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SIDE INFORMATION GENERATION IN DISTRIBUTED VIDEO CODING

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ABSTRACT

Distributed Video Coding (DVC) is a coding scheme for video compression used in applications which require low complexity encoders. The performance of DVC depends on the quality of side information. Several methods have been proposed for generating and improving side information. This paper reviews the recent advances in side information generation and improvement methods.

Keywords: Side information, Distributed Video Coding, Motion compensated, Full search

INTRODUCTION

Applications like wireless PC cameras, mobile camera phones, video sensor networks and wireless surveillance systems, the terminals have simple processing capability. To encode a huge video data from terminals the encoder should have high compression performance. DVC is based on the Slepian-Wolf theorem and Wyner_Ziv theorem which encodes sources independently while decoding jointly. It is possible to achieve efficient video compression by exploiting source correlation statistics at the decoder partially or totally. There are two types of video streams in DVC architecture – key frames and Wyner-Ziv frames. The key frames are encoded by traditional intra frame codec and the Wyner-Ziv frames Wyner-Ziv encoded. At the decoder, the key frames are decoded first. The side information is then got by interpolating the adjoining decoded key frames. On the basis of side information, the Wyner-Ziv frames are reconstructed.

The performance of DVC depends on the quality of side information. The side information is used as the estimation of the original data which can be corrected according to the information that parity bits provides. The side information should be accurate enough that there are only few differences compared to the original data. We discuss, in this paper, recent advances in side information generation and improvement methods. The DVC foundations are discussed in Section 2. We discuss motion compensated side information interpolation in section 3, adaptive block estimation for content based side information generation in section 4 and full search of side information in section 5.

DVC Foundations: Distributed Video Compression refers to the coding of two dependent random sequences. Two statistically dependent discrete signals X and Y are compressed using two independent encoders and are decoded by a joint decoder (Figure 1).

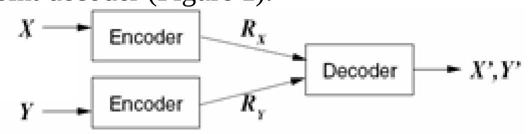

Figure 1. Distributed Source Coding

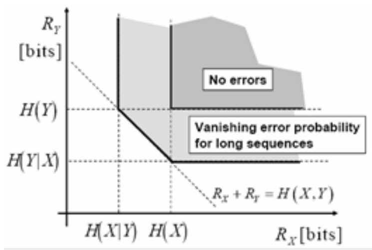

Figure 2. Rate Distortion

The Slepian-Wolf theorem on distributed source coding states that even if the encoders are independent, the achievable rate region for probability of decoding error to approach zero is $R_X \geq H(X|Y)$, $R_Y \geq H(Y|X)$ and $R_X + R_Y \geq H(X,Y)$ (Figure 2).

Motion Compensated Side Information Interpolation: Here a frame of video is divided into 8x8 blocks. In motion compensated interpolation, the moving distance between the current and the forward adjacent frames is assumed to be equal to the distance between the current frame and the backward adjacent frames. Figure 4 depicts the interpolation technique. The four steps involved are (i) Sub Pixel Interpolation (ii) Full search based on a region, (iii) Mean Absolute Difference (MAD) strategy with a value constraint & (iv) Initialised and overlapped motion compensation.

Adaptive Block Estimation for Content based side information generation: The DVC architecture with content based technique is shown in Figure 5. First the key frames are transferred to the decoder using conventional video compression techniques. These key frames are used as samples to train the classifier. A threshold classifier is used to segment the frames. The information from motion estimation and image content analysis are both used to generate side information. The content based side information generation algorithm consists of two key aspects namely feature extraction and frame segmentation and motion modification.

Feature Extraction: In video content analysis features including motion, texture, colour and contour can be used to characterize a video signal. The DVC uses only the motion information in side information generation. Content analysis can make the side information closer to the original signal. The texture information can also serve to improve the motion estimation accuracy. Gray scale histogram is used to represent image texture. An 8-level gray scale histogram is used as the feature vector for texture of a block. The motion vector obtained from conventional motion estimation is used as a motion feature vector. Both the vectors are integrated into one feature vector to represent the content of a block.

Figure 4. Motion compensated interpolation

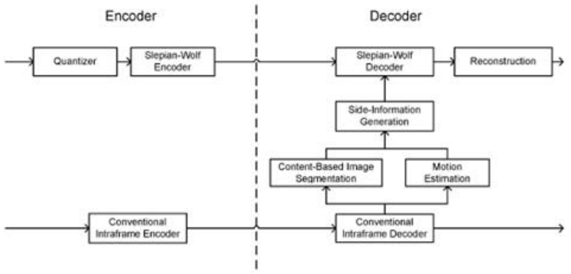

Figure 5. DVC architecture with content based technique

Then a distance metric is defined to measure the similarity of two feature vectors, which is the Euclidean distance. The more similar block is indicated by a shorter distance.

Frame segmentation and motion modification: A threshold classifier is used to conduct image segmentation after feature extraction and distance metric identification. In region growth algorithm, a block is identified as the feed block. If the distance between the feed block and its neighbour's feature vectors are short enough they are assumed to be of the same region. These new blocks are then used as feed blocks and the process repeated till there are no similar blocks in the region. After the region growth algorithm is conducted on a frame, the frame is segmented into several regions. The regions with number of blocks more than a threshold are assumed as believable. The regions with number of blocks less than a threshold are assumed as unbelievable. The motion vector of an unbelievable block is set to be the average of all its confident neighbours. If it does not have any confident neighbour, its motion vector is not changed.

Adaptive block estimation: Selection of a smaller block size results in more details but larger probability of motion search error, whereas a larger block has enough texture information to avoid the motion search error but looses some details. To solve the problem, an adaptive block size is used. First motion vectors are searched by larger blocks, 16x16. If the block's distortion is larger than a threshold the process is repeated with smaller blocks, 8x8 or 4x4, depending on the distortion. The adaptive block estimation technique improves the side information accuracy.

Full Search of Side Information: Traditional DVC schemes transmit hash bits for motion estimation at the decoder so that the side information can be identified. The motion estimation results obtained may not be as good as expected. In full search of side information the best side information in a given search window is found by performing side information search at the decoder. Generally when there are several side information candidates available, the one with the smallest crossover probability requires lowest rate which means smallest number of syndrome bits. If all the candidates fail, more syndrome bits are requested through the feedback channel and decoding is carried out until successful decoding.

CONCLUSION

Fundamentals of Distributed Video coding and the recent advances in side information generation and improvement methods have been presented in the paper. Experimental results of the comparative performance of the different methods are to be obtained.

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