Two-layer image coding compatible with JPEG XS

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ABSTRACT

A two-layer image coding method compatible with JPEG XS is proposed. JPEG XS is a new international standard for still image coding that has the characteristics of very low latency and very low complexity. However, the image quality is saturated at a certain quality level in general, although JPEG XS compression may be able to achieve visual lossless coding. The proposed method has a two-layer structure similar to JPEG XT, which consists of JPEG XS coding as the base layer and the extension layer. In an experiment, the proposed coding is demonstrated to outperform JPEG XT in terms of the coding efficiency, while maintaining compatibility with JPEG XS.

Keywords: JPEG XS, two-layer coding, lossy coding

1. INTRODUCTION

JPEG XS was standardized as a new still image coding method.[1] This standard is also expected to be applied to videos, and enables us to compress images with low latency and low complexity. This coding can achieve a high image quality, but even if the bitrate is increased, the image quality is saturated at a certain level in general. In contrast, in many applications such as medial images, master data of cinema and broad casting, lossless images or the highest quality images possible are required. JPEG XS is ineffective in such applications due to the saturation of the image quality.

A number of two-layer coding methods have been investigated to extend the limitations that a coding method has.[2–12] For example, JPEG XT[7] is a two-layer coding that uses JPEG as the first base layer in consideration of the compatibility with past JPEG decoders. Appending the second extension layer, the coding allows us to decode HDR images that the JPEG coding cannot support.

Because of such a situation, we propose extending JPEG XS for improving the issue above about the image quality. The extended coding has a two-layer structure, where the first layer, called base layer corresponds to the JPEG XS coding, and the second one, called extension layer is used for compressing residual data between an original image and the decoded image from the base layer. This two-layer structure has been inspired by JPEG XT.[7] In an experiment, the proposed coding is demonstrated not only to improve the compression performance of JPEG XS, but also to achieve lossless coding, while maintaining compatibility with JPEG XS.

2. JPEG XS

JPEG XS is intended for low latency and low complexity encoding, and is expected to be applied to video coding in which each frame is regarded as an independent still image. JPEG XS aims to compress images at a compression ratio of about 1/2 to 1/10 while maintaining visual lossless image quality, but it does not aim to improve the compression performance at a low bitrate. The JPEG XS encoding uses a wavelet transform as well as in JPEG 2000. However, the processing in the vertical direction is suppressed to a few lines, so it can achieve low latency and low complexity in the encoding and decoding. Furthermore, since there is no frame buffer for an entire image, it can be implemented at low cost.

However, although JPEG XS supports visual lossless coding, it does not support lossless one. Figure 1 shows rate-distortion curves of three JPEG XS decoded images. From this figure, the image quality of JPEG XS ones is illustrated to be saturated at a certain quality level.

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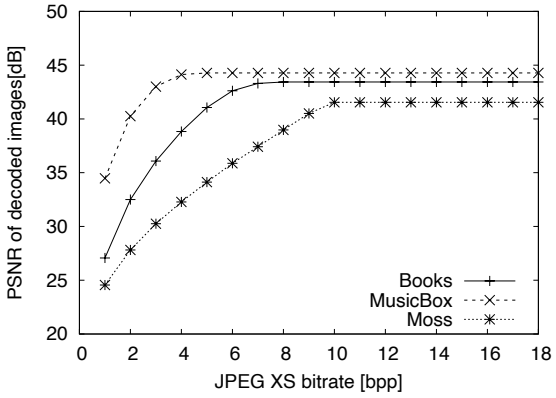
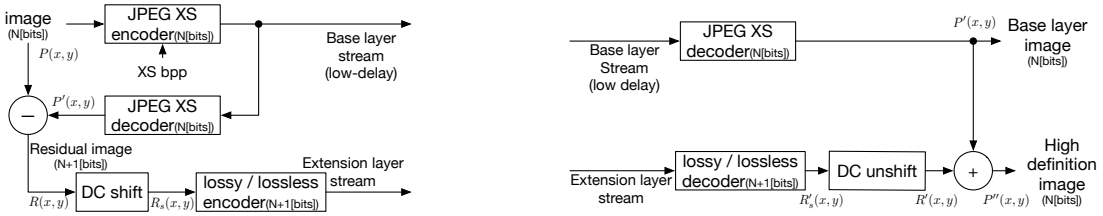


