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Motion-Compensated Wavelet Transform Coding for Full-Motion Color Video Signals

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Summary

The discrete wavelet transform (DWT) has recently received much attention in the context of image processing due to its flexibility in representing nonstationary image signals and its ability in adapting human visual characteristics. Its relationships to subband coding, Gabor transform, pyramid structure and other intermediate spatial-frequency representation have been investigated [MALL 89][BURT 89][VETT 90]. Most of current research in DWT has been concentrated on still image coding in the area of data compression. In [BAAZ 90], DWT was applied to decompose a sequence of images and no coding results were reported. It is the purpose of this paper to apply DWT to compress full motion color TV video signals using inter-frame motion-compensated coding, which, to the best of our knowledge, has not been researched previously.

The compression scheme we implemented in our work is an interframe hybrid DPCM/DWT scheme with a new motion compensation method. After motion compensation, the displaced frame difference (DFD) residue video signal is decomposed by wavelet representation and the wavelet pyramid samples are uniformly quantized in each band. The quantization process takes advantage of human visual characteristics and coefficients are weighted prior to the quantization. Motion vectors are noiselessly coded. All quantities are entropy-coded adaptively prior to the transmission. The number

of samples in the wavelet representation is equal to the samples in the original frame as a consequence of orthogonality of the decomposition.

Two new block-based motion estimation schemes, namely: intra-frame and inter-frame predictive motion estimation schemes, are used to find the displacement information prior to the wavelet decomposition on the displace difference frame. In the proposed intra-frame predictive pattern searching scheme (PPS), motion information in the neighboring blocks is exploited. This is especially useful in estimating motion vectors of video signals which contain large homogeneous areas and translations caused by object moving or camera panning. Therefore, motion vectors for these areas are highly correlated. The purpose of intra-frame PPS is to take advantage of this correlation and hereby reduce the searching area. The proposed inter-frame predictive pattern searching scheme is based on the "inertia" property of moving object. The motion vectors of a block is estimated from those of previous frames represented by an autoregressive model. The propose intra/inter PPS schemes not only significantly reduce the computational complexity of motion estimations, it also gives more realistic motion vectors.

The proposed motion compensated DWT coding scheme is implemented in our Abekas-60 based video compression testbed. The Abekas A-60 is basically a digital video recorder which allows a real-time playback of 25 second recorded CCIR 601 digital video. The Abekas system is interfaced with a SPARC workstation, where the compression software resides. By software simulation of the compression/decompression techniques in the SPARC, we can reconstruct video segments to compare with the original signal via a real-time play back. Therefore, we can evaluate compression performance, quality degradation, computational efficiency of different coding algorithms. The test sequences "CAR" and "TOPGUN" we use are two full-motion color video sequences in CCIR 601 format with 720 by 480 per frame, 16 bits per pixel in YUV format (or 24 bits in RGB format) and 30 frames/60 fields per second. We measured the first-order entropy of the DFD signal, the entropy of motion vectors, the reconstructed signal-to-noise ratio at a coding rate ranging from 1Mbps to 3

Mbps. Those results are also compared with the MPEG-like scheme which uses a motion-compensated hybrid DPCM/DCT scheme and is currently being standardized by the CCITT MPEG committee. The subjective and comparative results suggest that the DWT can be successfully applied to full-motion video compression and less "blocking effect" is observed compared to the DCT-based block transform coding with about the same data rate and signal-to-noise ratio.

References:

[MALL 89] S. Mallat, "Multifrequency Channel Decompositions of Images and Wavelet Models," *IEEE Trans. Acoustics, Speech and Signal Processing*, Vol.17, No.12, Dec.1989

[BURT 89] P.Burt, "Multiresolution techniques for image representation, analysis, and "smart" transmission," *SPIE Vol. 1199 Visual Communications and Image Processing IV, Nov. 1989*

[VETT 90] M.Vetterli and C.Herley, "Wavelets and Filter Banks: Relationships and New Results," *Proc. of ICASSP'90, April 3-6, 1990*

[BAAZ 90] N.Baaziz and Claude Labit, "Laplacian Pyramid Versus Wavelet Decomposition for Image Sequence Coding," *Proc. of ICASSP'90, April 3-6, 1990*

Brief Professional Biography of Authors

Dr. **Ya-Qin Zhang** is a senior member of technical staff of Contel Technology Center located in Chantilly, Virginia. His research interests are in the areas of image/video compression, packet video and medical imaging.

Mr. **Sohail Zafar** is a PhD candidate in the EE Dept. of University of Maryland at College Park. He is a research assistant at system research center of university of Maryland and has been working on his dissertation at Contel Technology Center since 1989. He got his M.S.E.E. in Columbia University, New York in 1986. His research interests are video compression and neural networks.

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