

Chapter 14

A Computational Model for Texture Analysis in Images with Fractional Differential Filter for Texture Detection

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ABSTRACT

This paper is dedicated to the modelling of textured images influenced by fractional derivatives for texture detection. As most of the images contain textures, texture analysis becomes the most important for image understanding and it is a key solution for many computer vision applications. Hence, texture must be suitably detected and represented. Nevertheless, existing texture detection algorithms consider texture as a unique feature from edges. The proposed model explores a novel way of developing texture detection algorithm by mimicking edge detection algorithms. The method assumes that texture feature is analogous to edges and thus, the time complexity is reduced significantly. The model proposed in this work is based on Gaussian kernel smoothing, Fractional partial derivatives and a statistical approach. It is justified to be robust to noisy images and possesses statistical interpretation. The model is validated by the classification experiments on different types of textured images from Brodatz album. It achieves higher classification accuracy than the existing methods.

1. INTRODUCTION

Texture analysis is very much important in a wide range of image processing applications from medical imaging, remote sensing to defect detection. It has been an active research area in the field of computer vision for more than two decades. It is found to be very hard because one is usually not aware of the number and type of texture classes that an image may contain. Many techniques have been proposed

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in the literature for texture analysis (Haralick, 1973; He, 1990; Chang, 1993; Yoshimura, 1997; Van de Wouwer, 1999; Vese, 2003; Targhi, 2006; Liao, 2009; Li, 2010; Chakraborty, 2012; Karthikeyan, 2012; Zingman, 2013). The ultimate aim is to detect, characterize and represent texture feature in images. But, most of the texture analysis techniques end up with texture segmentation (Chen, 1995; Ojala, 2001; Li C. T., 2003; Liu, 2006; Ranjan, 2014). Only a few techniques perform texture detection, characterization and representation which lead to texture classification (Haralick, 1973; Chang, 1993; Liao, 2009; Chakraborty, 2012; Karthikeyan, 2012) in images. Thus, there is a need for a suitable scheme for texture characterization and representation in images.

Some of the existing texture analysis methods and their issues are discussed in the following.

The Haralick's co-occurrence matrix method (Haralick, 1973) is based on computing second order probability density function of gray levels of various pixel pairs with different distances and orientations in the form of matrices. The decision on the distance and orientation parameters is crucial and thus, the computational complexity is more on this method. The texture number method was proposed in (He, 1990). In this method, texture is considered as a repetition of some primitives with a certain rule of placement and is represented as a number. The number ranges from 0 to 6560 and thus, the time complexity of handling up to 6561 components is very high.

A multiresolution approach using wavelet packets is suggested for texture analysis, which is based on an observation that a large class of natural textures can be modelled as quasi-periodic signals (Chang, 1993). However, it is found that experimental justification is missing in this work. An edge detection method is developed for texture images using genetic algorithms (Yoshimura, 1997). In this work, edges are characterized as the variance of texture feature in small image regions. If the variance is small, then edge detection is very difficult. Thus, the characterization of texture feature needs to be improved. A texture characterization approach is proposed based on functional minimization and partial differential equations in (Vese, 2003). This model is not able to distinguish between noise and texture. Another texture descriptor is suggested using the LU-transform on small image regions (Targhi, 2006). This method is not able to characterize texture, because, it is difficult to use LU-transform as a feature vector.

An autoregressive model was developed for texture classification (Karthikeyan, 2012). This method is based on Bayesian approach. In this method, auto-correlation coefficients are used to detect textures in small image regions. A morphological texture contrast (MTC) operator was introduced for detecting of textural regions in images and a morphological feature contrast (MFC) operator was developed for discriminating between non-textural regions (Zingman, 2013). This method focuses more on isolating textural features from other features and not on texture detection.

From the review of existing texture analysis methods, it is observed that most of these methods handle texture detection, characterization and representation by considering texture as a distinct feature from edges. But by looking at the descriptions of the edge and texture features, it is noticed that they are similar and comparable. Because an edge is defined to be an abrupt change in pixel intensities and texture is defined to be a function of spatial variation in pixel intensities. Thus, the texture can be described to be minute edges. This motivated us to build the texture detection algorithm from the scratch of edge detection algorithm.

In general, edge detection is performed using sharpening filters. The sharpening filters are always dependent on partial derivatives to find the variations between pixels in overlapping neighbourhoods in images. These variations are called residual values. Subsequently, statistical principles are applied to these values to detect an edge pixel (Chen M. H., 1991; Rakesh, 2004; Seetharaman, 2007). But it is found that the residual values are smaller for texture than for an edge. Moreover, the partial derivatives

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