# Chapter 14
# Image Processing Applications Based on Texture and Fractal Analysis

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## ABSTRACT

*Texture analysis research attempts to solve two important kinds of problems: texture segmentation and texture classification. In some applications, textured image segmentation can be solved by classification of small regions obtained from image partition. Two classes of features are proposed in the decision theoretic recognition problem for textured image classification. The first class derives from the mean co-occurrence matrices: contrast, energy, entropy, homogeneity, and variance. The second class is based on fractal dimension and is derived from a box-counting algorithm. For the purpose of increasing texture classification performance, the notions "mean co-occurrence matrix" and "effective fractal dimension" are introduced and utilized. Some applications of the texture and fractal analyses are presented: road analysis for moving objective, defect detection in textured surfaces, malignant tumour detection, remote land classification, and content based image retrieval. The results confirm the efficiency of the proposed methods and algorithms.*

## INTRODUCTION

Image texture, defined as a function of the spatial variation in pixel intensities (grey values), is useful in a variety of applications and has been a subject of intense study by many researchers. It is very hard to define rigorously the texture in an image. The texture can be considered like a structure which is composed of many similar elements (patterns) named textons or texels in some regular or continual relationship. Wilson (1988) points out that textured regions are spatially extended patterns based on more or less accurate repetition of some unit cell; the origin of the term is related to the weaving craft. Gonzalez (1992) relates texture to other concepts like smoothness,

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fineness, coarseness, graininess and describes three approaches for texture analysis: statistical, structural and spectral.

There are two points of interest in this chapter. The first point is texture classification and segmentation based on statistical features (especially derived from the mean co-occurrence matrix). The second point of interest is the analysis and classifications of textural images based on fractal dimension with a modified box-counting algorithm. We provide some applications in more detail that illustrate the discriminating power of the selected features, the efficiency of the mean co-occurrence matrix and the modified box-counting algorithm in texture classification and segmentation. The applications refer to road following, defect detection, remote image segmentation, classification of malignant tumours, and content based image retrieval.

## BACKGROUND

### Texture Analysis Features

Texture analysis has been studied using various approaches, such as statistical (grey level co-occurrence matrices and the features extracted from them, autocorrelation based features and power spectrum), fractal (box counting fractal dimension) and structural (the texture is composed of primitives and is produced by the placement of these primitives according to certain placement rules). The structural approach is suitable for analyzing textures where there is much regularity in the placement of texture elements. The statistical approach utilises features to characterise the stochastic properties of the distribution of grey levels in the image.

There are two important kinds of problems that texture analysis research attempts to solve: texture segmentation and texture classification. The process called texture segmentation involves identifying regions with similar texture and separating regions with different texture. This implies prior knowledge of the texture types and component number which exist in the analyzed image. Texture segmentation is a more difficult problem than the texture classification. The later involves deciding what texture class an observed image belongs to. Thus, one needs to have an a priori knowledge of the classes to be recognized. Because texture has many different dimensions and characteristics there is no single method of texture representation that is adequate everywhere. The features implied in the classification process can differ from one application to another. Wagner (Jähne, 1999) compares the performance of 318 textural features from 18 feature sets. On the other hand, texture classification can be used to segment multi-textured images. With this end in view, the image is divided into small textured region which are classified and indexed. Generally, the result is a coarse type of segmentation process. The segmentation fineness depends on the degree of partition of the initial images. If the degree of partition is too fine, then it is possible that the texture could disappear. Actually, for an application, a partition index is established taking into account the given image resolution and the texture fineness.

### Statistical Methods of Texture Analysis

The statistical approach to texture analysis is more useful than the structural one. The simple statistical features, the mean $\mu$ and variance $\sigma^2$, can be computed indirectly in terms of the image histogram $h$. Thus,

$$\mu = \frac{1}{N}\sum_{i=1}^{K} x_i h(x_i)$$

$$N = \sum_{i=1}^{K} h(x_i)$$

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