A New Method for Full Reference Image Blur Measure

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Abstract **- The measurement of image blurriness is a very important issue in image quality assessment. A number of algorithms have been developed by other researchers and used to calculate image blurriness. In this paper a new method is proposed and developed based on the full reference concept and demonstrated to show excellent results in measuring the blurriness in any image with a reference. We then compared our proposed method with previously developed methods and, based on the experimental results, the proposed method was shown to offer significant improvement in term of accuracy.**

Keywords - full reference, image, blur, measure.

I. INTRODUCTION

Image Quality Assessment has become a topic of interest for many researchers. Image Quality measures the image degradation. In a full-reference image quality assessment, the degraded image is compared with an ideal or perfect quality image. Another method is to measures the visibility difference between the corrupted image and the reference image using some properties of the Human Visual System (HVS). Blur affection in images is one of the most important parameters in determining the image quality. Categorizing images in term of blur is important in several applications such as image restorations and super-resolution image construction [1].

The point of blur investigation as a rule is to distinguish the picture and blur model parameters of a corrupted picture in order to re-establish it. There are two major methods to analyze the image blur. The first one is by using image modeling and maximum likelihood estimation, and the second one is via the detection of the image edges then estimating the blur in the perpendicular direction [1] .

The relative sharpness of an image can be determined by the spatial domain, by identifying the edges and comparing them with the reference image.

A method of using spatial domain approach was proposed based on edge profile acutance. This technique aimed at sharpness measurements of multiple versions of the same image. It uses a root mean square gradient normal to the edges of item and it's depending on accurate region detection [3].

Another method uses frequency domain, by evaluating the difference in high frequency energy attached to the edges with referring to the reference image [3].

An important term in image quality assessment is the sharpness metric. The sharpness metric depends on a statistical measure called multivariate kurtosis, applied to the distribution of the 2-D Fourier transform coefficients over the whole image. This method was described in [4].

In this paper we proposed a new algorithm to determine the blur in the image via the detection of the edges in an image or in other words, determining the blur's percentage based on edges' sharpness with respect to the reference image.

Other methods [5] proposed measuring the blurriness of an image using edge detection. In [6], the Multi-resolution Singular Value (MSV) metric and a maximum-likelihood estimation (MLE) based refinement was proposed to overcome the problems of an effective blur measure that is both pixel-wise and locally sharp consistent.

This paper is divided as follows: Section II presents the methods used for image blur measurement with a full reference image. Section III presents our methodology to measure the image blur, Section IV presents the experimental setup, Section V presents the results achieved and the comparisons made, and Section VI presents a comparison with existing methods.

II. RELATED WORK

A. Structure Dissimilarity (DSSIM)

The equation of the structure dissimilarity has been derived from the structure similarity methodology which is one of the most common used methodologies in the image quality assessment. DSSIM measures the difference between the reference and blurred image based on SSIM formula.

$$SSIM = [l(x,y)].[c(x,y)].[s(x,y)]$$

Where l(x,y), c(x,y) and s(x,y) can be obtained from [7].

$$DSSIM = 1 - SSIM$$

The dissimilarity of the images represent the corrupted amount in the sample image, which is the blur of the edges. The similar parts of the two images which represent non-edges parts are found out to be the same as in the reference image, with no corruption, and thus are not considered for blur calculation.

B. Average Difference Image

It is one of the simplest used methods to calculate the noise and possibly the blurriness of an image. It depends on the direct subtraction between each pixel in the reference image and its corresponding in the blurred image; as a result an absolute difference matric will be formed. The mean of this matric represents how different is the blurred image from the reference image. This difference represents the blurriness in the image.

$$AD = \frac{\sum_{i=1}^{M}\sum_{j=1}^{M} abs(X(i,j) - y(i,j))}{M \times N}$$

Where X(i,j) represents the original image, and y(i,j) represents the blurred image.
Then in order to normalize the Average difference, and obtain the percentage the Average Difference would be divided by 255.

$$AD\% = \frac{AD}{255}$$

C. Signal to Noise Ratio (SNR)

It highly depends on the mean square error (MSE) calculation, since it is the ratio between the signal and the mean square error. The SNR can be written as: [8]

$$SNR = \frac{X(i,j)^2}{MSE}$$

Where, $MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(X(i,j) - y(i,j))^2$

Where, $X(i,j)$ represents the original image and $y(i,j)$ represents the burred image. Apparently, the greatest the SNR between the two images, the more similar they are, and the less blur occurs. Low SNR values indicate corruption in the image, and thus indicate blurriness. [9]

Since the amount of blurriness is the desired parameter from the calculation the formula will be as following:

$$Blurriness = 1 - (\frac{SNR}{\max(SNR)})$$

Where the maximum SNR is theoretically equals to infinity, and practically was estimated as 37.

