ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Different Objective Image Quality Assessment Techniques

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Abstracts

Quality assessment plays an improle in image analysis.The study highlight wavelet transformation based technique which is basically a time frequency transformation and compares it with traditional methods like PSNR, MSE, SSIM, MSSIM, UQI, NO REF BASED. By applying the wavelet decomposition to the image.The low-freq. components and the high-frequency components of the image are successively obtained .The bases of the wavelet decomposition can be selected from Haar, Daubechies (N=3), and Daubechies (N=5). The original image is reconstructed from the low-freq. and high-freq. components. This procedure is called the inverse wavelet transform. By reconstructing the image only from high frequency component, high frequency image is obtained and this image can be used for edge detection.Daubechies wavelet metric ((DWM) uses the concept of sharpness and zero crossing .Zero crossing provide location of sharp signal variation. Sharpness is defined by the boundaries between zones of different tones or colors.Four bands are extracted from reference and distorted image by employing 2-D Daubechies wavelet decomposition namely: LL, LH, HL, and HH.Sharpness of both reference and distorted can be calculated from energy in wavelet sub bandand then sharpness similarity of both original and distorted image is measured.By calculatingnumber of edge points in original and distorted image edge structural similarity is measured.Zero crossing is found from edge structural similarity.By combining zero crossing and structural similarity DWM is obtained. We performed our experiment on 9 publicly available images on which blurring of different types JPEG compression and JPEG compression with blurring are applied. For these images Daubechies wavelet metric(DWM) and traditional metrics like MSE,PSNR,SSIM,MSSIM ,UQI,NO REF BASED are obtained and results are compared .By comparing these results it is found that DWMgives comparable result to MSSIM and is better correlated with subjective scores.

Keywords: PSNR(peak signal to noise ratio),MSE(Mean square error),SSIM(Structural Similarity Index Metric),MSSIM(Mean Square Structure Similarity Index Metric),WASH(Wavelet Based Sharp Features),HWSSIM (Haar Wavelet Based SSIM),DWM(Daubechies Wavelet METRIC),HVS(Human Visual System),IQA(Image quality Assessment).

Introduction

An image is a visual representation of something .Images can be visible,non-visible and abstract images.Visible images are photographs, Drawing, Document, and Painting. NON visible images are not stores as images but are displayed as images e.g. temperature gauge.Abstract images are computer generated images based on some arithmetic calculation e.g. fractals.Uncompressed images can be of order of several megabits.These images need to be stored, retrieved, transmitted and displayed.These large images present two problems: storage and transmission.In order to manage large images efficiently these images need to be compressed to reduce the size of image .Compression algorithm try to reduce size of these images.Being smaller in size it takes less transmission time over network.It also reduces storage and transmission costsCompression standards are defined by CCITT.These compression algorithm are of two types Lossy and Lossless.Lossy compression algorithm reduces quality of image.Blurring happens when camera is out of focus. Exactly what happens is what should be seen as a sharp point gets smeared out, usually into a disc shape. In image terms blurring means that each pixel in the source image gets spread over and mixed into surrounding pixels. It can also be considered as each pixel in the destination image is made up out of a mixture of surrounding pixels from the source image. Blurring also reduces quality of image.There are two methods for assessing image quality, the subjective and the objective method. The subjective methodareconsideredcostly, expensive, and time consuming but the results given by these methods are best correlated with human vision. In subjective method since we have to select a number of observers, show then a number of images and ask them to score images quality depending on their own opinion. The objective evaluation uses automatic algorithms to assess the quality of the image depending on the existence of the original image. . In our study we will study latest and traditional techniques to access image quality and give a comparison between them .I

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
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performed the study on 9 images .On these images first different blurring is applied than JPEG compression is applied than simultaneously blurring and compression is applied to same image. Image quality is accessed by traditional and latest techniques and a comparison of these parameter is done with mean opinion score (MOS) .It is found that DWM gives comparable result to MSSIM and is better correlated with subjective score.

Classification of IQA methods

The evaluation of image quality may be classified into two classes, subjective and objective methods as shown in Fig. 1.

