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Image De-Noising using Wavelets-A Clustering Based Method

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Abstract- In the process of image acquisition and transmission, noise is always contained inevitably. So it is necessary to image de-noising processing to improve the quality of image. Generally speaking, each algorithm has some filtering and threshold parameters. Taking variety kinds of images into account, it is a key problem of how to set these parameters in de-noising algorithms under different conditions to achieve better performance. There are many algorithms for the determination of the parameters, and each of them has its application field. Because the wavelet transform has good performance, therefore, it has been widely applied as a kind of signal and image processing tools. In this paper, wavelet transform is used in the image de-noising and we propose a new algorithm similar to k-means clustering in machine learning which gives better performance and Experimental results show the validity of the new algorithm.

Keywords- image de-noising, wavelet transform, k-means clustering, mean filter, median filter

1. Introduction-

In the process of image acquisition and transmission, noise is always contained inevitably. So it is necessary to image de-noising processing to improve the quality of image. Much practical noise can be approximated as white noise with Gauss distribution, and removal of superposition of Gauss white noise has become an important direction in image de-noising research. Generally speaking, each algorithm has some filtering and threshold parameters. Taking variety kinds of images into account, it is a key problem of how to set these parameters in de-noising algorithms under different conditions to achieve better performance. Simple linear smoothing filter, such as Gauss filter], will cause the detail information loss of image. In recent years, a large number of complex de-noising algorithms mean of nonlinear filter has appeared. Common algorithms include a variety of adaptive median filter algorithms: the wavelet threshold (also called wavelet shrinkage) algorithm, the anisotropic diffusion equation algorithm , the total variation minimization algorithm , non-local mean filter algorithm , etc.

At present, the noisy image restoration methods are mainly as the following three:

a.) Mean Filter Principle

Mean filter is also known as the linear filter, and the main methods are the neighborhood average method. The basic principle of linear filtering is to replace the original image pixel values with mean values. That is to say, for the current pixel (x, y) , we should select a template, which is composed of a plurality of pixels in its neighbor. Mean values for all pixels would be calculated and the give the mean values to the current pixel (x,y) as the gray(x,y)g in the points on the process image. This means:

$$g(x, y) = \frac{1}{M} \sum_{f \in s} f(x, y)$$

Where, s means template, and M is the total number of pixels including current pixel the template. Mean filter using neighborhood average method is applicable to remove granular noise in the scanning image. Neighborhood average method effectively suppresses the noise. But during the process of calculating the average value, scenery edge points would be processed too. Then, the image would be in the state of low resolution. Based on this situation, the improved algorithm is proposed to realize various mean filters, and new mean filter is developed, such as weighted mean filter, gray minimum variance mean filter, K nearest neighbor mean filter, symmetric neighbor mean filter and so on. When these filters are working, scene boundary smoothing is avoided, and it can greatly reduce the fuzzy image.

b.) The Median Filter

The median filter is a kind of effective noise suppression of nonlinear signal processing technology based on the order statistical theory. The basic principle of the median filter is a sample value replaced with the median value of points in neighborhood point set. Pixel gray value, which is different with surrounding pixel gray values, would be replaced by the close value with the neighborhood points. Then, isolated noise points would be removed. The main idea of the method is establishing a two-dimensional sliding template, in which the pixel values would be ordered by size. Two-dimensional data sequence would be generated monotonically increasing (or down). Two dimensional median filter output is

$$\bar{g}(x, y) = Med\{f(x-\bar{k}, y-l), (k, \bar{l}) \in W\}$$

Where f(x, y) and g(x ,y) are the original images and the processed images. W is a two-dimension template with usually 33 X or 55 X area, and it can be in different shapes, such as linear, circular, figure ten, ring, etc.

Median filtering is a nonlinear filtering technique. The advantage of the median filter is simple operation and faster speed, and it has excellent performance in filtering adding white noise and long tail noise. But for some more details, especially for a point, line and multi spire image should not use median filtering. In order to expand the scope of its application, the median filter has many improved algorithms, such as weighted median filter, switching median filter algorithm based on threshold, and adaptive median filter. In the weighted median filter, pixels within the window are to assign different weights to adjust the contradiction between noise suppression and detail preservation. However, the method obtains more effective detail preserving ability at an expense of noise suppression compared with a traditional filter. In switching median filter algorithm, it is based on threshold and gets the better effect by median filter for noise point and the flat region. This algorithm does not deal with the details in order to obtain good protection effect. For adaptive median filter, it can be used to deal with a high probability impulse noise. When it is processing, its neighborhood region can be changed rely on a certain condition. Its advantage is saving details in processing the smooth non impulse noise.

