Image Decomposition and Restoration for Blurred Images Using Filtering Techniques

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***Abstract*-In Image processing, image decomposition and restoration for blurred images are the significant challenges. Using bilateral filter, image is decomposed into two meaningful components. One is the cartoon component which is often called as geometrical part or sketchy approximation. Other is the texture component which is often called as oscillating part or small scale special pattern. Image restoration for blurred images with or without missing pixels can be performed using median filter and conservative filter. Median filter is a non-linear digital filter which is often used to remove noise. It preserves the edges while removing noise. Conservative filter is also a non-linear smoothing filter. It ensures that the value of the output pixel is within the bounds of its neighbours. Using these filters, degraded mages can be restored successfully. Thus, these filters are good in the image decomposition and restoration concepts.**

***Index Terms*- Decomposition, restoration, bilateral filter, median filter, conservative filter**

I. INTRODUCTION

Image decomposition and restoration are the two important problems in image processing. In image decomposition, image is decomposed into two meaningful parts. One is the sketchy approximation or geometrical part of an image which is called cartoon component and the other is the small scale special patterns or oscillating part of an image which is called texture component. The main task is to extract the cartoon and texture parts from the degraded images. These two parts play important role in object recognition, astronomical imaging, biomedical engineering, segmentation and inpainting problems.

Image restoration is the process of improving the quality of the image and eliminating the degradation parts. It is the recovery of an original image x[m,n] from a given degraded image with or without missing pixels y[m,n]. Degraded image is restored to its original quality by inverting the physical degradation parameters such as linear motion, defocus, additive noise and atmospheric degradation.

In [2], Anmin Liu, Weisi Lin, Manoranjan Paul, Chenwei Deng and Fan Zhang proposed total-variation based image decomposition to decompose an image into structural image (i.e., cartoon like, piecewise smooth regions with sharp edges) and textural image for estimation of EM (Edge Masking) and TM (Texture Masking). Daniel Szolgay and Tamas Sziranyi studied the image decomposition concepts [3]. Following a total variation based preprocesssing, they proposed an anisotropic diffusion with an orthogonality-based parameter estimation and stopping condition. Using this preprocessing, decomposition can only be performed. Image restoration can't be performed. Jian Bai and Xiang-Chu Feng presented a new model for image decomposition by nonconvex functional minimization [4]. Generally, Banach norm is used as fidelity term. Instead of using the Banach norm as the fidelity term, they used the integral of the square of residual component divided by its gradient as the fidelity term. This nonconvex fidelity term had very low value for the texture image and high value for the geometric image. So it was appropriate for image decomposition. The gradient descent procedure was used to solve the minimization problem. But this model may not restore the blurred images into better images. This restoration can be done by using illumination components [6]. In this paper, they used various illumination components for image restoration. They may not consider cartoon and texture components which play a vital role in image segmentation and inpainting.

In [7], Teng Li, Shuicheng Yan, Tao Mei, Xian-Sheng Hua, and In-So Kweon (2011) discussed about image decomposition with multilabel contexts. But the decomposition of image into cartoon and texture parts can't be made. Wang Shuwen and Huang [8] Wei proposed an algorithm for image inpainting based on decomposition. The color image was achieved by using color space for access decomposition and by using total variation (TV) noise model for image decomposition. This method reduced the complexity of numerical calculation. It can't restore the noisy image. Yigang Peng, Aravind Ganesh, John Wright, Wenli Xu and Yi Mo [9] proposed a model that searches an optimal set of image domain transformation. Here, the matrix of transformed images can be decomposed as the sum of a sparse matrix of errors and a low-rank matrix of recovered aligned images. Yuichi Tanaka and Keiichiro Shirai performed Directional image decomposition using retargeting pyramid [10].

Yunho Kim, John Garnett and Luminita Vese studied the Sobolev norms [11] and developed a new restoration model using Sobolev spaces for the blurred and noisy images. Using Sobolev spaces, the oscillating part (i.e texture) can be captured easily. They studied the Sobolev norms describing different behaviors of texture and noise. So they could be able to make a distinction between texture and noise. Using these

measurements, they restored a better image. They pointed out that their model was specifically designed to deal with noisy blurred images. Parameter insensitivity was one of the advantages of using a series of Sobolev spaces. Restoration for blurred images only can be performed and it can't perform any decomposition model for the images. Yuquan Xu, Xiyuan Hu, Lu Wang and Silong Pengg [12] found that the small gradients of image are not always helpful but sometimes harmful to alternative iterative algorithm. Using this iterative algorithm, image is decomposed into cartoon and texture parts. Cartoon part was only used for restoration process. Thus the stability and robustness of the algorithm can be improved. But the restoration can't be performed properly. This problem can be overcome by a novel high-quality intrinsic image recovery approach using optimization and user scribbles [5]. In [1], Michael K. Ng, Xiaoming Yuan and Wenxing Zhang used augmented Lagrangian method to regularize cartoon and texture parts. Blurred images can be restored and the clarity of the image is measured using Signal-to-Noise Ratio (SNR). This method can improve the quality upto 35 dB.