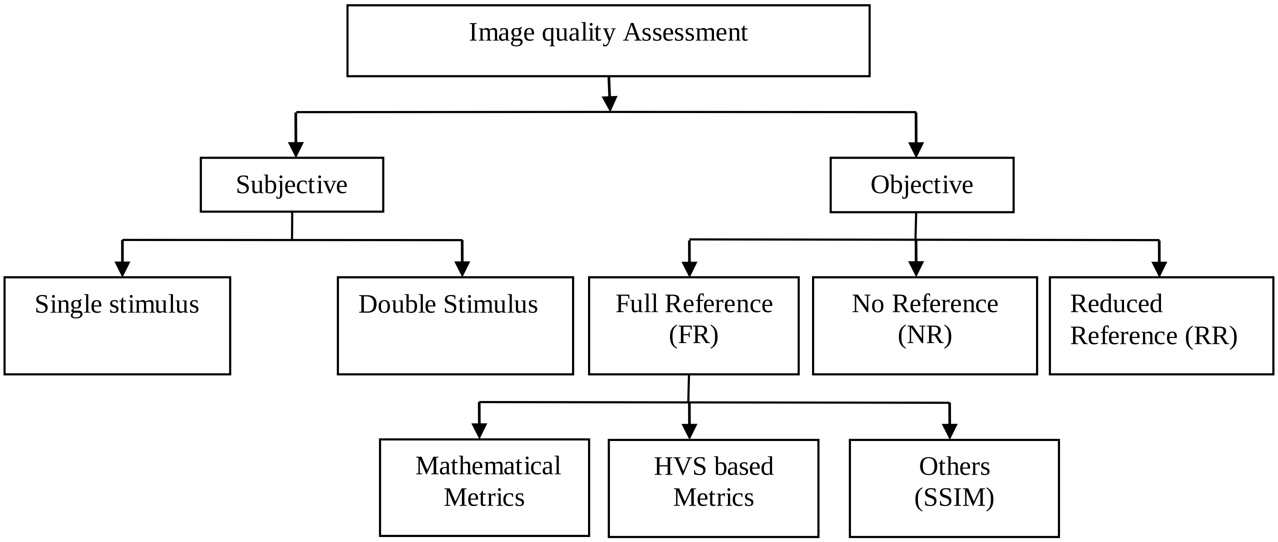

Fig. 1: Classification of IQA methods

Image quality metrics

A. PSNR

The Peak Signal to Noise Ratio is one of the most widely used metrics until now due to its computational simplicity. Mathematically, PSNR is represented as:

$$\mathrm{PSNR}=10\ \log_{10}\frac{\mathrm{L}^2}{\mathrm{MSE}} \qquad (1)$$

B. MSE

It means mean squared difference between the original image and distorted image. The mathematical definition for MSE [2] is:

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

Where a_{ij} is the pixel value at position (i, j) in the original image and b_{ij} is the pixel value at the distorted image.

C. HVS BASED METRIC

As human eye measure image quality this metric measures image quality in same way. Contrast, color and frequency changes are used by human to measure the image quality. The two most important HVS based metrics are SSIM and UQI.The structural similarity index is a method for measuring the similarity between two images [7]. In SSIM, μ_x and σ_x can be viewed as estimates of the luminance and contrast of x, and σ_{xy} measures the tendency of x and y to vary together, thus an indication of Structural similarity. The mean intensity is estimated as [2]

$$u_x=\sum_{i=1}^{N}x_i/N \qquad (2)$$

$$u_y=\sum_{i=1}^{N}y_i/N \qquad (3)$$

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The block diagram of SSIM [2]

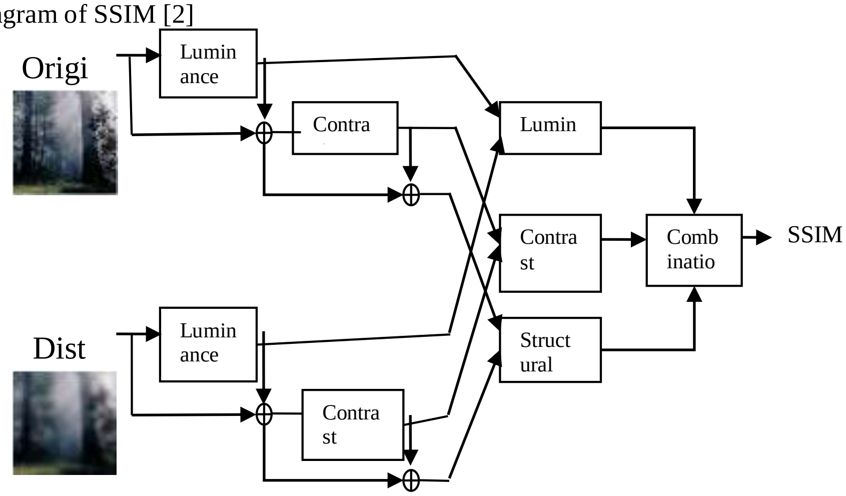

Fig. 2 Block Diagram OF SSIM [2]

