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Survey on Approaches used for Image Quality Assessment

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Abstract— **One of important factor affecting the overall performance of biometric system is quality of biometric data. Poor quality of biometric sample mostly results in spurious or missing features, which increases the enrollment failure and degrade the overall performance of biometric systems. Finding the quality of an image is the fundamental problem in image and video processing. For quality assessment of an image various methods have been estimated. Quality of biometric sample can be defined in two ways: one is subjective and other is objective methods. In this paper survey on the image quality assessment techniques which are necessary to improve the performance of biometric system is presented.**

Keywords: **Biometric system, Quality assessment, subject and objective image quality assessment**

I. INTRODUCTION

In the modern technological era of imaging and multimedia technologies, visual information, recorded by images has become the main resource for knowledge acquisition. In the process of visual information acquisition, processing, communication, management and storage, some artifacts or noise may be introduced to images which degrade the quality of visual information. In a typical digital image processing system, the image is captured and transformed into digital signal by the sensor .This digital signal is then processed to reduce the noise and is compressed for storage or transmission. When the image is finally displayed to the end user, it might not be same as the original image because it has been exposed to various kinds of distortions. The distortion could be ranged from motion blurring, Gaussian noise, sensor inadequacy, compression, error during transmission or the combination of many factors. Hence it is necessary to assess visual qualities of images to improve the performance of visual information recorded by images; so that it can maintain, control and possibly enhance the quality of the image before storage or transmission. Qualitymeasurement is needed for many image processing applications such as recognition, retrieval, classification, compression, restoration and similar fields.The objective of image quality assessment is to automatically evaluate the quality of images in agreement with human quality judgments.To evaluate the quality of images and videos, recently a various techniques have been designed. Image quality can be measured in two ways subjective and objective[1][6]. On the bases of subjective experiments subjective assessment of image is done where as objective image quality assessment methods were based on some mathematical measures.

II. RELATED STUDIES

Zhou Wang, Alan C. Bovik in 2002 presented a new universal image quality index and discussed that experimental performs better than MSE [1][5].Yusra A. Y. Al-Najjar, Dr. Der Chen Soong discussed that different types of Image Quality metrics differ in value according to types of distortion in the image and hard to get the same quality value even if the same distortion is implemented on different images. The author presented that, despite SSIM was built from UIQI, the result given by UIQI is closer to 1 than SSIM [11].Horé, A., Ziou, D presented a mathematical relationship between SSIM and PSNR with various kinds of image degradations such as Gaussian blur, additive Gaussian white noise and discussed that SSIM performs better than PSNR [2].X.ZhuandP.Milanfar presented sharpness metricbased on the local gradients of the without any edge detection. Its value drops when the test image either becomes blurred or corrupted by random noise. The author presented experiments to demonstrate the effectiveness and robustness of this metric using synthetic, natural, and compressed image [10].H. R. Sheikh and A. C. Bovik presented visual information fidelity (VIF) criterion for full-reference image QA. The VIF, derived from statistical model for natural scenes. Author demonstrated that VIF to be better than HVS-based method [12].Anu et. aldemonstrated that earlier techniques were based on mathematical metrics like PSNR, MSE but they do not correlate well with subjective perception values. A human visual system based metric MSSIM uses the luminance, structural and contrast information present in the given image. The validation results of these shows the robustness, feasibility of the MSSIM and it can perform better than PSNR and SNR [7].

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III. CLASSIFICATION OF IMAGE QUALITY ASSESSMENT METHODS:

Qualityof an Image is acharacteristic which measures the perceived image degradation imaging systems may introduce some amounts of distortion or artifacts in the signal, so the quality assessment is an important problem. The evaluation of Image quality can be classified as shown below Figure 1.

