A Low Complex Algorithm for DVC using Cross-Layer based Rate Control Method

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***Abstract*- Distributed Video Coding (DVC) is an emerging video coding technology that utilizes the distributed source coding principles to build very low complex video encoders. Motivated by this idea, for the Wyner-Ziv codec an algorithm is introduced in which after DCT only DC coefficients which contain maximum energy of respective blocks are transmitted. And for the conventional codec JPEG algorithm is modified. The proposed algorithm improves around 12% in PSNR at 38 db and shows significant improvement in data rate.**

Keywords- Distributed source coding(DSC), Distributed Video coding, DCT, Quantization, JPEG, Wyner-Ziv coding, LDPC codes, Cross layer.

INTRODUCTION

Compression of multimedia signals has seen very large improvements during the last twenty years. The concepts of predictive coding[9], transform coding[9] and combinations thereof were continually improved. In video coding, as standardized by MPEG or the ITU-T H.26x recommendations, where video is compressed using a hybrid of motion compensation and transform coding by the removal of statistical redundancies inherent in video as well as the reduction of the perceptual irrelevancy that can be tolerated by human visual system. These are characterized by an asymmetry in terms of complexity, typically having one complex encoder and many simpler decoders, which matches broadcast or down-link applications. In a number of emerging applications e.g. related to wireless communication, the complex encoder is disadvantageous in terms of physical size and power consumption.

However, efficient compression can also be achieved by exploiting source statistics at decoder side using concept introduced by Slepian-Wolf and Wyner-Ziv. Thus, DVC (Distributed Video Coding) reverses the complexity balance between encoder and decoder.

FOUNDATION OF DISTRIBUTED VIDEO CODING

DSC builds on the information theoretic discoveries of Slepian and Wolf[1] in 1973 and Wyner and Ziv[2][3] in 1976. The Slepian-Wolf and Wyner-Ziv theoremsprove that correlation between sources can be exploited without having direct access to realizations of the correlated source. Distributed coding exploits the source statistics in the decoder and, hence, the encoder can be very simple, at the expense of a more complex decoder.

A. Slepian-Wolf Theorem for Lossless Distributed coding

Consider two statistically dependent independent identically distributed (i.i.d.) finite-alphabet random sequences X and Y.(Figure 1) with separate conventional entropy encoders and decoders, one can achieve $Rx \geq H(X)$ and $Ry \geq H(Y)$, where H(X) and H(Y) are the entropies of X and Y, respectively. Interestingly, we can do better with joint decoding (but separate encoding), if we are content with a

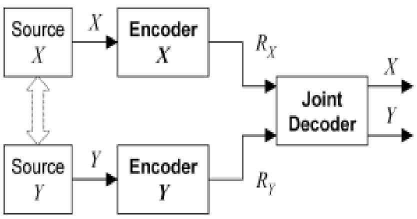


Fig. 1. Distributed compression of two statistically dependent random processes X and Y

residual error probability for recovering X and Y that can be made arbitrarily small (but, in general, not zero) for encoding long sequences. In this case, the Slepian–Wolf theorem establishes the rate region (Figure 2)

$$R_x + R_y \geq H(X,Y)$$
$$R_x \geq H(X|Y),$$
$$R_y \geq H(Y|X)$$

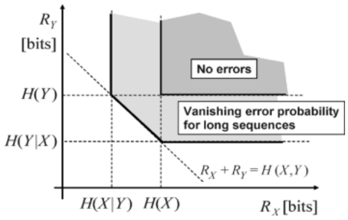


Fig. 2. Achievable rate region for distributed compression of two statistically dependent i.i.d. sources X and Y

Compression with decoder side information (Fig. 3) is a special case of the distributed coding problem (Fig.1). The source produces a sequence X with statistics that depend on side information. We are interested in the case where this side information Y is available at the decoder, but not at the encoder. Since R_Y =H(Y) is achievable for (conventionally) encoding Y, compression with receiver side information corresponds to one of the corners of the rate region in Fig.2 and, hence $R_X \geq$H(X/Y), regardless of the encoder's access to side information Y . Practically Slepian–Wolf coding is a close kin to channel coding.

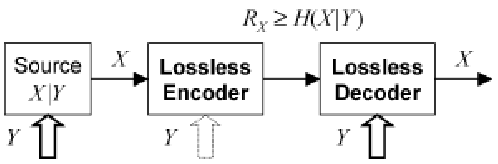


Fig.3. Compression of a sequence of random symbols X using statistically related side information Y.

We are interested in the distributed case, where Y is only available at the decoder, but not at the encoder.

