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Evaluating the Key Finding of Texture Smoothing & Filtering Techniques

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***Abstract*--**Many natural scenes and human-created art pieces contain texture i.e. some use full information or patterns. The graffiti and drawings can be commonly seen on brick walls, railroad boxcars, and subways; carpets, sweaters, and other fine crafts contain various geometric designs are some example of meaningful textures. It is particularly interesting that human visual system is fully capable to understand these pictures without needing to remove the textures. In psychology, it is also found that "the overall structural features are the primary data of human perception, not the individual details". This work has analysed various techniques for detecting and analyzing the texture in digital images. Extracting the meaningful structure from textures or complex background images is found to be important and critical task in vision processing. It is found that most of the existing researchers have neglecting the issue of haze and noise in images; so most of the existing techniques found to be inaccurate in case of any kind of disturbance in the image.

INDEX TERMS: *Texture Smoothing, Edge Preserving Smoothing, Visual System, Structure Extraction.*

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1. Introduction

Edge preserving smoothing is an image processing technique that smooths away textures while retaining sharp edges. The well known tool which can be used to perform an edge-preserving smoothing filter is known as bilateral filter, on a raster image. Bilateral filtering is a non-linear, edge-preserving and noise-reducing smoothing filter for images and the algorithm operates by convolving a kernel of weights with each grid cell and its neighbours in an image. The bilateral filter is same as Gaussian smoothing, in that the weights of the convolution kernel are partly determined by the 2 - dimensional Gaussian (i.e. normal) curve, which gives stronger weighting to cells nearer the kernel centre. The heavier weighting given to nearer and similar-valued pixels makes the bilateral filter an attractive alternative for image smoothing and noise reduction compared to the mean filter. The size of the filter is determined by setting the standard deviation distance parameter; the larger the standard deviation the larger the resulting filter kernel. The standard deviation can be any number in the range 0.5-20 and is specified in the unit of pixels. The standard deviation intensity parameter, specified in the same units as the z-values, determines the intensity domain contribution to kernel weightings. Bilateral filter like techniques find successful places in many applications, where low contrast details need to be enhanced [2][6] and is widely used for its simplicity and effectiveness in many applications [3]. In order to smooth out high contrast, fine scale oscillations by constructing local extreme envelopes.

2. Structure Extraction Based On Relative Total Variation

Many natural scenes and human-created art pieces contain texture i.e. some use full information or patterns. The graffiti and drawings can be commonly seen on brick walls, railroad boxcars, and subways; carpets, sweaters, and other fine crafts contain various geometric designs are some example of meaningful textures. In human history, mosaic has long been be an art form to represent detailed scenes of people and animals, and imitate paintings using stone, glass, ceramic, and other materials. When searching in Google Images, millions of such pictures and drawings can be searched quickly. They share the similarity that semantically meaningful structures are blended with or formed by texture elements. We call them "structure + texture" images. Meaningful structure extractions from textured surfaces enable many applications[6]. A few examples are shown as:

Fig 1: Texture smoothing

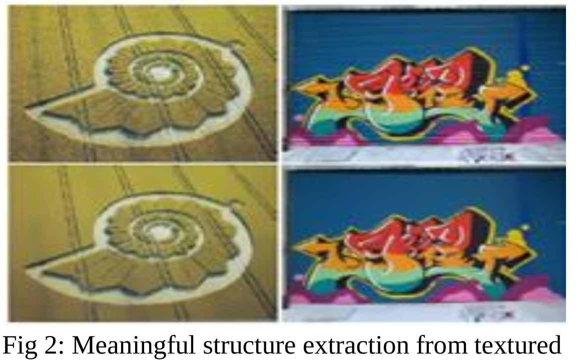

Fig 2: Meaningful structure extraction from textured surfaces.

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Examples from left to right are graffiti on brick, marble mosaic, crop circles, and graffiti on gate[6].

3. **Applications of structure extraction from texture images[6]**

a. Vectorization: Image vectorization is to turn a raster image to a vector graph that is theoretically arbitrarily scalable. It is difficult to deal with the structure and texture images due to complex patterns and common existence of local intensity oscillation so texture and structures are decomposed and a vector graph can be easily formed and can produce visually more pleasing results with sharp boundaries even with a large scaling factor, while not losing or mistaking details.

b. Edge Simplification and Detection: Edge simplification and extraction has its ability to remove many details and find main edges.

c. Enhancement and Composition: Enhancement is done in texture layers to improve contrast and generate different visual impressions. We then enhance the texture contrast and add the respective layers back to create the magnification effect. Graffiti images, paintings, and drawings cannot be directly used in seamless cloning and image composition because the source and target textures are incompatible.

d. Content-aware Image Resizing: Natural scenes generally contain many details, such as waves, grass, sand, mountain, rock, and tree. They are less important than the objects of interest, but would influence image resizing and our extracted structure has much less texture, making the majority of the seamsnot pass through the remaining salient edges and is produced by removing seams from the image. This method produce impressive results for highly textured images, but it may excessively smooth natural images so we construct a guidance image to perform joint bilateral filtering on the input image to achieve strong smoothing.

