Signal Processing 89 (2009) 1647–1652

Contents lists available at ScienceDirect

Signal Processing

journal homepage: www.elsevier.com/locate/sigpro

Fast communication

No-reference visually significant blocking artifact metric for natural scene images

Shan Suthaharan *

Department of Computer Science, University of North Carolina at Greensboro, Greensboro, NC 27412, USA

ARTICLE INFO

Article history:
Received 27 August 2008
Received in revised form
21 January 2009
Accepted 17 February 2009
Available online 24 February 2009

Keywords:
Natural scene images
JPEG compression
Neural channels
Blocking artifacts

ABSTRACT

Quantifying visually annoying blocking artifacts is essential for image and video quality assessment. This paper presents a no-reference technique that uses the multi neural channels aspect of human visual system (HVS) to quantify visual impairment by altering the outputs of these sensory channels independently using statistical "standard score" formula in the Fourier domain. It also uses the bit patterns of the least significant bits (LSB) to extract blocking artifacts. Simulation results show that the blocking artifact extracted using this approach follows subjective visual interpretation of blocking artifacts. This paper also presents a visually significant blocking artifact metric (VSBAM) along with some experimental results.

1. Introduction

We can find several block impairment metrics in the image and video processing literature, however, only very few metrics are no-reference (NR) metrics. The NR-metrics assume no knowledge of the original image when estimating the blocking artifacts. Most recently, authors of paper [1] considered eight NR-metrics and presented extensive comparison results. They compared the following eight NR-metrics: mean squared difference of slope (MSDS) [2], boundary discontinuity metric (BDM) [3], phase correlation (PCM) [4], blocking artifact metric (BAM) [5], generalized block impairment metric (GBIM) [6], power spectrum metric (PSM) [7], DCT-step metric (DSM) [8] and perceptually significant block impairment metric (PSBIM) [9]. The first metric MSDS uses a new concept called "mean square difference slope" which characterizes the level of block-edge artifact as a change in the intensity slope along the block boundaries. BDM defines the block-edge artifact using the shape of the blocky noise and the discontinuity along the block boundary. The minimum mean square error (MSE) is then used to estimate blocking artifacts. PCM uses the phase correlation and defines the block detector metric as a ratio between the measure of inter-block and intra-block similarity [4]. BAM is based on the homogeneous image regions in the compressed image [5]. GBIM uses the intensity changes along the adjacent block boundaries and incorporates contrast masking in the compressed domain. PSM smoothes the power spectrum to extract the frequencies associated with the blocking artifact. DSM uses shifted block concept, edge information in the DC coefficients of shifted blocks and human visual system (HVS) characteristics. PSBIM generates perceptual weights using a stimulus called "gradient image" and then uses these weights to measure the blocking artifacts. The experimental results in [1] show that the quality metric GBIM performs better than others by satisfying most of the expectations that they defined. In recent years significant attention has been given to the quality measurement of natural scene images [10,11]. Most importantly natural scene statistics have been used in the development of a blind quality metric for JPEG2000 compressed images [12]. This paper presents a NR blocking artifacts quantifier (BAQ) for natural scene images and it is presented in Section 2. It consists of

* Tel.: +1 336 256 1122; fax: +1 336 256 0439.
E-mail address: ssuthaharan@uncg.edu

0165-1684/$ - see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.sigpro.2009.02.007

two units. The first unit measures the visibility of distortions as a combination of blocking artifacts and undistorted image edges. This is achieved by using a multi neural channels concept of HVS and the standard score (SS) formula. It is discussed in detail in Section 3. The second unit uses bit patterns of the least significant bits (LSBs) to identify image regions that are affected by JPEG compression. This process is discussed in Section 4. A normalized visually significant blocking artifact metric (VSBAM) is presented in Section 5. The proposed VSBAM is compared with GBIM and differential mean opinion scores (DMOS) in Section 6. A conclusion is presented in Section 7.

