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Perceptual Image Quality Assessment through Spectral Analysis of Error Representations

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Abstract

In this paper, we analyze the statistics of error signals to assess the perceived quality of images. Specifically, we focus on the magnitude spectrum of error images obtained from the difference of reference and distorted images. Analyzing spectral statistics over grayscale images partially models interference in spatial harmonic distortion exhibited by the visual system but it overlooks color information, selective and hierarchical nature of visual system. To overcome these shortcomings, we introduce an image quality assessment algorithm based on the Spectral Understanding of Multi-scale and Multi-channel ErroR Representations, denoted as SUMMER. We validate the quality assessment performance over 3 databases with around 30 distortion types. These distortion types are grouped into 7 main categories as compression artifact, image noise, color artifact, communication error, blur, global and local distortions. In total, we benchmark the performance of 17 algorithms along with the proposed algorithm using 5 performance metrics that measure linearity, monotonicity, accuracy, and consistency. In addition to experiments with standard performance metrics, we analyze the distribution of objective and subjective scores with histogram difference metrics and scatter plots. Moreover, we analyze the classification performance of quality assessment algorithms along with their statistical significance tests. Based on our experiments, SUMMER significantly outperforms majority of the compared methods in all benchmark categories.

Keywords: Full-reference image quality assessment, visual system, error spectrum, spectral analysis, color perception, multi-resolution

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