# PREDICTIVE ENTROPY CODING OF GAIN-SHAPE VQ PARAMETERS

*Faruk M.Ö. ERYURTLU, Ahmet M. KONDOZ, Barry G. EVANS*

Centre for Satellite Engineering Research
University of Surrey
Guildford GU2 5XH
United Kingdom

## ABSTRACT

This paper presents a novel video coding algorithm which exploits past frame statistics for entropy coding of the gain-shape VQ parameters. Subband transform has been used to decorrelate the motion compensation residual in order to overcome the block visibility problem. The vectors with samples from different subbands are quantised using a gain-shape VQ technique which allows effective bit rate control. When compared to the H.261 standard, the proposed algorithm has given higher PSNR values at lower bit rates.

## 1. INTRODUCTION

The H.261 standard is based on the quantisation of DCT coefficients obtained from the motion compensation residual [1]. Although it is very successful in coding of low motion image sequences, the blocking effect due to the block DCT operation becomes noticeable at high compression ratios. This problem can be solved by using subband coding. In addition, vector quantisation of the subband samples at low rates gives good perceptual performance and efficiency.

In this paper, an efficient video coding algorithm is presented. After briefly describing motion compensation , subband decomposition and gain-shape VQ stages, the novelty of the algorithm, that is entropy coding gain levels and vector indices using the previous frame statistics, is explained. Simulation results of the algorithm are compared to those of the H.261 standard.

## 2. ALGORITHM DESCRIPTION

The proposed algorithm uses a similar block-matched motion estimation technique to the H.261 standard. One difference is the weighting of the motion estimation errors according to the corresponding motion vector. The weighting function used increases linearly with that of the motion vector magnitude, and thus, the occurrence of low magnitude vectors, which require less bits to encode, is increased.

In the H.261 algorithm, the difference between the motion parameters corresponding to successive blocks is entropy encoded. However, with the weighting function, less bits may be sufficient to encode the actual motion vectors rather than the differences. Therefore, 1 bit



0-7803-2431-5/95 $4.00 © 1995 IEEE

per frame is used to indicate the coding scheme for a given frame.

The motion compensation residual is split into different frequency bands by filtering it with low- and high-pass filters. Although the correlation between the subband signals is very low (orthogonal quadrature mirror filters are used), there is still a non-linear relation which can be exploited. A uniform decomposition structure is preferred in order to have an equal number of samples in each subband.

The correlation between the samples of the same subband is also very low, and therefore a linear prediction scheme may even reduce the coding efficiency. However, there is still some degree of dependency between samples, which is highly unstationary and has different characteristics in different parts of the frame and in different frames.

Vector quantisation can be employed to exploit the redundancy between the subbands if the vectors are formed by choosing the elements from different bands. Gain-shape VQ technique is preferred for encoding the subband signals. This technique does not only require a smaller codebook, but also allows an effective control over the bit rate by adjusting the quantiser step size for the gain values. Furthermore, in the case of very low vector gains, the shape information can be discarded resulting in significant savings in bits.

The shape codebook was trained using the LBG algorithm, and a scalar quantiser was designed for the gain values. Gains smaller than a certain threshold are set to zero and the corresponding codebook indices are not encoded. The scalar quantiser for the remaining gain values is uniform with an adjustable step size according to the buffer fullness.

The number of bits required to represent the codebook indices and gain levels are reduced by employing an adaptive bit allocation scheme. The probabilities of the parameters are estimated using the previous frame data. Then, entropy coding principles are used to allocate bits to the gains and indices. Thus, the indices or gain levels that are frequently used in the previous frame are encoded with less bits.

Due to motion compensation, most of the quantised gain values are zero for large image regions. In these regions, it is not efficient to encode the null gain values on a pixel by pixel basis. Therefore, 3 other options were added to the gain entropy coder. These represent 8x8, 4x4 and 2x2 blocks of null gain values. The bits allocated to these blocks are also computed using the previous frame's statistics.

## 3. RESULTS

For subband decomposition, 16-tap non-perfect reconstruction QMF filters were used [3]. The motion compensation residual was split into 16 uniform subbands resulting in a vector dimension of 16.

Residual subbands from 16 CIF and QCIF frames, randomly taken from the 'Salesman' and 'Tennis' image sequences, were used for training the shape codebook. For testing, the 'Miss America' sequence was used. Different shape codebook sizes were considered, and finally a codebook containing only 64 vectors was chosen.

The first frame was encoded using the subband gain-shape VQ algorithm designed for still images [2]. For the second frame, the statistical information needed for entropy coding was estimated from the training data.

The 'Miss America' sequence was encoded using a gain quantiser with a fixed step size of 4. However, the first step size was set to 7 in order to increase the number of null gain values. The results were then compared with the values of the H.261 standard algorithm using a fixed quantiser size of 22. Besides an improvement in the subjective quality by the removal of the blocking effect, better PSNR values were also obtained.

