

## Exhibit 1009

| Karczewicz (Ex. 1004)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Karczewicz 60/369,500 Provisional Application (Ex. 1006)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
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| <p>“The multimedia terminal 80 includes a variety of elements referred to as 'terminal equipment'. This includes video, audio and telematic devices, denoted generically by reference numbers 81, 82 and 83, respectively. The video equipment 81 may include, for example, a video camera for capturing video images, a monitor for displaying received video content and optional video processing equipment. The audio equipment 82 typically includes a microphone, for example for capturing spoken messages, and a loudspeaker for reproducing received audio content. The audio equipment may also include additional audio processing units. The telematic equipment 83, may include a data terminal, keyboard, electronic whiteboard or a still image transceiver, such as a fax unit.”</p> <p>Karczewicz, p. 44:5-15.</p> | <p>“The invention relates to a method, a system and a device for the coding of digital video. More specifically, the invention concerns the coding of quantised transform coefficients produced as a result of block-based transform coding in a video/image encoder/decoder using Variable Length Coding (VLC).”</p> <p>Karczewicz 60/369,500 Provisional Application, p. 1:16-18.</p> <p>“Typically, run-level pair is encoded as a single symbol. This is achieved [<i>sic</i>] by defining a mapping between each possible values of run-level pairs and code numbers. An example of a mapping of run-level pairs to code numbers as a look up table is illustrated in Table 3. Using the mappings in the look-up table, a code number is assigned to each (run,level) pair of the block and the resulting code numbers are encoded by VLC coding. For example, in Joint Model (JM) 2.0 Working Draft Number 2, Doc.JVT-B118, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG Pattaya, 2<sup>nd</sup> JVT Meeting, Geneva, CH, Jan. 29-Feb. 1, 2002", 2 different look-up tables are defined that map the (run,level) pairs onto code numbers. The selection which table to use is based on the QP value and the coding mode of the block.</p> |

| <b>Karczewicz (Ex. 1004)</b>                                                                                                                                                                                                                                                                                                                                                                   | <b>Karczewicz 60/369,500 Provisional Application (Ex. 1006)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
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|                                                                                                                                                                                                                                                                                                                                                                                                | <p>More specifically, if the coding mode is INTRA and the QP is smaller than 24, a different table is used than otherwise.”</p> <p>Karczewicz 60/369,500 Provisional Application, p. 2:21-30.</p> <p>“decoding (process): The process defined in this specification that reads an input coded bitstream and produces decoded pictures or audio samples.</p> <p>...</p> <p>encoding (process): A process, not specified in this specification, that reads a stream of input pictures or audio samples and produces a valid coded bitstream as defined in this specification.”</p> <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), p. 10.</p> |
| <p>“During data transmission from the multimedia terminal, the MUX DMUX unit 90 combines encoded and synchronised video and audio streams with data input from the telematic equipment 83 and possible control data, to form a single bit-stream. Information concerning the type of data encryption (if any) to be applied to the bit-stream, provided by encryption block 89, is used to</p> | <p>“The invention relates to a method, a system and a device for the coding of digital video. More specifically, the invention concerns the coding of quantised transform coefficients produced as a result of block-based transform coding in a video/image encoder/decoder using Variable Length Coding (VLC).”</p> <p>Karczewicz 60/369,500 Provisional Application, p. 1:16-18.</p>                                                                                                                                                                                                                                                                              |

| <b>Karczewicz (Ex. 1004)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Karczewicz 60/369,500 Provisional Application (Ex. 1006)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
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| <p>select an encryption mode. Correspondingly, when a multiplexed and possibly encrypted multimedia bit-stream is being received, MUX/DMUX unit 90 is responsible for decrypting the bit-stream, dividing it into its constituent multimedia components and passing those components to the appropriate codec(s) and/or terminal equipment for decoding and reproduction.”</p> <p>Karczewicz, p. 45:19-28.</p>                                                                                                                                                                                                                 | <p>“decoding (process): The process defined in this specification that reads an input coded bitstream and produces decoded pictures or audio samples.</p> <p>...</p> <p>encoding (process): A process, not specified in this specification, that reads a stream of input pictures or audio samples and produces a valid coded bitstream as defined in this specification.”</p> <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), p. 10.</p>                                                                                |
| <p>“The terminal's audio equipment is coupled to an audio codec, denoted in Figure 8 by reference number 86. Like the video codec, the audio codec comprises an encoder/decoder pair. It converts audio data captured by the terminal's audio equipment into a form suitable for transmission over the communications link and transforms encoded audio data received from the network back into a form suitable for reproduction, for example on the terminal's loudspeaker. The output of the audio codec is passed to a delay block 87. This compensates for the delays introduced by the video coding process and thus</p> | <p>“The invention relates to a method, a system and a device for the coding of digital video. More specifically, the invention concerns the coding of quantised transform coefficients produced as a result of block-based transform coding in a video/image encoder/decoder using Variable Length Coding (VLC).”</p> <p>Karczewicz 60/369,500 Provisional Application, p. 1:16-18.</p> <p>“decoding (process): The process defined in this specification that reads an input coded bitstream and produces decoded pictures or audio samples.</p> |

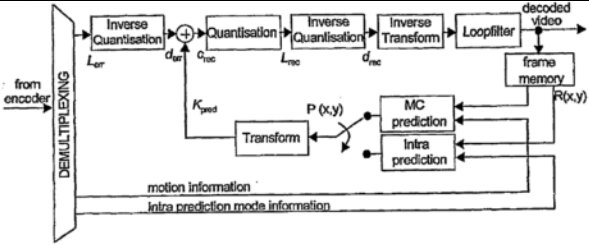
| <b>Karczewicz (Ex. 1004)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Karczewicz 60/369,500 Provisional Application (Ex. 1006)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
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| <p>ensures synchronisation of audio and video content”</p> <p>Karczewicz, p. 44:29-45:6.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), p. 10.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <p>“The video equipment 81 is coupled to a video codec 85. The video codec 85 comprises a video encoder and a corresponding video decoder both implemented according to the invention. Such an encoder and a decoder will be described in the following. The video codec 85 is responsible for encoding captured video data in an appropriate form for further transmission over a communications link and decoding compressed video content received from the communications network. In the example illustrated in Figure 8, the video codec is implemented according to ITU-T recommendation H.26L, with appropriate modifications to implement the adaptive variable length coding method according to the invention in both the encoder and the decoder of the video codec”</p> <p>Karczewicz, p. 44:17-27.</p> | <p>“The invention relates to a method, a system and a device for the coding of digital video. More specifically, the invention concerns the coding of quantised transform coefficients produced as a result of block-based transform coding in a video/image encoder/decoder using Variable Length Coding (VLC).”</p> <p>Karczewicz 60/369,500 Provisional Application, p. 1:16-18.</p> <p>“decoding (process): The process defined in this specification that reads an input coded bitstream and produces decoded pictures or audio samples.</p> <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), p. 10.</p> |
| <p>“The lower spatial resolution of the chrominance components is usually attained by sub-sampling.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <p>“macroblock: The four 8 by 8 blocks of luminance data and the two (for 4:2:0 chrominance format), four (for 4:2:2</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

