

Color Image and Video Compression Based on Direction Adaptive Partitioned Discrete Wavelet Transform

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Abstract: The main objective of this study is to use the Direction-Adaptive Partitioned Block Transform (DA-PBT) for compressing the color images and videos. It is same as the direction-adaptive block transform but it also have an additional direction-adaptive block partitioning to improve energy concentration. The selection of a directional mode determines the transform direction that provides directional basis functions. It reduces complexity and more efficient coefficient ordering for entropy coding. For image coding, the DA-PBT significantly outperforms the directional DCT. As a block transform, the DA-PBT can be directly incorporated into the prediction-based video coding standards to work with the block-based intra prediction as well as the block-based motion-compensated interframe prediction. The performance of the DA-PBT is compared with the 2D-DCT by using the Peak-Signal-to-Noise Ratio (PSNR) and Compression Ratio (CR). The experimental results shows that the DA-PBT performs well than the 2D-DCT.

Keywords: Compression techniques, discrete wavelet transforms, video coding standards

INTRODUCTION

Image compression has been the key technology for transmitting massive amount of real-time image data via limited bandwidth channels. The data are transferred in the form of image, graphics, audio and video. These types of data have to be compressed during the transmission process. Otherwise the data need a large storage capacity and transmission bandwidth if it is uncompressed. Huge amount of data can't be fit if there is low storage capacity present. To solve this problem the data has to be compressed by using any one of the algorithms and then it can be sent easily. Data compression is the process of converting an input data stream into another data stream that has smaller size. There are two types of image compression: lossless and lossy. With lossless compression, the original image is recovered exactly after decompression. Much higher compression ratios can be obtained if some error, which is usually difficult to perceive, is allowed between the decompressed image and the original image. This is lossy compression. In many cases, it is not necessary or even desirable that there be error-free reproduction of the original image. In such a case, the small amount of error introduced by lossy compression may be acceptable. Another application where lossy compression is acceptable is in fast transmission of still images over the Internet.

For over two decades, block transforms such as the 2-D DCT have been the key component in image coding techniques, e.g., the JPEG standard (Information Technology, 1992). Although more recently, convolutional transforms, such as the 2-D DWT, have been proved superior (Taubman and Marcellin, 2000; Information Technology, 2002), JPEG is still the prevalent image coding format to date. Block transforms also remain an integral part in most video coding standards since they can be effectively combined with block-based motion-compensated prediction (Wiegand *et al.*, 2003). In image coding, directional features such as lines and edges have significant impact on both the objective and the subjective performance. Block transforms are typically constructed in a separable manner, by cascading a 1-D vertical transform and a 1-D horizontal transform. Separable transforms tend to do well for image detail oriented strictly horizontally and vertically, while ringing and checkerboard artifacts are likely to appear around edges of other orientations, significantly deteriorating visual quality. To exploit directionality, the intra coding portion of the video coding standard H.264 predicts a block from previously encoded blocks using directional extrapolation (Wiegand *et al.*, 2003) and the residual is then encoded via a block transform. This approach is effective, but it requires perfect synchronization of the DPCM loops of encoder and decoder. Any deviation between encoder and decoder can propagate over the image, leading to an

overwhelming distortion. Therefore, it does not easily allow embedded coding, an important feature supported in the state-of-the-art image coding standard JPEG2000 (Taubman and Marcellin, 2000). Moreover, predictive coding can lead to an undesirable persistent offset or even limit-cycles (Pirsch, 1982). The drawbacks associated with directional predictive coding can be eliminated by incorporating directional adaptation directly into the transform. To this end, several direction-adaptive transforms have been proposed based on the DWT (Wang *et al.*, 2006; Velisavljevic *et al.*, 2007), the DCT (Zeng and Fu, 2006; Xu *et al.*, 2007) and separable transforms customized from training data (Ye and Karczewicz, 2008).

This study uses the Direction-Adaptive Partitioned Block Transform (DA-PBT). It can be viewed as a direction-adaptive block transform with additional direction-adaptive block partitioning to improve energy concentration. It reduces complexity and more efficient coefficient ordering for entropy coding. For image coding, the DA-PBT significantly outperforms the directional DCT. As a block transform, the DA-PBT can be directly incorporated into the prediction-based video coding standards to work with the block-based intra prediction as well as the block-based motion-compensated interframe prediction.

