A FAST TWO DIMENSIONAL DEBLOCKING FILTER FOR H.264/AVC VIDEO CODING

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Abstract

H.264/AVC as the most recent video coding standard delivers significantly better performance compared to previous standards, supporting higher video quality over lower bit rate channels. The H.264 in-loop deblocking filter is one of the several complex techniques that have realized this superior coding quality. The deblocking filter is a computationally and data intensive tool resulting in increased execution time of both the encoding and decoding processes. In this paper and in order to reduce the deblocking complexity, we propose a new 2-D deblocking filtering algorithm based on the existing 1-D method of the H.264/AVC standard. Simulation results indicate that the proposed technique achieves a 40% speed improvement compared to the existing 1-D H.264/AVC deblocking filter, while affecting the SNR by 0.15% in average.

Keywords*: H.264/AVC, in-loop deblocking filter.*

1. Introduction

Many Video coding methods employ block-based prediction, transformation, and quantization for encoding video streams. The use of block-based processing, however, decreases inter-block correlation in video frames and adds visible blocking artifacts to the reconstructed frames [1]-[3]. In order to overcome this problem, two techniques are generally used by the current video coding algorithms: 1) avoidance strategies for reducing the occurrence of blocking artifacts, in H.263 [4] and MPEG-4 [5]; 2) artifact cleaning schemes after frame reconstruction in H.264/AVC [6].

Among various encoding tools of the H.264 standard, the in-loop deblocking filter has a significant impact on the perception quality of video [7][8]. As shown in [1], compared to post filtering algorithms, the in-loop deblocking filter reduces the bit-rate typically by 5%-10% preserving the same objective video quality. Because of the advantages of in-loop deblocking over post filtering, H.264 deblocking filter is used in the prediction loop of both the encoder and the decoder modules. However, this improvement is achieved at the cost of a large amount of computation and memory read/write operations resulting in a reduced speed of both encoding and decoding processes. The deblocking filter is described in more details in [9].

In order to present an efficient architecture for real-time applications, two problems need to be addressed:

i. filtering process latency;
ii. data memory access.

Recently, many efficient hardware implementations for deblocking filter in H.264 have been proposed [7][10]-[12]. To satisfy the real-time constraints, most existing architectures have used various fast memory accessing techniques. None of these solutions considers the algorithmic enhancements for overall speedup. On the other hand, there are many new deblocking filtering techniques in the literature that have resulted in better video quality. They are based on iterative algorithms. For instance, a non-linear loop filter algorithm has been proposed in [13] which performs an orthonormal linear transform over the decoded frame and establishes a de-noising rule for the individual transform coefficients. Experimental results show about 10% bit-rate reduction for this algorithm compared to the existing H.264 deblocking filter. Other examples of the iterative algorithms are "maximum a posteriori (MAP)" [14] and "projection onto convex sets (POCS)" [15]. Even though, the iterative methods result in better performance, they are not efficient for real-time applications or devices with low computational power. This paper follows the low-pass filtering strategy and proposes a fast 2-D deblocking algorithm for H.264/AVC. Many concepts from the existing 1-D deblocking filter are borrowed for defining the new 2-D filtering rules. A significant speedup of more than 40% is achieved at the cost of losing only 0.15% SNR in average.

The paper is organized as follows. The H.264/AVC deblocking filtering algorithm is reviewed in Section 2. Our proposed 2-D algorithm is described in Section 3. In Section 4, simulation results are presented and compared with the reference model. Finally, the paper ends with conclusion in Section 5.

2. The H.264/AVC Deblocking Algorithm

According to the last version of H.264 recommendation [6], the deblocking filtering algorithm is a conditional process that has to be applied to all $N \times N$ block boundaries of the picture. For luminance component (Y) N is selected equal to the size of the applied transform, four or eight. However, the algorithm filters the chrominance components (U and V) in terms of 4×4 blocks. Except for the picture boundary edges, the algorithm filters all the block edges inside the picture. Figure 1 shows the boundaries of three Y, U, and V macroblock data. Bold lines demonstrate the boundaries that should be filtered for both 4×4 and 8×8 transforms. The boundaries which are represented by