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Thyagarajan et al.

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(54) **CONTRAST SENSITIVE VARIANCE BASED ADAPTIVE BLOCK SIZE DCT IMAGE COMPRESSION**

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This patent is subject to a terminal disclaimer.

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(58) **Field of Search** 382/239, 240, 382/248, 232, 253; 358/433, 261.2, 426.14; 375/240.02, 240.11, 240.2, 240.24

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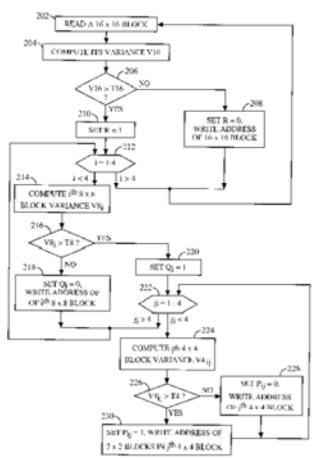
(57) **ABSTRACT**

A system and method for image compression utilizing adaptively sized blocks and sub-blocks of discrete cosine transform coefficient data is presented. A block size assignment element in the encoder selects the block or sub-block of an input block of pixels to be processed. The selection is based on the variance of pixel values. Blocks with variances larger than a threshold are subdivided, while blocks with variances smaller than a threshold are not subdivided. A transform element transforms the pixel values of the selected blocks into the frequency domain. The frequency domain values may then be quantized, serialized, and variable length coded in preparation for transmission.