| <b>Karczewicz (Ex. 1004)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Karczewicz 60/369,500 Provisional Application (Ex. 1006)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
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| <p>Typically, each frame of a video sequence is divided into so-called 'macroblocks', which comprise luminance (Y) information and associated chrominance (U, V) information which is spatially sub-sampled. Figure 3 illustrates one way in which macroblocks can be formed. Figure 3a shows a frame of a video sequence represented using a YUV colour model, each component having the same spatial resolution. Macroblocks are formed by representing a region of 16x16 image pixels in the original image (Figure 3b) as four blocks of luminance information, each luminance block comprising an 8x8 array of luminance (Y) values and two spatially corresponding chrominance components (U and V) which are sub-sampled by a factor of two in the x and y directions to yield corresponding arrays of 8x8 chrominance (U, V) values (see Figure 3c). According to certain video coding recommendations, such as International Telecommunications Union (ITU-T) recommendation H.26L, the fundamental block size used within the macroblocks can be other than 8x8, for example 4x8 or 4x4. (See G. Bjontegaard, "H.26L Test Model Long Term Number 8 (TML-8) draft 0",</p> | <p>chrominance format) or eight (for 4:4:4 chrominance format) corresponding 8 by 8 blocks of chrominance data coming from a 16 by 16 section of the luminance component of the picture. Macroblock is sometimes used to refer to the sample data and sometimes to the coded representation of the sample values and their data elements defined in the macroblock header of the syntax defined in this part of this specification. The usage is clear from the context.”</p> <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), p. 12.</p> <p>“3.2 Subdivision of a picture into macroblocks</p> <p>Pictures (both frame and field) are divided into macroblocks of 16x16 pixels. For instance, a QCIF picture is divided into 99 macroblocks as indicated in FIGURE 1. A number of consecutive macroblocks in coding order (see FIGURE 1) can be organized in slices. Slices represent independent coding units in a way that they can be decoded without referencing other slices of the same frame.”</p> <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), p. 16.</p> |

| Karczewicz (Ex. 1004)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Karczewicz 60/369,500 Provisional Application (Ex. 1006)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
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| <p>VCEG-N10, June 2001, section 2.3).”</p> <p>Karczewicz, p. 2:18-3:3.</p> <p>“A QCIF image comprises 11x9 macroblocks. If the luminance blocks and chrominance blocks are represented with 8 bit resolution (that is by numbers in the range 0 to 255), the total number of bits required per macroblock is <math>(16 \times 16 \times 8) + 2 \times (8 \times 8 \times 8) = 3072</math> bits. The number of bits needed to represent a video frame in QCIF format is thus <math>99 \times 3072 = 304,128</math> bits. This means that the amount of data required to transmit/record/display an uncompressed video sequence in QCIF format, represented using a YUV colour model, at a rate of 30 frames per second, is more than 9 Mbps (million bits per second). This is an extremely high data rate and is impractical for use in video recording, transmission and display applications because of the very large storage capacity, transmission channel capacity and hardware performance required.”</p> <p>Karczewicz, p. 3:5-16.</p> | <p>“4.4.4 IntraPrediction Mode (Intra_pred_mode)</p> <p>Even in Intra mode, prediction is always used for each sub block in a macroblock, A 4x4 block is to be coded (pixels labeled a to p below). The pixels A to Q from neighboring blocks may already be decoded and may be used for prediction. When pixels E-H are not available, whether because they have not yet been decoded, are outside the picture or outside the current independent slice, the pixel value of Dis substituted for pixels E-H. When pixels M-P are not available, the pixel value of L is substituted for pixels M-P.”</p> <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), p. 28.</p> <p>“Residual coding</p> <p>The residual coding is based on 4x4 transform. But similar to coding of chrominance coefficients, another 4x4 transform to the 16 DC coefficients in the macroblock are added. In that way we end up with an overall DC for the whole MB which works well in flat areas.”</p> <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), p. 32.</p> |

| <b>Karczewicz (Ex. 1004)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Karczewicz 60/369,500 Provisional Application (Ex. 1006)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
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| <p>“Frames of a video sequence which are compressed using motion- compensated prediction are generally referred to as INTER-coded or P- frames. Motion-compensated prediction alone rarely provides a sufficiently precise representation of the image content of a video frame and therefore it is typically necessary to provide a so-called 'prediction error' (PE) frame with each INTER-coded frame. The prediction error frame represents the difference between a decoded version of the INTER-coded frame and the image content of the frame to be coded. More specifically, the prediction error frame comprises values that represent the difference between pixel values in the frame to be coded and corresponding reconstructed pixel values formed on the basis of a predicted version of the frame in question. Consequently, the prediction error frame has characteristics similar to a still image and block-based transform coding can be applied in order to reduce its spatial redundancy and hence the amount of data (number of bits) required to represent it.”</p> <p>Karczewicz, p. 5:5-23-6:5.</p> | <p>“5.3.1 Transform for Blocks of Size 4x4 Samples</p> <p>Instead of a discrete cosine transform (DCT), an integer transform with a similar coding gain as a 4x4 DCT is used. The transformation of input pixels <math>X=\{X00 \dots X33\}</math> to output coefficients <math>Y</math> is defined by:</p> <p>...</p> <p>For input pixels with 9-bit dynamic range (because they are residuals from 8-bit pixel data), the transform coefficients are guaranteed to fit within 16 bits, even when the second transform for DC coefficients is used. Thus, all transform operations can be computed in 16-bit arithmetic. In fact, the maximum dynamic range of the transforms coefficients fills a range of only 15.2 ‘bits; this small headroom can be used to support a variety of different quantization strategies (which are outside the scope of this specification).</p> <p>The transform and inverse transform matrices above have orthogonal basis functions. Unlike the DCT, though, the basis functions don’t have the same norm. Therefore, for the inverse transform to recover the original pixels, appropriate normalization factors must be applied to the transform coefficients before quantization and after dequantization. Such factors are absorbed by the quantization and dequantization scaling factors described below.”</p> |

| <b>Karczewicz (Ex. 1004)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Karczewicz 60/369,500 Provisional Application (Ex. 1006)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
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| <p>“The prediction error information for each block of the macroblock is passed to DCT transformation block 104, which performs a two-dimensional discrete cosine transform on each block of prediction error values to produce a two- dimensional array of DCT transform coefficients for each block. DCT transformation block 104 produces an array of coefficient values for each prediction error block, the number of coefficient values depending on the nature of the blocks which make up the macroblock. For example, if the fundamental block size used in the macroblock is 4x4, DCT transformation block 104 produces a 4x4 array of DCT coefficients for each prediction error block. If the block size is 8x8, an 8x8 array of DCT coefficients is produced.”</p> <p>Karczewicz, p. 11:29-12:7.</p> <p>“The transform coefficients for each prediction error block are passed to quantiser 106 where they are quantised using a quantisation parameter QP, in a manner analogous to that described above in connection with operation of the</p> | <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), pp. 42-43.</p> <p>“8.1.5 Intra Prediction Mode (Intra_pred_mode)</p> <p>Intra_pred_mode is present when Intra 4x4 or SIIntra 4x4 prediction types are indicated by the MB_Type. Intra_pred_mode indicates which intra prediction mode is used for a 4x4 block in the macroblock. The code_number for SIIntra 4x4 is the same as that described in the Intra_pred_mode entry of TABLE 7.</p> <p>Coding of Intra 4x4 prediction modes</p> <p>Coding of the intra prediction modes for SIIntra 4x4 blocks in SI-pictures is identical to that in I-pictures, i.e., the intra prediction modes of the neighboring blocks are taken into account as described in Section 3.4.3.1.1. Coding of the intra prediction modes for Intra 4x4 blocks in SI-pictures differs from I-picture coding if the neighboring block is coded in SIIntra 4x4 mode. In this case the prediction mode of the neighboring Sintra 4x4 block is treated to be ‘mode 0: DC_prediction.’</p> |