4. **Tree Filter Using Minimum Spanning Tree**

Tree filter is a weighted average filter that can smooth out high contrast details while preserving major image structures [9]. It utilizes minimum spanning tree extracted from input image to determine the weights of the filter kernel as well as collaborative filtering, to perform weighted average among pixels. Minimum spanning tree makes all image pixels connected through the tree endues the filter with the power to smooth out high-contrast, fine-scale details while preserving major image structures. It proposed an efficient linear time MST extraction algorithm to further improve the whole filtering speed and give a great advantage in low computational complexity (linear to number of image pixels) and fast speed. The tree filter can be used on a variety of applications such as[9]:

1. **Scene simplification:** Tree filtering is a pre- processing tool used to reduce trivial details for example edge detection, image abstraction, shape matching in the scene and produce simplified scene for better edge or boundary detection.

2. **Joint filtering:** Tree filtering can automatically pick up the major structures in guidance image to perform joint filtering and avoiding trivial details of the image and result into the filtered image.

3. **Texture editing:** Iterative tree filtering are able to separate textured image into texture layer and structure layer for better smoothing and edge detection.

Related work

KostadinDabov et al. [2007] [1] in paper “Image denoising by sparse 3-D transform-domain collaborative filtering” has analyzed image denoising strategy based on an enhanced sparse representation in transform domain. The enhancement of the sparsity is achieved by grouping similar 2-D image fragments (e.g., blocks) into 3-D data arrays is called “groups.” Collaborative filtering is a special procedure developed to deal with these 3-D groups. The three successive steps: 3-D transformation of a group, shrinkage of the transform spectrum, and inverse 3-D transformation. The 3-D estimate that consists of the jointly filtered grouped image blocks. By attenuating the noise, the collaborative filtering reveals even the finest details shared by grouped blocks and, at the same time, it preserves the essential unique features of each individual block. The filtered blocks are then returned to their original positions. Because these blocks are overlapping, for each pixel, we obtain many different estimates which need to be combined. ZeevFarbman et al. [2008] [2] in paper “Edge-Preserving Decompositions for Multi-Scale Tone and Detail Manipulation” proposed a new method to construct edge-preserving multi-scale image decompositions. We illustrate that current base detail decomposition techniques, based on the bilateral filter, are limited in their ability to extract detail at arbitrary scales. Instead, to use an alternative edge-preserving smoothing operator, based on the weighted least squares optimization framework, which is mainly well suited for progressive coarsening of images and for multi-scale detail extraction. After describing this operator, we express how to use it to construct edge-preserving multi-scale decompositions, and compare it to the bilateral filter, as well as to other schemes. Finally, we demonstrate the effectiveness of our edge-preserving decompositions on variety of applications including tone mapping, contrast manipulation, and image abstraction etc. Jean Stawiask et al. [2009] [3]in paper “Minimum spanning tree adaptive image filtering” has analyzed anisotropic morphological edge preserving filters for image denoising. The neighbourhood filters define on the minimal spanning tree (MST) of an image (according to a local dissimilarity measure between adjacent pixels). The designed filters take advantage of the property of the minimal spanning tree to detect and follow the local features of an image. This approach leads to neighborhood filters where the structuring elements adapt their shape to the minimal spanning tree structure and therefore to the local image features. The quality of given method is on natural and synthetic images. Takanori Koga et al. [2011] [4] in paper "Structural-context-preserving image abstraction by using space-filling curve based on minimum spanning tree" proposed an image abstraction method which generates a non-photographic painting-like image automatically from a photographic natural image while preserving its structural context, detailed structures. In given method, the space-filling curve based on a minimum spanning tree (SFC-MST) was employ to decide one-dimensional image scanning order. By applying the vector ε-filter along the space-filling curve based on a minimum spanning tree, a detail preserved paint-like image was obtained automatically. The structural-context preserving abstraction capability of the given method is verified by some experimental results and examples. Minjie Chen et al. [2011] [5] in paper" Adaptive Context-Tree-Based Statistical Filtering for Raster Map Image Denoising" proposed a statistical filtering algorithm dealing with map images distorted by impulsive noise, additive Gaussian noise, and mixed Gaussian-impulsive noise. A statistical feature of local context has analyzed to avoid damage to pixel-level patterns, which is frequently caused by conventional filters. This filter incorporate an information fusion process which exploit both the color distribution in red, green and blue(RGB)space and the conditional probabilities of a given pixel in a local context and with no prior knowledge of the properties of the noise and aims at maximal preservation of repetitive structures of the image and it provides robust and reliable filtering performance and good structure preservation ability and also investigate the context contamination problem in conditional probability estimation in statistical filtering and a context-merging strategy proposed to improve the estimation accuracy for those infrequent contexts. The given method can be used for color palette images such as engineering drawings, schemes, comic books, and similar art imagery. Li Xu et al. [2012] [6] in paper "Structure extraction from texture via relative total variation" proposed a new inherent variation and relative total variation measures, which capture the essential difference of these two types of visual forms, and develop an efficient optimization system to extract main structures. The novel variation measures are validated on millions of sample patches. This method finds a number of new applications to manipulate, render, and reuse the immense number of structure with texture images and drawings that were traditionally difficult to be edited properly.