35 Claims, 3 Drawing Sheets



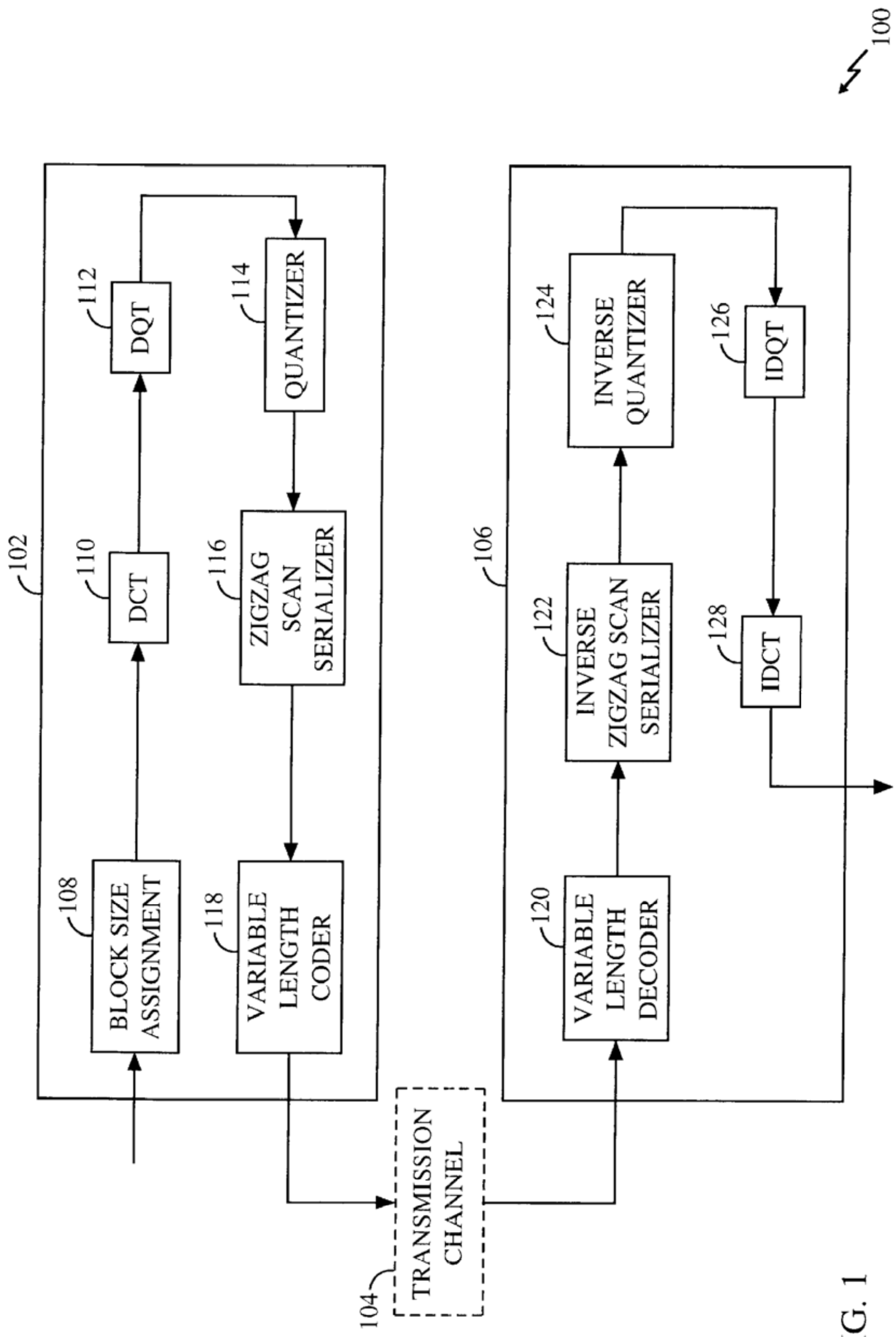

100
102
BLOCK SIZE ASSIGNMENT
108
DCT
110
DQT
112
QUANTIZER
114
ZIGZAG SCAN SERIALIZER
116
VARIABLE LENGTH CODER
118
TRANSMISSION CHANNEL
104
106
VARIABLE LENGTH DECODER
120
INVERSE ZIGZAG SCAN SERIALIZER
122
INVERSE QUANTIZER
124
IDQT
126
IDCT
128