Figure 1. Rate distortion curves of JPEG XS decoded images



(a) Encoder (b) Decoder

Figure 2. Block diagram of proposed method

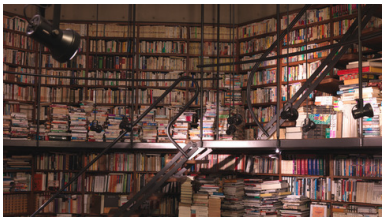
3. PROPOSED METHOD

We propose a two-layer coding method that consists of a base layer and an extension layer. Figure 2(a) shows the encoder structure of the proposed coding for N-bit-images. The coding-path for generating the base layer is backward compatible with JPEG XS. For the extension layer, a residual image ($R(x, y)$) is generated by calculating the difference between a decoded base layer image ($P'(x, y)$) and the original image ($P(x, y)$). After the DC shifting operation, $R_s(x, y)$ is encoded by using an lossy or lossless encoder. To maintain the low-delay property of JPEG XS, two streams are transmitted separately. Accordingly, the first stream from the base layer has the low-delay property, and high-quality images are stored by combining the first stream with the second one from the enhance layer.

Figure 2(b) shows the decoder structure of the proposed method. Bitstreams of the base layer are decoded by using a JPEG XS decoder, and those of the extension layer are decoded by a lossy or lossless decoder. A residual image is reconstructed from the decoded image by using the DC inverse-shift operation, and is added to an image from the base layer. Therefore, we can obtain both a decoded image $P'(x, y)$ of JPEG XS from the base layer and a higher quality image $P''(x, y)$ from both layer streams.

4. EXPERIMENTAL RESULTS

In the experiment, the reference software of JPEG XS provided by the JPEG committee was used, and the Kakadu software[13] (JPEG 2000 codec) was also used in the residual path as the lossless or lossy image encoder for the proposed method. 2K-images with a depth of 30 bits provided from the Institute of Image Information and Television Engineers (ITE)[14] were used in this experiment. Figure 4 shows three images used in the experiment. In Fig. 4, the proposed coding was compared with JPEG XS with one-layer for the three images: 'MusicBox', 'Books' and 'Moss', where XS bpp is a bitrate value assigned to the base layer. From Fig. 4, the proposed method outperformed JPEG XS in terms of the rate distortion on high bitrate areas. It was also confirmed that the proposed method enables us to losslessly encode images, although the PSNR values of JPEG XS were



(a) Books

(b) MusicBox

(c) Moss

Figure 3. Test images

saturated at around 44[dB]. For image 'Moss', the JPEG XS achieved a slightly higher PSNR value on low bit rate areas, but the proposed method provided a higher PSNR one in higher bitrate areas.

5. CONCLUSION

We proposed a novel two-layer coding method with backward compatibility to JPEG XS. In the proposed coding, JPEG XS is used as the base layer, and the difference between an original image and the an image from the base layer image is encoded in the extension layer by using an encoder. In the experiment, the proposed method was confirmed not only to achieve lossless coding, but also to improve the compression performance of JPEG XS, while maintaining compatibility with JPEG XS.