| Karczewicz (Ex. 1004)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Karczewicz 60/369,500 Provisional Application (Ex. 1006)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
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| <p>encoder in INTRA-coding mode. Again, selection of the quantisation parameter QP is controlled by the control manager 160 via control line 115.”</p> <p>Karczewicz, p. 12:9-13.</p> <p>“The motion coefficients are passed from motion field coding block 140 to motion compensated prediction block 150. Motion compensated prediction block 150 also receives the best-matching candidate region of pixel values identified by motion estimation block 130 from frame store 120. Using the approximate representation of the motion vector generated by motion field coding block 140 and the pixel values of the best-matching candidate region of pixels from the reference frame, motion compensated prediction block 150 generates an array of predicted pixel values for each block of the macroblock. Each block of predicted pixel values is passed to combiner 116 where the predicted pixel values are subtracted from the actual (input) pixel values in the corresponding block of the current macroblock. In this way a set of prediction error</p> |  <p>FIGURE 26<br/>A generic block diagram of S-picture decoder</p> <p>8.2 S-frame decoding</p> <p>A video frame in SP-picture format consists of blocks encoded in either Intra mode (Intra 4x4, Intra 8x8 or Intra 16x16 Modes) or in SP mode (Skip or NxM). Similarly, SI-pictures consist of macroblocks encoded in either Intra mode or in SI mode (SIntra 4x4). Intra macroblocks are decoded identically to those in I- and P-pictures. FIGURE 26 depicts a generic S-picture decoding for SI and SP modes. In SP mode, the prediction <math>P(x,y)</math> for the current macroblock of the frame being decoded is formed by the motion compensated prediction block in the identical way to that used in P-picture decoding. In SI mode, the prediction <math>P(x,y)</math> is formed by intra prediction block in the identical way to that used in I-picture decoding. After forming the predicted block <math>P(x,y)</math>, the decoding of SI and SP-macroblocks follows the same steps. Firstly, the received prediction error coefficients denoted by <math>L_{err}</math> are dequantized using quantization parameter PQP and the results are added to the transform coefficients <math>K_{pred}</math> of predicted block which are found by applying forward transform, see Section Error! Reference</p> |

| Karczewicz (Ex. 1004)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Karczewicz 60/369,500 Provisional Application (Ex. 1006)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
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| <p>blocks for the macroblock is obtained.”</p> <p>Karczewicz, p. 15:1-12.</p> <p>“Operation of the video decoder 200, shown in Figure 2 will now be described. The decoder 200 comprises a video multiplex decoder 270, which receives an encoded video bit-stream 135 from the encoder 100 and demultiplexes it into its constituent parts, an inverse quantiser 210, an inverse DCT transformer 220, a motion compensated prediction block 240, a frame store 250, a combiner 230, a control manager 260, and an output 280.”</p> <p>Karczewicz, p. 15:14-19.</p> | <p>source not found., to the predicted block. The resulting sum is quantized with the quantization parameter SPQP. These steps are combined in a single step as follows:</p> $Y_{QREC}(i,j) = \frac{Y_{PRED}(i,j) \cdot Q((QP2+12)\%6,i,j) + Y_{QERR}(i,j) \cdot F(QP1,QP2,i,j) + f}{2^{15+(QP2+12)/6}}, \quad i,j=0,\dots$ <p>where</p> $F(QP1,QP2,i,j) = \frac{Q((QP2+12)\%6,i,j) \cdot 2^{15+(QP2+12)/6} + Q((QP1+12)\%6,i,j)}{Q((QP1+12)\%6,i,j)}$ <p>and the values of f and the coefficients Q(m,i,j) are defined in Subsection <b>Error! Reference source not found.</b>. Here QP<sub>1</sub> is signaled by PQP value and the QP<sub>2</sub> is signaled by the additional QP parameter SPQP. Notice that when QP<sub>1</sub>=QP<sub>2</sub>, then the calculation of Y<sub>QREC</sub> reduces simply to the sum of the received level and the level found by quantizing the predicted block coefficient. The coefficients Y<sub>QREC</sub> are then dequantized using QP=QP<sub>2</sub> and inverse transform is performed for these dequantized levels, as defined in Subsections <b>Error! Reference source not found.</b> and <b>Error! Reference source not found.</b>, respectively. Finally, after the reconstruction of a macroblock, filtering of this macroblock takes place as described in Section <b>Error! Reference source not found.</b>.”</p> <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), p. 69-70.</p> |
| <p>“Operation of a video decoder 700 according to an embodiment of the</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <p>“decoding (process): The process defined in this specification that reads an input coded</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

| <b>Karczewicz (Ex. 1004)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Karczewicz 60/369,500 Provisional Application (Ex. 1006)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
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| <p>invention will now be described with reference to Figure 7. The structure of the video decoder illustrated in Figure 7 is substantially identical to that of the prior art video decoder shown in Figure 2, with appropriate modifications to those parts of the decoder which perform variable length decoding operations. All parts of the video decoder which implement functions and operate in a manner identical to the previously described prior art video decoder are identified with identical reference numbers. In the description which follows it is assumed that all variable length decoding operations are performed in video multiplex decoder 770. However, it should be appreciated that in alternative embodiments of the invention a separate variable length decoding unit or units may be provided.”</p> <p>Karczewicz, p. 39:8-19.</p> <p>“Operation of the video decoder will now be described in detail. Here it is assumed that the video decoder of Figure 7 corresponds to the encoder described in connection with Figure 6 and is therefore capable of receiving and</p> | <p>bitstream and produces decoded pictures or audio samples.</p> <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), p. 10.</p> <p>“The invention relates to the variable length coding of the quantised transform coefficients produced as a result of block-based transform coding in a video encoder. The method according to the present invention seeks to address the aforementioned problems relating to improving the adaptability of variable length coding methods to the type and statistical properties of the data symbols to be coded while maintaining low computational complexity and good error resilience. One aim of the invention is to provide new and more efficient schemes for coding of (run, level) pairs representing non-zero-valued quantized transform coefficients.</p> <p>One aim of the invention provides methods of encoding of number of non-zero coefficients within a block and also it provides methods of encoding of non-zero coefficients within the block. The invention establishes a relationship between the number of non-zero coefficients belonging to the neighboring : blocks. It involves the use of at least two sets of VLC codewords and defines rules for switching between the sets of codewords, which take into account</p> |

