Optimized Quality Evaluation Approach of Toned Mapped Images Based on Objective Quality Assessment

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Abstract

Conversion of High dynamic range images to Low dynamic range images is still an area of concern in Image processing domain. The Tone mapped Operators are one such operators used to convert HDR to LDR for better visualization in practical Standard LDR displays. There is wide variety of Tone mapped images for wide variety of practical applications, so which Tone mapped operator (TMO) is best, so without an appropriate analysis and quality measurement, comparison of Tone mapped operators cannot be done. In order to perform this comparison, subjective rating approach is best assessment method, though its performance is outstanding its quite expensive and more time consuming one, moreover, precisely when come to optimization frameworks its quite difficult to embedded. Here, the proposed Algorithm proposes a novel Quality measurement Algorithm for TMOs i.e. Objective quality assessment algorithm by combining the Modified structural similarity index values and natural images statistics values. The proposed tone-mapped image quality index (TMQI) has good correlation as in subjective ranking score.

Introduction

From the last 60 years lot of development happened in image processing domain and in its applications criteria. One such application criteria is HDR (high dynamic range) images, whose intensity levels are very high, naturally in the range of 10000 to 1. The accurate depiction of luminance difference in real scenes allows HDR images, for example range (ranging) between absolute sun light to swoon starlight. HDR images is always area of research in the field of image processing and graphical tools, by this availability of HDR images are quite easy now a days. Normally a problem arises when visualizing the HDR images in Standard displays that
An innovative and alternative to Subjective analysis is proposed in this algorithm i.e. Objective quality assessment approach, when compare the experimental results based on the Objective approach both test and reference show good dynamic range intensity values. Only few Objective quality assessment methods are proposed till now for HDR images. In order to visualize the super threshold distortion and sub threshold distortion a predictor named HDR visible difference prediction method (VDP) is proposed. HDR VDP is designed to compare the two HDR images but not for the comparison of HDR images to LDR images.

Later, HDR VDP improves by using the independent approach in a dynamic range and this approach produces quality maps in three distinctive categories i) loss of visible features ii) invisible features amplification iii) contrast polarity reversal. These different quality maps when compare with subjective approach it gives good correlation of image distortion, image sharpening, blur etc, but it cannot provide the overall quality score for the entire image at a time.

Using the HDR images as references, a novel framework for assessment of quality of tone mapped images done based on

gives scope to design of LDR images, which makes the visualization an ease to human visual system. The conversion of HDR images to LDR is not an easy task, high intensity values should change to low intensity values in order to perform this task in innovative way, lot of Tone mapping operators are came into existence.

Every TMO has its own pro’s and con’s, without knowing its main approach no TMO is compared with another TMO for quality assessment. The main drawback facing while usage of TMO’s is loss of information which changing the high intensity values of HDR images to low intensities of LDR images, So naturally a question arises which TMO is best for preserving the original information and made high intensity values suitable to standard displays. As discussed in literature many TMO’s are compared with each other based on factors like brightness, contrast, illuminance etc. The approach is mainly based on subjective analysis which is quite expensive and time consuming. The loss of information is mainly critical issue which is not observed by users in experiments, so subjective analysis is not an favorite method for quality assessment of Toned mapped images.
objective approach. The proposed method achievement mainly relies on two innovative design principles one is SSIM and later one is Natural scene statistics (NSS). The proposed method combines the structural fidelity based on multi scale approach and measurement of statistics of natural scene leading to tone mapped image quality index (TMQI). Optimization of parameters is done in a simple way by TMQI an it fuses the images in Adaptive way.

**EXISTING METHOD:**

**Contourlet in Image Quality Assessment**

In this project, it first study Contourlet transform in IQA. Contourlet is employed to decompose image into different scales and direction subbands, and then contrast sensitivity function (CSF) masking is applied to obtain same visual sensitivity information within an image. Thereafter, based on the properties of human vision systems (HVS), we define a rational sensitivity threshold, and, with this threshold, compute visual sensitivity coefficients in each subband. Finally, evaluation measurement of distorted images is built by comparing the computed coefficients between original and distorted images. It is shown in fig.

**Fig:** Image decomposition with the contourlet transforms.

**Assessment of quality**

During the process of conversion of HDR images to LDR images, Toned mapped operators cannot preserve all the information in HDR images because of sudden reduction in dynamic range. While viewing the particular LDR images by human visual system this loss of information can’t be observed. For making the LDR images to human visual system in a pleasant way Structural similarity index matrix (SSIM) plays a critical role. On the later end, Structural fidelity does not give whole quality measurement; therefore it cannot alone sufficient to provide overall quality measurement. In order to provide a visually good quality LDR image a unique combination of preservation of structural similarity statistics and naturalness’ statistics must be needed, but combing this two critical factors (structural similarity statistics
and naturalness statistics) is still a complex factor (in some cases).

