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Werner et al.

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(54) **DIGITAL SIGNAL COMPRESSION ENCODING WITH IMPROVED QUANTISATION**

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(57) **ABSTRACT**

In compression encoding of a digital signal, such as MPEG2, transform coefficients are quantised with the lower bound of each interval being controlled by a parameter λ. In the MPEG2 reference coder, for example, λ=0.75. Because the quantised coefficients are variable length coded, improved quality or reduced bit rates can be achieved by controlling λ so as to vary dynamically the bound of each interval with respect to the associated representation level. The parameter λ can vary with coefficient amplitude, with frequency, or with quantisation step size. In a transcoding operation, λ can also vary with parameters in the initial coding operation.

4 Claims, 3 Drawing Sheets

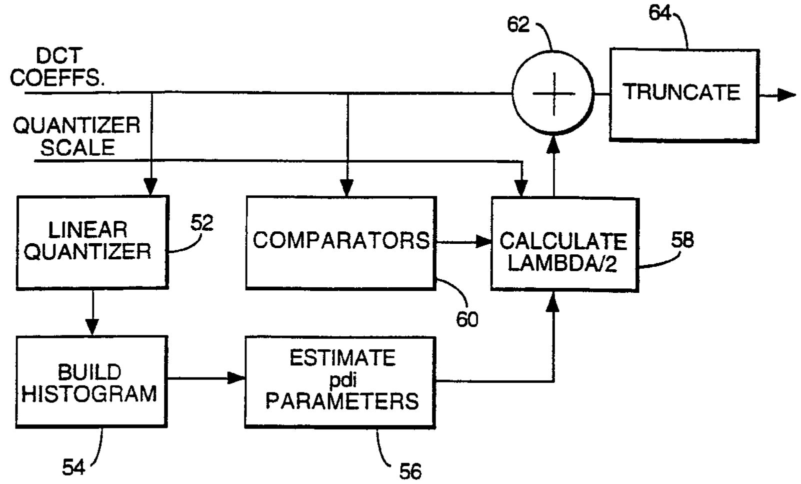


Fig.1.

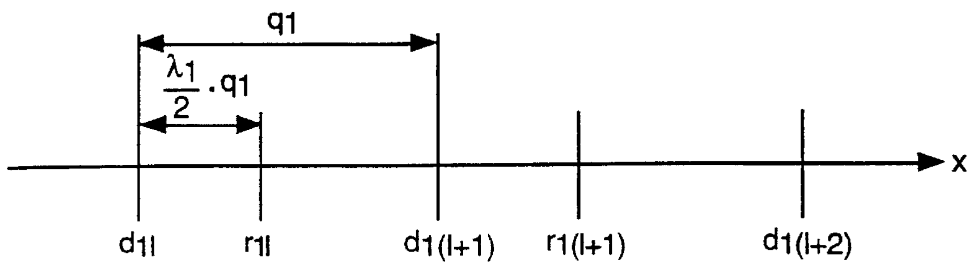

q1
λ1/2 .q1
x
d1l
r1l
d1(l+1)
r1(l+1)
d1(l+2)

Fig.2.