III. PROPOSED METHOD

The sharpness of the edges is the best criteria to indicate the amount of the existing blur in any image [10]. The proposed method was designed to calculate the blur in the image based on the edges' sharpness, since the sharpness is inversely proportional to the blur. Thus, our concern is on the edges of the image. The other parts of the image are assumed ideally to have zero intensity variations. Figure A depicts a blurred image. The blue square is one of where an edge occurred, and thus it will have intensity variations between the center and neighbor pixels. The red square is one of where no intensity variations occur, and is assumed ideally to have zero intensity variations between the center and neighbor pixels.

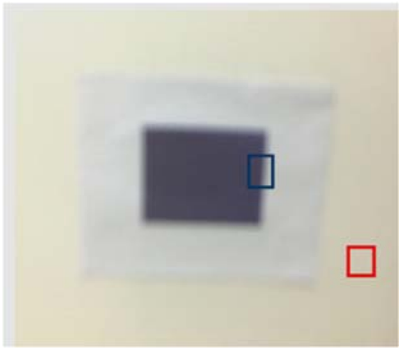


Figure 1. The blurring effect on an image

The algorithm used to measure the image blur in grayscale is as follows:

1-For every pixel in both the reference image and the blurred image, both assumed to be of size $(M \times N)$, compute the difference between the center pixel and its 8 neighbor pixels. In other words, compute the intensity variation of the 8 neighbor pixels for each pixel of both images. Store the result in A for the reference image, and in B for the blurred image.

x_1	x_2	x_3
x_4	$\boldsymbol{x}$	x_5
x_6	x_7	x_8

Figure 2. A pixel with it's eight neighbours

For the reference image:
Compute $(x - x_i)$ for each pixel
$A = \max(x - x_i)$ for each pixel

For the blurred image:

Compute $(x - x_i)$ for each pixel
$B = \max(x - x_i)$ for each pixel

2- A and B are now $(N-2) \times (M-2)$ matrices containing the maximum values of the intensity variations. After doing the above for all the pixels in both images, compute the average of maximum values for both images.

$$Z_1 = average(A) \qquad Z_2 = average(B)$$

3- The image blur percentage is calculated as:

$$blur = \frac{abs(Z_1 - Z_2)}{Z_1} \times 100\%$$

Figure 3 below illustrates the process.

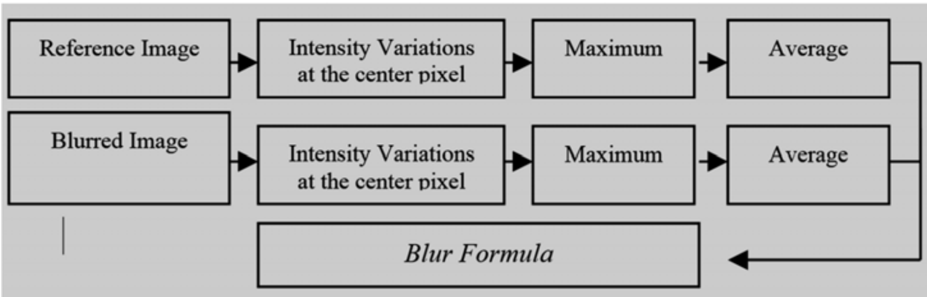


Figure 3. Diagram of the algorithm.

IV. Experimental Setup

Several images with their blurred version were chosen to perform the experiment. The images with their sizes are listed below.

