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Removal of PCA Based Estimated Noise in Processed Images

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Abstract: ***Noise is an important problem in image processing applications. This noise level is to be estimated and is to be removed. Blind noise level estimation is an important image processing step. The proposed system is a new noise level estimation and removal method. It estimates noise based on principal component analysis (PCA) of image blocks. Principal component analysis is one of the statistical techniques frequently used in signal processing to the data dimension reduction or to the data correlation. In PCA first rearrange image blocks into vectors and compute the covariance matrix of these vectors. Then select the covariance matrix eigen values, which correspond only to noise. This allows estimating the noise variance as the average of these eigen values. The blocks to process are selected from image regions with the smallest variance. After noise level estimation the noise is removed using denoise function. It does not require images with homogeneous areas.***

Keywords: Covariance Matrix, Eigen vectors, Principal Component Analysis, Variance, noise

1. Introduction

In image processing applications noise is a major problem. So algorithms for denoising, compression and segmentation takes noise as an input parameter and the accuracy of the algorithm is heavily depend on the noise level estimate. Signal-independent additive white Gaussian noise [2] is the most widely used noise model. The proposed system is a new noise level estimation and removal method. It is based on principal component analysis (PCA)[1] of image blocks. PCA is widely used in signal processing applications. Principal component analysis is one of the statistical techniques frequently used for data dimension reduction or to the data correlation. In PCA first block information of each block is obtained and then rearrange image blocks into vectors and compute the covariance matrix of these vectors. Covariance matrix is a matrix whose element in i, j position is the covariance between ith and jth element of a random vector. Then noise variance can be estimated as the average of the eigen values which correspond only to noise. For processing the blocks are selected from image regions with the smallest variance. An image with homogenous areas is not required. It can process images even containing textures The advantages of the proposed method are: Computational efficiency is very high, It can process images with textures, even if there are no homogeneous areas and it is at least 15 times faster and compared with the methods with similar accuracy it is 2 times more accurate, and also it will remove the estimated noise.

2. Related Works

Image noise level estimation by using discrete cosine transform (DCT)[3] of image blocks is based on image structures in low frequency transform coefficients and noise variance is estimated using high frequency coefficients. 3D DCT of image block stacks makes use of self-similarity in images in order to separate the signal from the noise..Gray Scale images are used for estimating noise. In wavelet components [6] two training methods were used. In the first method, the noise standard deviation estimate is computed as a linear combination of normalized moments with learned coefficients. In the second method, the value of the cumulative distribution function (CDF) of local variances at a given point is computed for training images and stored in a lookup table against the noise variance. For a new image, the noise variance estimate is taken from the lookup table using the Cumulative Distribution Function value of this image.

All these methods are based on the assumption that the processed image contains a sufficient amount of homogeneous areas [4]. However, this is not always the case, since there are images containing mostly textures. The problem of the noise variance estimation for images containing mostly textures has not been solved yet. Also the existing systems do not remove the estimated noise from the noisy image.

3. Module Description

3.1 Noisy Image Generation

Here an image and a standard deviation value is given as parameters to generate_noisy_image function and it will give the noisy image as the output. In this, to generate the noisy image, the standard deviation value is multiplied with a random value and then it is added with the original image. So this shows the accuracy of the project since we can compare the inputted standard deviation with the estimated noise level as:

```
function y=generate_noisy_image(x,standardev)
x = double( x )
y = x + standardev * randn(size(x))
y = uint8(y)
```

3.2 Image block model

It will divide bthe image into a number of blocks and generate the information of each block in the image as a matrix as following.

```
function block_info = BlockInfo( I,M,imax,M1,M2)
 block_info = zeros( size(I,1)*size(I,2), 3 )
```

```
block_count = 0
for y = 1 : size(I,1) - M2
for x = 1 : size(I,2) - M1
sum1 = 0.0
sum2 = 0.0
count = 0
for by = y : y + M2 - 1
for bx = x : x + M1 - 1
val = I(by,bx)
sum1 = sum1 + val
sum2 = sum2 + val*val
if val == 0 || val == 255
count = count + 1
end
end
end
```

3.3. Principal Component Analysis

PCA_calc function will calculate eigen values of the computed covariance matrix and will return the sorted eigen values.

```
function eigen_value = PCA_calc( sum1, sum2, subset )

 mean = sum1 / subset
 cov_matrix = sum2 ./ subset - mean * mean
 eigen_value = sort( eig(cov_matrix) )
 end
```