METHODOLOGY

Direction-adaptive block partitioning: Compared to the 2-D DCT, one disadvantage of both the DDCT and the DA-BT is the increase in the maximum length of the constituent 1-D DCTs. The increase in complexity can be significant for a large block size. To reduce the complexity of the DA-BT, DA_PBT further divide the block into directional partitions. That divides a block into 2 partitions for the diagonal-down-right mode and 3 partitions for the vertical-right mode the maximum required length is equal to that of the 2-D DCT. To further exploit the correlation among partitions, a Stage-3 transform is applied to the DC coefficients.

Quantization: Given the quantization step size that controls the quality of the reconstruction, a transform coefficient is mapped to the quantization index by and then reconstructed to the representative level. In JPEG, so that every quantization interval has the same size and the representative levels are always located in the middle of a quantization interval (Ahumada and Peterson, 1993).

To design the quantization matrices for the eight directional modes of the DA-PBT, we propose the

following approach that avoids cumbersome subjective tests typically required in other approaches. Assume that a quantization matrix for the 8x8 2-D DCT, It is already available and achieves the best visual quality in the reconstructed block.

Image coding algorithm:

- Get the input color image
- Convert the image from RGB Color Space to HSV Color Space
- Then down sample the image
- Apply ADPBT algorithm on the image
- Then up sample the image
- Convert the image from HSV Color Space into RGB Color Space
- Finally we get the compressed image

Video coding algorithm:

- Get the input the video
- Convert the video into frames
- For each frames apply the following step
 - Get the input color image
 - Convert the image from RGB Color Space to HSV Color Space
 - Then down sample the image
 - Apply ADPBT algorithm on the image
 - Then up sample the image
 - Convert the image from HSV Color Space into RGB Color Space
 - Finally we get the compressed image
- Combine the Compressed images to form the compressed video

RESULTS AND ANALYSIS

Experimental images: The performance of the algorithm is evaluated on several real images and videos. These pictures and videos are the most widely used for compression algorithms. The image contains a nice mixture of detail, flat regions, shading and texture that do a good job of testing various image processing algorithms. These are till in the industry standard for tests. It is a good test images. These images are used for many image processing researches.

The pictures shown in Fig. 1 are the frames of the original video.

The pictures shown in Fig. 2 are the experimental images for the compression.

Performance metrics: To evaluate the performance of the compression techniques several performance

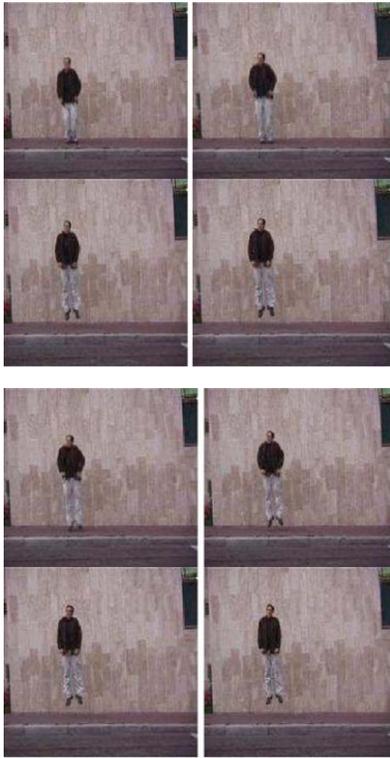


Fig. 1: Frames of the original video

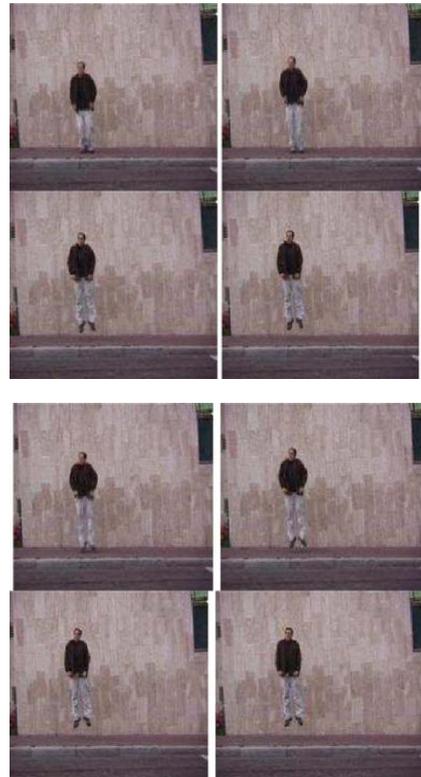


Fig. 3: Frames of the compressed video

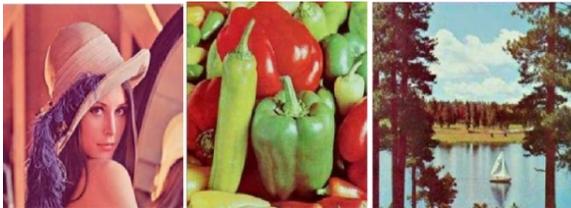


Fig. 2: Experimental images

metrics are available. We use the Peak-Signal-to-Noise-Ratio and Compression Ratio to analyse the performance of the DA-PBT technique.