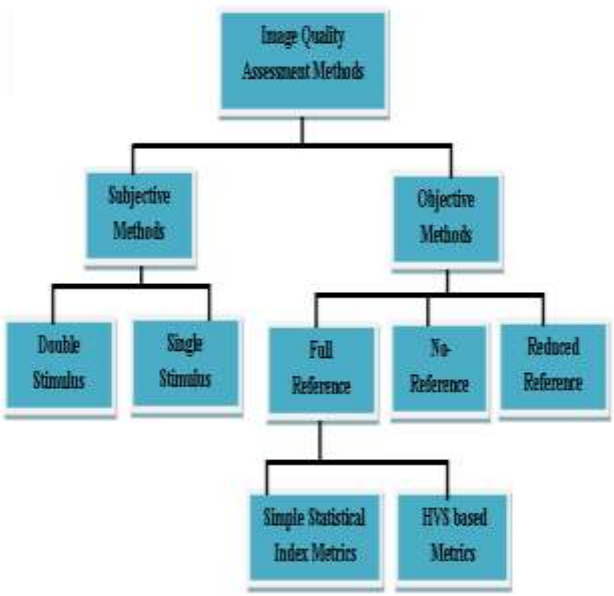

Figure 1: Classification of Image Quality Assessment Methods:

A. Subjective Method

In the subjective method human judges the quality of an image by themselves. Hence these methods are said to be the most precise measures of perceptual quality and are the only widely recognized method of judging perceived quality. Nisha and Sunil Kumar discussed thatin order to evaluate the quality of distorted images; images are provided to a number of observers and are asked to compare original images with distorted images. Subjective methods are again categorized into stimulus and double stimulus methodology[13]. In double-stimulus methodology, before evaluating their qualities on a linear quality scale, subject is presented with the source and test images where as in single-stimulus methodology; the subject evaluates the quality of the test images on a linear quality scale without the source as reference. The scores evaluated by multiple subjects are averaged for each test image to obtain mean opinion score and difference mean opinion score.Mean opinion score (MOS) is calculated based on their evaluation which is taken as the image quality index. Mean Opinion Score (MOS) scores scales from 1 to 5 shown in below Table 1.

1	2	3	4	5
Very Poor Quality	**Poor Quality**	**Good Quality**	**Very Quality Good**	**Excellent Quality**

Table1: Mean Opinion Score

In this method, it is known that subjective image quality varies from one individual to another: usually, the scores given by different individuals are not same. The score depends on observer's general experience, personal appreciation and may vary according to his mood. To solve this problem, an average score is computed. This Mean Opinion Score is denoted by MOS or the Difference Mean Opinion Score.However, subjective quality assessment is usually too inconvenient, expensive, time-consuming and also these methods are in general not applicable in environments which require real-time processing [13].

B. Objective Method

In the objective method quality of an image is evaluated by algorithms.This is a quantitative approach in which intensity of two images; reference and distorted type are used to calculate a number which indicate the image quality. Based on the availability of reference image,the objective IQAcan be classified into full-reference, reduced-reference and no-reference [3].

No Reference (NR) Models:

In these methods, in general the human visual system does not require a reference sample to determine the quality level of an image. This method is also called "blind models" methods. This method can be used in any application where a quality measurement is required without any reference information [9-10].

Reduced Reference (RR) models:

In this method the reference image is only partially available, in the form of a set of extracted features made available as side information to help evaluate the quality of the distorted image. However, from the original reference image some set of features are extracted and they are being utilized by the quality assessment system, which helps assessment system to evaluate the quality of the distorted image and quantify it[7-8].

Full Reference (FR) model:

In full reference model, the human visual system requires a reference sample to determine the quality level of an image. In this, quality assessment algorithms have access to perfect version of image from which it can compare a 'distorted version'. Generally the 'perfect version' comes from a high-quality acquisition device, before it is distorted by compression artifacts or transmission errors. In general there are two classes of objective quality assessment approach, simple statistical error metrics and human visual system feature based metrics.

a) Simple statistical error metrics:

i) **Mean Square Error (MSE):** MSE is the mean of squared difference between the original image and distorted image. The mathematical equation for MSE is [4]

$$MSE=(1/MXN)\sum_{i=1}^{M}\sum_{j=1}^{N}(a_{ij}-b_{ij})^2$$

in the above equation a_{ij} means pixel value at position (i,j) in the original image and b_{ij} means pixel value at the same position in the corresponding distorted image.