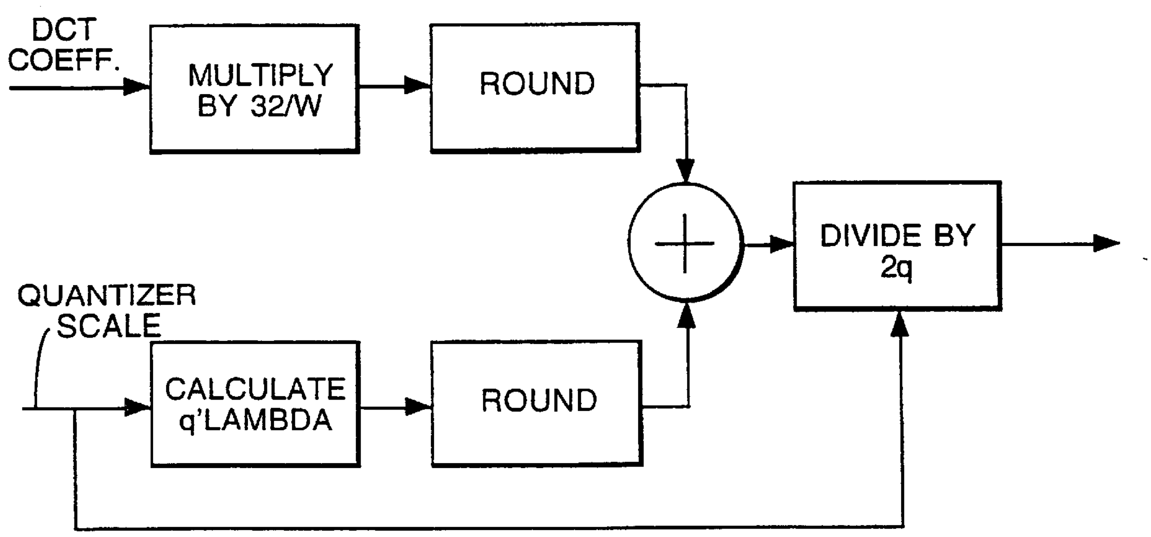

DCT COEFF.
MULTIPLY BY 32/W
ROUND
DIVIDE BY 2q
QUANTIZER SCALE
CALCULATE q'LAMBDA
ROUND

Fig.3.

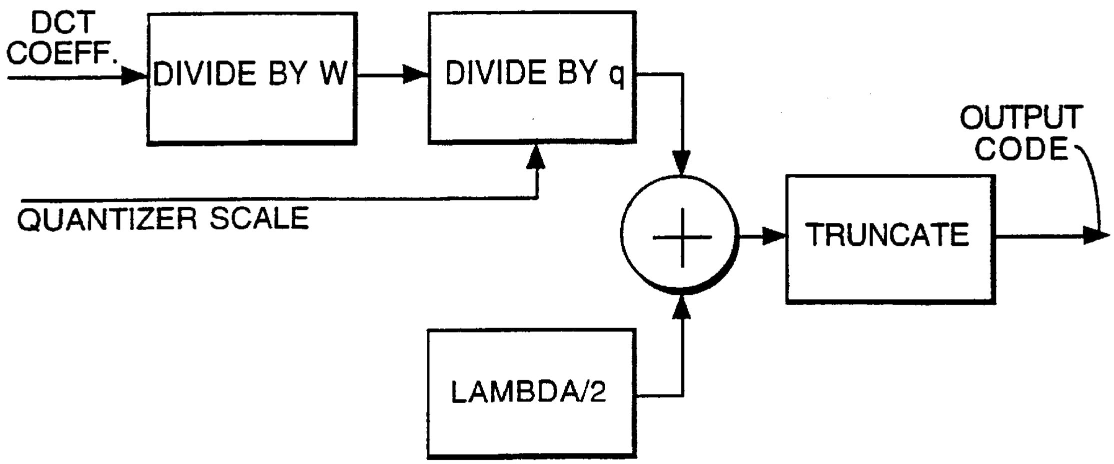

DCT
COEFF.
DIVIDE BY W
DIVIDE BY q
QUANTIZER SCALE
OUTPUT
CODE
TRUNCATE
LAMBDA/2

Fig.4.

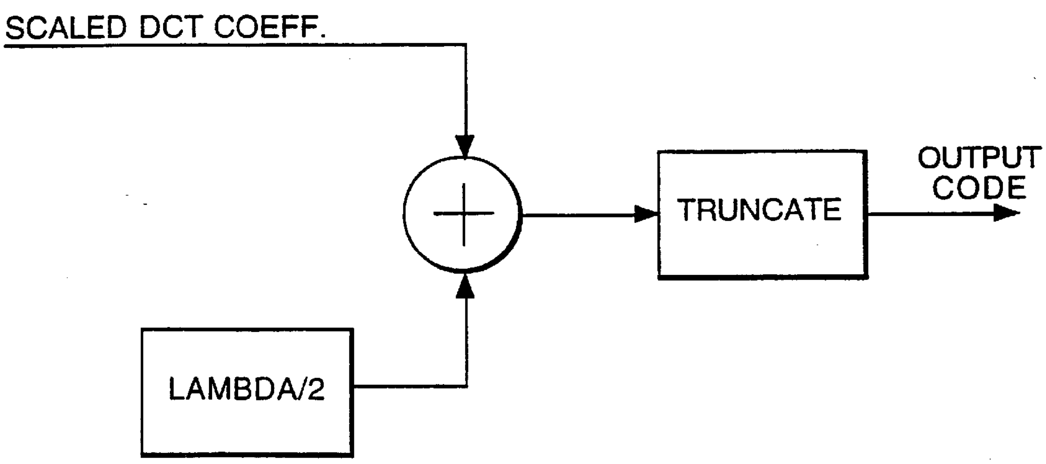

SCALED DCT COEFF.
TRUNCATE
OUTPUT
CODE
LAMBDA/2

Fig.5.