| <b>Karczewicz (Ex. 1004)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Karczewicz 60/369,500 Provisional Application (Ex. 1006)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
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| <p>decoding the bit-stream 635 transmitted by encoder 600. In the decoder, the bit-stream is received and separated into its constituent parts by video multiplex decoder 770. As explained in connection with the earlier description of prior art, the compressed video data extracted from the bit-stream is processed on a macroblock-by-macroblock basis. The compressed video data for an INTRA-coded macroblock comprises variable length codewords representing the VLC coded Nc value and (run, level) pairs for each block of the macroblock, together with encoded control information (for example, relating to quantisation parameter QP). The compressed video data for an INTER-coded macroblock comprises VLC encoded prediction error information for each block (comprising a VLC coded Nc value and VLC coded (run, level) pairs), motion vector information for the macroblock and encoded control information.”</p> <p>Karczewicz, p. 39:21-40:4.</p> <p>“More specifically, when decoding the VLC coded (run, level) pairs for an INTRA- or INTER-coded image block, video multiplex</p> | <p>the properties of the data symbols to be variable length coded. In this way improved data compression efficiency is obtained compared with VLC coding methods that use fixed codeword tables, for example. The switching rules are designed so that a bit-stream comprising VLC codewords formed according to the inventive method can be decoded without requiring any information relating to the choice of codewords to be included in the bit-stream. In other words, there is no need to provide an explicit indication of the set from which each codeword in the bit-stream was chosen. This property enhances data compression efficiency. A set of VLC codewords is selected to encode/decode the next symbol based on the previously encoded/decoded symbols. The previously encoded/decoded symbols could be chosen from the neighborhood of the current symbol to be encoded.”</p> <p>Karczewicz 60/369,500 Provisional Application, p. 8:7-27.</p> <p>“The invention proposes a method of VLC coding of the number of non-zero coefficients in the block. We also propose a method of VLC coding of (run,level) pair corresponding to the non-zero coefficients within the block.</p> <p>At least two sets of variable length codewords are provided for variable length coding the number of non-zero coefficients</p> |

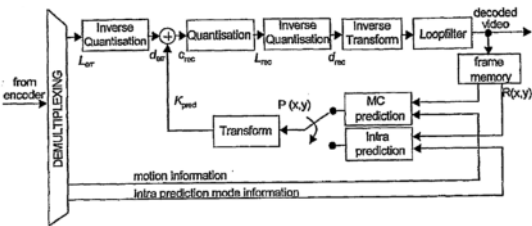
| <b>Karczewicz (Ex. 1004)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Karczewicz 60/369,500 Provisional Application (Ex. 1006)</b>                                                                                                                                                                                                                                                                                                                                                                                                            |
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| <p>decoder 770 first determines the number of non-zero-valued quantised transform coefficients in the block. As previously explained, information relating to the number of non-zero-valued quantised transform coefficients, Nc, is inserted into bit- stream 635 by encoder 600. Decoder 700 extracts this information from the received bit-stream. According to the invention, the Nc value is itself VLC coded and therefore video multiplex decoder 770 performs an appropriate variable length decoding operation to recover the information relating to Nc. As explained above, the VLC coding table used to encode the Nc value for a particular image block is selected on the basis of the Nc value(s) associated with a previously encoded image block or blocks. This means that the codeword representative of the Nc value for a given block can, in general, be decoded without an explicit indication of the VLC coding table from which the codeword chosen. Thus, it is only necessary for the decoder to know the VLC coding table from which the Nc value for the first (few) encoded image block was selected, the coding order of the image blocks and the rule used to determine the VLC table to be</p> | <p>in the block, denoted by the Nc symbol. An Nc symbol is variable length coded using a codeword selected from one of the at least two sets of variable length codewords responsive to the values of previously coded Nc symbols. The previously coded Nc symbols that are used to assign VLC codewords could be advantageously chosen from the blocks that reside close to the block in question.”</p> <p>Karczewicz 60/369,500 Provisional Application, p. 9:13-22.</p> |

| <b>Karczewicz (Ex. 1004)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Karczewicz 60/369,500 Provisional Application (Ex. 1006)</b>                                                                                           |
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| <p>used in coding subsequent Nc values. The exact number of image blocks for which it is necessary to have explicit knowledge of the selected VLC coding table for Nc depends on the nature of the rule used to select the VLC coding table for subsequent Nc values and the block scanning order. For example, in the case that Nc values from blocks to the left, top-left, top and top- right are used to select the VLC table for coding subsequent Nc values and the block scanning (coding) order is from the top-left of an image, row-by-row, it is advantageous to encode Nc values for blocks in the first row of the image, plus the first block on the second row according to a predetermined scheme. Then the Nc values for all subsequent image blocks can be encoded according to the rule described by equation (1) above and can be decoded at the decoder without any explicit indication of the VLC coding table used.”</p> <p>Karczewicz, p. 40:11-41:8.</p> |                                                                                                                                                           |
| <p>“The prediction error information for each block of the macroblock is passed to DCT transformation block 104, which performs a two-dimensional discrete cosine</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <p>“decoding (process): The process defined in this specification that reads an input coded bitstream and produces decoded pictures or audio samples.</p> |

| <b>Karczewicz (Ex. 1004)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Karczewicz 60/369,500 Provisional Application (Ex. 1006)</b>                                                                                                                                                                                                                                                                                                                                                                                                                  |
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| <p>transform on each block of prediction error values to produce a two- dimensional array of DCT transform coefficients for each block. DCT transformation block 104 produces an array of coefficient values for each prediction error block, the number of coefficient values depending on the nature of the blocks which make up the macroblock. For example, if the fundamental block size used in the macroblock is 4x4, DCT transformation block 104 produces a 4x4 array of DCT coefficients for each prediction error block. If the block size is 8x8, an 8x8 array of DCT coefficients is produced.”</p> <p>Karczewicz, p. 11:29-12:7.</p> | <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), p. 10.</p> <p>“Residual coding</p> <p>The residual coding is based on 4x4 transform. But similar to coding of chrominance coefficients, another 4x4 transform to the 16 DC coefficients in the macroblock are added. In that way we end up with an overall DC for the whole MB which works well in flat areas.”</p> <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), p. 32.</p> |
| <p>“INTER-coded frames are also decoded macroblock by macroblock, each INTER-coded macroblock being decoded substantially as soon as encoded information relating to it is received in the bit-stream 135. The video multiplex decoder 270 separates the encoded prediction error information for each block of an INTER-coded macroblock from encoded motion vector information and possible control information relating to the</p>                                                                                                                                                                                                              | <p>“Residual coding</p> <p>The residual coding is based on 4x4 transform. But similar to coding of chrominance coefficients, another 4x4 transform to the 16 DC coefficients in the macroblock are added. In that way we end up with an overall DC for the whole MB which works well in flat areas.”</p> <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), p. 32.</p>                                                                                     |