II. SYSTEM OVERVIEW

The proposed model comprises the decomposition and restoration for blurred images. Image decomposition for blurred images can be performed using bilateral filer. A bilateral filter is non-linear, edge-preserving and noise-reducing smoothing filter. In this, the intensity value at each pixel in an image is replaced by weighted average of intensity values from nearby pixels.

Blurred images can be restored using median filter and conservative filter. Median filter is a non-linear filter that removes the small to moderate levels of noise such as speckle and salt & pepper noise. Main idea of this filter is to run through the signal entry by entry with the median of neighbouring entries. The pattern of neighbours is called the 'window', which slides entry by entry over the entire image. If the window has an odd number of entries, then the median is just the middle value after all the entries in the window are stored numerically. For an even number of entries, there is more than one possible median. Conservative filter is also a non-linear smoothing filter. It ensures that the value of the output pixel is within the bounds of its neighbours. The maximum and minimum values of the pixels adjacent to the input pixel are calculated. If the input pixel is within this range, it is not changed. If it is greater than its largest neighbour, then the output pixel is set to that maximum value. Similarly, if it is less than its smallest neighbour, then the output is set to that minimum value. It does not involve any averaging so conservative smoothing preserves edges.

2.1 Data Search

Select an input image from data base or folder using matlab. The selected input image may be a colored image or a black and white image. In order to find the noise rate of the input image, the image is converted into double precision. The clarity of the input image can be measured using PSNR (Peak Signal to Noise Ratio).

PSNR is calculated using,

$$\mathbf{PSNR = 20 \log_{10} (MAX_I) - 10 \log_{10} (MSE)}$$

Where,

- MAX_I is the maximum possible pixel value of the image.
- MSE is Mean Squared Error which measures the average of the squares of errors.

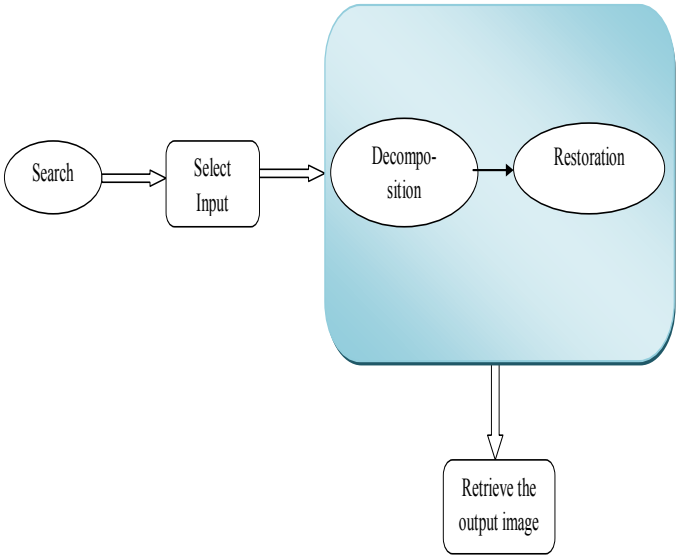

Fig. 1 System Architecture

2.2 Image Decomposition

Given image is decomposed into cartoon and texture parts by using bilateral filter. It is non-linear, edge-preserving and noise-reducing smoothing filter.

The bilateral filter is defined as:

$$\mathbf{I(x_i) - I(x)||)g_s(||x_i - x||)\ I^{filtered}(x) = \sum_{x_{i\epsilon\Omega}} I(x_i) f_r(||x_i - x||)}$$

where:

- $I^{filtered}$ is the filtered image
- I is the original input image to be filtered
- X are the coordinates of the current pixel to be filtered
- Ω is the window centered in x
- f_r is the range kernel for smoothing differences in intensities. This function can be a Gaussian function
- g_s is the spatial kernel for smoothing differences in coordinates. This function can be a Gaussian function

The bilateral filter has several qualities that explain its success:

- Its formulation is simple
- It depends only on two parameters that indicate the size and contrast of the features to preserve
- It can be used in a non-iterative manner. This makes the parameters easy to set since their effect is not cumulative over several iterations
- It can be computed at interactive speed even on large images

For image decomposition, initially bilateral filter parameters such as half-width (w) and standard deviation (sigma) and image abstraction parameters are set. Then grayscale or color bilateral filtering is applied to the black and white and color image respectively.

In the grayscale bilateral filtering, Gaussian distance weight is computed. Local region of the given image is extracted. Gaussian intensity weights and bilateral filter response are calculated.

In the color bilateral filtering, the given color image which is in sRGB color space is converted into the CIELab color space. Then the process which is done in the grayscale filtering is performed. Finally the filtered image is converted back into the sRGB color space.

