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Histogram based perceptual quality assessment method for color images

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ABSTRACT

A histogram based perceptual quality assessment (HPQA) method for color images is presented in this paper. Basically, the HPQA combines two quality assessment approaches (color image quality assessment and histogram based image quality assessment) and it uses the fourier transform. Its range is between 0 and 1. 1 represents the best quality result, 0 represents the worst quality result for the HPQA. The HPQA results are more suitable than its counterparts in terms of the HVS and they can be obtained faster than the other methods' results. In addition, it can easily differentiate effects of low distortions on color images.

1. Introduction

After digital images are acquired, they are subjected to many processing or manipulations for various reasons (compression, data hiding, acquisition, coding, etc.). Image quality assessment (IQA) methods play a very essential role in almost all aspects of multimedia signal processing operations. An image can be used for visual browsing, for medical diagnosis or for extracting information via machine learning methods. The amount of measured distortion in an image may have rather different interpretations with respect to different applications and determines whether the given image has the required amount of quality to be useful for the application at hand. Therefore, it is important to develop application specific IQA methods [1–5]. An important issue in evaluation of digital image processing algorithms is to define reliable IQA methods to estimate quality.

A diagnostic image quality assessment method measures the quality of the image for the purpose of medical diagnosis. Likewise, remote sensing imagery is used to estimate some of the relevant parameters for the analysis of its content. Unbounded errors in pixel values due to compression may lead to unacceptable estimation errors in subsequent analysis. A measure used successfully in an application may provide rather poor results in a different application. Therefore, the design of an application specific IQA method is rather important.

A fundamental task in many image processing applications is the visual evaluation of a distorted image. There are many measures for examining image quality, such as Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), PSNR-HVS-Modified [1], Structural SIMilarity (SSIM) [2], MultiScale-Structural SIMilarity (MS-SSIM) [3], Universal Quality Index (UQI) [4], and so on. The simplest and the most widely used full-reference IQA method is the MSE. It is computed by averaging the squared intensity differences of distorted and original image pixels, along with the related quantity of the PSNR. Although the PSNR is mostly used in the literature, it is not very well matched with the perceived visual quality [5].

The PSNR-HVS-M had been designed to improve the performance of the PSNR and the MSE. It divides the image into 8×8 pixels non-overlapping blocks. Then, the Discrete Cosine Transform (DCT) based $\delta(i, j)$ is calculated. After that $\delta(i, j)$ difference between the original and the distorted blocks is weighed for every 8×8 block by the coefficients of the Contrast Sensitivity Function (CSF) [1]. The SSIM has followed a strategy of modifying the MSE measure so that errors are penalized in accordance with their visibility. It compares local patterns of pixel intensities that have been normalized for luminance and contrast [2]. The MS-SSIM is layered on the SSIM. The algorithm calculates multiple SSIM values at multiple image scales (resolutions). By running the algorithm at different scales, the quality of the image is evaluated for different viewing distances. MS-SSIM also puts less emphasis on the luminance component compared to the contrast and structure components. In total, MS-SSIM has been shown to increase the correlation between the MS-SSIM index and subjective quality tests. However, the trade-off is that the MS-SSIM takes longer to run than the straight

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0920-5489/

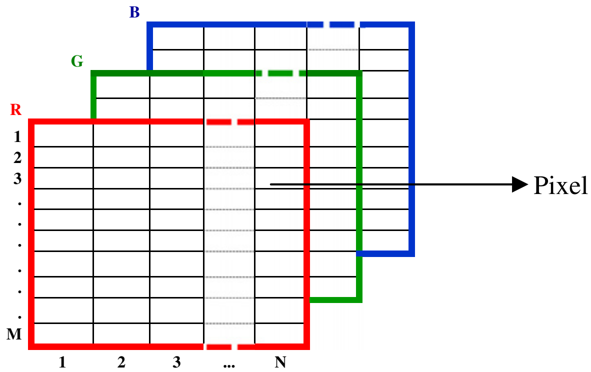

Fig. 1. Digital color image structure.

SSIM algorithm [3]. The UQI has been designed by modeling any image distortion as a combination of three factors: loss of correlation, luminance distortion, and contrast distortion [4]. It is not based on Human Vision System (HVS).

In addition to the IQA methods presented above, much attempt has gone into the development of IQA methods that take advantage of well-known characteristics of the HVS in the last decade [6]. Sparking from these facts, the proposed histogram based perceptual quality assessment (HPQA) method offers a new strategy for qualifying of the color images. The HPQA combines two image quality measurement approaches. The first one is HVS based color image quality measure approach [7] and the second one is histogram based image quality measurement approach [8]. In contrast to these approaches' classical view, the processes are realized on the Fourier Transform (FT) domain because it is seen that magnitude values of the FT coefficients present more suitable results for the HVS.