| <b>Karczewicz (Ex. 1004)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Karczewicz 60/369,500 Provisional Application (Ex. 1006)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
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| <p>macroblock in question. As explained in the foregoing, the encoded prediction error information for each block of the macroblock comprises variable length codewords representing the entropy coded level and run values for the nonzero quantised transform coefficients of the prediction error block in question. The video multiplex decoder 270 decodes the variable length codewords using a variable length decoding method corresponding to the encoding method used in the encoder 100 and thereby recovers the level and run values. It then reconstructs an array of quantised transform coefficient values for each prediction error block and passes them to inverse quantiser 210. Control information relating to the INTER-coded macroblock is also decoded in the video multiplex decoder 270 using an appropriate decoding method and is passed to control manager 260. Information relating to the level of quantisation applied to the transform coefficients of the prediction error blocks is extracted from the encoded bit-stream and provided to control manager 260 via control line 217. The control manager, in turn, conveys this information to inverse quantiser 210 via control line 218. Inverse</p> | <p>“5.3.1 Transform for Blocks of Size 4x4 Samples</p> <p>Instead of a discrete cosine transform (DCT), an integer transform with a similar coding gain as a 4x4 DCT is used. The transformation of input pixels <math>X=\{X00 \dots X33\}</math> to output coefficients <math>Y</math> is defined by:</p> <p>...</p> <p>For input pixels with 9-bit dynamic range (because they are residuals from 8-bit pixel data), the transform coefficients are guaranteed to fit within 16 bits, even when the second transform for DC coefficients is used. Thus, all transform operations can be computed in 16-bit arithmetic. In fact, the maximum dynamic range of the transforms coefficients fills a range of only 15.2 ‘bits; this small headroom can be used to support a variety of different quantization strategies (which are outside the scope of this specification).</p> <p>The transform and inverse transform matrices above have orthogonal basis functions. Unlike the DCT, though, the basis functions don’t have the same norm. Therefore, for the inverse transform to recover the original pixels, appropriate normalization factors must be applied to the transform coefficients before quantization and after dequantization. Such factors are absorbed by the quantization and dequantization scaling factors described below.”</p> |

| <b>Karczewicz (Ex. 1004)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Karczewicz 60/369,500 Provisional Application (Ex. 1006)</b>                                                                                                                                                                                                                                                                                                                                                                                                             |
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| <p>quantiser 210 inverse quantises the quantised DCT coefficients representing the prediction error information for each block of the macroblock according to the control information and provides the now inverse quantised DCT coefficients to inverse DCT transformer 220. The inverse quantised DCT coefficients representing the prediction error information for each block are then inverse transformed in the inverse DCT transformer 220 to yield an array of reconstructed prediction error values for each block of the macroblock.”</p> <p>Karczewicz, p. 17:7-18:4.</p> | <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), pp. 42-43.</p>                                                                                                                                                                                                                                                                                                                                                                                     |
| <p>“Operation of the video decoder 200, shown in Figure 2 will now be described. The decoder 200 comprises a video multiplex decoder 270, which receives an encoded video bit-stream 135 from the encoder 100 and demultiplexes it into its constituent parts, an inverse quantiser 210, an inverse DCT transformer 220, a motion compensated prediction block 240, a frame store 250, a combiner 230, a control manager 260, and an output 280.”</p>                                                                                                                                | <p>“decoding (process): The process defined in this specification that reads an input coded bitstream and produces decoded pictures or audio samples.</p> <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), p. 10.</p> <p>“8.1.5 Intra Prediction Mode (Intra_pred_mode)</p> <p>Intra_pred_mode is present when Intra 4x4 or SIIntra 4x4 prediction types are indicated by the MB_Type. Intra_pred_mode indicates which intra prediction mode is</p> |

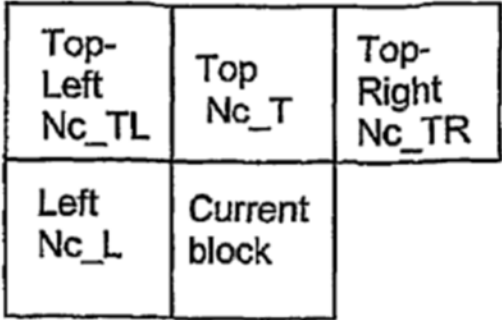
| Karczewicz (Ex. 1004)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Karczewicz 60/369,500 Provisional Application (Ex. 1006)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
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| <p>Karczewicz, p. 15:14-19.</p> <p>“The encoded motion vector information associated with the macroblock is extracted from the encoded video bit-stream 135 by video multiplex decoder 270 and is decoded. The decoded motion vector information thus obtained is passed via control line 225 to motion compensated prediction block 240, which reconstructs a motion vector for the macroblock using the same motion model as that used to encode the INTER-coded macroblock in encoder 100. The reconstructed motion vector approximates the motion vector originally determined by motion estimation block 130 of the encoder. The motion compensated prediction block 240 of the decoder uses the reconstructed motion vector to identify the location of a region of reconstructed pixels in a prediction reference frame stored in frame store 250. The reference frame may be, for example, a previously decoded INTRA-coded frame, or a previously decoded INTER-coded frame. In either case, the region of pixels indicated by the reconstructed motion vector is used to form a prediction for the macroblock in question. More</p> | <p>used for a 4x4 block in the macroblock. The code_number for SIIntra 4x4 is the same as that described in the Intra_pred_mode entry of TABLE 7.</p> <p>Coding of Intra 4x4 prediction modes</p> <p>Coding of the intra prediction modes for SIIntra 4x4 blocks in SI-pictures is identical to that in I-pictures, i.e., the intra prediction modes of the neighboring blocks are taken into account as described in Section 3.4.3.1.1. Coding of the intra prediction modes for Intra 4x4 blocks in SI-pictures differs from I-picture coding if the neighboring block is coded in SIIntra 4x4 mode. In this case the prediction mode of the neighboring Sintra 4x4 block is treated to be ‘mode 0: DC_prediction.’</p>  <p>FIGURE 26<br/>A generic block diagram of S-picture decoder</p> <p>8.2 S-frame decoding</p> <p>A video frame in SP-picture format consists of blocks encoded in either Intra mode (Intra 4x4, Intra 8x8 or Intra 16x16 Modes) or in SP mode (Skip or NxM). Similarly, SI-pictures consist of macroblocks encoded in either Intra mode or in SI mode (SIIntra 4x4). Intra macroblocks are decoded identically to those in I- and P-pictures.</p> |

