties in image processing.

Signal processing techniques are especially suited for texture analysis. The methods can be divided into spatial domain, frequency domain and join spatial/spatial domain techniques.

Table 1 shows a summery list of some key texture analysis methods.

TABLE I. SUMMERY LIST OF SOME KEY TEXTURE ANALYSIS METHODS

Approaches	Algorithms
Statistical	1. Histogram features 2. Co-occurrence matrices (GLCM) 3. Grey level difference matrix 4. Run lengths 5. Autocorrelation features 6. Local binary patterns 7. Sum of difference
Geometrical	1. Voronoi tessellation features 2. Textons 3. Texems 4. Primal sketch
Model-based	1. Fractal model 2. Random field models 3. Autoregressive model 4. Eptinome model
Signal processing	1. Gabor filters 2. Power spectrum 3. Laws features 4. Eigenfilter 5. Gaussian pyramid features 6. Laplacian pyramid 7. Ring filter 8. Wavelets

These methods and algorithms for texture analysis have significant theoretical and computational complexity. This imposes certain limitations on their use. Therefore the aim of the author's research was to develop an algorithm for computation of a set of textural features which characterized by computational simplicity, and not inferior to the efficiency of existing algorithms.

IV. ALGORITHM FOR TEXTURE FEATURE CALCULATION

This algorithm requires the computation of textural features using local masks. Masks of size 3 × 3, 5 × 5 and 7 × 7 (Fig. 3). All N = 11 masks are used for texture features calculation. We consider only those pixels that are under the gray cells of the mask ("significant pixels").

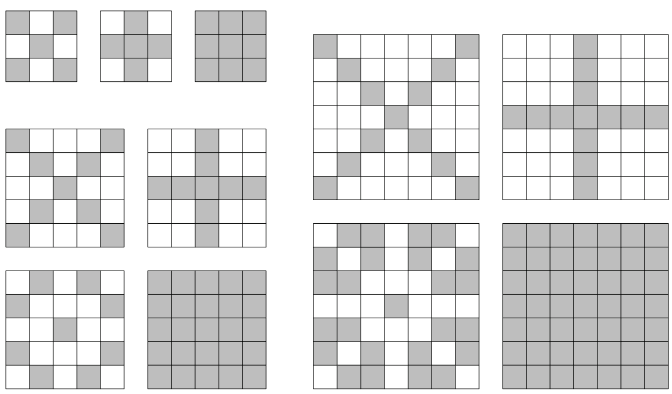

Figure 3. Masks

For each pixel of the image feature vector is formed as follows:

$$Y_{k1} = X(i,j) - median \quad (1)$$

$$Y_{k2} = X(i,j) - \min \quad (2)$$

$$Y_{k3} = X(i,j) - \max \quad (3)$$

where

$X(i,j)$ - value of the current pixel under the center of the mask;

Y - value of the corresponding texture feature;

k – number of mask, $k = \overline{1,N}$;

median – the average value of "significant pixels";

min - minimum value of "significant pixels";

max - the maximum value among the "significant pixels".

Thus, each pixel will be placed in the vector of the 33 textural features (Fig. 4).

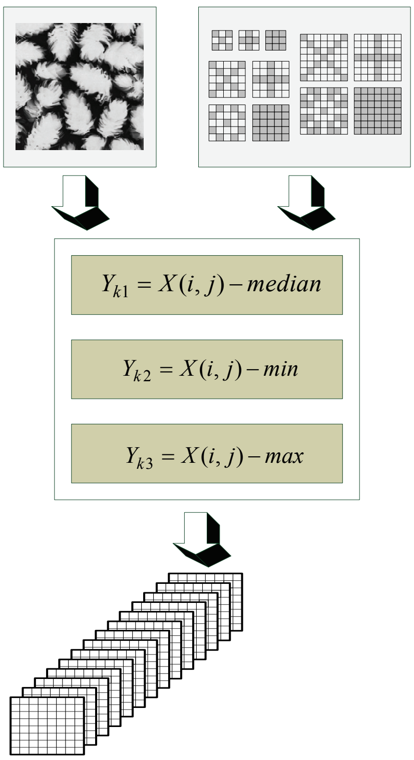

Figure 4. Scheme of proposed algorithm

V. Experimental Results

We have used proposed algorithm for unsupervised texture segmentation. The Brodatz's photo album is a well-known benchmark database for evaluating texture recognition algorithms [8].

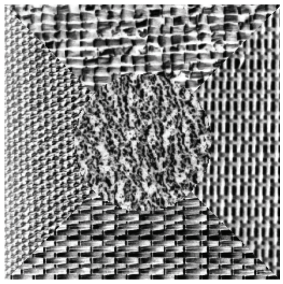

Figure 5. An example of the Brodatz texture mosaic

Brodatz texture mosaics have been used for experiments (Fig. 5). For each of these images the proposed algorithm is used. The K-means algorithm is utilized. Experiments show that proposed algorithm has been used with segmentation rate 88%.

The proposed features have been compared to the feature Sum of differences [9]. They have the same accuracy. But the proposed algorithm for texture features computation has simple and fast computing scheme.

VI. Conclusion

In this paper we proposed a novel algorithm for texture feature computation. This scheme is useful in environments where speed is essential calculations, rather than their accuracy. We plan to improve this algorithm and to exam it using the other databases. Those issues will be explored in our future work.

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