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An efficient approach for structure-texture image decomposition with edge-preservation

Anuj Kumar Singh, Bhupendra Gupta *

PDPM IIITDM, Jabalpur, India

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ABSTRACT

The decomposition of an image into its structural part and texture part is a difficult task and has application in various areas such as medical imaging and image segmentation, etc. Various methods have been proposed to decompose an image into its structure part containing large scale variation in pixel intensity and texture part containing small scale variation in pixel intensity. Unfortunately almost all available methods in the literature have a common drawback that they remove or blur the fine geometric edges while removing the texture, as both geometrical edges and texture both belongs to the high frequency domain. In this work, we propose a new approach to deal with this drawback. The proposed approach effectively remove the texture without affecting the geometrical edges. Also we compare the experimental results with state-of-the-art methods to show the efficiency and effectiveness of proposed approach.

1. Introduction

In various problems of image analysis, we have an observed image, which contains texture (existence of patterns having finer details) and/or noise (existence of random patterns in the input image). The goal of image processing is to extract the meaningful information such as texture, structural information and edges from the image considered. The decomposition of given input image into meaningful components can be considered as a challenging problem because edges are also extracted with the texture part. Usually when an image is decomposed texture information of different regions is removed from the given image and outputs structure part.

Texture is perceived as small intensity variations and patterns represents the finer details. On the other hand the smooth regions and large scale structural information consist in structure part. Image decomposition is essential for analyzing and understanding of image. Since these two components contain different kinds of information. This variation of information contained in different components makes it an important tool to study computer vision and computer graphics and applicable in computer vision algorithms such as segmentation, recognition, and object matching.

It is observed that the texture part consists of small intensity variations and patterns with finer details, it is a part of the high frequency component (HFC) of an image and HFC can be removed by using low pass filter (e.g., Gaussian filter). Unfortunately, when we apply low pass filter on an image, it loses some structural information and results blurriness in filtered (or smoothed) image. Many researchers worked in the area of image decomposition. In spite of its benefits, it is still a challenging problem to decompose an image into structure part and texture part without losing structural information such as fine edges and region boundaries of an image. In this paper, we proposed a method which is capable in separating texture part from the input image by decomposing it into its structure part and texture part and at the same time it is capable of preserving information such as fine edges and region boundaries. We propose a simple and effective method for this purpose. Proposed method can significantly separate the texture part from an image without effecting boundaries between regions of different textures. Results are compared with available literature to demonstrate the effectiveness of proposed method.

2. Related work

A widely accepted tool to decompose an image into its base layer and texture layer is the bilateral filter proposed by Tomasi et al. [1]. Thereafter, Soonmin Bae et al. [2] suggested another approach

* Corresponding author. Tel.: +91 9425155354.
E-mail addresses: anujksingh1992@gmail.com (A.K. Singh), gupta.bhupendra@gmail.com (B. Gupta).

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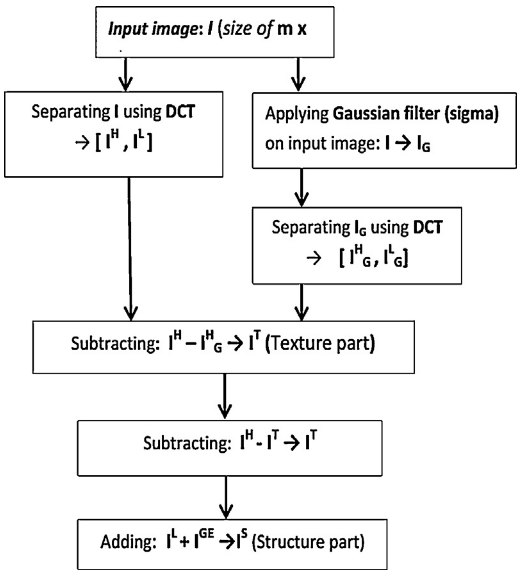

Fig. 1. Step wise block diagram of proposed method.

based on a two scale non-linear decomposition of an image. In this approach, authors modified different layers based on their histograms. Also authors[2] introduce Poisson correction terminology that controls the spatial variation and preserves the details. Another interesting approach has been given by Durand et al. [3]. In their study, authors proposed an approach which is based on a two-scale decomposition of an image into its base layer, encoding large-scale variations and a detail layer. After conducting experiment authors found that contrast is reduced only in base layer and there is no loss in information content of detail layer. Both of the above described approaches are able to preserve the details up to a good extent, however it is not able to effectively handle texture which is having high contrast edges. It blurs the edges and loses sharp geometrical information when more texture part is to be removed.