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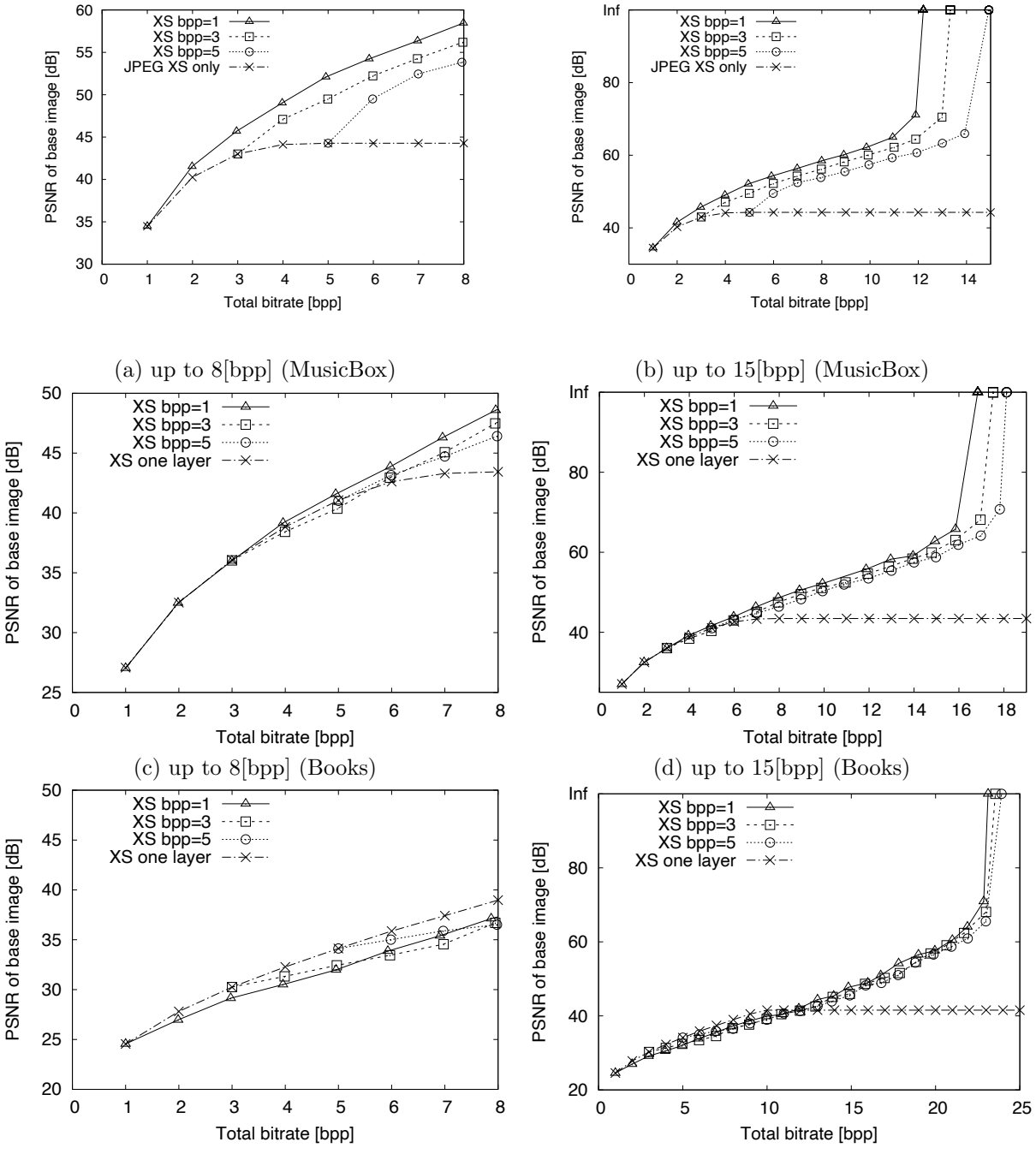

(a) up to 8[bpp] (MusicBox)

(b) up to 15[bpp] (MusicBox)

(c) up to 8[bpp] (Books)

(d) up to 15[bpp] (Books)

(e) up to 8[bpp] (Moss)

(f) up to 15[bpp] (Moss)

Figure 4. Rate distortion curves of proposed coding

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