B. Wyner and Ziv Rate-Distortion Theory for Lossy Compression

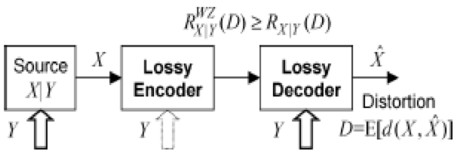


Fig. 4. Lossy compression of a sequence X using statistically related side information Y.

Consider X and Y represent samples of two i.i.d. random sequences, modeling source data and side information, respectively. The source values X are encoded without access to the side information Y (Fig 4). The decoder, however, has access to Y, and obtains a reconstruction X'of the source values. A distortion $D=E[d(X,\hat{X})]$ is acceptable.

The Wyner–Ziv rate-distortion function $R^{WZ}_{X|Y}(D)$ then is the achievable lower bound for the bit-rate for a distortion D. We denote by $R_{X|Y}(D)$ the rate required if the side information were available at the encoder as well. In general, a Wyner–Ziv coder[4][5] can be thought to consist of a quantizer followed by a Slepian–Wolf encoder in fig 5.

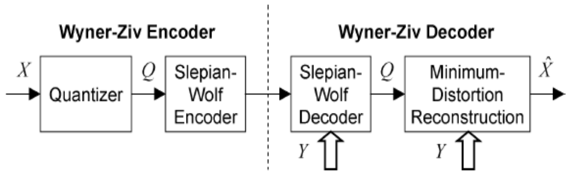


Fig 5.Wyner Ziv Codec

PROPOSED DVC ARCHITECHTURE

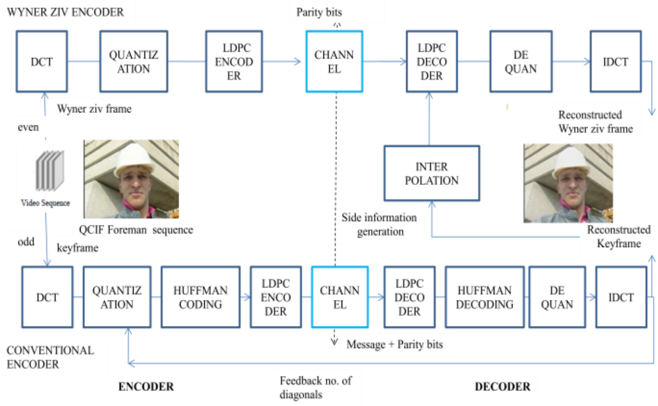


Fig 6 Proposed Architecture of DVC

Fig 6 shows the architecture for proposed DVC [10][11][12]. It consists of conventional intra frame codec and Wyner-Ziv codec. Video frames are divided into even frames and odd frames. Odd frames are called keyframes and even frames are called wyner-ziv frames. Color space of video frames are converted from RGB to YCbCr for transmission.

RESULTS AND DISCUSSION

It was observed that transform domain Wyner-Ziv encoding performs better than traditional intraframe coding as well as with DISCOVER DVC.

A. Assumptions of Constraints For Simulation

Various standard and non standard video sequences are used for the simulation e.g. foreman sequence, hall monitor, coast guard sequence etc.

- Video is divided into odd frames and even frames thus Group of Picture (GOP) is 2. Odd frames are considered as keyframes and even frames are considered as wyner-ziv frames.
- Convert RGB color space of frames to YCbCr color space.
- For different combination of diagonals of Cb component matrix and Cr component matrix PSNR is calculated.
- For DC coefficients and AC coefficients different techniques are used.
- Amplitude of DC coefficient is high hence DC coefficients are first divided by 8 and then difference coding is applied. For AC coefficients standard quantization matrix is used.
- Huffman Dictionary and symbols are transmitted with 10 bits per coefficients.

B. Comparison with Existing Codec for Foreman Sequence

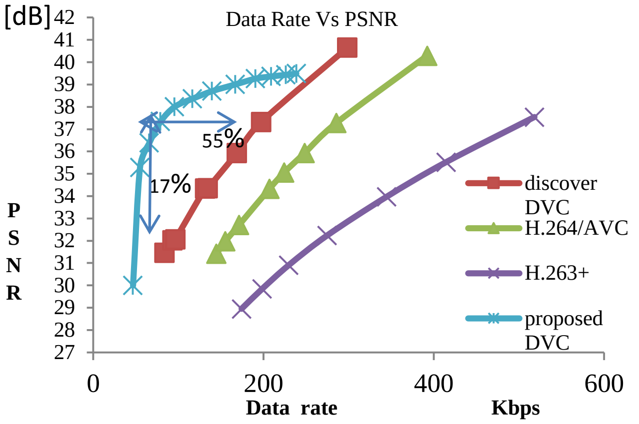
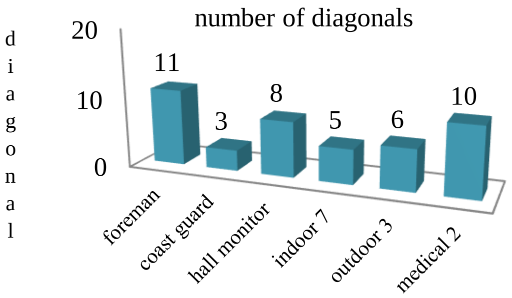


