2-Dimensional Optimum Partition of Frequency Band for Subband Image Coding

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Summary

In transmitting or recording of digital image signals, the data compression for these signals are important, since their data rate is huge. Subband coding is a more efficient image coding technique than JPEG which is an international standard for a still image coding. Subband coding has two features; (1) blocking artifacts which degrade image quality severely are not generated, and (2) the influence of the transmission error is restricted in small area both in spatial and frequency domains. In a subband coding, an input signal sequence must be decomposed into several subbands, then a decomposed signal is quantized and corresponding bits are assigned to the subband. To obtain a higher compression rate and a higher image quality, it is important to (1) decompose the frequency domain into an adequate set of decomposed band, where we must match to the property of the input image signal and (2) to assign the adequate quantization bits in proportion to the signal power contained in each subband. At the last stage, we must re-consider the overall bit assignment combining the results obtained in (1) and (2). This paper have focused on optimization problem of how to decompose the 2-dimensional frequency domain for a subband image coding. The goal of this study is to derive theoretically the optimum band partition of 2-dimensional frequency domain, and to construct the filter bank applying the obtained optimum band partition.

At the viewpoint of the theoretical derivation of the optimum band partition :

1. For an important problem on how to decompose the 2-dimensional frequency domain, a proposed optimum band partition gives an answer to obtain minimum quantization noise power under the condition of the given constant coding rate. In the 1-dimensional signal case, the optimum band partition is derived theoretically considering the stochastic characteristics of the input signal. The numerical examples of the optimum band partition are shown for the first order Markov signal with a correlation coefficient of near unity which approximate a correlation of real image signal. It is clarified that the reduction of the quantization noise power by the optimum band partition is nearly the same as that is obtained in the case of the wavelet transform which adopts the conventional band partition method.
2. In the case of 2-dimensional signals which represent real image signals, 2-dimensional optimum band partition is derived theoretically based on a proposed construction model of analysis/syn-

thesis filter bank. Two-types of the theoretical model for image signals are introduced after the investigation of the correlation characteristics using various kind of natural images, and the numerical examples of the optimum band partition are shown for these models. It is clarified that the quantization noise power reduction performances for the optimum band partition are better than those for the conventional band partition methods including DCT which is employed in JPEG by about 2[*dB*] at the same coding rate.

At the viewpoint of the application to the image coding :

3. In a subband image coding of a higher compression rate and a higher image quality, the coder is apt to be complicated and is expensive, then it is especially important to simplify the coder. To achieve this, first, a fixed optimum band partition is investigated based on band blocks, where the band blocks are defined by the set of 2-dimensional frequency pieces. The fixed optimum band partition can approximate an obtained theoretical optimum band partition characteristics, and its filter bank configuration is presented. Secondly, in order to adopt the non-stationary characteristics of natural images, an adaptive optimum band partition which is optimized to the statics of each input image is proposed. It is clarified from the band partition experiments using several natural images that the fixed/adaptive optimum band partitions whose band partition number is only five exhibits *SNR* improvement of about 1[*dB*] over (8×8) DCT at the same entropy rate. And, the fixed band partition can be achieved good performances nearly the same as in the case of the adaptive one for almost all images.
4. To obtain the high quality coded images, the optimum band partition with human visual sensitivity is discussed based on band blocks. This method can minimize the weighted quantization noise power under the condition of the constant coding rate, and its filter bank configuration is shown. It is clarified that the weighted mean square error is reduced by the optimum band partition, and the improvement in a *MOS*(Mean Opinion Score) scale for *MOS* method of coded images by the optimum band partition are better than those for (8×8) DCT by about 1.0 in the average.

In conclusion, we have given the optimum band partition of 2-dimensional frequency domain for subband image coding considering theoretically and practically.

The further problem is to develop a more efficient subband image coding system combining the optimum band partition and the bit assignment.

Keywords : subband coding, optimum band partition, quantization noise power, band block, adaptive band partition, human visual sensitivity, mean opinion score