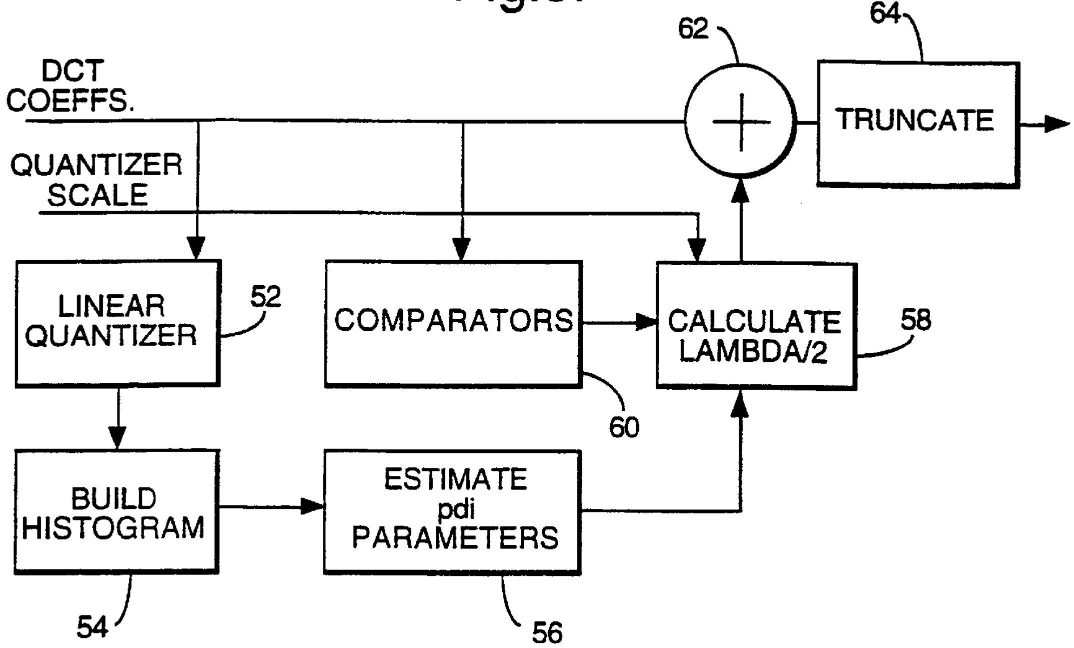
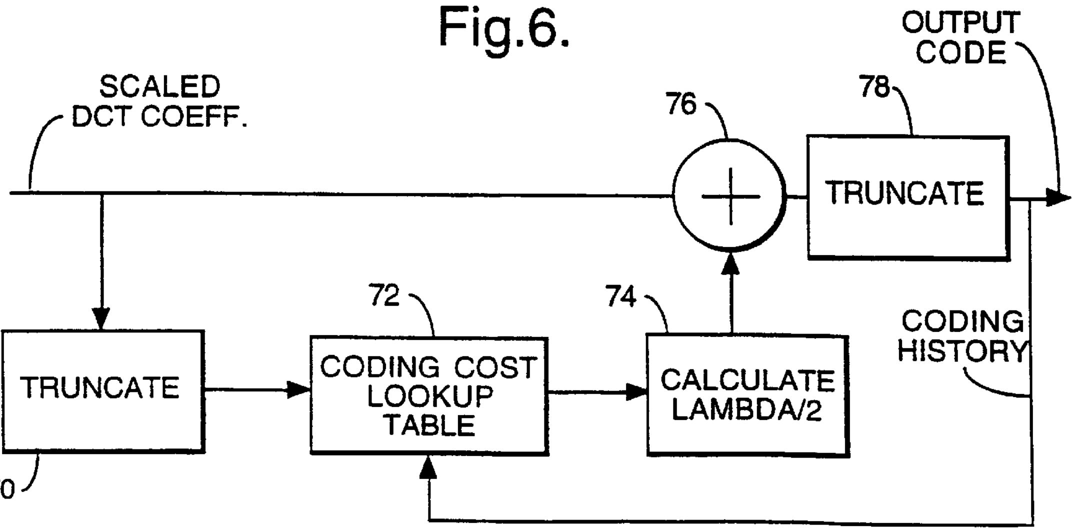

DCT
COEFFS.
QUANTIZER
SCALE
62
64
TRUNCATE
LINEAR
QUANTIZER
52
COMPARATORS
CALCULATE
LAMBDA/2
58
60
BUILD
HISTOGRAM
ESTIMATE
pdi
PARAMETERS
54
56

Fig.6.


OUTPUT
CODE
SCALED
DCT COEFF.
76
78
TRUNCATE
72
74
CODING
HISTORY
TRUNCATE
CODING COST
LOOKUP
TABLE
CALCULATE
LAMBDA/2
70

DIGITAL SIGNAL COMPRESSION ENCODING WITH IMPROVED QUANTISATION

FIELD OF THE INVENTION

This invention relates to the compression of digital video, audio or other signals.