For the CIF-size 'Miss America' sequence including 120 frames, the average PSNR value for the H.261 standard was 36.60 dB with 8122 bits per frame on average. The proposed algorithm resulted in an average PSNR of 37.64 dB using 7604 bits per frame on average.

For a comparison on an equal basis, the first frames in both algorithms were encoded using the H.261 standard at the same bit rate. Our method resulted in an average PSNR of 37.31 dB with an average bit rate of 7429 bits per frame.

The subband reconstruction stage splits the quantisation error into a wide image area including the static background. Therefore, the motion compensation residual in the stationary regions includes additional errors which do not exist in the block transform methods. After encoding a number of frames, the error level becomes stable and the PSNR decrease saturates. Since the errors are spread, subjective assessment of the encoded video quality favors the subband coding technique. As shown in Fig. 1, the frames encoded using the proposed algorithm look more natural than the images encoded by the H.261 standard codec.

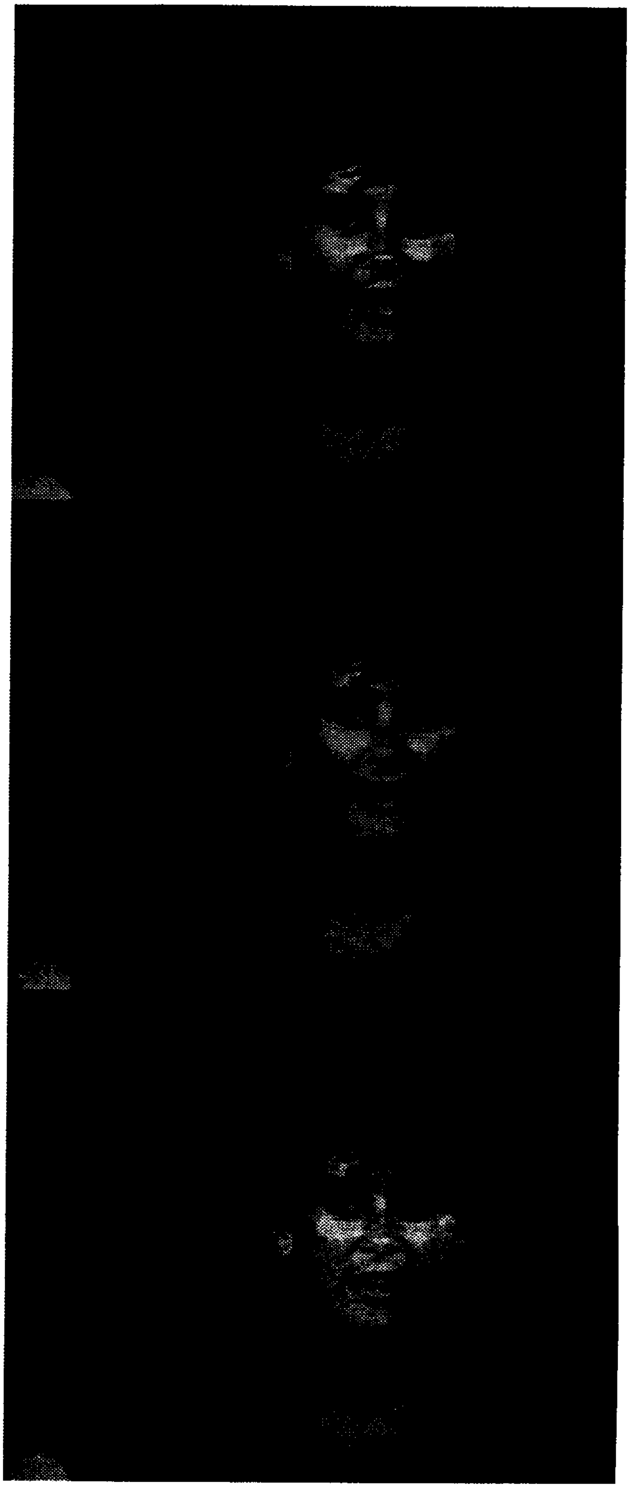

Figure 1: Same CIF-size frame from original (top) and encoded 'Miss America' sequences using H.261 standard (middle) and proposed algorithm (bottom)

## 4. CONCLUSION

A low rate video coding algorithm using subband decomposition and gain-shape VQ has been presented. A bit allocation scheme which exploits the previous frame data has been introduced. Better results than the H.261 standard have been obtained at bit rates around 0.05-0.1 bpp.

## 5. REFERENCES


[1] CCITT Recommendation H.261. *"Video codec for audiovisual services at P×64 kbit/s"*, 1990.

[2] F. Eryurtlu, A.M. Kondoz, and B.G. Evans. "A sub-band image coding algorithm using vector quantisation". In *IEEE International Symposium on Multimedia Technologies*, Southampton, UK, April 1993.

[3] J.D. Johnston. "A filter family designed for use in quadrature mirror banks". In *Proc. of ICASSP*, pages 291–294, 1980.