After performing this grayscale or color bilateral filtering, gradient magnitude of luminance is determined and using this magnitude simple edge map is created. Finally, gradient edges are added to the quantized bilaterally filtered image. Thus cartoon part is extracted from the image. From this component, texture part is retrieved.

2.3 Restoration

Image restoration refers to removal or minimization of degradations in an image. This includes de-blurring of images degraded by the limitations of a sensor or its environment, noise filtering, and correction of geometric distortion or non-linearity due to sensors.

After decomposition, red, green and blue channels are separated. The noise is calculated for individual channel. All the noises in the image are removed by using median and conservative filtering concepts. Median filter is a non-linear filter that removes the small to moderate levels of noise such as speckle and salt & pepper noise. Main idea of this filter is to run through the signal entry by entry with the median of neighbouring entries. The pattern of neighbours is called the 'window', which slides entry by entry over the entire image. If the window has an odd number of entries, then the median is just the middle value after all the entries in the window are stored numerically. For an even number of entries, there is more than one possible median. Conservative filter is also a non-linear smoothing filter. It ensures that the value of the output pixel is within the bounds of its neighbours. The maximum and minimum values of the pixels adjacent to the input pixel are calculated. If the input pixel is within this range, it is not changed. If it is greater than its largest neighbour, then the output pixel is set to that maximum value. Similarly, if it is less than its smallest neighbour, then the output is set to that minimum value. It does not involve any averaging so conservative smoothing preserves edges.

Edge preservation is an important problem in image restoration. Using conservative filter edges are preserved.

2.4 Calculation of image pixel value

The image pixel value is calculated by using image histogram for optimization problem in an image. An image histogram is a type of histogram that acts as a graphical representation of the tonal distribution in a digital image. It plots the number of pixels for each tonal value. By looking at the histogram for a specific image a viewer will be able to judge the entire tonal distribution at a glance.

2.5 Retrieving the output image

For each response of the query we are calculating the Performance. Finally display the restored image without taking too long time.

III. RESULTS

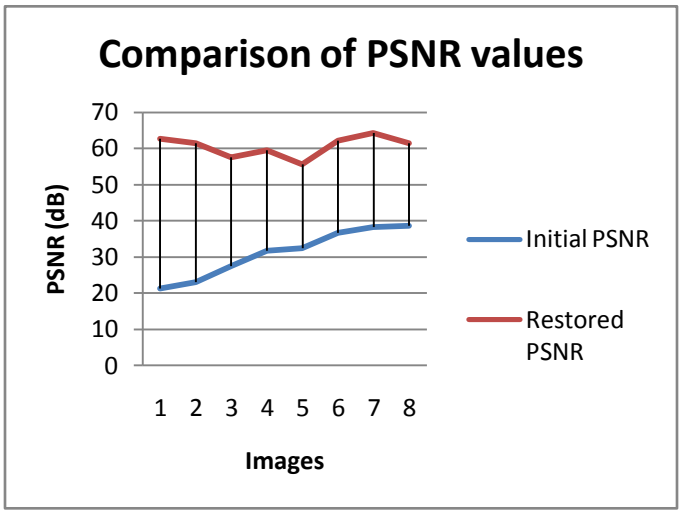

Fig. 2 Changes of the PSNR with respect to filters

In Fig. 2, PSNR values of the original image and restored image which are achieved by filtering mechanism are compared. Using filtering mechanism, clarity of the images can be improved.

The PSNR value of the original image is calculated using the formula. Elapsed time for image decomposition and restoration is based on the PSNR value of the given image. If

the PSNR value is too low, then the image is highly degraded and it consumes more time for decomposition and restoration. If the PSNR of the given image is moderate value, then decomposition and restoration are performed quickly.

TABLE I

IMAGE DECOMPOSITION ON IMAGE WITH BLURRY

Image	$PSNR^0$	Elapsed time	PSNR
Baby	21.3	40.7	62.7
Fruit	23	38.2	61.5
Barbara	27.4	27.2	57.6
Lotus	31.7	25.4	59.5
Strawberry	32.4	22.7	55.6
Rose	36.7	22.9	62.1
Parrot	38.2	21.5	64.3
Building	38.6	21	61.4

In Table I, the numerical performance for images with different blurs is specified. "$PSNR^0$" represents the initial PSNR value of the blurred image. "PSNR" represents the PSNR value of the restored image. Elapsed time is calculated in terms of seconds.

IV. CONCLUSION AND FUTURE WORK

Thus bilateral filter, conservative filter and median filter are effective when the noise rate of image is upto certain limit. Thus decomposition and restoration of images with blurry and/or missing pixels can be performed successfully.

Several future research directions can be investigated. Images with a large region of missing pixels are difficult to restore, it can be considered in the future work. Many other total variation terms can also be considered, providing restoration in a better manner.

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