Peak signal-to-noise-ratio: We use the Peak Signal-to-Noise Ratio (PSNR) to evaluate the quality between the compressed image and the original image. The PSNR formula is defined as follows:

$$PSNR = 10 \times \log_{10} \frac{255 \times 255}{\frac{1}{H \times W} \sum_{x=0}^{H-1} \sum_{y=0}^{W-1} [f(x, y) - g(x, y)]^2} \text{ dB}$$

where, H and W are the height and width of the image, respectively; and f (x, y) and g (x, y) are the grey levels

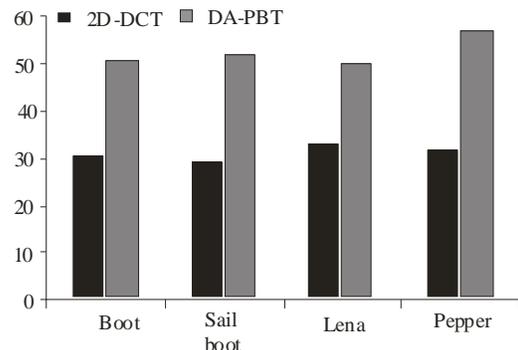


Fig. 4: Comparison analysis of PSNR with higher DA-PBT

located at coordinate (x, y) of the original image and compressed image, respectively.

Compression ratio: We use the Compression Ratio (CR) to find the how many number of bits are compressed by using the compression algorithm. The CR formula is defined as follows:

$$CR = (\text{Number of compressed bits} / \text{total number of bits}) * 100$$

Experimental results: The compressed frames of the video is shown in Fig. 3.

Table 1: Comparison analysis of PSNR with higher DA-PBT

| | 2D-DCT | DA-PBT |
|-----------|--------|--------|
| Boat | 30.12 | 50.25 |
| Sail boat | 29.47 | 51.87 |
| Lena | 32.59 | 49.72 |
| Pepper | 31.47 | 56.89 |

Table 2: Comparison analysis of PSNT with lower DA-PBT

| | 2D-DCT | DA-PBT |
|-----------|--------|--------|
| Boat | 22.15 | 32.14 |
| Sail boat | 21.57 | 31.38 |
| Lena | 22.91 | 32.67 |
| Pepper | 27.75 | 34.56 |



Fig. 5: Compressed images

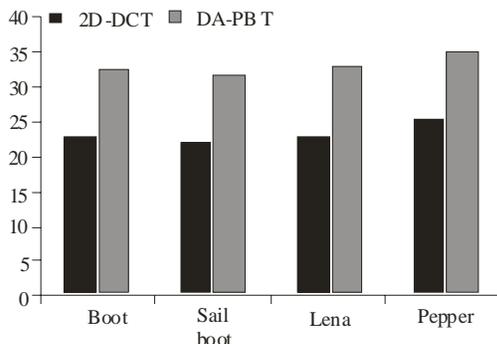


Fig. 6: Comparison analysis of PSNR with lower DA-PBT

From the Table 1 it is shown that PSNR and Compression value is higher for DA-PBT. This is shown in Fig. 4. The pictures shown in Fig. 5 are the compression images after applying the DA-PBT.

The PSNR values for the various compressed images are calculated by using the proposed algorithm and DCT Transform. The result is given below.

The CR values for the various compressed images are calculated by using the proposed algorithm and DCT Transform. The result shown in Table 2.

From the above table it is shown that CR and Compression value is higher for DA-PBT. This is shown in Fig. 6.

CONCLUSION

This project used a Direction-Adaptive Partitioned Block Transform (DA-PBT) for compress the color images and videos. The DA-PBT avoids the typical ringing and checkerboard artifacts. So it gives higher

PSNR value. The DA-PBT also outperforms a previously proposed directional DCT. Because it takes less computation time than the DCT. The experimental results show that DA-PBT achieves higher PSNR value and higher Compression Rate than the traditional DCT transform.

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