A MULTI-DIMENSIONAL MEASURE FOR IMAGE QUALITY

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A serious concern for many applications involving imagery as a major type of data is the massive storage and bandwidth requirements. Image compression provides an immediate solution to this problem by reducing the number of bits or the range of frequencies needed. As lossy compression techniques are based on different mathematical approaches (transform coding, vector quantization, fractals, singular value decomposition, etc.), they result in dissimilar types of impairments in the reconstructed images. Relevant research shows that a single compression technology cannot be effectively used in most of the applications, and points to a need for non-uniform compression. It therefore becomes necessary to develop a quality measure that is capable of determining (1) the amount of degradation, (2) the type of degradation, (3) the impact of compression on different frequency ranges, in a reconstructed image.

Recent surveys of the work in image quality measurement show that almost all the measures are numerical, combining the pixel differences in the original and degraded images into a single number. Although there are some efforts to establish a stronger relationship with subjective evaluation, the scalar measures are not able to describe either the degradation type or the local error. The only general purpose graphical measure in the literature that can be used with some success to express both the amount and the type of degradation is Hosaka plots. Nevertheless, its application to a set of images with different impairments has indicated a number of difficulties: (1) The selection of the two critical parameters for the block size and the variance threshold is not trivial and depends on the compression ratio, compression technique, and the frequency contents of the impaired image; (2) The plots clearly display the artifact of blockiness but are not equally successful in showing blurriness.

In this paper, we discuss the development of a new graphical measure based on three criteria. To be able to make a local error analysis, we first divide a given image (the original or a degraded) into areas with certain activity levels using, as in the case of Hosaka plots, a quadtree decomposition. The largest and smallest block sizes in our decomposition scheme are 16 and 2, respectively. This gives us 4 classes of blocks having the same size. Class $i$ represents the collection of $i \times i$ blocks; a higher value of $i$ denotes a lower frequency area of the image. After obtaining the quadtree decomposition for a specified value of the variance threshold, we compute three values for each class $i$ ($i = 2, 4, 8, 16$), and normalize them: (1) The number of pixels/the number of pixels in the entire image; (2) The number of distinct pixel values/the number of possible pixel values; (3) The average of the standard deviations in the blocks/a preset maximum standard deviation. The essential characteristics of the image are then displayed in a normalized bar chart.

We believe that the proposed graphical measure is more useful than Hosaka plots because a collection of valuable data is provided concerning the type and amount of degradation as well as the impact of compression on different frequency ranges. In addition, the selection of the two parameters, block size and variance threshold, are not critical. Undoubtedly, increasing the dimensionality of image quality measurement results in much more information than can be obtained by scalar measures. This, in turn, lays the foundations for designing optimized image coders. Further investigation is needed, however, to better understand how reconstructed images lose their sharpness. An analysis of the structure of edges may generate new results for additional dimensions to improve the quality measure.