**Structural similarity index matrix (Structural fidelity)**

Measurement of structural similarities between two different images for accurate quality measurement needs novel techniques to in order to perform this innovative task, one such a technique is proposed in literature is Structural similarity index matrix (SSIM). Structural fidelity mainly applied on local features and the comparison between three main components mainly luminance, contrast and brightness. Since Toned mapped operators are intended to change the intensity of local features and contrast. So it is unacceptable to compare the intensity of local features and contrast. So let us consider the typical example of structural fidelity, let take two patches ‘x’ and ‘y’ from HDR image and as well as LDR image respectively. Then the structural fidelity measuring between these two patches is given as

\[
S_{local}(x,y) = \frac{2\sigma_x'\sigma_y' + C1}{\sigma_x'^2 + \sigma_y'^2 + C1} \cdot \frac{\sigma_{xy} + C2}{\sigma_x\sigma_y + C2}
\]

Where local standard deviations and the HDR image patches cross correlation with LDR image patches is given as \(\sigma_x',\sigma_y'\) and \(\sigma_{xy}\), and \(C1, C2\) are positive stabilizing constants. Here in comparison process luminance part is missing while comparison in SSIM, the signal strength based on SSIM is further modified based on two innovative considerations, one is difference of HDR image patches to LDR image patches signal strength is correct by calculations getting on two results, one is above threshold and another is below threshold (both must be significant) and the second case is where one image patch is significant and the second one is in significant. Original SSIM is quite different from the modified one as shown in above discussion.

In order to know the difference between the significant image patches from the insignificant image patches, as shown in equation Sigma parameter and sigma transpose parameter we derive the significant values to 1 and insignificant values to 0. This particular process is called non linear mapping and the non linear mapping tends to visualize the fixed threshold in contrast feature, but Human visual system does not have any fixed threshold length for contrast feature in practical. Now in order to know the significant and insignificant image patches a
detection probability is needed and that detection probability is Psychometric function. This psychometric function evaluates the 50% of detection probability; most commonly used detection probability function is normal cumulative distribution function. The normal cumulative distribution function is given by

\[ p(s) = \frac{1}{\sqrt{2\pi} \theta_s} \int_{-\infty}^{s} \exp \left[ -\frac{(x - \tau_s)^2}{2\theta_s^2} \right] dx \]

Where \( p \) is the function of detection probability, \( s \) is sinusoidal stimulus amplitude and \( \tau_s \) is modulation threshold and \( \theta_s \) is the standard deviation of normal distribution that controls the continuous variation is detection probability function, and the ratio is given as

\[ k = \frac{\tau_s}{\theta_s} \]

According to the Crozier's law, the K term in equation represents a constant, and its range is in between 2.3 to 4, and if the value is 3 then the probability of occurrence of false detection is low and it is considerably low. Contrast sensitivity function is one function that collects all data which is psychological functions is used to know the visual contrast sensitivity.

\[ A(f) \approx 2.6[0.0192 + 0.114f] \exp \left[ -(0.114f)^{1.1} \right] \]

Where \( f \) denotes the spatial frequency, this function is normalized have peak value 1, thus provides the relative sensitivity function of frequency function. In our proposed framework usage of Kelly CSF measurement function combining the Kelly CSF function with above equation we got as follows

\[ \tau_s(f) = \frac{1}{\lambda A(f)} \]

By using the above equation, calculation of contrast threshold function is done assuming the pure sinusoidal stimulus. In order to convert it to the signal strength, two factors taken into account. one contrast sensitivity and later is mean signal intensity, for this signal strength threshold is measured using the standard deviation of the signal. And the threshold value measured on standard deviation of signal is calculated as follows

\[ \tau_s(f) = \frac{\bar{\mu}}{\sqrt{2\lambda A(f)}} \]

Where \( \bar{\mu} \) mean intensity value is obtained by combing the mean signal intensity and
standard deviation, then based on crozier's law equation is as follows

$$\theta_\sigma(f) = \frac{\tau_\sigma(f)}{k}$$

Then, we can mapping can be between sigma and sigma transpose is done as follows

$$\sigma' = \frac{1}{\sqrt{2\pi \theta_\sigma}} \int_{-\infty}^{\infty} \exp \left[ -\frac{(x - \tau_\sigma)^2}{2\theta_\sigma^2} \right] dx$$