TABLE 1: IMAGES WITH THEIR SIZE USED

Figure No.	Image Size (Reference and Blurred)
Figure 4	300x300
Figure 5	800x800
Figure 6	768x512
Figure 7	411x274
Figure 8	800x800
Figure 9	748x637
Figure 10	748x637
Figure 11	748x637

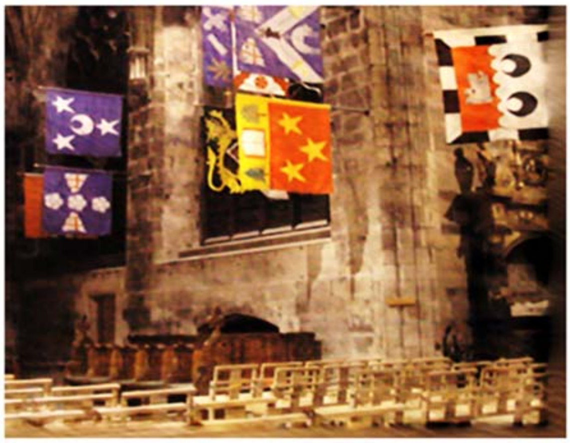
Figures 5,6 and 8 were acquired from [11]. Other images were acquired from public references and were blurred in different amounts and examined.

The following section of the paper shows the results of the proposed algorithm on the figures mentioned above.

V. Results

The results of the figures described previously are as below.

Reference Blured
Figure 4. Blur = 25.39%



Reference

Blurred
Figure 5. Blur 65%

Reference

Blurred
Figure 6. Blur = 34.56%

Reference

Blurred.
Figure 7. Blur = 94.91%

Reference.

Blurred
Figure 8. Blur = 76.9%

Reference Blurred
Figire 9. Blur = 21.31%

As the image gets more blurred, all edges disappear. When it gets fully blurred, the image will not be recognizable by any means. Figure 10 illustrates this.

Reference Blurred (white image)
Figure 10. Blur = 100%

However, if the blurred image is exactly the same as the reference image, no blur occurs and the result is 0% as it can be seen in Figure 11 below.

Reference Blurred 0%

Figure 11. Blur = 0%

VI. COMPARISION

Comparison of existing methods described in Part II (Related work) with the proposed method described in Part III (Methodology) has been carried out, and the proposed method showed significant improvement. Table 1 shows the result of the method used to calculate the blurriness according to the SNR. Table 2 shows the result of the method used to calucate the blurriness according to the average difference. Table 3 shows the result of the dissimilarity between the two images.

TABLE 2: BLURINESS ACCORDING TO SNR RESULTS

Method	MSE	SNR	Blurriness According to SNR
Figure 4	109.6074	27.2296	26.41%
Figure 5	355.3791	10.1941	72.45%
Figure 6	304.0367	14.8894	59.76%
Figure 7	1.6285e+03	8.8071	76.20%
Figure 8	1.7996e+03	6.5016	82.43%
Figure 9	821.1532	18.6594	49.57%
Figure 10	4.6337e+03	11.1444	69.88%
Figure 11	0	37	0

TABLE 3: STRUCTURE DISSIMILARITY RESULTS

Method	Structural Similarity	Structural Dissimilarity %
Figure 4	0.9602	3.98%
Figure 5	0.7035	29.65%
Figure 6	0.7921	20.79%
Figure 7	0.1468	85.32%
Figure 8	0.3827	61.73%
Figure 9	0.8795	12.05%
Figure 10	0.9044	9.56%
Figure 11	1	0%

TABLE 4: BLURINESS ACCORDING TO AVERGAE DIFFERENCE RESULTS

Method	Average Difference	Average Difference %
Figure 4	2.4356	0.96%
Figure 5	13.7636	5.40%
Figure 6	8.7062	3.41%
Figure 7	32.1674	12.61%
Figure 8	31.4141	12.32%
Figure 9	10.0780	3.95%
Figure 10	18.3374	7.19%
Figure 11	0	0%

It can be seen that the results shown in Table 5 are much better than the other results in Table 2, 3 and 4. In Figure 7, the image appears to be almost fully blurred, and the blurriness should be not less than 90%. The proposed method achieved 94.91%, while other results 76.20% and 85.32%. As a result, the Structure Dissimilarity method achieved closer results to the proposed method.

TABLE 5: PROPOSED METHOD RESULTS

Method	Proposed Method
Figure 4	25.39%
Figure 5	65%
Figure 6	34.56%
Figure 7	94.91%
Figure 8	76.90%
Figure 9	21.31%
Figure 10	100%
Figure 11	0%

VII. CONCLUSION

In conclusion, the measurement of the blurriness is a very important concern in the quality assessment field. There are a number of developed algorithms have been used to calculate the image blurriness. However, in this paper, it was proven that the proposed method has excellent results in measuring the blurriness in any image with a reference. Moreover, a compression between the proposed method and the previously used methods has been done, and based on the experimental results the proposed method had shown a significant improvement in term of accuracy.

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