2. Proposed model

Natural scene images are formed by several groups of pixels that show closely tight relationships in visual characteristics such as brightness, contrast and color [11]. Hence a JPEG compressed image displays a combination of *primary edges*, *undistorted image edges* and *blocking artifacts*, where blocking artifacts consist of *distorted image edges* and *block edges*. Hence mathematically we can write

$$CE = PE + UE + BA \quad \text{and} \quad BA = DE + BE$$

where *CE*, *PE*, *UE*, *DE*, *BE* and *BA* represent edges in a compressed image, primary edges, undistorted edges, distorted edges, block-edges and blocking artifacts, respectively. The terms primary, undistorted, distorted and block edges are defined as follows:

- *Primary edges*: The edges that are derived from the DC-only image which is constructed using only DC values of iterative blocks of size 8×8 pixels as described in [8]. These edges primarily provide global description of the image and they are not affected by the compression schemes.
- *Undistorted edges*: The edges that are not primary edges as well as not affected by the compression scheme. These edges primarily provide local description of the image and they are not affected by the compression schemes.
- *Distorted edges*: They are mainly present in high activity areas (such as the image regions with high statistical variance) and along the sharp edges (such as high contrast edges).
- *Block edges:* They are mainly present in less activity areas (such as the image regions with medium or low statistical variance) and homogeneous areas (such as the image regions with near zero statistical variance).

The goal of this paper is to estimate *PE* and *UE* and then filter them out from *CE* to obtain an estimate for *BA*. Fig. 1 illustrates the proposed BAQ approach to estimate blocking artifacts. It shows two units that are labeled as the visual effect and the physical effect. The *visual effect* unit has two processes. The first process displays both primary and undistorted image edges as well as blocking artifacts. In this process image x is first transformed (*FFT*) into Fourier components X. Then neural channels are generated using different ranges of spatial frequencies. Subsequently Fourier components are modified (X') using the standard score (*SS*) formula in Eq. (1). The second process displays primary edges of the input image. The primary edges are detected using DC-only image y that is generated using the iterative (shifted) blocks of size 4×4 as explained in [8]. The image y is transformed into Fourier components Y and then the same *SS* formula is applied. The modified Fourier components are denoted by Y'. In *iFFT* module, inverse FFT is applied to the absolute difference of X' and Y'. The *physical effect* unit uses the output of *iFFT* module and the bit patterns in the LSBs of the image x to output a BAM. It identifies three types (e.g. see Fig. 2(b)) of bit patterns in the LSBs: (i) blocks with random bit patterns (it is called *random bit blocks*) (ii) blocks with line-like patterns and (iii) homogeneous blocks. It uses the knowledge that the original scene images have more random bit blocks than their compressed images. Subsequently it considers edges in the image regions with random bit blocks as undistorted and filters them out from the output of *iFFT* module.

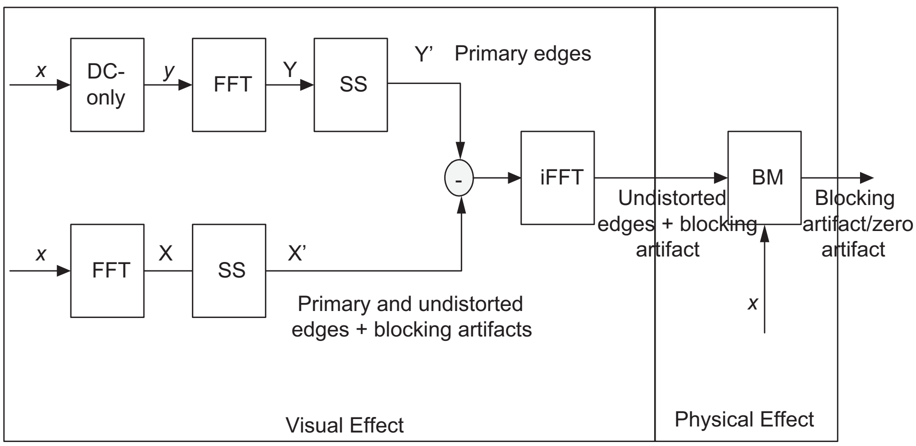

Fig. 1. Processes of the BAQ approach to quantify blocking artifacts.