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A Review of Image Denoisng Techniques

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Abstract

One of the most fundamental challenges in the field of image processing is image denoising, where the primary objective is to estimate the original image by removing noise from a noisy version of the image. Many algorithms have been proposed so far for removal of noise from the digital images. This paper review different image denoising techniques. It has been found that the most of the previous denoising techniques like gaussian filtering; bilateral filtering may remove fine details from the image. So a non local method known as non-local means solve this problem. This technique estimates a noise-free pixel as a weighted average of all similar pixels in the image. Non local euclidean median is a image denoising technique. Denoising performance of a noisy image improved by replacing the mean by the euclidean median and this new denoising algorithm the non-local euclidean medians (NLEM). This technique proves that the median is more vigorous to outliers than the mean

Keywords: Denoising, Gaussian Filtering, Median Filtering, NLM, NLEM

Introduction

Image denoising plays a vital role in a wide range of applications such as image restoration , image segmentation, and image classification, where obtaining the original image is important for better performance .Whereas many algorithms have been proposed for the purpose of image denoising. Image denoising is still an effervescent research topic. Its goal is to recover the original image from the noisy image. Typically a noisy image is modelled as z= *u + v, where z* is the observed noisy image, *u* is the original clean image and *v* is noise. The methods used for removing noise from the image and improving the quality of digital images are known as image denoising techniques. .a good image denoising techniques will remove noise while preserving edges. One general approach is to use a gaussian filter..for some purposes this kind of denoising is satisfactory. One big advantage of linear noise removal technique is its speed. But a drawback of this technique is that they are not able to preserve edges in a superior manner. Other approach is bilateral filtering, which is a non-linear.This technique work as edge-preserving and noise-reducing smoothing filter for images. Median filtering is also a denoising technique but it is less efficient in removing gaussian noise. Many of these algorithms remove the fine details and structure

of the image in addition to the noise .the non-local means algorithm is also a denoising technique based on the fact that image contains an wide amount of redundancy. These redundancies can then be exploited to remove the noise in the image. Non local median is also a denoising technique that is proven to be better than previous techniques. Now we discuss each technique one by one.

A. Gaussian Filtering

Gaussian filter [1][5] change the input signal by complication with a gaussian function. This type of filtering is used to remove noise from the image.
The gaussian function is used in several examine areas:
− It explains a probability distribution for noise or data.
− It is a smoothing worker.
− It is also used in mathematics.
Gaussian function is represented by this equation :

$$Gx) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-x^2}{2\sigma^2}}$$

When functioning with images we require to apply the two dimensional gaussian function and is given by this formula:

$$G(x, y) = \frac{1}{2\pi\sigma^2} e^{\frac{-x^2+y^2}{2\sigma^2}}$$

This is simply the product of two 1d gaussian functions (one for each direction). In this formula x represent the distance from the origin in the horizontal axis, y represent the distance from the origin in the vertical axis, and σ is the standard deviation of the Gaussian distribution. Values obtained from this distribution are used to construct a convolution matrix which is applied to the original image. Each pixel's new value is set to a weighted average of that pixel's neighborhood. The gaussian filter is a non-uniform low pass filter. When this formula is applied in two dimensions, it produces a plane whose contours are concentric circles with a gaussian distribution from the center point. The kernel coefficients weaken with growing distance from the kernel's centre. Central pixels have a higher weighting than those on the margin. Larger values of σ create a wider peak (greater blurring). Kernel size must enlarge with increasing σ to preserve the gaussian nature of the filter. The kernel is rotationally symmetric with no directional favoritism. Gaussian kernel is distinguishable which allows fast computation. Gaussian filters may not preserve image luster.