D. FEATURE BASED METHOD

Feature contains a lot of information about the image and therefore can be used in image quality measurements .Discontinuities in edge, decreases in edge sharpness, offsets of edge positions, missing edge points, falsely detected edge points are some examples of feature degradations.

1) *HAAR WAVELET BASED SSIM(HWSSIM):*It proposes a new full reference based image quality assessment etric.IN this both reference and distorted images are decomposed by 2-D haar wavelettransform:LL,LH,HL,HH.Luminance and contrast information is extracted from LL band and edge information is obtained from other three bands and whole image metric is defined as MHWSSIM [6].
2) *DAUBECHIES WAVELET METRIC(DWM)****:*** This Image quality assessment metric based on human visual system which accounts for sensitivity of human vision to distinct features of image e.g sharpness and zero crossing. Edge points obtained by zero crossing and sharp regions are highly attentive to early vision are important that gives good quality estimation .Four bands are extracted from reference and distorted image by employing 2-D Daubechies wavelet decomposition namely :LL, LH,HL,HH. Our metric uses three bands LH,HL, HHbands to calculate sharpness similarity of reference and distorted image and final ratio of zero crossing and this metric is defined as DWM.Fig below shows how wavelet decomposition is applied ,image is decomposed into four bands and from these bands edge information can be extracted[10]

Fig. 3(a): Apply wavelet decomposition at level 2

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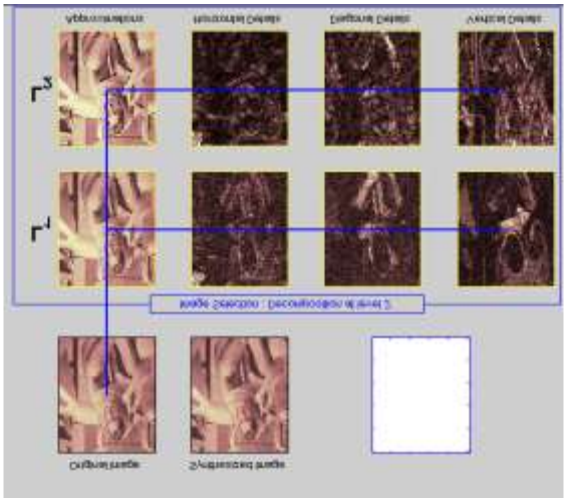

Fig.3 (b): Applying wavelet decomposition to extract horizontal, vertical and diagonal detail

Procedure to calculate Daubechies metric

This metric uses the concept of sharpness and zero crossing.

Sharpness: Sharpness is most important image quality factor because it determines the amount of detail an imaging system can reproduce.

Zero crossing: In the field of Digital Image Processing, great emphasis is placed on operators which seek out edges within an image. They are called 'Edge Detection' or 'Gradient filters'. A gradient filter is a filter which seeks out areas of rapid change in pixel value. These points usually mark an edge or a boundary. A Laplace filter is a filter which fits in this family, though it sets about the task in a different way. It seeks out points in the signal stream where the digital signal of an image passes through a pre-set '0' value, and marks this out as a potential edge point. Because the signal has crossed through the point of zero, it is called a zero-crossing.

Test Images

Some of the images used in this paper are given below:

Original blurred1 blurrr1. jpegcompr blurred2 blurred2jpeg1

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Results

The following table shows the analytical results obtained by applying the specific techniques discussed in the paper on the images.

