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METHOD FOR IMAGE DECODING

Field of the invention

The present invention pertains generally to the field of the processing of images, and more precisely to the coding and to the decoding of digital images and of sequences of digital images.

The invention can thus, in particular, be applied to the video coding implemented in current video coders (MPEG, H.264, etc.) or forthcoming video coders (ITU-T/VCEG (H.265) or ISO/MPEG (HEVC).

Background of the invention

Current video coders (MPEG, H.264, etc.) use a block-wise representation of the video sequence. The images are split up into macro-blocks, each macro-block is itself split up into blocks and each block, or macro-block, is coded by intra-image or inter-image prediction. Thus, certain images are coded by spatial prediction (intra prediction), while other images are coded by temporal prediction (inter prediction) with respect to one or more coded-decoded reference images, with the aid of a motion compensation known to the person skilled in the art.

For each block there is coded a residual block, also called prediction residual, corresponding to the original block decreased by a prediction. The residual blocks are transformed by a transform of discrete cosine transform (DCT) type, and then quantified with the aid of a quantification for example of scalar type. Coefficients, some of which are positive and others negative, are obtained on completion of the quantification step. They are thereafter traversed in an order of reading, generally zig-zag (as in the JPEG standard), thereby making it possible to utilize the significant number of zero coefficients in the high frequencies. On completion of the aforementioned path, a one-dimensional list of coefficients is obtained, which will be called “quantified residual”. The coefficients of this list are then coded by an entropy coding.

The entropy coding (for example of arithmetical coding or Huffman coding type) is performed in the following manner:

- an item of information is coded entropically to indicate the location of the last non-zero coefficient of the list,

- for each coefficient situated before the last non-zero coefficient, an item of information is coded entropically to indicate whether the coefficient is or is not zero,
- for each previously indicated non-zero coefficient, an item of information is coded entropically to indicate whether the coefficient is or is not equal to one,
- for each non-zero coefficient not equal to one situated before the last non-zero coefficient, an amplitude item of information (absolute value of the coefficient decreased by two) is coded entropically,
- for each non-zero coefficient, the sign which is assigned to it is coded by a ‘0’ (for the + sign) or a ‘1’ (for the - sign).

According to the H.264 technique for example, when a macroblock is split up into blocks, a data signal, corresponding to each block, is transmitted to the decoder. Such a signal includes:

- the quantified residuals contained in the aforementioned list,
- information representative of the mode of coding used, in particular:
    - the mode of prediction (intra prediction, inter prediction, default prediction carrying out a prediction for which no item of information is transmitted to the decoder (“skip”));
    - information specifying the type of prediction (orientation, reference image, etc.);
    - the type of partitioning;
    - the type of transform, for example 4 × 4 DCT, 8 × 8 DCT, etc.
    - the motion information if necessary;
    - etc.

The decoding is done image by image, and for each image, macroblock by macroblock. For each partition of a macroblock, the corresponding elements of the stream are read. The inverse quantification and the inverse transformation of the coefficients of the blocks are performed so as to produce the decoded prediction residual. Next, the prediction of the partition is computed and the partition is reconstructed by adding the prediction to the decoded prediction residual.

The intra or inter coding by competition, such as implemented in the H.264 standard, thus relies on various items of coding information, such as those aforementioned, being set into competition with the aim of selecting the best mode, that is to say that which will optimize the coding of the partition considered according to a predetermined performance criterion, for example the bitrate/distortion cost well known to the person skilled in the art.

The information representative of the mode of coding selected is contained in the data signal transmitted by the coder to the decoder. The decoder is thus capable of identifying the mode of coding selected at the coder, and then of applying the prediction in accordance with this mode.

In the document "Data Hiding of Motion Information in Chroma and Luma Samples for Video Compression", J.-M. Thiesse, J. Jung and M. Antonini, International workshop on multimedia signal processing, 2011, there is presented a data hiding method implemented in the course of video compression.