C.)Wavelet Transform

Wavelet transform is a time-frequency analysis method with fixed window size and varied shape with time. Principle of removing noise by wavelet transform is that the noise mostly belongs to the high frequency information. Therefore, noise information is mostly concentrated in sub blocks with infra-low frequency, infra-high frequency, and high frequency. Sub blocks with high frequency are almost composed of noise information. Therefore, if we set high frequency sub block to zero and suppress low frequency and high frequency sub blocks on certain inhibition, it can achieve a certain effect of the noise removal. Usually the image denoising processing based on wavelet method is as the following: wavelet transform; threshold of wavelet detail coefficients; reconstruction. The principle of the wavelet denoising shows that wavelet transform is fit for removing the image with a high frequency signal. Now, the wavelet transform is often used to remove the white Gauss noise. Due to the characteristic of multi-resolution analysis of wavelet transform, it can be put in the signal and noise in different frequency domain to recognize them. For the signal, wavelet denoising is a signal filtering problems. Although largely wavelet denoising can be seen as a low pass filter, it is still better than the traditional low pass filter due to the retaining of the image feature after denoising. Thus, wavelet denoising is actually a comprehensive feature extraction and low passes filter function. Generally speaking, each algorithm has some filtering and threshold parameters. Due to the variety of the image content, how to set these parameters for denoising algorithms to achieve a better performance under different conditions is a key problem. In research image denoising method, many algorithms have been developed, such as adaptive wavelet transform with soft threshold denoising algorithm , algorithm of systolic function considering the gradient, scale and spatial geometric consistency information into consideration in in adaptive process , adaptive wavelet transform with two step variance adaptive algorithm and local variance and balanced multi wavelet coefficient model, multivariate generalized Gauss model, estimation of threshold parameter with correlated noise and the edges of the image , steerable wavelet reconstruction algorithm , and so on. Because the wavelet transform has good local character, therefore, it has been widely applied as a kind of signal and image processing tools. Since the concept of wavelet threshold has been proposed, because it can obtain the optimal estimate in the

Besov space and other linear estimators cannot get the same result, much attention has been paid on it. Wavelet thresholding is a nonlinear method, and denoising purpose can be achieved according to the process of wavelet coefficients in the wavelet domain. Its theoretical premise is coefficients of the image followed Gauss distribution, and wavelet coefficient with absolute larger magnitude is mainly obtained from the transformed signal and wavelet coefficient with absolute smaller magnitude is mainly obtained from the noise signal transformed. Then we can clear the noise by setting a threshold.

In this paper, wavelet transform is used in the image denoising, and a new type of algorithm is used to de-noise image. The main contribution of the paper is to the proposal of a new algorithm for image denoising using wavelet transform.

D.) K-means clustering algorithm

K-means is one of the simplest unsupervised learning algorithms that solve the well-known clustering problem. The procedure follows a simple and easy way to classify a given data set through a certain number of clusters (assume k clusters) fixed apriority. The main idea is to define k centers, one for each cluster. These centers should be placed in a cunning way because of different location causes different result. So, the better choice is to place them as much as possible far away from each other. The next step is to take each point belonging to a given data set and associate it to the nearest center. When no point is pending, the first step is completed and an early group age is done. At this point we need to re-calculate k new centroids as barycenter of the clusters resulting from the previous step. After we have these k new centroids, a new binding has to be done between the same data set points and the nearest new center. A loop has been generated. As a result of this loop we may notice that the k centers change their location step by step until no more changes are done or in other words centers do not move any more

Finally, this algorithm aims at minimizing an objective function knows as squared error function given by:

$$J(V) = \sum_{i=1}^{c} \sum_{j=1}^{c_i} (\|x_i - v_j\|)^2$$

where,

'$||x_i - v_j||$' is the Euclidean distance between x_i and

'c_i' is the number of data points in i^{th} cluster.

'c' is the number of cluster centers.

2. Proposed Algorithm: -

This algorithm tries to combine the features of both the spatial filters and wavelets based filters using procedure similar to k-means clustering in order to obtain better results

Algorithm step wise-

Step1- apply wavelet transform on the given image so that we can have its detailed and approximate coefficients

Step2-then we have to determine the value of thresholding using the spatial filter technique- here we took the mean of the pixel as the threshold for the same after that we applied soft/hard threshold to reduce the noise level

Step3- now we know that the detailed coefficient has be penalized and the points left in the detailed coefficient are the noisy points. now similar to k-means clustering algorithm we consider these noisy points as cluster center , number of clusters is equal to the number of noisy points In the detailed coefficients but here instead of determining the position of cluster we fix the cluster at the position of the noisy point then we travers the image pixel by pixel to assign them to given any one of the given clusters after this traversal every pixel in the image has been assigned to a cluster based on the distance it has from the cluster .the pixel has been assigned to the cluster which has minimum Euclidian distance from the pixel

Now we for every cluster we have we calculate the mean of pixels that has been assigned to it and store it.