| Karczewicz (Ex. 1004)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Karczewicz 60/369,500 Provisional Application (Ex. 1006)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
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| <p>specifically, the motion compensated prediction block 240 forms an array of pixel values for each block of the macroblock by copying corresponding pixel values from the region of pixels identified in the reference frame. The prediction, that is the blocks of pixel values derived from the reference frame, are passed from motion compensated prediction block 240 to combiner 230 where they are combined with the decoded prediction error information. In practice, the pixel values of each predicted block are added to corresponding reconstructed prediction error values output by inverse DCT transformer 220. In this way an array of reconstructed pixel values for each block of the macroblock is obtained. The reconstructed pixel values are passed to the video output 280 of the decoder and are also stored in frame store 250. As subsequent macroblocks of the INTER-coded frame are decoded and stored, a decoded frame is progressively assembled in the frame store 250 and thus becomes available for use as a reference frame for motion-compensated prediction of other INTER-coded frames.”</p> | <p>FIGURE 26 depicts a generic S-picture decoding for SI and SP modes. In SP mode, the prediction P(x,y) for the current macroblock of the frame being decoded is formed by the motion compensated prediction block in the identical way to that used in P-picture decoding. In SI mode, the prediction P(x,y) is formed by intra prediction block in the identical way to that used in I-picture decoding. After forming the predicted block P(x,y), the decoding of SI and SP-macroblocks follows the same steps. Firstly, the received prediction error coefficients denoted by Lerr are dequantized using quantization parameter PQP and the results are added to the transform coefficients Kpred of predicted block which are found by applying forward transform, see Section Error! Reference source not found., to the predicted block. The resulting sum is quantized with the quantization parameter SPQP. These steps are combined in a single step as follows:</p> $Y_{QREC}(i,j) = \frac{Y_{PRED}(i,j) \cdot Q((QP2+12)\%6,i,j) + Y_{QERR}(i,j) \cdot F(QP1,QP2,i,j) + f}{2^{15+(QP2+12)/6}}, \quad i,j = 0, \dots$ <p>where</p> $F(QP1,QP2,i,j) = \frac{Q((QP2+12)\%6,i,j) \cdot 2^{15+(QP2+12)/6} + Q((QP1+12)\%6,i,j)}{Q((QP1+12)\%6,i,j)}$ <p>and the values of f and the coefficients Q(m,i,j) are defined in Subsection <b>Error! Reference source not found.</b> Here QP<sub>1</sub> is signaled by PQP value and the QP<sub>2</sub> is signaled by the additional QP parameter SPQP. Notice that when QP<sub>1</sub>=QP<sub>2</sub>, then the calculation of Y<sub>QREC</sub> reduces simply to the sum of the received level and the level found by quantizing the predicted block</p> |

| Karczewicz (Ex. 1004)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Karczewicz 60/369,500 Provisional Application (Ex. 1006)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
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| Karczewicz, p. 18:6-19:3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <p>coefficient. The coefficients YQREC are then dequantized using <math>QP=QP2</math> and inverse transform is performed for these dequantized levels, as defined in Subsections <b>Error! Reference source not found.</b> and <b>Error! Reference source not found.</b>, respectively. Finally, after the reconstruction of a macroblock, filtering of this macroblock takes place as described in Section <b>Error! Reference source not found.</b>.”</p> <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), p. 69-70.</p>                                                                                                           |
| <p>“When video multiplex coder 670 receives a block (two-dimensional array) of quantised transform coefficients, it determines the number of non-zero- valued coefficients in the array. According to the invention, this number, referred to as <math>N_c</math>, is variable length coded and transmitted to the decoder in bit-stream 635. At least two sets of variable length codewords are provided for variable length coding of the <math>N_c</math> value. In an embodiment of the invention, these are, for example, the VLC codewords defined respectively in Tables 2 and 5, previously described in the text. More specifically, <math>N_c</math> is variable length</p> | <p>“decoding (process): The process defined in this specification that reads an input coded bitstream and produces decoded pictures or audio samples.</p> <p>Karczewicz 60/369,500 Provisional Application, Appendix 3 (JVT-B118), p. 10.</p> <p>“The invention relates to the variable length coding of the quantised transform coefficients produced as a result of block-based transform coding in a video encoder. The method according to the present invention seeks to address the aforementioned problems relating to improving the adaptability of variable length coding methods to the type and statistical properties of the data symbols to</p> |

| Karczewicz (Ex. 1004)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Karczewicz 60/369,500 Provisional Application (Ex. 1006) |                    |                    |              |                  |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
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| <p>encoded using a codeword selected from one of the at least two sets of variable length codewords responsive to the values of previously coded Nc symbols. Advantageously, the previously coded Nc symbols used to assign the VLC codewords are chosen from blocks that reside close to the block being coded.”</p> <p>Karczewicz, p. 33:29-34:9.</p> <table><tr><td>Top-Left<br/>Nc_TL</td><td>Top<br/>Nc_T</td><td>Top-Right<br/>Nc_TR</td></tr><tr><td>Left<br/>Nc_L</td><td>Current<br/>block</td><td></td></tr></table> <p>Fig. 5</p> <p>Karczewicz, Fig. 5.</p> <p>“Figure 5 depicts an image block to be VLC encoded and its neighboring blocks. The terms Nc_L, NC_TL, NC_T and NC_TR denote respectively the number of non-zero quantized coefficients in blocks to the Left, Top-Left, Top</p> | Top-Left<br>Nc_TL                                        | Top<br>Nc_T        | Top-Right<br>Nc_TR | Left<br>Nc_L | Current<br>block |  | <p>be coded while maintaining low computational complexity and good error resilience. One aim of the invention is to provide new and more efficient schemes for coding of (run, level) pairs representing non-zero-valued quantized transform coefficients.</p> <p>One aim of the invention provides methods of encoding of number of non-zero coefficients within a block and also it provides methods of encoding of non-zero coefficients within the block. The invention establishes a relationship between the number of non-zero coefficients belonging to the neighboring : blocks. It involves the use of at least two sets of VLC codewords and defines rules for switching between the sets of codewords, which take into account the properties of the data symbols to be variable length coded. In this way improved data compression efficiency is obtained compared with VLC coding methods that use fixed codeword tables, for example. The switching rules are designed so that a bit-stream comprising VLC codewords formed according to the inventive method can be decoded without requiring any information relating to the choice of codewords to be included in the bit-stream. In other words, there is no need to provide an explicit indication of the set from which each codeword in the bit-stream was chosen. This property enhances data compression efficiency. A set of VLC codewords is selected to encode/decode the next symbol based on the previously encoded/decoded symbols. The previously</p> |
| Top-Left<br>Nc_TL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Top<br>Nc_T                                              | Top-Right<br>Nc_TR |                    |              |                  |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Left<br>Nc_L                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Current<br>block                                         |                    |                    |              |                  |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

| Karczewicz (Ex. 1004)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Karczewicz 60/369,500 Provisional Application (Ex. 1006)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
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| <p>and Top-Right of the current image block to be encoded.”</p> <p>Karczewicz, p. 34:11-14.</p> <p>“The Nc value for the current image block is variable length encoded using a codeword from one of the available sets of VLC codes, chosen by considering the already coded Nc value(s) of immediately neighboring block(s). The following code presents an exemplary procedure for assigning a variable length code to an Nc value, taking into account the Nc values of the previously encoded neighbouring image blocks:</p> <p>VLC_N = Nc_map[fn(Nc_L, Nc_TL, Nc_T.Nc_TR); (1)</p> <p>In expression (1), fn is a function (an example of which is defined below in equation (2)), Nc_map is an array that maps integer values to different available VLC codes and VLC_N indicates the number of the table from which the codewords are to be selected. Examples of fn include "average" and "median". In an embodiment of the invention, the "average" of Nc_L and NC_T is used. According to this exemplary embodiment, the assignment</p> | <p>encoded/decoded symbols could be chosen from the neighborhood of the current symbol to be encoded.”</p> <p>Karczewicz 60/369,500 Provisional Application, p. 8:7-27.</p> <p>“The invention proposes a method of VLC coding of the number of non-zero coefficients in the block. We also propose a method of VLC coding of (run,level) pair corresponding to the non-zero coefficients within the block.</p> <p>At least two sets of variable length codewords are provided for variable length coding the number of non-zero coefficients in the block, denoted by the Nc symbol. An Nc symbol is variable length coded using a codeword selected from one of the at least two sets of variable length codewords responsive to the values of previously coded Nc symbols. The previously coded Nc symbols that are used to assign VLC codewords could be advantageously chosen from the blocks that reside close to the block in question.”</p> <p>Karczewicz 60/369,500 Provisional Application, p. 9:13-22.</p> |