FIG. 1

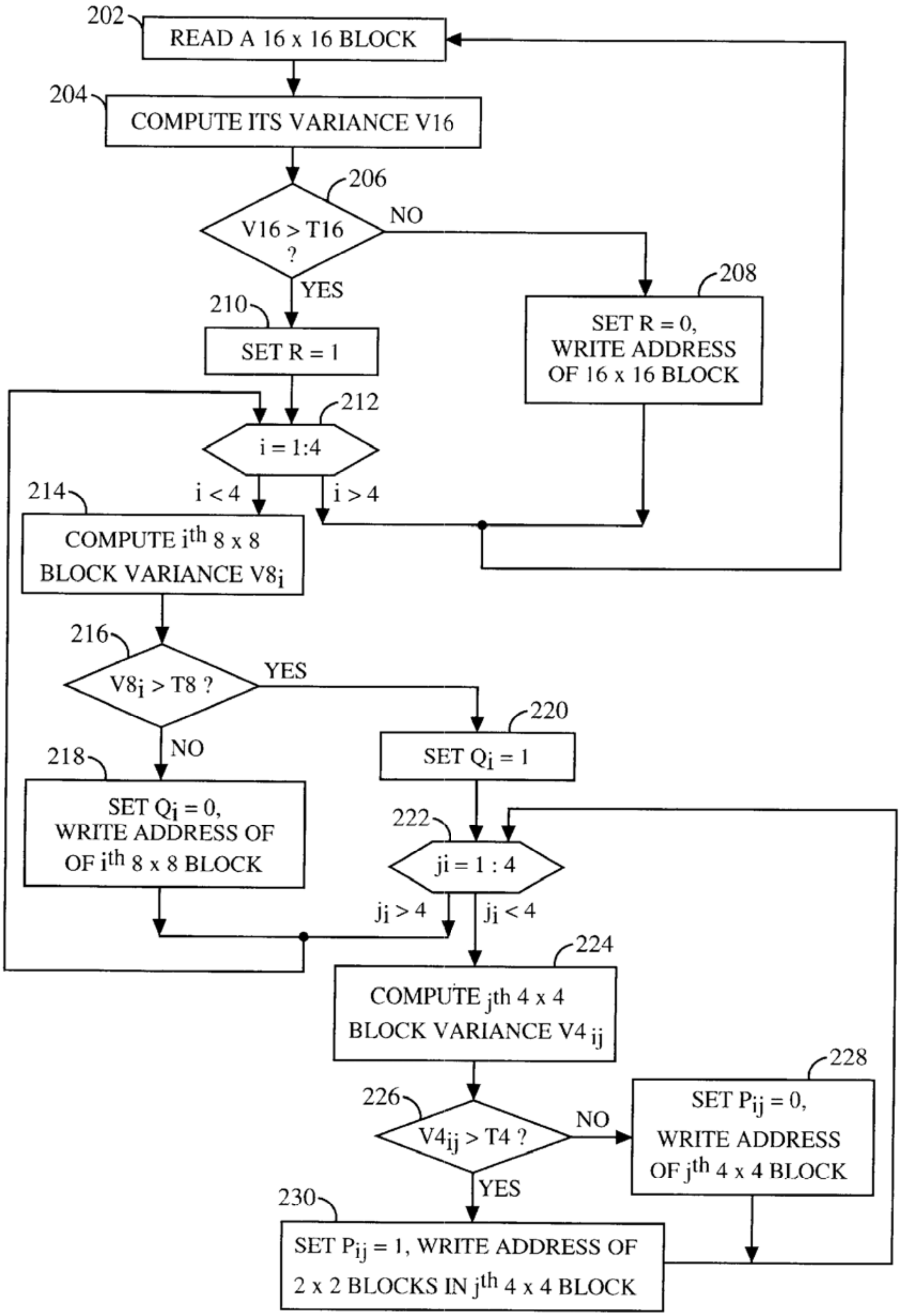

202
READ A 16 x 16 BLOCK
204
COMPUTE ITS VARIANCE V16
206
V16 > T16 ?
NO
YES
208
SET R = 0, WRITE ADDRESS OF 16 x 16 BLOCK
210
SET R = 1
212
i = 1:4
214
i < 4
i > 4
COMPUTE i th 8 x 8 BLOCK VARIANCE V8i
216
V8i > T8 ?
YES
NO
220
SET Qi = 1
218
SET Qi = 0, WRITE ADDRESS OF OF i th 8 x 8 BLOCK
222
ji = 1 : 4
ji > 4
ji < 4
224
COMPUTE j th 4 x 4 BLOCK VARIANCE V4 ij
226
V4ij > T4 ?
NO
228
SET Pij = 0, WRITE ADDRESS OF j th 4 x 4 BLOCK
YES
230
SET Pij = 1, WRITE ADDRESS OF 2 x 2 BLOCKS IN j th 4 x 4 BLOCK

FIG. 2

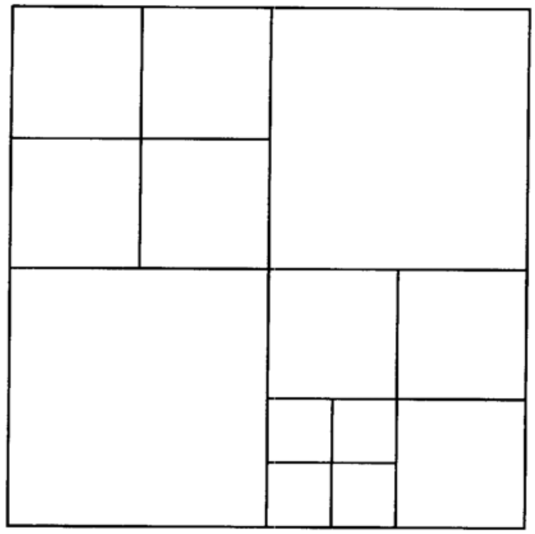


FIG. 3A

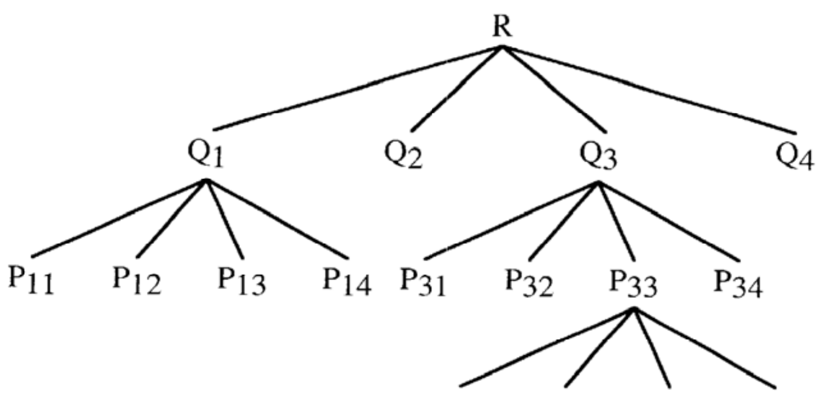


FIG. 3B

1	1	0	1	0	0	0	0	0	0	0	1	0

PQR DATA

FIG. 3C

CONTRAST SENSITIVE VARIANCE BASED ADAPTIVE BLOCK SIZE DCT IMAGE COMPRESSION

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates to image processing. More specifically, the present invention relates to a compression scheme for image signals utilizing adaptively sized blocks and sub-blocks of encoded discrete cosine transform coefficient data.

II. Description of the Related Art

In the field of transmission and reception of video signals such as are used for projecting "films" or "movies", various improvements are being made to image compression techniques. Many of the current and proposed video systems make use of digital encoding techniques. Digital encoding provides a robustness for the communications link which resists impairments such as multipath fading and jamming or signal interference, each of which could otherwise serious degrade image quality. Furthermore, digital techniques facilitate the use signal encryption techniques, which are found useful or even necessary for governmental and many newly developing commercial broadcast applications.