Then the mapped versions of sigma and sigma transpose in x and y patches are evaluated by 0 and 1. 0 represents the insignificant value and 1 represents the significant value. Visibility of image depends on the distance between the image the resultant observer and this distance is calculated based on the sampling density of the image. Based on the capability of human visual system multi scale approach is introduced in order to evaluate the weighted SSIM values and the to down sampled the image by low pass filtering method and then create the pyramid structure. By using the two different TMO’s on HDR image and on LDR image local structural fidelity map is generated. In this process loss of information may attain in LDR image compared to the HDR image, in some scenarios bright regions may miss, in some regions dark regions may miss, but it cannot be observed in LDR image. Then single score attain by pooling algorithm is as follows

$$S_l = \frac{1}{N_l} \sum_{i=1}^{N_l} S_{local}(x_i, y_i)$$

Where xi and yi are HDR and LDR image patches. Where Nl is the number of patches. Then overall structural fidelity is attained by combining the scale fidelity score is as follows

$$S = \prod_{l=1}^{L} S^R_l$$
First the structural fidelity performance is measured. Second the fidelity is checked at each stage and then by using the window overall standard deviation is obtained. Third distance of image from resultant user is measured by applying the CSF. Fourth main intensity values are attained by setting the mean of dynamic range of LDR image values. Then by combing all this measures we get overall psychological experiments. In order to perform this on RGB image it has to convert to Yxy space using the Y component.

**Statistical quality assessment (natural scene)**

The high quality of LDR images does not mean that it has all information same as in HDR image. Subjective approach has more drawbacks regarding cost of process and time consuming while processing on contrast, brightness etc. By using Objective approach we can get better correlation than subjective it can be compared with subjective approach, in naturalness of scene in HDR to LDR is evaluated as follows

\[
P_m(m) = \frac{1}{\sqrt{2\pi\sigma_m}} \exp \left[ -\frac{m - \mu_m}{2\sigma_m^2} \right]
\]

Above equation the intensity and contrast values which is used for quality measurement of global contrast and intensity values of tone mapping images, Then HDR to LDR in natural scenes is evaluated as follows as

\[
P_d(d) = \frac{(1 - d)^{\beta d^{-1}} d^{a_d - 1}}{B(a_d, \beta_d)}
\]

And the statistical measurement is as follows

\[
N = \frac{1}{K} P_m P_d
\]

**Quality assessment model**

In much wide variety of applications, users preferred the single score by combining the overall score, IQA (Image quality assessment) is measured as follows

\[
Q = aS^\alpha + (1 - a)N^\beta
\]

Alpha and beta parameters play a crucial role in quality assessment. The objective assessment is innovative method which overcomes the all drawbacks we faced in literature, and by using the innovative methods quality assessment of images is done in ease way by IQA.
Simulation Results and analysis

The Structural fidelity is done in multi scale approach as shown in following figures, here ‘S’ is total multi scale score and ‘s1’ ‘s2’ ‘s3’ ‘s4’ ‘s5’ are number of multi scales used in Structural fidelity. ‘Q’ is total quality score and where as ‘N’ is scene naturalness. The objective approach mainly relies on structural fidelity “S” and Scene naturalness measurement “N”.
Applications

(1) Benchmarking and Monitoring Applications

(2) Signal and image processing

(3) Computer vision

(4) Visual psychophysics
(5) Neural physiology
(6) Information theory
(7) Machine learning
(8) The image acquisition, communication, and display systems.

Conclusion

The proposed method is proposed based on the objective quality assessment approach, basically objective quality approach is proposed on gray scale images but HDR images is taken in Color spaces. The objective quality assessment approach is mainly relies on two methods, first multi scale structural fidelity and second one is scene naturalness. First the structural fidelity performance is measured. Second the fidelity is checked at each stage and then by using the window overall standard deviation is obtained. Third distance of image from resultant user is measured by applying the CSF. Fourth main intensity values are attained by setting the mean of dynamic range of LDR image values.

Then by combing all this measures we get overall psychological experiments. In order to perform this on RGB image it has to convert to Yxy space using the Y component. Every time we cannot process TMO’s on after visualization, for example in
medical images, images are often taken in HDR images, so in that we process before visualization. In order to apply TMO’s in all applications, optimization methods are adapted for this type of scenarios. The proposed method gives good quality score compared to previous objective approach in grayscale images and it is more reliable than available subjective approach.

**Extension**

Quality assessment of images is quite different from quality assessment of videos, because image is a collection of pixels and moreover it’s static in behavior, while videos are collection of frames and its motion in behavior. The proposed method proposes the quality of Image; extension can be done on quality assessment videos. Quality measurement of videos is a huge task as it includes frame rate, psnr values, frame separation, noise detection etc.

Assessment of videos is a time consuming process, as video size increases simultaneously time to read all frames in a video also increases. Till now assessment of videos is done on subjective approach, which is quite expensive and time consuming, so in near future extension of proposed method done on videos in objective approach which is more reliable.

**References**


