IMAGE TEXTURE ANALYSIS TECHNIQUES – A Survey

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ABSTRACT

This paper contains a survey of image texture analysis techniques. Three broad classes of methods are discussed: pixel-based, local-feature based and region-based. The pixel-based models include grey level cooccurrence matrices, difference histograms and energy-measures. The local feature-based models mostly rely on edges as local features and include Marr's primal sketch model and a generalization of cooccurrence matrices. Region-based models include a region-growing model and a topographic model which treats the texture image as a digital terrain model.

INTRODUCTION

This paper presents an overview of techniques for image texture analysis, emphasizing methods for describing image textures for the purpose of image classification.

A textured area in an image is characterized by a non-uniform spatial distribution of image intensities. Although color images also contain textures, we will limit our attention to grey scale images. Very little research has been devoted to computational models of color textures which make essential use of color information.

The variation in intensity which characterizes a texture ordinarily reflects some physical variation in the underlying scene. Although it is possible, in principle, to account for
the texture by modeling this physical variation, in practice this is quite difficult to do. Horn (1) discusses such image models. Rather, the approaches which we will discuss will treat texture as a two-dimensional pattern of intensities, and will not consider the physical basis of the texture. In fact, we will adopt an intuitive model for image textures in which a texture is composed of pieces: the size, shape, shades, and spatial arrangement of the cells are the critical factors in discriminating between different textures. Notice that the cells might actually form a partition of the image (i.e., form a mosaic) or might be scattered on a homogeneous background (as "bombs" dropped on a field). Although it is possible to develop formal mathematical image models for such patterns (see, e.g., Ahuja (2), Schachter et al (3) or Zucker (4), this paper will not consider the development of texture analysis procedures based on such models. Rather, the texture description models which we will discuss are more heuristically motivated. They have been applied to a wide variety of practical problems, including, e.g., texture analysis of many biomedical images and satellite images.

Texture description models can be broadly classified into three main classes:

1) pixel-based models, where the texture is described by statistics of the distribution of grey levels, or intensities, in the texture,

2) local feature-based models, where the statistics are computed with respect to the distribution of local features, such as edges or lines, in the texture, and

3) region-based models, where the texture is first segmented into regions, and then statistics on the shape and spatial arrangement of the regions are used to characterize the texture.

Section 2 of this paper reviews pixel-based models; Section 3 deals with local feature-based models, and Section 4 discusses region-based models.

PIXEL-BASED TEXTURE MODELS

Perhaps the most widely used pixel-based texture model is the grey level cooccurrence matrix, or GLCM. GLCM's were first introduced by Haralick et al (5), and are defined as follows. Let f be a digital image and let \( D = \{(dx, dy)\} \) be a set of image displacement vectors. Then the GLCM of \( f \) with