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Progressive Recovery of Image through Hybrid Graph Laplacian Regularization

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Abstract:
The problem of image restoration has a long and well-travelled history. Image restoration is still a valid challenge. The two main limitations in image accuracy are noise and blur. Image restoration includes removing noise from the image and removing the blur from the image. This paper proposes a unified framework for performing image denoising and deblurring. The restoration task is performed progressively and the task of restoration executed in a repeated manner. The number of repetition is based on the noise or blur level, and then the task of restoration is performed. In this way it recovers more and more image details and edges. We test our algorithm based on psnr value and it shows a higher performance than state-of-the-art algorithms.

Keywords: *Image restoration, denoising , deblurring, psnr.*

1. Introduction

The problem of image restoration from corrupted observations is encouraged in many engineering and science applications, ranging from security, consumer electronics to medical imaging. The two main problems that reduce the accuracy in image processing field is noise and blur. Images can contain various type of noise and the blur can be in varying level. These problems can be happened during image acquisition and transmission.

The noises can be in different types. Among them impulse noise is the most frequently happened noise. The task of impulse noise removal is a challenging image processing problem. The main point to be considered in the image restoration task is that they should preserve all the important image structures, such as edges and major texture features.

There are large numbers of image denoising and deblurring methods are available in the literature, varies from different fields of signal processing, mathematics and statistics. In the task of image restoration, we consider two main properties or assumption about intensity consistency of natural image. The assumptions we use are (1) nearby pixels are likely to have the same or similar intensity values and (2) pixels on the same structure are likely to have the same structure or similar intensity values.

The existing methods of image restoration can be divided into multiple image restoration methods and single image restoration methods. The proposed work deals with multiple image restoration method. There are many applications for this and cryptography is one of the important fields that take advantage over this method. In this restoration technique we have two or more images or multiple images of the same scene. The algorithms in this category can be classified as linear methods and non-linear methods. Low pass filtering is an example of linear method, which is performed by removing the high frequency components of images based on the assumption that the noisy pixels have a high frequency. Smooth regions in the image can be restored effectively using this method, but it does not hold edge preservation property of image processing. Decision based filter is an example of non-linear filtering, which employ an impulse noise detector to determine which pixels should be filtered and the filtered pixel is replaced by median values or its variants and all other pixels became unchanged.

2. Prograssive Image Restoration

In the proposed work the restoration of image is performed progressively. The task of restoration includes denoising and deblurring.

When the noise level is heavy, most of the denoising techniques will fail. In the proposed work an adaptive median filter is used to remove excess of the noise components. Adaptive median filter performs spatial processing for preserving the detail and smooth regions. The main benefit of the adaptive median filtering is that repeated filtering does not erode away edges or other smaller structure in the image. In general, the basic operation of digital image processing is as follows: - for each pixel in the digital image we consider a neighborhood around that point, values of all pixels in the neighborhood region is analyzed according to some algorithm, and then replaces the pixel with another pixel value based on the analysis. For every pixel in the image this process is repeated.

Adaptive median filtering has many advantages because it performs spatial processing to determine the pixels which are affected by the noise. The purpose of using adaptive median filter includes: - it removes the impulse noise, smoothing of other noise, reduce distortion (excessive thinning or thickening of object boundaries).

Consider I as the corrupted image, I_{ij} is the pixel in I with co-ordinate i&j. I_{min}&I_{max} are the minimum and maximum value that a pixel can be taken. I_{med} is the median value of pixel. W is the current window size, W_{max} is the maximum window sizecan be taken. Adaptive median filter will work like follows: -

1. If $I_{min}<I_{med}<I_{max}$, then
   - I_{med} is not a noise. Go to step 2 to test if I_{ij} is noise
   - *else* I_{med} *is impulse*
2. If $I_{min}<I_{ij}<I_{max}$, then
   - I_{ij} is not noise

The above algorithm gives an idea of adaptive median filtering. After performing filtering, we find out the number of times the down sampling to be performed and it is find out as a function of noise. The figure given below is the diagram of proposed method.

Deblurring is performed based on Point Spread Function (PSF) value. Deblurring is also performed progressively. In the first step deblured image is produced based on normal PSF, then deblured image is produced based on under PSF then produced based on lower PSF. After producing these three images combine them to produce more accurate result.