High definition video is an area which benefits from improved image compression techniques. When first proposed, over-the-air transmission of high definition video (or even over-wire or fiber-optical transmission) seemed impractical due to excessive bandwidth requirements. Typical wireless, or other, transmission systems being designed did not readily accommodate enough bandwidth. However, it has been realized that compression of digital video signals may be achieved to a level that enables transmission using reasonable bandwidths. Such levels of signal compression, coupled with digital transmission of the signal, will enable a video system to transmit with less power with greater immunity to channel impairments while occupying a more desirable and useful bandwidth.

One compression technique capable of offering significant levels of compression while preserving the desired level of quality for video signals utilizes adaptively sized blocks and sub-blocks of encoded Discrete Cosine Transform (DCT) coefficient data. This technique will hereinafter be referred to as the Adaptive Block Size Differential Cosine Transform (ABSDCT) method. This technique is disclosed in U.S. Pat. No. 5,021,891, entitled "Adaptive Block Size Image Compression Method And System," assigned to the assignee of the present invention and incorporated herein by reference. DCT techniques are also disclosed in U.S. Pat. No. 5,107,345, entitled "Adaptive Block Size Image Compression Method And System," assigned to the assignee of the present invention and incorporated herein by reference. Further, the use of the ABSDCT technique in combination with a Differential Quadtree Transform technique is discussed in U.S. Pat. No. 5,452,104, entitled "Adaptive Block Size Image Compression Method And System," also assigned to the assignee of the present invention and incorporated herein by reference. The systems disclosed in these patents utilizes what is referred to as "intra-frame" encoding, where each frame of image data is encoded without regard to the content of any other frame. Using the ABSDCT technique, the achievable data rate may be reduced from around 1.5 billion bits per second to approximately 50 million bits per second without discernible degradation of the image quality.

The ABSDCT technique may be used to compress either a black and white or a color image or signal representing the image. The color input signal may be in a YIQ format, with Y being the luminance, or brightness, sample, and I and Q being the chrominance, or color, samples for each 4×4 block of pixels. Other known formats such as the YUV or RGB formats may also be used. Because of the low spatial sensitivity of the eye to color, most research has shown that a sub-sample of the color components by a factor of four in the horizontal and vertical directions is reasonable. Accordingly, a video signal may be represented by four luminance components and two chrominance components.

Using ABSDCT, a video signal will generally be segmented into blocks of pixels for processing. For each block, the luminance and chrominance components are passed to a block interleaver. For example, a 16×16 (pixel) block may be presented to the block interleaver, which orders or organizes the image samples within each 16×16 block to produce blocks and composite sub-blocks of data for discrete cosine transform (DCT) analysis. The DCT operator is one method of converting a time-sampled signal to a frequency representation of the same signal. By converting to a frequency representation, the DCT techniques have been shown to allow for very high levels of compression, as quantizers can be designed to take advantage of the frequency distribution characteristics of an image. In a preferred embodiment, one 16×16 DCT is applied to a first ordering, four 8×8 DCTs are applied to a second ordering, 16 4×4 DCTs are applied to a third ordering, and 64 2×2 DCTs are applied to a fourth ordering.

The DCT operation reduces the spatial redundancy inherent in the video source. After the DCT is performed, most of the video signal energy tends to be concentrated in a few DCT coefficients. An additional transform, the Differential Quad-Tree Transform (DQT), may be used to reduce the redundancy among the DCT coefficients.

For the 16×16 block and each sub-block, the DCT coefficient values and the DQT value (if the DQT is used) are analyzed to determine the number of bits required to encode the block or sub-block. Then, the block or the combination of sub-blocks that requires the least number of bits to encode is chosen to represent the image segment. For example, two 8×8 sub-blocks, six 4×4 sub-blocks, and eight 2×2 sub-blocks may be chosen to represent the image segment.

The chosen block or combination of sub-blocks is then properly arranged in order into a 16×16 block. The DCT/DQT coefficient values may then undergo frequency weighting, quantization, and coding (such as variable length coding) in preparation for transmission.

Although the ABSDCT technique described above performs remarkably well, it is computationally intensive. Thus, compact hardware implementation of the technique may be difficult. An alternative technique that would make hardware implementation more efficient is desired. An image compression method and system that is more computationally efficient is provided by the present invention in the manner described below.

SUMMARY OF THE INVENTION

The present invention is system and method of image compression that utilizes adaptively sized blocks and sub-blocks of Discrete Cosine Transform coefficient data. In one embodiment, a 16×16 block of pixels is input to an encoder. The encoder comprises a block size assignment element, which segments the input block of pixels for processing. The block size assignment is based on the variances of the input

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