Advantages
 a) Gaussian smoothing is very effective for removing gaussian noise
 b) The weights give higher implication to pixels near the edge (reduces edge blurring
 c) Computationally efficient (large filters are implemented using small 1d filters)

Disadvantage
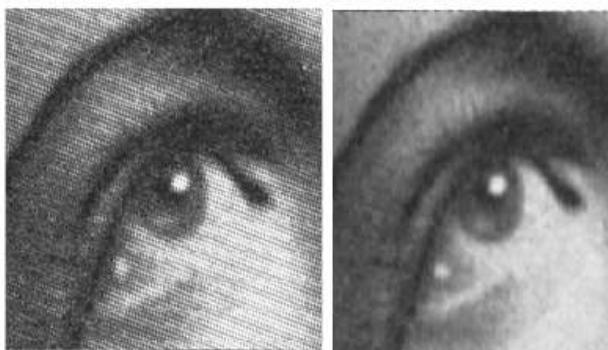 a) Takes time, reduces details

Fig 1 (a) Noisy Image   (b) result of gaussian filtering.[12]

Fig 1(a) shows a noisy image which is to be denoised in order to get a noise free image. Fig 1(b) shows the denoised version of previous noisy image. Image is denoised by using the concept of gaussian filtering.

B. Bilateral filtering
    A bilateral filter is an image denoising technique to remove the noise from the image .it comes under the category of non-linear filter. Here, value at each pixel in an image is replaced by a weighted average of values from close by pixels. This weight can be based on a gaussian distribution. significantly, the weights depend not only on euclidean distance of pixels, but also on the radiometric difference This is also known as edge-preserving and noise-reducing smoothing filter for images This conserve pointed edges by thoroughly looping through each pixel and adjusting weights to the neighboring pixels accordingly. The bilateral filter is defined as

$$I^{\text{Filtered}} = \frac{1}{W_P} \sum_{x_i \in \Omega}^{n} I\,(X_I)\,F_R\big(\big|\big|I(x_i) - I(x)\big|\big|\big)\,g_s\big(\big|\big|x_i - x\big|\big|\big)$$

Where the normalization term ensures that the filter preserves image energy

$$W_P = \sum_{x_i \in \Omega}^{n} F_R\big(\big|\big|I(x_i) - I(x)\big|\big|\big)\,g_s\big(\big|\big|x_i - x\big|\big|\big)$$

 • I^{Filtered} Is the filtered image and i is the original input image to be filtered;
 • x are the coordinates of the current pixel to be filtered;
 • f_r Is the range kernel for smoothing differences in intensities.This function can be a gaussian function

Advantages
 a) Averaging is good to remove random noise
 b) To improve the denoising efficiency.

Disadvantage
 a) Bilateral filtering is slow.

Fig2(a) original image (b) result of bilateral filtering [13]

Fig 2(a) shows the original image fig 2(b) shows the denoised version of noisy image by using the concept of bilateral filtering

C. Median filtering

The median filter is a non linear filtering technique, repeatedly used to remove noise. This noise reduction is a classic pre-processing step to improve the outcome of later on processing (for example, edge detection on an image). Median filtering is widely used in digital image processing because, under some conditions, it preserves edges while removing noise

The major suggestion behind the median filter is that it run through the signal pixel by pixel and replace each pixel with the median of neighboring pixel . The outline of neighbors is called the "window". For one dimensional signal, the most obvious window is the first few pixels, and for 2d (or higher-dimensional) signals such as images, more difficult window patterns are feasible. if the window has an odd number of pixels, then the median is easily calculated and it is just the middle value after all the pixels in the window are sorted numerically. For an even number of entries, there is more than one probable median.

All smoothing techniques are efficient at removing noise in flat patches or flat regions of a signal, but unfavorably affect edges, while removing noise from the signal, it is important to preserve the edges. Median filtering is one kind of smoothing method; it is a <u>linear gaussian filtering</u>. Edges are of significant importance to the visual appearance of images. for example For little to temperate levels of (gaussian) noise, the median filter is apparently better than gaussian blur at removing noise while preserving edges for a given, fixed window size. But, its performance is not that much better than gaussian blur for high levels of noise

Advantages

a)   Preserving sharp edges
b)   The median value is much like neighborhood pixels and will not affect the other Pixels significantly.
c)   Median filter preserves brightness differences resulting in minimal blurring of regional boundaries.
d)   Preserves the positions of boundaries in an image, making this method useful for visual examination and measurement.