3.4. Variance Estimate

Function NoiseLevel(I) takes the result of function UpperBound as the initial estimate and iteratively calls function Nextvariance until convergence is reached. Parameter imax is the maximum number of iterations. Function UpperBound computes a noise variance upper bound. This function is independent from image block PCA in order to increase the robustness of the algorithm. Similar to many other noise estimation algorithms, it is based on the analysis of the image block variance distribution. Namely, this function returns C0Q(p0). The value of C0=3.1 and p0=0.0005. The variance is estimated as:

```
block_info = BlockInfo( image,M, imax,M1,M2)
block_info = sortrows( block_info, [1] )
[sum1, sum2, subset] = Statistics( image, block_info,Delta_p,P_min,M,M1,M2)
up_bound = UpperBound( block_info,P0, C0)
variance0 = 0
variance1 = up_bound
 for itr = 1 : 10
 if( abs(variance0 - variance1) < 1e-6 )
 break
 end
 variance0 = variance1
variance1 = Next_Variance( sum1, sum2, subset, variance1, up_bound,m,T )
 end
```

3.5. Removal of Estimated Noise

The function denoise() will remove the estimated noise from the noisy image.

```
function t=denoise(I,sigma)
[r c]=size(I)
x=[-1 0 1;-1 0 1;-1 0 1]
 y=[-1 -1 -1;0 0 0;1 1 1]
 z=exp(-(x.^2+y.^2)/(2*sigma*sigma))
for i=2:r-1
 for j=2:c-1
 q=I(i-1:i+1,j-1:j+1)
 w=(double(q)).*(z)
 a1=mean2(w)
 t(i,j)=a1
 end
end
t=uint8(t)
```

4. Experimental Results

The proposed system estimates the noise level in the noisy image and also it will remove the estimated noise to generate the original image. Figure 1 shows the noisy image and the original image after removing the noise.

Figure 1 Noisy Images and Noise removed Images

Figure 2 shows the output of the proposed system. Here first we have to browse an input image and a standard deviation value is given as input. The second image is the noisy image produced by adding the SD value to the original image. It will also estimate the noise in the noisy image. The test result in Figure 2 shows that this value is very much closer to the inputted SD value. The third image is the denoised image obtained by removing the estimated noise from the noisy image.

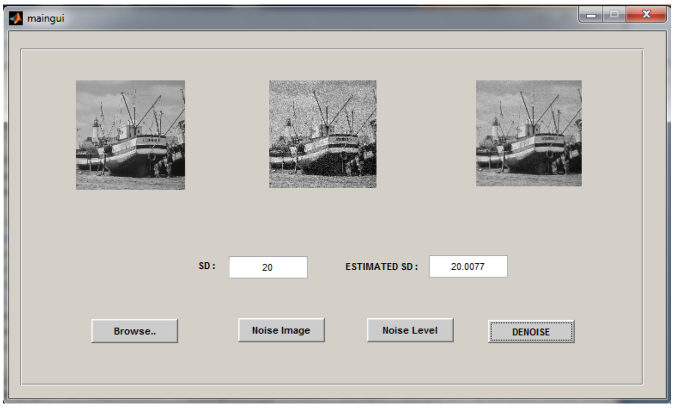

Figure 2 Experimental Output

5. Conclusion

Image noise level estimation by principal component analysis is a new noise level estimation algorithm. Here an image and a standard deviation value is given as input and it will give the noisy image as well as the estimated noise value. so this shows the accuracy of the project since we can compare the inputted standard deviation with the estimated noise level. These two values are almost equal. The comparison with the several best state of the art methods shows that the accuracy of this approach is the highest in most cases. Among the methods with similar accuracy, this algorithm is always more than 15 times faster. This is computed by comparing the execution times. Also this method can be used for removing the estimated noise from noisy images. Since this method does not require the existence of homogeneous areas in the input image, it can also be applied to textures. Experiments show that only stochastic textures, whose correlation properties are very close to those of white noise, cannot be successfully processed.

6. Future Scope

The proposed system is based on gray scale images. So as a future enhancement it is to be applied for coloured images also in order to estimate the noise level and remove the noise from coloured images.

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Author Profile

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