Now let threshold that was the mean of pixels of image bet, let the number of noisy points left in the detailed coefficient be clust ,that is clust is the number of cluster points now we define an array cl[] of size clust*2 to store the position of each cluster point .then we define an array im[] of size I*J*K to store the assigned cluster of each pixel where [I J K]=size(noisy _image) we also define an array mean[ ] of size k to store the mean value of each cluster.

a-)

```
clust=0;      //number of clusters

for i from 1 to I{

 for  j in 1 to J{

for k in 1:K{

if (pixel_value>0)

clust++

} } }
```

Now after this applying this algo on all 3 detailed coeffiecnts we will have number of clusters

b-)

```
cl[clust][2];   //for storing cluster position

r=0;

for i from 1 to I{

 for  j in 1 to J{

for k in 1:K{

if (pixel_value>0)

      cl[r][1]=I;

      cl[r][2]=j;

      r++; }  } }
```

now we have stored all the cluster position in array cl[][]

c-) cluster assignment

```
im[I][J][K]

for i from 1 to I{

 for  j in 1 to J{

for k in 1:K{

min=dis(cl[1][1],cl[1][2],I,j)       //calculates distance between points (x1,y1)and (x2,y2) by dis
                                              (x1,y1,x2,y2)

for 1 to clust{

m=dis(cl[l][1],cl[l][2],I,j)

if(min>m)

min=m

im[i][j][k]=l //assigning cluster

}}}}
```

Now we have assigned cluster to every pixel

d-)

mean[clust]   //to store the mean value of each cluster array

```
 for l=1:clust
sum=0;
n=0;
    for i=1:I
for j=1:J
for k=1:K

    if(im(i,j,k)==l)
       sum=sum+x(i,j,k);
       n=n+1;
    end

end
end
    end
    meanl)=(sum/n);
    if(sum==0)
    mean(l)=0;
    end
end
```

Step4-

Now we apply inverse wavelet transform to get the denoised image back but noisy points that were left in detailed coefficients were still there so to remove those points we have calculated the cluster position and mean value for each cluster so that we can now replace the noisy point with the optimized value we obtained in step3

Now we set a window size of 2 & 1 so that we can replace the noisy point with the our optimized value and the space around it that is pixel's around it can also be replaced by the same value based on the window size.

Hence reducing the noise level in our image

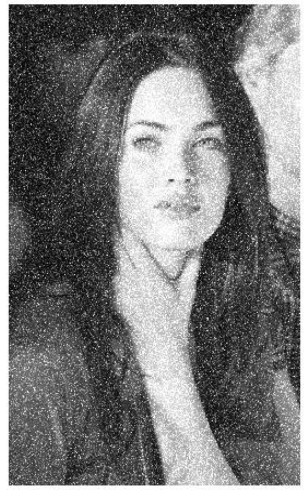
now we have calculated mean value for each cluster

```
w=2//window size

for l in 1 to clust {    k=1;

    u=cl(i,2)-k;
    d=cl(i,2)+k;
    l=cl(i,1)-k;
    r=cl(i,1)+k;

    if(me(i)>sum)
    y(cl(i,1),cl(i,2),1)=me(i);
```

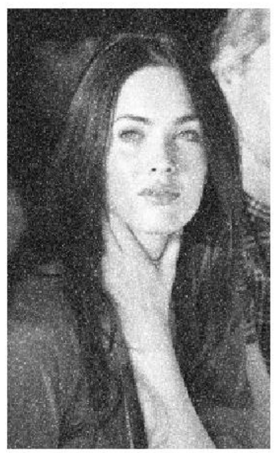
```
if(l>=2 && r<J && u>=2 && d<I )
    y(l,u,1)=me(i);
    y(cl(i,2),u,1)=me(i);
    y(r,u,1)=me(i);

  y(l,cl(l,2),1)=me(i);
  y(cl(l,1),cl(l,2),1)=me(i);
  y(r,cl(l,1),1)=me(i);

  y(l,d,1)=me(i);
  y(cl(l,1),d,1)=me(i);
  y(r,d,1)=me(i);

  y(l-1,u-1,1)=me(i);
  y(l,u-1,1)=me(i);
  y(l-1,u,1)=me(i);
    y(cl(i,2),u-1,1)=me(i);
    y(r,u-1,1)=me(i);
    y(r+1,u-1,1)=me(i);
    y(r+1,u,1)=me(i);


  y(l-1,cl(l,2),1)=me(i);
  y(r+1,cl(l,1),1)=me(i);


  y(l-1,d+1,1)=me(i);
  y(l,d+1,1)=me(i);
  y(l-1,d,1)=me(i);

  y(cl(l,1),d+1,1)=me(i);
  y(r,d+1,1)=me(i);
  y(r+1,d+1,1)=me(i);y(r+1,d,1)=me(i);}
```