Disadvantages

a)   Less effective in removing gaussian or random-intensity noise. The median filter can remove noise only if the noisy pixels occupy less than one half of the neighborhood area.

Fig 3(a) noisy image (b) result of median filtering [14]
Fig 3(a) shows the noisy image that is affected by the gaussian noise.fig 3(b) shows the denoised version of previous noisy image. Image is denoised by using the concept of median filtering.

D Non Local Means

Non-local means [9] is an algorithm that is used in image processing for image denoising. Other filters such as local filters that update a pixel's value with an average of the pixels around it. But non local filters [2] update the pixel value by using a weighted average of the pixels that are judged to be most similar to it. The local smoothing method was not capable for preservation of the fne structure, details and texture. So the details and fine structures are smoothed out because they behave in all well-designed aspects as noise. The nl-means algorithm tries to take advantage of the high extent of redundancy of any normal image. A non local method called as non-local means estimates noise-free pixel intensity as a weighted average of all pixel intensities in the image, and the weights are relative to the resemblance between the local neighbourhood of the pixel being processed and local neighbourhoods of neighbouring pixels. Given a noisy image, the denoised image at pixel is computed using the given formula. This sum is ideally performed over the whole image.

$$NL[U](i) = \sum_{j \epsilon I} w(i,j) v(j)$$

Where the weight w(i,j) [6] depends on the distance between   observed gray level vectors at points i and j. such distance can be represented as

$$d = ||v(N_i) - v(N_j)||^2_{2,a}$$

So the weight [4][8]can be defined as

$$w(i,j) = \frac{1}{Z(i)} e^{\frac{-\left\|v(N_i)-v(N_j)\right\|^2_{2,a}}{h^2}}$$

Fig 4(a) noisy image (b) result of non local means [15]

Fig 4(a) shows the noisy image that is affected by the gaussian noise.fig 4(b) shows the denoised version of previous noisy image. Image is denoised by using the concept of non local means.

Advantage
   a) This technique work for the removal of noise and it give better result as compare to the previous denoising techniques that leads to the smoothning of image.

Disadvantage
   a) This denoising method work only for low noise level.

E. Non Local Medians

Non local Euclidean [7] is a image denoising technique. Denoising performance of a noisy image improved by replacing the mean by the euclidean median and this new denoising algorithm the non-local euclidean medians (NLEM). This technique proves that the median is more vigorous to outliers than the mean [9][10]. Nlem performs superior than nlm in the nearby area of edges, mainly at large noise levels. Nlem can be efficiently implemented using iteratively reweighted least[3] squares.the euclidean mean is the minimizer of $||v(N_i) - v(N_j)||^2$ Over all patches and euclidean median is the minimizer of $||v(N_i) - v(N_j)||$ Over all patches .by using the concept of euclidean median must better result is obtained as compare to non local means but at high noise level.
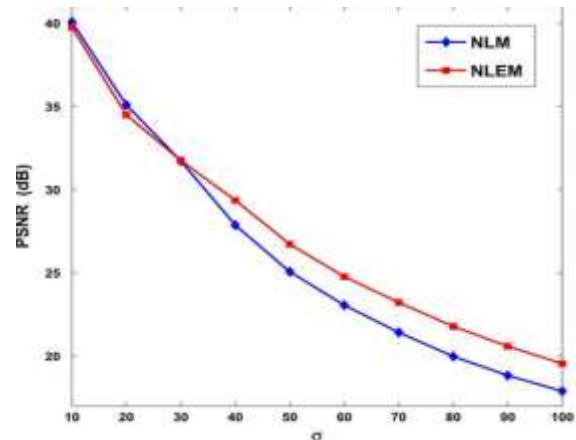

Fig 5 NLM AND NLEM [7]

This figure shows the graphical result of non local means and non local median. Median show better result than mean.

Advantage
   a) This technique is used to improve the denoising performance of nlm in the vicinity of edges using the euclidean median.