Yves Meyer [4], introduce this notion of oscillating patterns in natural images and suggests that these oscillating patterns can be explained by non-linear equations, and provides the mathematics necessary for their analysis. The work of Yves Meyer inspired many researchers to work on the problem of image decomposition by considering that an image f is a composition of $u + v$, where u represents image structure (contains object structure and sharp edges) and v represents texture and/or noise (where texture is considered as repeated and meaningful structure of small patterns and noise is related as uncorrelated random patterns). Luminita et al. [5] proposed a method to model image which contains texture by functional minimization and partial differential equations. They used space of oscillating functions to model the v component introduced in [4]. A method to decompose an image into u and v components was introduced by Aujol et al. [6]. They have explain that this u component can be used in non-textured SAR image restoration by minimizing a convex functional to achieve this decomposition. This convex functional depends on the two components u and v and minimization in each variable depends on a projection algorithm which aims in minimizing total variation. Aujol et al. [7] extracted the texture component after applying different energy terms and functional spaces components to extract the structural part of image to achieve this decomposition.

Farbman et al. [8] introduced a weighted least squares (WLS) based filter to construct edge-preserving multi scale decompositions which preserves edges better than bilateral filters. In another work Cho et al. [9] proposed a method to remove the texture by applying low pass filter. Authors in their study used deconvolving operation with the same blur kernel to regain edges and region boundaries. Results shows that proposed methodology is capable in removing more texture with higher value of standard deviation (σ) using Gaussian filter. Buades et al. [10] introduced an image decomposition method using a non-linear filter pair (low-pass/high-pass filter pair) by retaining both the essential features of Meyers model [4]. The decomposition of an image into structure part u and texture part v depends on a parameter named as texture-scale which is measured in pixel mesh. After literature review authors of present paper found that though all of the above mentioned methods are able to remove texture, still they have a common drawback that

Fig. 2. Results of proposed method. (a) Original input image, (b) smoothed image after applying Gaussian filter ($\sigma = 5$), (c) resultant structure part by proposed method and (d) texture part removed from the original image using proposed method.

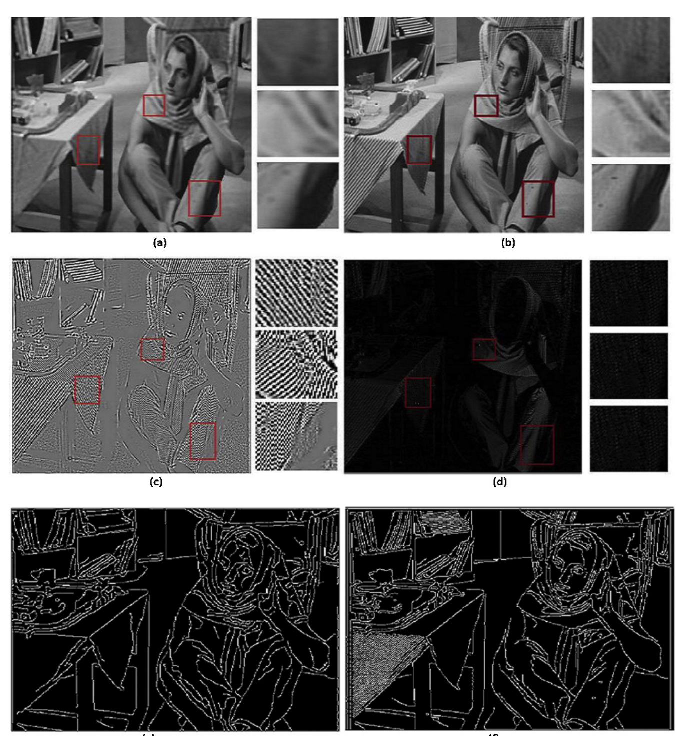

Fig. 3. The first column shows results of proposed method and second column shows results of Buades's method. (a) Structure part by Buades's method. (b) Structure part by proposed method. (c) Texture part by Buades's method. (d) Texture part by proposed method. (e) and (f) Show edges obtained by canny edge detection method performed on structure part obtained in (a) and (b).