3. Result:-

We applied our algorithm on 4 images that had salt and pepper noise, gamma noise, gaussian noise and poisson noise and calculated the PSNR value by both traditional wavelet transform method using thresholding and our new proposed algorithm it was found that our algorithm was able to give better results. Show below is one of the four images we have shown original image, noisy image with gamma noise and denoised image with both traditional and proposed method.

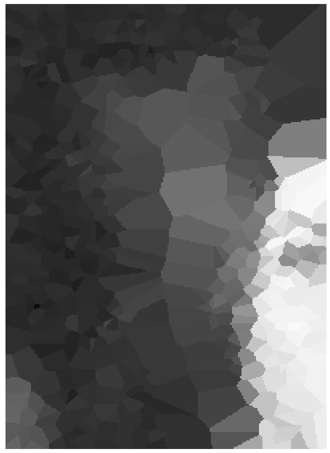


Original image noisy image

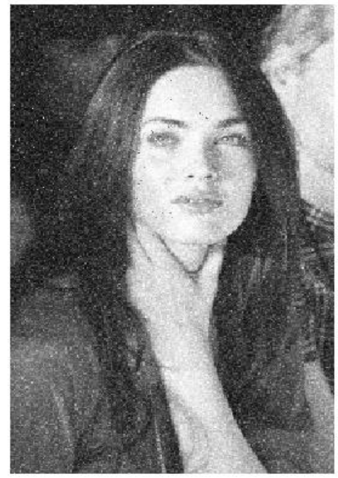


Denoised Image using traditional method

Intermediate cluster- assignments step



de-noised image using improved algorithm



It is an image of Megan fox a famous movie star.

Table comparing the PSNR values for the different type of noisy images using traditional method and new proposed method

Noise type	PSNR using traditional technique	PSNR using proposed method
Gamma noise image	15.8	15.9
Gaussian noise image	21.7	21.7
Salt and pepper image	21.2	21.7
Poisson image	32.3	32.3

4. Conclusion

It is necessary to image de-noising processing to improve the quality of image. Much practical noise can be approximated as white noise with Gauss distribution, and removal of superposition of Gauss white noise has become an important direction in image de-noising research. Since the concept of wavelet threshold has been proposed, for its optimal estimate in the Besov space, much attention has been paid on it and various algorithms based on it have been developed. Wavelet thresholding used for de-noising is according to the adjustment of wavelet coefficients in the wavelet domain. In this paper, wavelet transform is used in the image de-noising, is used to estimate the de-noising results. Four typical images are used to verify the validity of the new algorithm, and the results show that the new algorithm can improve the signal to noise ratio compared with the traditional algorithm. This algorithm provides low improvement in psnr values but visually image quality improves tremendously

Future Work:-

In this proposed method we have used mean to decide thresholding value methods like vishu shrink , bayes shrink and other complicated methods can be used instead.

Then after assigning clusters to the pixels we have taken mean of the pixels in the given cluster we could have taken median or any other complicated statistical function like used in lee filter etc.

So in future we could work on these proposed fields to further improve the image quality and we can have combinations of these technique's to get a better result

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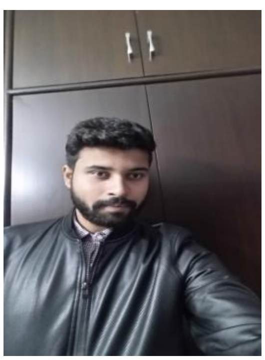

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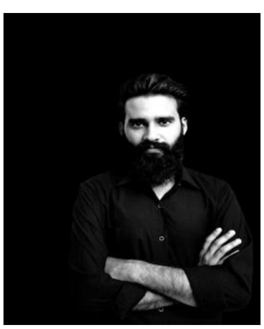

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