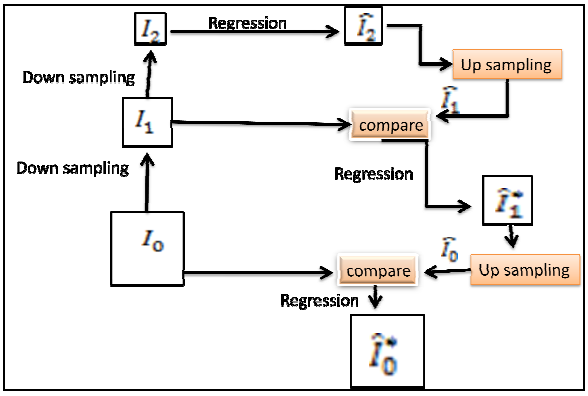

Figure 1

3. Related Works

Here we are discussing some techniques of image restoration.

3.1. Kernal Regression for Image Processing and Reconstruction

Kernal regression model [6] uses and expand ideas about kernal regression for image restoration. Kernal regression methods are used widely with the recent emergence of machine learning methods. It takes the corrupted image, and then measures a function of local gradient. Local gradient is computed based on neighboring values and use this estimate for giving weight to respective measurements. As an example, if we consider a pixel, which is located near an edge, then the pixel on the edge in the same side will poses a much stronger influence in filtering. Based on this intuition, this work proposes a two-step approach. In the first step, initial estimate of image gradient is computed by using any type of gradient estimator. In the second step, the estimate is used for measuring the dominant orientation of local gradient.

3.2. Fast two-phase Image Deblurring under Impulse Noise

As the name indicate this method work in two stages [7]. In the first stage, outlier candidates are identified. An outlier candidate means the pixels that are likely to be corrupted by the impulse noise. Then in the second stage, the image is restored by a method which works by using the essentially outlier free data. Here only the corrupted pixels are restored.

3.3. Bilateral Filter for Gray and Color Images

Bilateral filtering [8] restores the image while preserving edges. It works by a nonlinear combination of nearby image values. It is a simple, non iterative and local method. In bilateral filtering image smoothing is done by creating aproximity function which is capable for capturing the important features or patterns by leaving out the noise. The main advantage of this method is that it preserves edges this method uses the intensity consistency property of images. In earliest filters the filtering method process one band at a time.

Different bands are in different contrast. So when we apply filtering the smoothening is done in every band differently. It will produce an unexpected color combination. But in bilateral filtering three bands are treated at the same time. It is a range filtering.

3.4. Gaussian Smoothing

It is based on Riesz's theorem. Positivity of kernal is used to express the smoothing requirements. This Gaussian smoothing is work by without losing of generality. In this method the noise reduction property depends on the fact that, if we consider a large neighborhood for smoothing then the noise gets reduced by averaging.

Gaussian smoothing [5]does not alter the points in the image, but it smoothens the points at a Gaussian constant scale which is much larger than sampling scale. Gaussian method works optimally in harmonic function.

3.5. Total Variation

Radin and Oscher introduce the total variation minimization method [5] for image restoration. Let the original image proposes a simple geometric description, can be viewed as a group of connected sets, objects and the edges or contours which is used represent the relationship between the objects. Total variation is a function of random measure. Total variation is proposed as the solution of constrained minimization problem of recovering the original image u(x). From the view of this method the solution should be regular as possible. The difference between noisy and original image is consider as noise. That is if v(x) is the original image then v(x)-u(x) is located as error.

4. Discussion

Several experiments are conducted to test the power of proposed method. Images are tested under two types of impulse noise: salt & pepper noise and random valued noise. Different methods of image restoration are applied to number of images. From experimental study it can be seen that kernal regression, two phase method by Cai will work similar if noise level is 80%. The comparisons are made based on visual appreciation and further quantitatively by Peak Signal to Noise Ratio (PSNR). If noise level exceeds 90% then all the method will fail. But the proposed method will work very well even if the noise level is greater than 90%.

5. Conclusion

The proposed method is an efficient and effective method for image restoration. The restoration is performed progressively. For denoising the image is down sampling, regression, up sampling is done in the image continuously. For deblurring first, the task is performed based on under psf, over psf, normal psf. Then these three images are combined to produce the actual output. Experimental result shows that the proposed method work efficiently even the blur or noise level is higher than 90%.

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