Image Performance Tuning Using Contrast Enhancement Method with Quality Evaluation

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ABSTRACT:

Quality of an image plays a very crucial role in various image processing applications such as, recognition, identification, transmission etc. Therefore identifying the quality of an image is very necessary in such areas. Restoration of the good image from a degraded image will improve the quality of the image. The purpose of this paper is to find the quality value of an image using a new metric after some preprocessing steps. Here one particular type of image distortion taken into account that is contrast change and enhancing the contrast using an additive gamma correction method. After this preprocessing the quality value is found using a new image quality assessment metric called normalized perceptual information distance. For this metric, the main concept used is kolmogorov complexity and normalized information distance.

Keywords: *Contrast enhancement, Image quality assessment, gamma correction, normalized information distance, kolmogorov complexity.*

I. INTRODUCTION

Image quality has an important role in many image processing applications mainly in the case of recognition. Quality of an image can be degraded because of the presence of various distortions like blur, contrast change, noise, blocking artifacts etc. A low quality or degraded image may not match with the existing image in the database. So image quality measurement is important. In the above case if some preprocessing is done to remove some distortions, then it will increase the image quality. A quality measurement method is the used to measure the image quality.

For measuring the quality, image quality assessment (IQA) algorithms are used. These IQA methods are classified into three, 1) no reference 2) reduced reference and 3) full reference [1]. In no reference method, only distorted image will be available. No information about the original image is given. Because of this, blind calculation of the image quality is possible. In the case of reduced reference method, a portion of the original reference image will be available whereas, in full reference, a full original image will be given. The quality metric can be calculated by comparing distorted image with the original image. In full reference approach, many quality metrics are available for calculating the quality. Structural similarity index measure (SSIM) [1], visual information fidelity (VIF) [2], visual signal to noise ratio (VSNR) [3] etc. is some of the full reference methods.

This paper investigating a full reference image quality assessment metric based on kolmogorov complexity and normalized information distance (NID) [7]. These two concepts are rarely been studied in the field of image processing. As a new method of introducing kolmogorov complexity in image quality assessment, it shows comparable performance with the other existing methods.

One particular type of distortion usually present in images is contrast change. This may occur due to the bad lighting condition or because of the camera problem. In this paper we combined a preprocessing method for image contrast enhancement with the quality metric calculation. There are many methods available for contrast enhancement. Here, contrast enhancement based on gamma correction and a weighting distribution function is used. A normalization function is also applied to the enhanced image to improve the quality of the image.

This paper is organized as follows. In section 2, contrast enhancement method using additive gamma correction (ACG) [4] is explained. This contrast enhancement method is taken as a preprocessing step and embedded to the final image quality assessment framework. In section 3, a full reference image quality measurement based on kolmogorov complexity and normalized information distance [6] is explained. In section 4, the results after implementing this method are given. Finally, in section 5, conclusions are described.

II. CONTRAST ENHANCEMENT USING ACG

The problem with most of the contrast enhancement methods is their high computational time and cost. The proposed approach is resolving this problem. In ACG method [4], the densely associated pixels in the input dimmed image are smoothened by using a weighting distribution. The flow chart for ACG is given in Fig. 1.

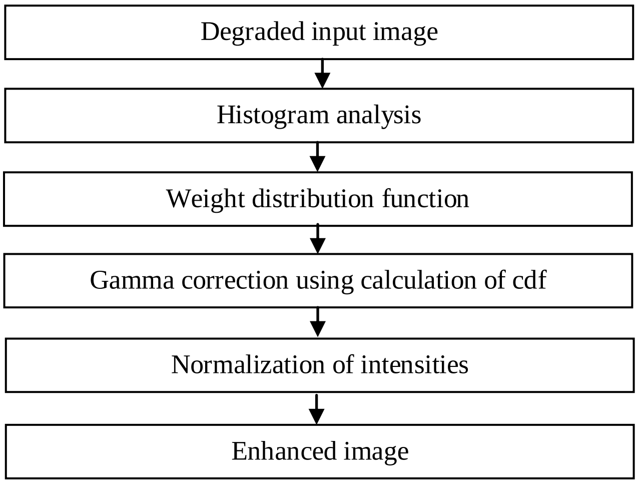

Fig. 1 Flow chart of the AGC method

Firstly, a dimmed image is given as input to this method. Histogram analysis can be done to see the densely oriented pixels. The gamma correction function used here is,

$$T(l) = l_{max}(l/l_{max})^{\gamma} = l_{max}(l/l_{max})^{1-cdf(l)} \tag{1}$$

where l_{max} gives the maximum intensity of the dimmed input image. $T(l)$ represents the transformed intensities of the dimmed image after gamma correction. This gamma correction method includes cdf calculation. For cdf calculation, probability density function (pdf) has to be calculated. A weighting distribution function is using here for pdf calculation. This will modify the histogram and decrease any adverse effects. The weighting distribution function is,