| Karczewicz (Ex. 1004)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Karczewicz 60/369,500 Provisional Application (Ex. 1006)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
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| <p>presented in expression (1 ) becomes:</p> $\text{VLC\_N} = \text{Nc\_map}[(\text{Nc\_L} + \text{NC\_T}) / 2]; \quad (2)$ <p>The following example further illustrates the encoding of Nc according to the method of the invention. Assume that the current Nc value to be encoded is 3, the neighboring NC_L and NC_T values are given by 4 and 2, respectively and Nc_map is given by Nc_map=[1 1 1 1 2 2 2 2] where VLC1 and VLC2 correspond to the codewords from Table 2 and Table 5, respectively. Applying equation (2), VLC_N is equal to 1. In this case Nc = 3 is encoded as 00100 using the VLC codewords from Table 2.”</p> <p>Karczewicz, p. 34:16-35:10.</p> <p>“Operation of a video decoder 700 according to an embodiment of the invention will now be described with reference to Figure 7. The structure of the video decoder illustrated in Figure 7 is substantially identical to that of the prior art video decoder shown in Figure 2, with appropriate modifications to those parts of the decoder which perform variable length decoding operations. All</p> | <div></div> <p>Karczewicz 60/369,500 Provisional Application, p. 10, Fig. 1.</p> <p>“Figure 1 depicts an image block to be encoded and its neighboring blocks. Let Nc_L, Nc_TL, Nc_T and Nc_TR denote the number of non-zero quantized coefficients of the blocks Left, Top-Left, Top and Top-Right, respectively.</p> <p>A first embodiment of the invention provides that Nc value is encoded by one of the available VLC codes which is chosen by considering the already coded Nc value(s) of the immediate neighboring block(s). The following code presents an exemplary procedure for assigning a VLC to an Nc value, taking into account the preceding Nc values:</p> $\text{VLC\_N} = \text{Nc\_map}[\text{fn}(\text{Nc\_L}, \text{Nc\_TL}, \text{Nc\_T}, \text{Nc\_TR})]; \quad (1)$ <p>In expression (1), fn is a function to be defined and Nc_map is an array that maps integer values to different available VLC codes. Examples of fn include "average" and "median". In one embodiment of the</p> |

| Karczewicz (Ex. 1004)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Karczewicz 60/369,500 Provisional Application (Ex. 1006)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
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| <p>parts of the video decoder which implement functions and operate in a manner identical to the previously described prior art video decoder are identified with identical reference numbers. In the description which follows it is assumed that all variable length decoding operations are performed in video multiplex decoder 770. However, it should be appreciated that in alternative embodiments of the invention a separate variable length decoding unit or units may be provided.”</p> <p>Karczewicz, p. 39:8-19.</p> <p>“More specifically, when decoding the VLC coded (run, level) pairs for an INTRA- or INTER-coded image block, video multiplex decoder 770 first determines the number of non-zero-valued quantised transform coefficients in the block. As previously explained, information relating to the number of non-zero-valued quantised transform coefficients, Nc, is inserted into bit- stream 635 by encoder 600. Decoder 700 extracts this information from the received bit-stream. According to the invention, the Nc value is itself VLC coded and therefore video</p> | <p>invention, one could make use of the "average" of the Nc_L and Nc_T. Specifically, the assignment becomes:<br/> <math display="block">\text{VLC\_N} = \text{Nc\_map}[(\text{Nc\_L} + \text{Nc\_T})/2]; (2).</math> Let us illustrate the encoding of Nc according to this embodiment of the invention with an example. Assume that the current Nc value to be encoded is 3, the neighboring Nc_L and Nc_T values are given by 4 and 2, respectively and Nc_map is given by Nc_map=[1 1 1 1 1 2 2 2 2] where VLC1 and VLC2 correspond to the codewords from Table 2 and Table 5, respectively. Using the equation (2), VLC_N becomes 2. Then Nc=3 will be encoded as 0100 using Table 5 with VLC2.”</p> <p>Karczewicz 60/369,500 Provisional Application, p. 10:1-23.</p> |

| <b>Karczewicz (Ex. 1004)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Karczewicz 60/369,500 Provisional Application (Ex. 1006)</b> |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|
| <p> multiplex decoder 770 performs an appropriate variable length decoding operation to recover the information relating to Nc. As explained above, the VLC coding table used to encode the Nc value for a particular image block is selected on the basis of the Nc value(s) associated with a previously encoded image block or blocks. This means that the codeword representative of the Nc value for a given block can, in general, be decoded without an explicit indication of the VLC coding table from which the codeword chosen. Thus, it is only necessary for the decoder to know the VLC coding table from which the Nc value for the first (few) encoded image block was selected, the coding order of the image blocks and the rule used to determine the VLC table to be used in coding subsequent Nc values. The exact number of image blocks for which it is necessary to have explicit knowledge of the selected VLC coding table for Nc depends on the nature of the rule used to select the VLC coding table for subsequent Nc values and the block scanning order. For example, in the case that Nc values from blocks to the left, top-left, top and top- right are used to select the VLC table for coding subsequent </p> |                                                                 |

| <b>Karczewicz (Ex. 1004)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Karczewicz 60/369,500 Provisional Application (Ex. 1006)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Nc values and the block scanning (coding) order is from the top-left of an image, row-by-row, it is advantageous to encode Nc values for blocks in the first row of the image, plus the first block on the second row according to a predetermined scheme. Then the Nc values for all subsequent image blocks can be encoded according to the rule described by equation (1) above and can be decoded at the decoder without any explicit indication of the VLC coding table used.”</p> <p>Karczewicz, p. 40:11-41:8.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <p>“Table 2 presents the first 16 UVLC codewords, generated according to the scheme presented in Table 1, while Table 3 shows some of the different data-symbol-to-codeword mappings provided according to H.26L. For a complete description of the mappings, the reader should again refer to Working Draft Number 2, Doc. JVT-B118, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG Pattaya, 2nd JVT Meeting, Geneva, CH, Jan. 29 – Feb. 1 , 2002.”</p> <p>Karczewicz, p. 20:23-29.</p>                              | <p>“Table 2 presents the first 16 UVLC codewords, generated according to the scheme presented in Table 1, while Table 3 shows some of the different data-symbol-to-codeword mappings provided according to ' H.26L. For a complete description of the mappings, the reader should refer to “Working Draft Number 2, Doc. JVT-B118, Joint Video Team (JVT) of ISO/NEC MPEG and ITU-T VCEG Pattaya, 2" JVT Meeting, Geneva, CH, Jan. 29 - Feb. 1, 2002".”</p> <p>Karczewicz 60/369,500 Provisional Application, p. 3:11-15.</p> |

**Karczewicz (Ex. 1004)**

| Codeword index | VLC Codeword |
|----------------|--------------|
| 0              | 1            |
| 1              | 010          |
| 2              | 011          |
| 3              | 00100        |
| 4              | 00101        |
| 5              | 00110        |
| 6              | 00111        |
| 7              | 0001000      |
| 8              | 0001001      |
| 9              | 0001010      |
| 10             | 000010000    |
| 11             | 000010001    |
| 12             | 000010010    |
| 13             | 000010011    |
| 14             | 000010100    |
| 15             | 000010101    |
| ....           | ....         |

Table 2: The First 16 UVLC Codewords of H.26L Generated According to the Scheme Presented in Table 1

Karczewicz, p. 21, Table 2.

