TECHNICAL RESEARCH REPORT

Hierarchical Coding of High Data Rate Video for ATM Networks

by R. Sivarajan

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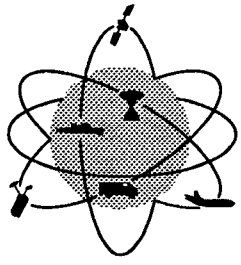

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Hierarchical Coding of High Data Rate Video for ATM Networks

A PRELIMINARY REPORT

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Abstract: A hierarchical DCT-based system is presented that prioritizes and compresses high data rate video for transmission over cell-based ATM networks. The proposed system is both robust to cell loss, and efficient in bandwidth utilization. Cell loss due to network congestion can significantly deteriorate the visual quality of the received image. Various cell loss concealment techniques have been proposed in the literature. The system proposed here will significantly reduce complexity of cell loss concealment circuitry at the receiver.

ATM standards allow one bit for priorities; thus a two-level hierarchical scheme is examined. We also study performance for priorities greater than two. When the ATM network needs to drop cells due to congestion, the low-priority cells are dropped first. We assume that the high-priority cells are received without any cell loss whereas the low-priority cells are subject to a non-zero cell loss probability rate.

The transmission rate is the 130 Mbps H4 access rate. Due to this high rate, the coder is kept simple and only intrafield coding is considered. Variable length coding is utilized to noiselessly compress the data before transmission. Two lossless techniques are examined: adaptive Huffman coding and arithmetic coding. The codecs will be tested assuming a Markov source with varying orders of memory (as well as the memoryless case). Simulation results are used to judge performance of this hierarchical system.

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I. Introduction

Motion video is an important service providing an impetus for the development of a Broadband Integrated Services Digital Network (BISDN). Video is an integral part of the idea of multimedia. Video conferencing, video-on-demand, broadcast digital video, and HDTV are speculated to have a substantial consumer market. For high data rate (HDR) motion video, efficient transmission as well as a maintenance of very high image quality is desired. The transmission issue is resolved by the Asynchronous Transfer Mode (ATM) over a fiber network that provides high transmission rates combined with low error probabilities.

For an ATM network, data bits are combined to form fixed-sized cells of length 53 bytes. Cell loss occurs due to either network congestion or non-correctable bit errors in the cell header field. One lost cell results in 48 bytes (or 384 bits) of lost information. For uncoded systems, such a loss will have a noticeable effect on the received picture quality. For coded systems, such as those utilizing variable length coding (VLC) schemes, the effect of cell loss is amplified since code synchronization may be lost [1]. The proposed hierarchical coding scheme provides robust source coding that results in graceful degradation of the received image quality in the event of cell loss.

II. Description of System

Our scheme is a refinement of that proposed by Tzou [1]. The modifications include greater number of priorities and testing other model-based schemes for lossless compression. The following is a brief description of the system; details can be found in [2]. Fig. 1 shows a schematic for the encoder. System performance is measured on luminance components of images represented by 8 bits per pixel. The test images were provided by Comsat Laboratories, Clarksburg, MD. Blocks of size 8x4 pixels are transform coded by DCT into 8x4 blocks of DCT coefficients. These coefficients represent the image data in the frequency domain. The human visual system (HVS) is more sensitive to low-frequency DCT coefficients. The DCT blocks are appropriately scaled by a weighting matrix to reflect the HVS. For each block, the 2-D to 1-D scan results in a 1-D array of size 32 that prioritizes the coefficients according to the HVS model.

