Chapter 37
A New Image Distortion Measure Based on Natural Scene Statistics Modeling

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ABSTRACT

In the field of Image Quality Assessment (IQA), this paper examines a Reduced Reference (RRIQA) measure based on the bi-dimensional empirical mode decomposition. The proposed measure belongs to Natural Scene Statistics (NSS) modeling approaches. First, the reference image is decomposed into Intrinsic Mode Functions (IMF); the authors then use the Generalized Gaussian Density (GGD) to model IMF coefficients distribution. At the receiver side, the same number of IMF is computed on the distorted image, and then the quality assessment is done by fitting error between the IMF coefficients histogram of the distorted image and the GGD estimate of IMF coefficients of the reference image, using the Kullback Leibler Divergence (KLD). In addition, the authors propose a new Support Vector Machine-based classification approach to evaluate the performances of the proposed measure instead of the logistic function-based regression. Experiments were conducted on the LIVE dataset.

INTRODUCTION

Performances of image processing algorithms can be evaluated essentially based on the perceived image quality. As a result, an image quality assessment method is required. Indeed, subjective measures can be involved. They are based essentially on human observers' opinion. A popular method for assessing image quality involves asking people to quantify their subjective impressions by selecting one of the five classes: Excellent, Good, Fair, Poor, Bad, from the quality scale (ITU, 2000), then these opinions are converted into scores. Finally, the average of the scores is computed to get the Mean Opinion Score (MOS). However, subjective measures cannot be applied

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in real-time applications due to the time required for subjective experiments.

Beside subjective measures, objective measures assess the quality automatically with no need to human observers. But up to now, an objective measure which can replace the human observer does not exist.

General-purpose objective measures belong to Full Reference (FR) approaches. Thanks to the availability of the reference image, they can use a pixel-to-pixel comparison like the well-known Peak-Signal-to-Noise (PSNR) or introduced statistical features-based similarity measure (Wang, Bovik, Sheikh, & Simoncelli, 2004). Nevertheless, in real-world applications (like transmission) the reference image is not always available. In that case, No-Reference (NR) approaches are more suitable. They attempt to assess the quality of a processed image without any cue from its unprocessed version. For this goal, they need a prior information on the distortion. As consequence, most of NR approaches are conceived for specific distortion type and cannot be generalized to other distortions (Wang, Sheikh, & Bovik, 2002). Reduced Reference (RR) approaches provide a good compromise between FR and NR, as only partial information is involved. They rely on perceptually relevant features that have to be extracted from the reference image. These features are used at the receiver side for detecting visual quality degradation. Consequently, the measure proposed in this paper falls in the RR approaches.

Recently, a number of authors have successfully introduced RR methods based on: image distortion modeling (Gunawan & Ghanbari, 2003; Kusuma & Zepernick, 2003), human visual system (HVS) modeling (Carnec, Le Callet, & Barba, 2003, 2005), or finally natural image statistics modeling (Wang & Simoncelli, 2005; Ait Abdelouahad, El Hassouni, Cherifi, & Aboutajdine, 2011). Wang and Simoncelli (2005) introduced a RRIQA measure called WNISM and based on Steerable pyramids (a redundant transform of wavelets family). Although, this method has known some success when tested on five types of distortion, it suffers from some weaknesses. First, steerable pyramids are a non-adaptive transform, and depend on a basis function. This later cannot fit all signals, and when this happens, a wrong time-frequency representation of the signal is obtained. Consequently it is not sure that steerable pyramids will achieve the same success for other type of distortions. Furthermore, the wavelet transform provides a linear representation which cannot reflect the nonlinear masking phenomenon in human visual perception (Foley, 1994). A novel decomposition method was introduced by Huang et al. (1998), named Empirical Mode decomposition (EMD). It aims to decompose non stationary and non linear signals to finite number of components: Intrinsic Mode Functions (IMF), and a residue. It was first used in signal analysis, and then it attracted more researchers' attention. A few years later Nunes, Bouaoune, Delechelle, Niang, and Bunel (2003) proposed an extension of this decomposition in the 2D case Bi-dimensional Empirical Mode Decomposition (BEMD). A number of authors have benefited from the BEMD in several image processing algorithms: image watermarking (Taghia, Doostari, & Taghia, 2008), texture image retrieval (Andaloussi et al., 2009), and feature extraction (Wan, Ren, & Zhao, 2008). In contrast to wavelet, EMD is nonlinear and adaptive method, it depends only on data since no basis function is needed.

Motivated by the advantages of the BEMD, and to remedy the wavelet drawbacks discussed above, here we propose the use of BEMD as a representation domain. As distortions affects IMF coefficients and also their distribution. The investigation of IMF coefficients marginal distribution seems to be a reasonable choice. In the literature, most RR methods use a logistic function-based regression method to predict mean opinion scores from the values given by an objective measure. These scores are then compared in term of correlation with the existing subjective scores. The higher is the correlation, the more accurate is the

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