Zhuo Su et al. [2013] [7] in paper "Edge-preserving texture suppression filter based on joint filtering schemes" proposed an edge-preserving texture suppression filter to obtain a satisfactory result which has both properties of texture-smoothing and edge-preserving. It developed the iterative asymmetric sampling and the local linear model to produce the degenerative image to suppress the texture, and apply the edge correction operator to achieve edge-preserving. An efficient accelerating implementation is introduced to improve the performance of filtering response. It demonstrated that our filter produces satisfactory outputs with both properties of texture-smoothing and edge-preserving, while compared with the results of other popular EPS approaches in signal, visual and time analysis. Finally, it extended our filter to a variety of image processing applications. Kaiming He et al. [2013][8] in paper "Guided Image Filtering" proposed a novel filter called guided filter for edge preserving smoothing like bilateral filter, but it has better behaviors near edges. This guided filter is more generic than smoothing and is applicable for structure-transferring, enabling novel applications of filtering-based feathering/matting and dehazing and guided feathering. The guided filter has a fast and non approximate linear time algorithm, regardless of the kernel size and the intensity range and also one of the fastest edge-preserving filters. The guided filter is widely used in great variety of computer vision and computer graphics applications, including edge-aware smoothing, detail enhancement, HDR compression and joint up sampling, etc. LinchaoBao et al. [2014] [9] in paper "Tree filtering: efficient structure-preserving smoothing with a minimum spanning tree" proposed a tree filter for strong edge preserving smoothing of images in presence of high-contrast details. The tree filter utilizes a minimum spanning tree extracted from image, as well as collaborative filtering, to perform weighted average among pixels. Pixel connectedness is acquired by treating pixels as nodes in a minimum spanning tree extracted from the image. Minimum spanning tree makes all image pixels connected through the tree endues the filter with the power to smooth out high-contrast, fine-scale details while preserving major image structures. It proposed an efficient linear time MST extraction algorithm to further improve the whole filtering speed. The algorithms give tree filter a great advantage in low computational complexity (linear to number of image pixels) and fast speed. The tree filter can be used on a variety of applications.

5. Key findings

Many natural scenes and human-created art pieces contain texture i.e. some use full information or patterns. Extracting the texture efficiently become more significant in real time applications. But it has been found that the most of the existing research has neglected the use of efficient filters to extract the texture in noisy and complex background images. Following are the various gaps in existing study:-

1. The use of efficient filters like tree filter has been neglected to improve the texture extraction area.
2. Edge detection of textured image has been neglected in the most of the existing research.
3. The texture extraction of complex background images is also neglected in the most of the existing research.

6. Conclusion and Future directions

The human visual system is fully capable to understand the textured pictures without needing to remove the textures. In psychology, it is also found that "the overall structural features are the primary data of human perception, not the individual details". This paper has reviewed various techniques for detecting, analysing, filtering and extracting the meaningful texture from digital images. Extracting the meaningful structure from textured or complex background images has found to be critical task in digital image processing. It has been shown that the most of the existing researchers have neglecting the issue of haze and noise in images; so most of the existing techniques found to be inaccurate in case of any kind of disturbance in the image.

In near future we will propose a new technique to efficiently detect meaning full structure from complex background images.

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