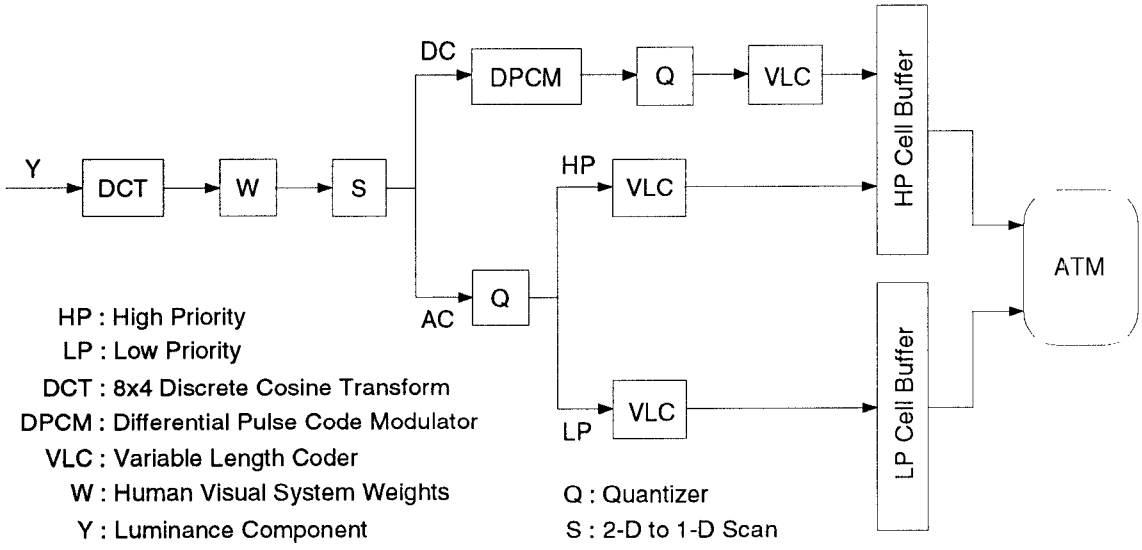

Fig. 1. Block diagram for encoder.

The DC component of a DCT block is the most important in the HVS model and is thus treated separately from the remaining AC coefficients. The DPCM outputs differences between two contiguous DC components. The resulting prediction errors are quantized by an 8-bit Lloyd-Max modified non-uniform quantizer based on a Gaussian distribution. The quantized values are noiselessly compressed by a VLC.

The AC coefficients are quantized by a 7-bit Lloyd-Max modified non-uniform quantizer based on a Laplacian distribution. The quantized AC terms are separated into priorities by grouping consecutive elements from the scanned 1-D array. For the two priority case, the 31 quantized AC terms are separated into k high-priority (HP) elements and $(31-k)$ low-priority (LP) elements, where $1 \leq k \leq 30$. The two streams are noiselessly compressed by a VLC. The HP bit stream (representing DC terms and HP AC terms) are assembled into HP ATM cells. The LP bit stream are assembled into LP ATM cells. Both types of cells are sent to the ATM network.

ATM cell loss is simulated by dropping LP cells according to a fixed probability of cell loss. For each LP cell, a pseudo-random number is generated and the cell is dropped if the number falls within a specified interval. The HP cells are guaranteed to arrive at the receiver without any lost cells. The decoder for the system is schematically the reverse of the encoder (see fig.2).

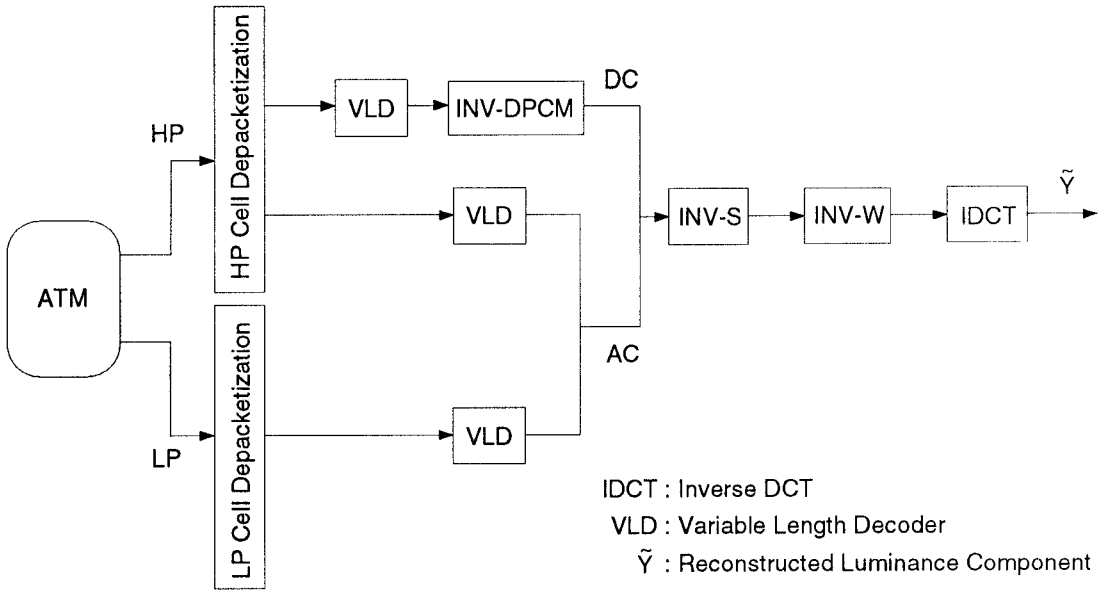

Fig. 2. Block diagram for decoder.

References

[1] K.H. Tzou, "An intrafield DCT-based HDTV coding for ATM networks," *IEEE Trans. CSVT*, vol. 1, no. 2, pp. 184-196.

[2] R. Sivarajan, "Hierarchical coding of high data rate video for ATM networks," under preparation.