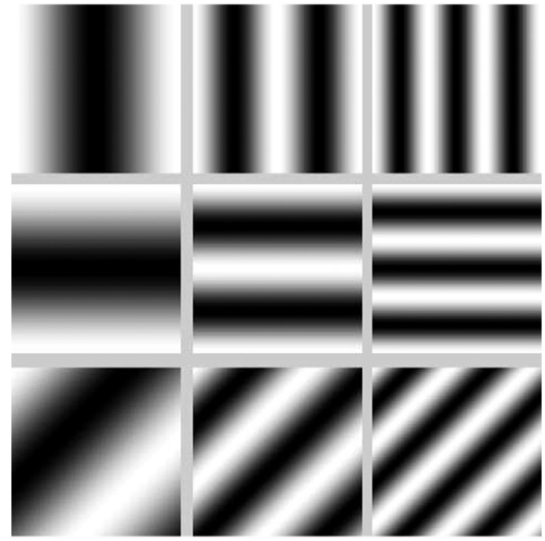

Fig. 3. Sample 2-D Fourier basis images.

The rest of the paper is organized as follows. In Section 2, YUV transformation, the Fourier Transform (FT) and image histogram are briefly introduced. The proposed method's details are explained in Section 3. Section 4 presents experimental results and comparisons with the previous works. The paper is concluded in Section 5.

2. Some preliminaries

2.1. YUV transformation

A classical digital color image is represented with a 3-dimensional array composed of M rows, N columns and 3 channels (R, G and B).

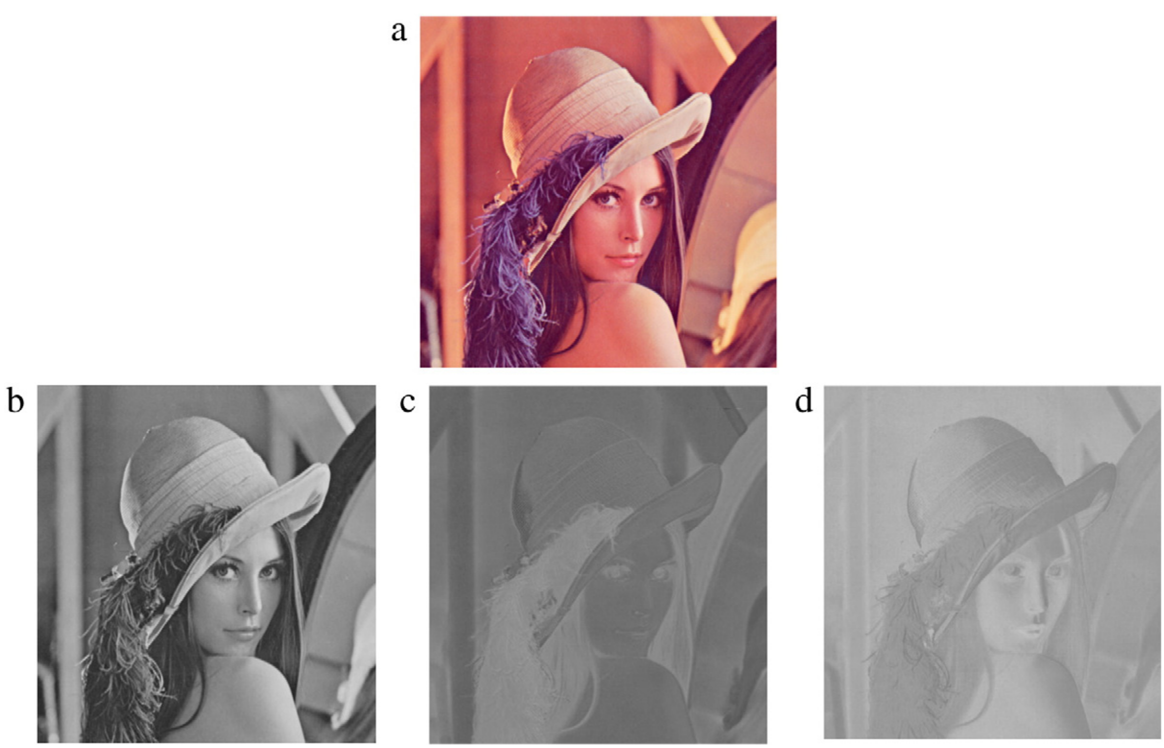

Fig. 2. An RGB image (a) and Y (b), U (c) and V (d) channels.