$$pdf_w(l) = pdf_{max}\left(\frac{pdf(l) - pdf_{min}}{pdf_{max} - pdf_{min}}\right)^{\beta} \tag{2}$$

where pdf_{max} is the maximum pdf and pdf_{min} is the minimum pdf. α is the adjusting parameter. This can be used to find cdf as follows,

$$cdf_w(l) = \sum_{l=0}^{l_{max}} pdf_w(l) / \sum pdf_w \tag{3}$$

sum of pdf_w is calculated as follows,

$$\sum pdf_w = \sum_{l=0}^{l_{max}} pdf_w(l) \tag{4}$$

This can be applied in Eq. 1 to get the transformed intensities. While implementing this algorithm, first the image is converted into HSV. Here H and S contain the color information. We are preserving the color information and changing only value V. Sometimes the output enhanced image may be appeared as whitish after gamma correction. In order to solve this problem, a normalization of the intensity levels of the output image is used. Equation for that is given in Eq. (2.6).

$$I'_j = ((w \times I_j) + T(I_j))/(w+1) \tag{5}$$

where I_j are original intensities of the input image. $T(I_j)$ are the intensities produced after gamma correction. *w* is the non negative weight. w is selected based on the improvement in the quality.

III. IMAGE QUALITY ASSESSMENT USING NPID

The problem with most of the contrast enhancement methods is their high computational time and cost. The overall architecture of the proposed approach is given in Fig. 2.

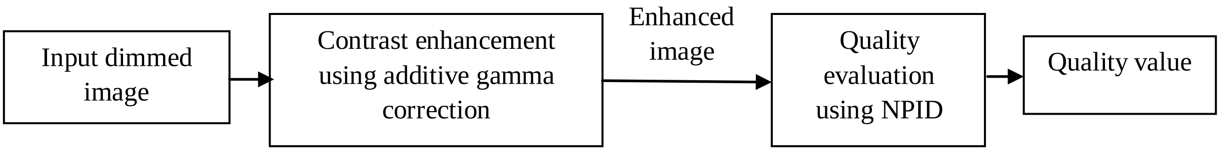

Figure 2. Flow chart for the proposed system

Contrast enhancement method is described in section 2. For quality evaluation using NPID [6], important mathematical concepts used are kolmogorov complexity and normalized information distance (NID). These two concepts are rarely studied in the context of image processing. Kolmogorov complexity [8] is a non computable concept. General equation for NID is,

$$NID(P,Q) = \frac{\max\{K(p|q^*), K(p|q^*)\}}{\max\{K(p), K(q)\}} \tag{6}$$

where $K(p|q^*)$ is the kolmogorov complexity of two objects x and y. For the implementation of NPID metric, first transform the original and the reference image into the wavelet domain. The two images are decomposed into subbands in that domain. Particular type of wavelet transform used here is 5 scale laplacian pyramid transformation [11]. Then kolmogorov complexity can be formulated as,

$$K(p|q) = \sum_{i=1}^{n} K(p_n|q_n) \tag{7}$$

where p_n and q_n are the subbands of reference image and the distorted image. Using this, NID can be calculated as,

$$NID_s(p,q) = \frac{\max\{\sum_{i=1}^{n} K(p_n|q_n), \sum_{i=1}^{n} K(q_n|p_n)\}}{\max\{\sum_{i=1}^{n} K(p_n), \sum_{i=1}^{n} K(q_n)\}} \tag{8}$$

Because of the non computable nature of kolmogorov complexity, NID is also non computable. To solve this problem, kolmogorov complexity can be replaced with Shannon entropy. Shannon entropy gives how much information contained in an image. And also for finding information content, subband can be modeled using a gaussian scale mixture model [9]. So the final formula for finding NPID image quality metric is,

$$NPIS_i = \frac{I(\overrightarrow{M_i}; \overrightarrow{N_i})}{\max\{I(\overrightarrow{M_i}; \overrightarrow{A_i}), I(\overrightarrow{N_i}; \overrightarrow{A_i})\}} \tag{9}$$