Sr. no.	DMOS	File name	MSE	PSNR	SSIM	MSSIM	DWM	UQI	NR
1	0.491053	Bikerace							
1	0.467895	bikerace_blur1	2.4815	0.4418	0.9955	0.9991	0.8909	0.998	8.3745
1	0.54	bikerace_blur1_jpeg1	2.8007	0.4366	0.9953	0.9991	0.9008	0.9979	6.6167
1	0.622105	bikerace_blur2	4.4343	0.4166	0.9883	0.9977	0.8927	0.9949	7.5125
1	0.627368	bikerace_blur2_jpeg1	4.6672	0.4144	0.988	0.9976	0.9036	0.9948	6.3464
2	0.418421	Cows							
2	0.486842	cows_blur1	0.9822	0.4821	0.999	0.9998	0.898	0.9995	9.7168
2	0.542105	cows_blur1_jpeg1	1.1784	0.4742	0.9989	0.9998	0.9243	0.9995	6.5302
2	0.531053	cows_blur2	1.4756	0.4644	0.9974	0.9995	0.9285	0.9988	8.6293
2	0.652105	cows_blur2_jpeg1	1.604	0.4608	0.9973	0.9995	0.954	0.9988	5.9465
3	0.412632	Elephant							
3	0.457368	elephant_blur1	2.3929	0.4434	0.9943	0.9369	0.8857	0.9976	8.8766
3	0.470526	elephant_blur1_jpeg1	2.6587	0.4388	0.9947	0.9369	0.895	0.9974	6.7098
3	0.591053	elephant_blur2	4.2181	0.4188	0.9871	0.9371	0.8895	0.994	8.3139
3	0.624211	elephant_blur2_jpeg1	4.3912	0.4171	0.9854	0.9371	0.9001	0.9938	6.1894
4	0.473684	Iceroad							
4	0.54	iceroad_blur1	2.328	0.4446	0.9954	0.9991	0.8921	0.9979	9.0162
4	0.492632	iceroad_blur1_jpeg1	2.4843	0.4418	0.5112	0.999	0.9195	0.9977	6.463
4	0.636316	iceroad_blur2	3.6296	0.4253	0.5149	0.9977	0.9137	0.9951	8.1594
4	0.633158	iceroad_blur2_jpeg1	3.7302	0.4241	0.515	0.9976	0.9364	0.9948	5.7546
5	0.604211	Lakebuilding							
5	0.610526	lakebulding_blur1	2.4639	0.2666	0.9958	0.9992	0.9224	0.9872	8.9633
5	0.665263	lakebuilding_blur1_jpeg1	2.6553	0.4389	0.9983	0.9997	0.9459	0.9857	6.2309
5	0.660526	lakebuilding_blur2	3.8395	0.4229	0.9952	0.999	0.9322	0.9821	8.1483
5	0.751579	lakebuilding_blur2_jpeg1	3.9632	0.4215	1.0368	.9989	0.9499	0.9728	5.7077
6	0.588947	Lunch							
6	0.641579	lunch_blur1	2.1606	0.4479	.9912	.9985	0.9063	0.9852	8.1743
6	0.683684	lunch_blur1_jpeg1	2.3904	0.4435	0.9902	0.998	0.9238	0.9755	6.6496
6	0.702632	lunch_blur2	3.8733	0.4225	0.9808	0.9962	0.9105	0.976	7.268