Fig 7 Comparison with existing codec

Output of proposed DVC is compared with DISCOVER DVC, H.264/AVC and H.263+intra codec in the Fig 7. It has been observed that for the range of 30 to 39 dB PSNR proposed DVC gives better performance. Data rates of proposed DVC and DISCOVER DVC are compared at 37 db PSNR, improvement of 60 % in data rate is observed.

C. *Results for Targeted PSNR at 39 db*



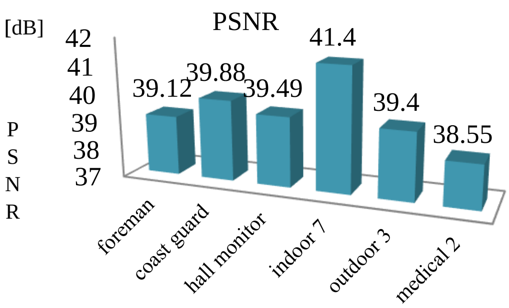


Fig 8 various results for targeted PSNR 39 dB

shows Fig 8 various outputs for various video sequences.

For all sequences at the decoder PSNR is set to 39 db and to achieve this PSNR number of diagonals is calculated. It has been observed that different sequences require different number of diagonals. As the number of diagonals varies data rate varies.

PSNR of proposed DVC and DISCOVER DVC are compared at data rate 110 kbps, improvement of 19 % in PSNR is observed.

CONCLUSION

Here two simple but novel algorithms are introduced for the transmission of video on wireless channel.

The algorithm for Wyner Ziv encoder encodes individual frame, and transmits only DC component per block of Y (luminance) component. Also the proposed algorithm transmits fix number of data without feedback hence require less time. Thus the wyner ziv encoder becomes less complex.

The algorithm for conventional codec is modified JPEG algorithm in which instead of sending all the data only optimum data is transmitted.

The simulation results shows improvements, at least 10% in PSNR at data rate 110 kbps with respect to DISCOVER and shows significant improvement in data rate from 50kbps to 300 kbps.

For various video sequences number of zigzag coefficients (diagonals) to be transmitted are calculated, for 37db PSNR Indoor sequence required 4 diagonals to achieve 38.2 dB PSNR at 51.5 kbps. Coast guard sequence required 3 diagonals to achieve 39.2 dB PSNR at 38.53. Hall monitor, outdoor & foreman sequences required 5 diagonals to achieve PSNR 37.09, 38.3 & 37.36 dB at 95.55,57 & 104.4 kbps respectively. Endoscopy sequence requires 9 diagonals to achieve 37.06 dB PSNR at 228 kbps.

For various video sequence number of zigzag coefficients (diagonals) to be transmitted are calculated, for 39 dB PSNR Indoor sequence required 5 diagonals to achieve 41.4 dB PSNR at 96.55 kbps. Coast guard sequence required 3 diagonals to achieve 39.2 dB PSNR at 38.53 kbps.Hall monitor seq. required 8 diagonals to achieve 39.49 dB PSNR at 175.5 kbps.Outdoor sequence required 6 diagonals to achieve 39.4 dB PSNR at 104.58 kbps.Foreman sequence required 11 diagonals to achieve 39.12 dB PSNR at 348.64 kbps

Thus for various video sequences, calculating optimum number of diagonals to achieve a particular PSNR, thus data rate can be controlled.

FUTURE SCOPE

The implementation given in this project is for GOP =2, can be further implement for GOP=4, 8. The implemented Wyner Ziv codec can be cascaded with various intraframe codec such as H.263+ and H.264/AVC.

It can be modified for live streaming applications like video streaming, video chat etc. The implementation code was developed in MATLAB which does not have facility to implement and demonstrate live streaming of videos. Also MATLAB is a high end programming language which requires a high speed processor. Converting these codes into Java executables will help this model run on a cell phone or devices which has low end processors.

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