Disadvantage
   a) This technique work only for high density noise.

Related work

A.Buades [1] show a common mathematical and experimental tactic to evaluate and categorize standard image denoising algorithms and to propose an algorithm (non local means) addressing the maintenance of structure in a digital image.

A. Dauwe [2], shows numerous improvements to the original non-local means algorithm introduced by buadeset all. The power of this algorithm is to develop the monotonous nature of the image in order to denoise the image. Due to the huge amount of weight computations, the original algorithm has a high computational cost.

Rick chartrand [3] make use of use of iteratively reweighted algorithms for computing local minima of the non convex problem and improvements are also observed for the reweighted approach.

Tolga tasdizen [4] proposed a new algorithm referred to as principal neighborhood dictionary nonlocal means represent full study of a deviation of the non-local means (NLM) image denoising algorithm that uses principal component analysis to accomplish a advanced precision whereas sinking computational weight.

A buades [5] propose a new denoising technique known as nlm algorithm. It classifies a

mathematical and experimental method to evaluate and grade common image denoising algorithms and to recommend a nonlocal means algorithm addressing the maintenance of configuration in a digital image.

Dimitri van de ville [6] use a technique to enhance non local means that is used for image denoising. It is an useful denoising means that applies adaptive averaging based on similarity between neighborhoods in the image. A pretty manner to both advance and speed-up nlm is by first performing a linear protrusion of the neighborhood.

Kunal Chaudhury [7] shows that the denoising performance of non-local means at huge noise levels. This performance can be enhanced by using euclidean median instead of mean.this new denoising algorithms is known as the non-local euclidean medians.

Enmingluo [8] derive a generalized nl-means (gnl-means), which is specifically used to deal with non-i.i.d. Noises in the nl-means filtered images. In this paper author perform denoising iteratively, the idea is also to iteratively apply nl-means. However, nlmeans can't be applied directly due to the correlated noises in the image filtered by nl-means.

Dixita. A.[9] noise removal and image enhancement are the important tasks addressed by many image processing algorithms, especially, when the images are corrupted by high noise level

Dixit a. A [10] defines a new technique called non local means for denoising of images. Images are mostly contaminated with noise during acquisition, retrieval from storage media and during transmission.

Gaps in earlier work

The survey has shown that the most of image denoising techniques have certain limitations. Following are the main limitations in earlier work.

a. Gaussian filtering, bilateral filtering and median filtering are filtering techniques that remove noise from the image but these techniques also remove some fine details from the image.

b. .NLM (non-local means) is a denoising technique that is used for the preservation of structure in digital image and it perform well only at low noise level and it does not work for vicinity of edges or preservation of edges.

c. NLEM (non-local euclidean means) is also a denoising technique that is used for the removal of noise from a noisy image and it improves the performance of NLEM in the vicinity of edges by using the concept of euclidean median.

d. Main limitation of NLM and NLEM is that NLM work only for low noise level and NLEM works only for large noise level so we conclude that both of these techniques are not suitable for every kind of noise level i.e one can work for low density noise an[[d other work for high density noise.

e. Both of these techniques not work for the preservation of edges.

Conclusion and future directions

One of the primary challenges in the field of image processing is image denoising, where the basic goal is to approximate the original image from a noisy version of the image. Various denoising techniques are discussed in this paper. From this we conclude that out of all denoising NLM and NLEM gives better results. NLEM (non-local Euclidean means) is a denoising technique that is used for the removal of noise from a noisy image and it improves the performance of NLM in the vicinity of edges by using the concept of Euclidean median. main limitation of NLM and NLEM is that NLM work only for low noise level and NLEM works only for large noise level therefore both are not suitable for every kind of noise level i.e. One may work efficiently for low density noise and other work for high density noise. Also both techniques does not focus on preserving the edges.

To overcome the shortcomings of the available techniques in near future we will modify the existing method with a new one that work for every level of noise. we can alsol use the concept of image gradients as a post processing operation to preserve the edges in an efficient manner. However no implementation is considered in this work so in near future suitable simulation tool will be used.

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