Directional Fuzzy Edge Detection Based Modified Edge Regeneration System for Efficient JPEG Artifacts Reduction

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Abstract. Presently, the image and video compression are the most crucial and demanding requirements for the visual data communication due to the channel bandwidth and data storage limitations. Transform based coding using the Discrete Cosine Transform (DCT), is a popular technique for the image and video compression. However, at lower bit-rates, for the DCT based image compression, the reconstructed images suffer from several visual distortions. Edge regeneration is one of the most recent and important technique to suppress the visual distortions generated by DCT compression at lower bit-rates. This paper proposed an innovative modification of the edge regeneration technique by increasing its initial edge prediction capability under the presence of artifacts using directional fuzzy edge detection. The proposed JPEG artifacts reduction system addresses all the three types of artifacts, which are common in JPEG images: blocking, edges blurring, and aliasing. Furthermore, the proposed system enhances the quality of the JPEG compressed images via two stages. First, it removes blocking artifacts via boundary smoothing and guided filtering. Then, in the second stage, it reduces blurring and aliasing around the edges via proposed modified local edge regeneration based on directional fuzzy edge detection technique. A sound comparison of the proposed algorithm with other existing JPEG artifact removal algorithms has been also presented on the basis of the two important parameters, peak signal to noise ratio (PSNR) and mean square error (MSE). Performance evaluation illustrates that the proposed system provides maximum PSNR, minimum MSE, and hence leads to efficient JPEG artifact reduction as compared to the other state of the art algorithms.

Keywords: JPEG image artifacts removal, Blocking artifacts, Edge blurring, Edge regeneration, Directional fuzzy edge detection, DCT, PSNR, MSE.

Introduction

In present scenario image and video compression persists to be in high demand. The Block Discrete Cosine Transform (BDCT) (Ahmed *et al*., 1974; Thakur *et al*., 2014, 2015) is the most accepted and extensively used transform based lossy compression technique in image and video compression standards, owing to its optimum energy compaction property and easiness of implementation. The most important and widely accepted international image compression standard was developed by Joint Photographic Expert Group (JPEG) based on BDCT named as JPEG standard. For JPEG, one of the widely recognized limitation is that at low bit rates, compression process leaves discontinuities of intensities among adjacent blocks (named as blocking artifacts). JPEG can also lead to further visual artifacts such as degraded textures, blurring, and distortion of edges. Altogether, decreasing the bit rate will increase the severity and dominance of these visual artifacts. Over the past few decades, abundant algorithms have been proposed to enhance the visual quality of JPEG compressed images by attempting to remove the artifacts. These techniques generally fall into two broad categories: encoder-based methods and post-processing based methods.

The encoder based techniques work by making modifications to the encoder, such as transform-domain methods (Malvar and Staelin, 1989; Chen *et al*., 2001; Xu *et al*., 2006), interleaved block transform (Pearson and Whybray, 1984), interactive methods (Zakhor, 1992), lapped transform (Malvar, 1998), combined transform (Zhang *et al*., 1993) or wavelet based filtering (Liew *et al*., 2004). However, the drawback of this process is a deviation from the rules of JPEG standard.

Post-processing techniques basically improve the visual quality by removing artifacts via processing of the image after decoding. This process does not require any modifications to the available JPEG encoder or decoder, and can thus be used on existing JPEG images. Post-processing can generally be divided into spatial-domain techniques (Reeve and Lim, 1984; Ramamurthi and Gersho, 1986; Apostolopoulos and Jayant, 1999), DCT-domain techniques (Kasezawa, 1997; Choy *et al*.,