“For this reason modifications of the basic UVLC coding scheme have been proposed. More specifically, it has been suggested to include more than one set of VLC codewords. One such proposal was made by Gisle Bjontegaard in Q.15/SG16 "Use of Adaptive Switching Between Two VLCs for INTRA Luma

**Karczewicz 60/369,500 Provisional Application (Ex. 1006)**

| codeword index | VLC codeword |
|----------------|--------------|
| 0              | 1            |
| 1              | 010          |
| 2              | 011          |
| 3              | 00100        |
| 4              | 00101        |
| 5              | 00110        |
| 6              | 00111        |
| 7              | 0001000      |
| 8              | 0001001      |
| 9              | 0001010      |
| 10             | 000010000    |
| 11             | 000010001    |
| 12             | 000010010    |
| 13             | 000010011    |
| 14             | 000010100    |
| 15             | 000010101    |
| ....           | ....         |

Table 2: The First 16 UVLC Codewords of H.26L Generated According to the Scheme Presented in Table 1

Karczewicz 60/369,500 Provisional Application, pp. 3-4, Table 2.

“The UVLC entropy coding scheme does, however, also suffer from some disadvantages. In particular, the fixed codewords and the limited degree of adaptability provided by the different datasymbol- to-codeword mappings, inevitably result in less than optimum data compression. This is due to the fact that, in image coding, the frequency of occurrence (i.e. probability) of different transform coefficients, and hence the probability of different (run, level) pairs, changes depending on the image content and the type of the image being encoded. Thus, if a single set of variable length codewords is used and only a single mapping between the data symbols to be encoded/decoded and the VLCs is provided, in general, optimum coding efficiency cannot be achieved. For

| <b>Karczewicz (Ex. 1004)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Karczewicz 60/369,500 Provisional Application (Ex. 1006)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Coefficients", Doc. Q15-K-30, August 2000. This proposal suggested the use of a second set of VLC codewords for the entropy coding of certain types of information. According to document Q15-K-30, the proposed second set of VLC codewords, referred to as VLC2, is constructed according to the scheme shown below in Table 4. It is used in particular to code the run and level values associated with quantised transform coefficients of 4x4 pixel INTRA- coded luminance blocks scanned using the double scan zigzag scanning scheme defined according to H.26L. Table 5 shows, in explicit form, the first 16 codewords of VLC2."</p> <p>Karczewicz, p. 24:1-14.</p> | <p>this reason modifications of the basic UVLC coding scheme have been proposed. More specifically, it has been suggested to include more than one set of VLG codewords. One such proposal was made by Gisle Bjontegaard in Q.15/SG16 "Use of Adaptive Switching Between Two VLCs for INTRA Luma Coefficients", Doc. Q15-K-30, August 2000. This proposal suggested the use of a second set of VLC codewords for the entropy coding of certain types of information. According to document Q15-K-30, the proposed second set of VLC codewords, referred to as VLC2, is constructed according to the scheme shown below in Table 4. It is used in particular o code the run and level values associated with quantised transform coefficients of 4x4 pixel INTRA-coded luminance blocks scanned using the double scan zigzag scanning scheme defined according to H.26L. Table 5 shows, in explicit form, the first 12 codewords of VLC2."</p> <p>Karczewicz 60/369,500 Provisional Application, p. 8:14-30.</p> |

## Karczewicz (Ex. 1004)

| Codeword Index | VLC2 Codeword |
|----------------|---------------|
| 0              | 10            |
| 1              | 110           |
| 2              | 111           |
| 3              | 0100          |
| 4              | 0101          |
| 5              | 0110          |
| 6              | 0111          |
| 7              | 001000        |
| 8              | 001001        |
| 9              | 001010        |
| 10             | 001011        |
| 11             | 001100        |
| 12             | 001101        |
| 13             | 001110        |
| 14             | 001111        |
| 15             | 00010000      |

Table 5: The First 16 VLC2 Codewords of Q.15/SG16 Document Q15-K-30, Generated According to the Scheme Presented in Table 4

Karczewicz, pp. 24-25, Table 5.

## Karczewicz 60/369,500 Provisional Application (Ex. 1006)

| Codeword Index | VLC2 codeword |
|----------------|---------------|
| 0              | 10            |
| 1              | 110           |
| 2              | 111           |
| 3              | 0100          |
| 4              | 0101          |
| 5              | 0110          |
| 6              | 0111          |
| 7              | 001000        |
| 8              | 001001        |
| 9              | 001010        |
| 10             | 001011        |
| 11             | 001100        |
| 12             | 001101        |
| 13             | 001110        |
| 14             | 001111        |
| 15             | 00010000      |

Table 5: The First 16 VLC2 Codewords of Q.15/SG16 Document Q15-K-30, Generated According to the Scheme Presented in Table 4

Karczewicz 60/369,500 Provisional Application, p. 6, Table 5.

“Figure 1 depicts an image block to be encoded and its neighboring blocks. Let  $Nc\_L$ ,  $Nc\_TL$ ,  $Nc\_T$  and  $Nc\_TR$  denote the number of non-zero quantized coefficients of the blocks Left, Top-Left, Top and Top-Right, respectively.

A first embodiment of the invention provides that  $Nc$  value is encoded by one of the available VLC codes which is chosen by considering the already coded  $Nc$  value(s) of the immediate neighboring block(s). The following code presents an exemplary procedure for assigning a VLC to an  $Nc$  value, taking into account the preceding  $Nc$  values:

$$VLC\_N = Nc\_map[fn(Nc\_L, Nc\_TL, Nc\_T, Nc\_TR)]; (1)$$

| Karczewicz (Ex. 1004) | Karczewicz 60/369,500 Provisional Application (Ex. 1006)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                       | <p>In expression (1), fn is a function to be defined and Nc_map is an array that maps integer values to different available VLC codes. Examples of fn include "average" and "median". In one embodiment of the invention, one could make use of the "average" of the Nc_L and Nc_T. Specifically, the assignment becomes:<br/> <math display="block">\text{VLC\_N} = \text{Nc\_map}[(\text{Nc\_L} + \text{Nc\_T})/2]; \quad (2).</math></p> <p>Let us illustrate the encoding of Nc according to this embodiment of the invention with an example. Assume that the current Nc value to be encoded is 3, the neighboring Nc_L and Nc_T values are given by 4 and 2, respectively and Nc_map is given by Nc_map=[1 1 1 1 1 2 2 2 2] where VLC1 and VLC2 correspond to the codewords from Table 2 and Table 5, respectively. Using the equation (2), VLC_N becomes 2. Then Nc=3 will be encoded as 0100 using Table 5 with VLC2."</p> <p>Karczewicz 60/369,500 Provisional Application, p. 10:1-23.</p> |