Let $\overrightarrow{A_j} = (\overrightarrow{A_1}, \ldots\ldots, \overrightarrow{A_N})_j$ are the N elements of subband A_j, and $\overrightarrow{M_j}$, $\overrightarrow{N_j}$ are defined in the same way. Information content between the subbands can be calculated as [10],

$$I(\overrightarrow{A_j}; \overrightarrow{M_j}) = \frac{1}{2} \sum_{i=1}^{N} \sum_{k=1}^{K} \log_2 \left(1 + \frac{s_i^2 \lambda_k}{\sigma_n^2}\right) \tag{10}$$

$$I(\overrightarrow{A_j};\overrightarrow{N_j}) = \frac{1}{2}\sum_{i=1}^{N}\sum_{k=1}^{K} log_2\left(1 + \frac{g^2 s_i^2 \lambda_k}{\sigma_n^2 + \sigma_v^2}\right) \quad (11)$$

$$I(\overrightarrow{M_j};\overrightarrow{N_j}) = \frac{1}{2}\sum_{i=1}^{N}\sum_{k=1}^{K} log_2\left(\frac{[g^2 s_i^2 \lambda_k + (\sigma_n^2 + \sigma_v^2)](s_i^2 \lambda_k + \sigma_n^2)}{[(\sigma_n^2 + \sigma_v^2)s_i^2 + \sigma_n^2 g^2 s_i^2]\lambda_k + \sigma_n^2(\sigma_n^2 + \sigma_v^2)}\right) \quad (12)$$

To calculate the information content estimation of the parameters g, s, σ, λ are important. These parameters are calculated based on the information from [6].

IV. RESULT ANALYSIS

The proposed algorithm is applied on the images in CSIQ (Categorial Image Quality) database [5]. This database is publicly available for download. The database contains 866 distorted images for 30 reference images. Different types of distortions include contrast change, jpeg compression, noise, blur etc. Each distortion is at four to five distortion levels.

Figure. 3. Some of the reference images present in CSIQ database

Figure 4. Five levels of contrast change for child_swimming image in CSIQ database and its corresponding contrast enhanced images.

For the proposed approach, contrast change distortion is taken into account. For each image, five levels of contrast change is there in the database. For each level, contrast enhancement is done, and to the enhanced image, the quality metric is applied. The result obtained after performing the contrast enhancement for some of the images in the CSIQ database is given in Fig. 4.

The quality metric values obtained for the enhanced images after performing the image quality assessment algorithm based on normalized perceptual information distance (NPID) is given in Table 1.

Table 1. Results obtained before and after performing the algorithm to the images in CSIQ database

Image name	1st level		2nd level		3rd level		4th level		5th level	
	before	after	before	after	before	after	before	after	before	after
1600	0.9057	0.7675	0.8963	0.8037	0.8419	0.8454	0.8194	0.8477	0.8194	0.8473
Aerial_city	0.8886	0.7273	0.8488	0.7712	0.7495	0.8261	0.7083	0.8222	0.7083	0.8222
boston	0.8921	0.7043	0.8433	0.755	0.7084	0.8059	0.6277	0.7868	0.6277	0.7868
bridge	0.9115	0.6655	0.8948	0.6812	0.8582	0.7071	0.8398	0.7207	0.8398	0.7207
butter_flower	0.9014	0.7324	0.8653	0.7815	0.7245	0.7909	0.6913	0.7241	0.6913	0.7241
child_swimming	0.8934	0.6295	0.8461	0.6854	0.7107	0.7567	0.646	0.7489	0.646	0.7489
couple	0.9201	0.6138	0.9013	0.6301	0.8568	0.6538	0.8377	0.6607	0.8377	0.6607
family	0.8824	0.7255	0.8476	0.7668	0.7739	0.8239	0.724	0.8275	0.724	0.8275
lake	0.9145	0.7257	0.8861	0.7673	0.8182	0.8253	0.7893	0.8363	0.7893	0.8363
log_seaside	0.9161	0.5775	0.8969	0.5946	0.8523	0.6202	0.835	0.6269	0.835	0.6269
monument	0.9154	0.651	0.8958	0.6729	0.8518	0.7116	0.8378	0.7216	0.8378	0.7216
native_american	0.9069	0.6664	0.8839	0.6863	0.8325	0.7156	0.8098	0.7229	0.8098	0.7229
redwood	0.9032	0.7592	0.8761	0.7904	0.8099	0.8351	0.7869	0.8413	0.7869	0.8413
roping	0.9031	0.7203	0.8765	0.7557	0.8172	0.8049	0.782	0.8147	0.782	0.8147
rushmore	0.9054	0.4891	0.8814	0.507	0.8282	0.5347	0.8064	0.543	0.8064	0.543

Results from the above figure shows that the contrast enhancement function works well if the image quality lies in the range less than 0.8. If the quality value is greater than 0.8 then enhancing the image may decrease the image quality.

V. CONCLUSIONS

In this paper, we combined the performance tuning of images with quality evaluation. Major two steps performed in the proposed method is contrast enhancement using additive gamma correction and quality metric calculation using normalized perceptual information distance. The algorithm is implemented on publicly available CSIQ database and the results are obtained. If the quality is very poor, the contrast enhancement works well and quality is improved in a good manner. If the image is of good quality, then no change is needed. This work can be extended for finding the quality of video after performance tuning of video frames.

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BIOGRAPHIES

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