ii) **Average Difference (AD):** is the average difference between the reference signal and the test image. AD is given by [4]

$$AD=(1/MN)\sum_{i=1}^{M}\sum_{j=1}^{N}(x(j,j)-y(i,j))$$

iii) **Maximum Difference (MD):** is the maximum of the error signal i.e.the reference signal and the test image. MD is given by the equation[4]

$$MD=MAX|x(j,j)-y(i,j|$$

iv) **Mean Absolute Error(MAE):** is the average of absolute difference betweenthe reference signal and the test image. MAE is given by [4]

$$MAE=(1/MN)\sum_{i=1}^{M}\sum_{j=1}^{N}|x(j,j)-y(i,j)|$$

v) **Peak Mean Square Error**: is given by [4]

$$\frac{1}{MN}\times\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}(x(i,j)-y(i,j))^2}{(MAX(x(i,j))^2}$$

The simplest and most widely used full reference image quality measure is MSE and PSNR. The advantage of MSE and PSNR is that, they are very fast and easy to implement. They simplify and objectively quantify the error signal.

vi) **Peak Signal to Noise Ratio:** is defined as the ratio between maximum possible power of a signal and the power of corrupting noise that affect its fidelity of its representation [4][11].

$$PSNR = 10\log_{10} 255^2/ MSE$$

In the above equation 255 is maximum possible value of the image pixel when pixels are represented using 8 bit per sample. MSE is the Euclidian distance between the original and degraded images.

b) **Human Visual System (HVS) feature based metrics:** is another approach of measuring image quality. The method uses human eye as a reference. The main idea is that humans are interested in different attributes of the image other than taking it as a whole. These attributes include brightness, contrast, texture, orientation etc.

i) **Universal Image Quality Index (UIQI)**

It breaks the comparison between original and distorted image into three comparisons: luminance, contrast, and structural comparisons. Wang et. al discussed that their experimental results performs better than MSE [1].

$$UIQI(x,y)=\frac{4\mu_x\mu_y\mu_{xy}}{(\mu_x^2+\mu_y^2)(\sigma_x^2+\sigma_y^2)}$$

ii) **Structural Similarity Index Measure (SSIM):** ismethod for measuring the similarity between two images. In SSIM, measuring image quality is based on an initial uncompressed or distortion-free image as reference. Image is compared by using information about luminous, contrast and structure. This method is designed to iSmprove on traditional methods like PSNR and MSE. SSIM is given by the equation [5]:

$$SSIM(x,y) = \frac{\{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)\}}{\{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)\}}$$

Where μ_x x is average of x, μ_x y is average of y and are the standard deviation between original and processed images pixels. C1, C2 are positive constant.

iii) **Mean Structural Similarity Index Measure (MSSIM):** is given by [12]

$$MSSIM = 1/M \sum_{l=1}^{M} SSIM(xl, yl)$$

iv) **Dissimilarity Structural Similarity Index(DSSIM):** is structural dissimilarity metric. It is given by the equation[5]:

$$DSSIM(x, y) = 1/(1-SSIM(x, y))$$

IV. RESULTS

First, theimages are selected from Lossless True Color Image Suite" provided by "LIVE Image Quality Assessment Database" provided by Laboratory of Image and Video Engineering at University of Texas, Austin. The selected images were then converted into gray images using the function RGB2grayin MATLAB, and then the metrics were implemented upon these images. Lastly a comparison has been done between four objective evaluations: pixel-difference based measurement Peak Signal-to-Noise Ratio (PSNR), HVS using Fourier Transform, Structural Similarity Index (SSIM), and Universal Image Quality Index (UIQI) metrics by simulating them using MATLAB software. MATLAB is identical software for dealing with graphics since it has an image processing tool box. The original images and distorted images are shown in Figure 2 and figure 3. The comparison of six original and distorted images buildings,caps, toys, butterfly, parrots, airplane, and light house is shown in TABLE I.