BACKGROUND OF THE INVENTION

Compression encoding generally involves a number of separate techniques. These will usually include a transformation, such as the block-based discrete cosine transform (DCT) of MPEG-2; an optional prediction step; a quantisation step and variable length coding. This invention is particularly concerned in this context with quantisation.

The quantisation step maps a range of original amplitudes onto the same representation level. The quantisation process is therefore irreversible. MPEG-2, (in common with other compression standards such as MPEG-1, JPEG, CCITT/ITU-T Rec.H.261 and ITU-T Rec.H.263) defines representation levels and leaves undefined the manner in which the original amplitudes are mapped onto a given set of representation levels.

In general terms, a quantizer assigns to an input value, which may be continuous or may previously have been subjected to a quantisation process, a code usually selected from quantization levels immediately above and immediately below the input value. The error in such a quantization will generally be minimised if the quantization level closest to the input value is selected. In a compression system, it is further necessary to consider the efficiency with which respective quantization levels may be coded. In variable length coding, the quantization levels which are employed most frequently are assigned the shortest codes.

Typically, the zero level has the shortest code. A decision to assign a higher quantization level, on the basis that it is the closest, rather than a lower level (and especially the zero level) will therefore decrease coding efficiency. In MPEG2, the overall bit rate of the compressed signal is maintained beneath a pre-determined limit by increasing the separation of quantization levels in response to a tendency toward higher bit rate. Repeated decisions to assign quantization levels on the basis of which is closest, may through coding inefficiency thus lead to a coarser quantization process.

The behaviour of a quantizer in this respect may be characterised through a parameter λ which is arithmetically combined with the input value, with one value of λ (typically λ=1) representing the selection of the closest quantization level or "rounding". A different value of λ (typically λ=0) will in contrast represent the automatic choice of the lower of the two nearest quantization levels, or "truncating". In the MPEG2 reference coder, an attempt is made to compromise between the nominal reduction in error which is the attribute of rounding and the tendency toward bit rate efficiency which is associated with truncating, by setting a standard value for λ of λ=0.75.

Whilst particular attention has here been paid to MPEG2 coding, similar considerations apply to other methods of compression encoding of a digital signal, which including the steps of conducting a transformation process to generate values and quantising the values through partitioning the amplitude range of a value into a set of a adjacent intervals, whereby each interval is mapped onto a respective one of a set of representation levels which are to be variable length coded, such that a bound of each interval is controlled by a parameter λ. The transformation process may take a large variety of forms, including block-based transforms such as the DCT of MPEG2, and sub-band coding.

SUMMARY OF THE INVENTION

It is an object of one aspect of the present invention to provide an improvement in such a method which enables higher quality to be achieved at a given bitrate or a reduction in bitrate for a given level of quality.

Accordingly, the present invention is in one aspect characterised in that λ is controlled so as to vary dynamically the bound of each interval with respect to the associated representation level.

Suitably, wherein each value is arithmetically combined with λ.

Advantageously, λ is:

a function of the quantity represented by the value;

where the transformation is a DCT, a function of horizontal and vertical frequency;

a function of the quantisation step size; or

a function of the amplitude of the value.

In a particular form of the present invention, the digital signal to be encoded has been subjected to previous encoding and decoding processes and λ is controlled as a function of a parameter in said previous encoding and decoding processes.

In a further aspect, the present invention consists in a (q, λ) quantiser operating on a set of transform coefficients x_k representative of respective frequency indices f_k in which λ is dynamically controlled in dependence upon the values of x_k and f_k.

Advantageously, λ is dynamically controlled to minimise a cost function $D+\mu H$ where D is a measure of the distortion introduced by the quantisation in the uncompressed domain and H is a measure of compressed bit rate.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described by way of example with reference to the accompanying drawings, in which:

FIG. **1** is a diagram illustrating the relationships between representation levels, decision levels and the value of λ;

FIG. **2** is a block diagram representation of the quantization process in the MPEG2 reference coder;

FIG. **3** is a block diagram representation of a simplified and improved quantization process;

FIG. **4** is a block diagram representation of the core elements of FIG. **3**;

FIG. **5** is a block diagram representation of a quantization process according to one aspect of the present invention; and

FIG. **6** is a block diagram representation of a quantization process according to a further aspect of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In the specifically mentioned compression standards, the original amplitude x results from a discrete cosine transform (DCT) and is thus related to a horizontal frequency index f_{hor} and a vertical frequency index f_{ver}. Whilst this approach is taken as an example in what follows, the invention is not restricted in this regard.

In general, a quantiser describes a mapping from an original amplitude x of frequencies f_{hor} and f_{ver} onto an

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