ISSN: 2277-9655
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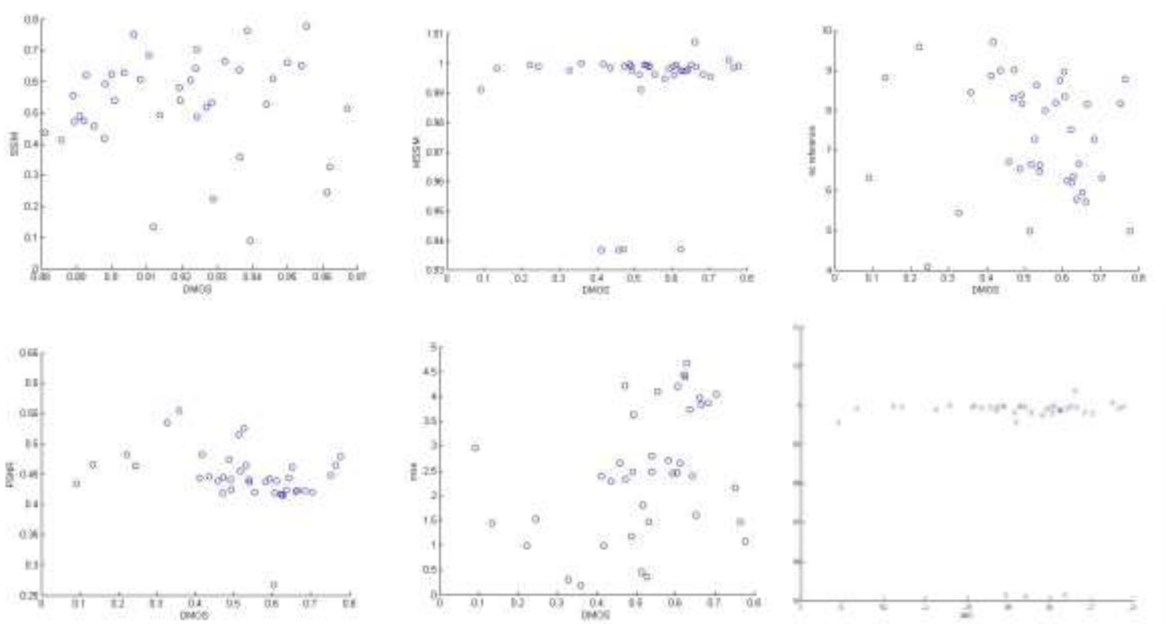
6	0.134211	lunch_blur2_jpeg1	4.0377	0.4207	0.9786	0.9957	0.9242	0.9754	6.3042
7	0.517368	Market							
7	0.536842	market_blur1	1.4437	0.4654	0.9923	0.9985	0.9119	0.9601	8.8108
7	0.581579	market_blur1_jpeg1	1.8024	0.4557	0.9561	0.9912	0.9269	0.9518	6.6361
7	0.091053	market_blur2	2.7192	0.4379	0.9752	0.995	0.9192	0.9457	8.1848
7	0.222632	market_blur2_jpeg1	2.9629	0.4341	0.9554	0.9911	0.9394	0.9445	6.3097
8	0.776842	palace2							
8	0.764737	palace2_blur1	0.9889	0.4818	0.9975	0.9995	0.9288	0.9971	9.5837
8	0.772632	palace2_blur1_jpeg1	1.0759	0.4781	0.9961	0.9992	0.9554	0.996	4.9744
8	0.243684	palace2_blur2	1.4719	0.4645	0.9932	0.9986	0.9386	0.9951	8.7893
8	0.435263	palace2_blur2_jpeg1	1.5245	0.463	0.9957	0.9991	0.9612	0.9945	4.0853
9	0.592632	Railwaystation							
9	0.554737	railwaystation_blur1	2.2824	0.4455	0.9936	0.9987	0.8812	0.9949	8.9944
9	0.606316	railwaystation_blur1_jpeg1	2.4461	0.4425	0.9906	0.9981	0.8982	0.9947	8.7405
9	0.124211	railwaystation_blur2	4.09.5	0.4201	0.9809	0.9962	0.889	0.993	7.9861
9	0.437368	railwaystation_blur2_jpeg1	4.2098	0.4189	0.9801	0.996	0.9081	0.9875	8.3429

Scatter plots of the different results are given below. From all these scatter plots, we can easily visualize that wavelet based MSSIM out performs the other conventional image quality assessment techniques used in the past. Based on the value of objective scores (DMOS), we have plotted the scatter diagrams. From the scatter diagrams we have noticed that the wavelet based MSSIM has better correlativity than any other quality metrics. The data points are densely scattered in Improved MSSIM where as in other quality metrics, the data points are sparsely scattered.

Plots revels that more closely the points come to a best fit a single straight line, correlation is said to be more perfect and in scatter diagrams, we have seen that only the wavelet based MSSIM approaches to perfect correlation. And in other metrics the points are sparsely scattered and hence poor correlativity with DMOS.



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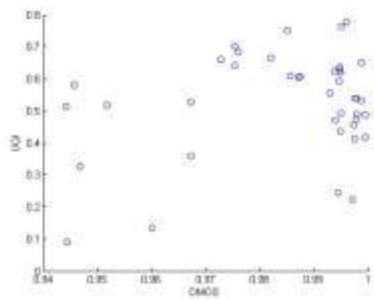

Conclusion

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In this paper, we have summarized the traditional method of image quality assessment which are based on error sensitivity and its limitations in images. We have also discussed about the structural approaches of image quality measurement. We demonstrate the disadvantages of traditional approach. Our paper introduces wavelet decomposition to access image quality. Experiments results indicate that proposed method is better correlated with HVS and gives comparable results to MSSIM

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