TABLE-I

Comparison of Image quality measurements applied on images

Image	PSNR	SSIM	UIQI	DSSIM
Buildings	18.22	0.62	0.99	2.65
Caps	28.38	0.82	0.99	5.58
Airplane	25.10	0.84	0.99	6.07
Lighthouse	22.22	0.69	0.99	3.22
Toys	21.48	0.77	0.99	4.26
Parrots	28.09	0.87	0.99	7.59

Figure 2 Original images a) to f) used in the experiment

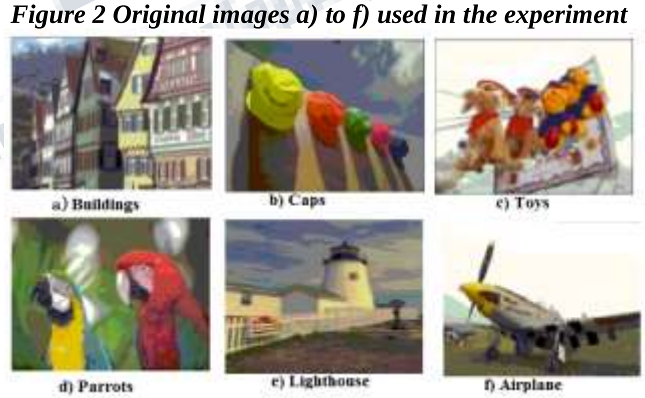

Figure 3 Distorted images from a) to f) used in the experiment

TABLE-II also shows the comparison of UIQI with other statistical methods such as PSNR, SSIM and DSSIM. The specific contents of the type of noise we have used here is salt & pepper noise. Plot for buildings image in figure 4 is drawn according to the TABLE II. This shows the various accessing parameters with respect to noise densityvariations. Figure 4 clearly shows that curve for

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UIQI is almost a straight line parallel to the axis which is used to show the noise density variations and the variations of this is greater than the other three.

TABLE-II

Comparison of Image quality measurements applied on images

Image	Noise	PSNR	SSIM	UIQI	DSSIM
Buildings	0.1	18.40	0.77	0.99	4.34
	0.2	15.31	0.66	0.98	2.91
	0.3	13.46	0.56	0.97	2.28
	0.4	12.10	0.47	0.95	1.89
	0.5	11.04	0.39	0.93	1.64
	0.6	10.17	0.31	0.92	1.45
	0.7	9.42	0.23	0.90	1.31
	0.8	8.74	0.15	0.88	1.18

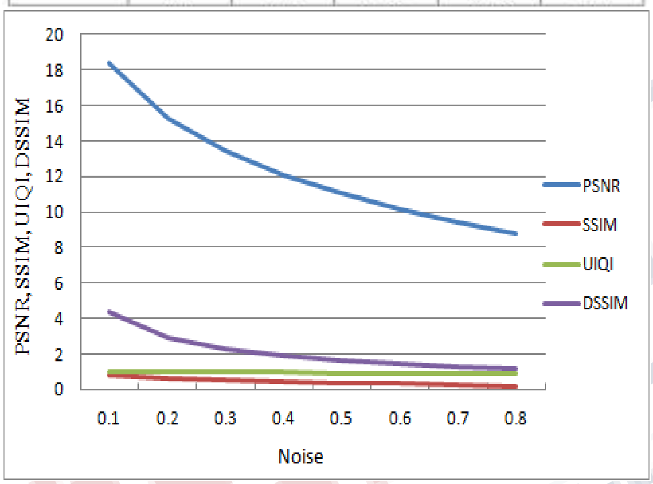

Figure 4 plot for buildings image with different noise density

V. DISCUSSION

From TABLEI and TABLE-II it can be seen that different types of Image Quality metrics differ in value according to types of distortion in the image and hard to get the same quality value even if the same distortion is implemented on different images. Despite, SSIM was built from UIQI; the result given by UIQI is closer to 1 than SSIM but still we need lots of work to get close to subjective image quality measurement.

VI. CONCLUSION

Image Qualitymeasurement is a fundamental and challenging task in various image processing applications like medical imaging, biomedical systems, monitoring and communications. Many processes can affect the quality of images. Therefore, accurate measurement of the image quality is an important step. The goal of objective IQA is to design an algorithm that can automatically evaluate the image quality. In recent years a great deal of effort has been made to develop objective image quality metrics but there are still limitations. In this paper we discussed about various approaches (subjective and objective) used for image quality assessment.From the study it is clear that subjective IQM are time consuming and expensive. Objective methods are useful than subjective methods but still need lots of work.

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