More precisely, it is proposed to avoid including in the signal to be transmitted to the decoder at least one competition index such as arises from a plurality of competition indices to be transmitted. Such an index is for example the index MVComp which represents an item of information making it possible to identify the motion vector predictor used for a block predicted in Inter mode. Such an index, which can equal 0 or 1, is not inscribed directly into the coded data signal, but transported by the parity of the sum of the coefficients of the quantified residual. An association is created between the parity of the quantified residual and the index MVComp. By way of example, the even value of the quantified residual is associated with the index MVComp of value 0, while the odd value of the quantified residual is associated with the index MVComp of value 1. Two cases can occur. In a first case, if the parity of the quantified residual already corresponds to that of the index MVComp that it is desired to transmit, the quantified residual is coded in a conventional manner. In a second case, if the parity of the quantified residual is different from that of the index MVComp that it is desired to transmit, there is undertaken a modification of the quantified residual in such a way that its parity is the same as that of the MVComp index. Such a modification consists in incrementing or decrementing one or more coefficients of the quantified residual by an odd value (e.g.: +1, −1, +3, −3, +5, −5, etc.) and to retain only the modification which optimizes a predetermined criterion, in this instance the aforementioned bitrate-distortion cost.

At the decoder, the index MVComp is not read from the signal. The decoder simply makes do with determining the residual conventionally. If the value of this residual is even, the index MVComp is set to 0. If the value of this residual is odd, the index MVComp is set to 1.

In accordance with the technique which has just been presented, the coefficients which undergo the modification are not always chosen in an optimal manner, so that the modification applied gives rise to disturbances in the signal transmitted to the decoder. Such disturbances are inevitably detrimental to the effectiveness of the video compression.

Moreover, the index MVComp does not constitute the most beneficial item of information to be hidden since the probabilities that this index is equal to 0 or to 1 are not equal. Consequently, if this index is coded in a conventional manner by entropy coding, it will be represented, in the compressed file to be transmitted to the decoder, by a smaller quantity of data than one bit per index MVComp transmitted. Consequently, if the index MVComp is transmitted in the parity of the quantified residual, the quantity of data thus saved is smaller than one bit per index MVComp, whereas the parity of the residual could make it possible to transport an item of information of one bit per index.

Consequently, the reduction in the signalling cost, as well as the effectiveness of the compression, are not optimal.

Object and summary of the invention

One of the aims of the invention is to remedy the drawbacks of the aforementioned prior art.

To that end, one object of the present invention relates to a device for decoding a data signal according to claim 1.

Brief description of the drawings

Other characteristics and advantages will become apparent on reading two preferred embodiments described with reference to the figures in which:

- Figure 1 represents the general steps of the coding method according to the invention.
- Figure 2 represents a coding device according to the invention which is able to perform the steps of the coding method of Figure 1.
- Figure 3 represents a particular embodiment of the coding method according to the invention.
- Figure 4 represents a particular embodiment of a coding device according to the invention.
- Figure 5 represents the general steps of the decoding method according to the invention.
- Figure 6 represents a decoding device according to the invention which is able to perform the steps of the decoding method of Figure 5.
- Figure 7 represents a particular embodiment of the decoding method according to the invention.
- Figure 8 represents a particular embodiment of a decoding device according to the invention.

Detailed description of the coding part

A general embodiment of the invention will now be described, in which the coding method according to the invention is used to code a sequence of images according to a binary stream close to that which is obtained by a coding according to the H.264/MPEG-4 AVC standard. In this embodiment, the coding method according to the invention is for example implemented in a software or hardware manner by modifications of a coder initially complying with the H.264/MPEG-4 AVC standard.

The coding method according to the invention is represented in the form of an algorithm comprising steps S1 to S40, represented in **Figure 1**.

According to the embodiment of the invention, the coding method according to the invention is implemented in a coding device or coder CO of which an embodiment is represented in **Figure 2**.

In accordance with the invention, there is undertaken, prior to the coding proper, a splitting of an image IE of a sequence of images to be coded in a predetermined order, into a plurality Z of partitions B_1, B_2, ..., B_i, ..., B_z, as represented in **Figure 2**.

It should be noted that, within the meaning of the invention, the term "partition" signifies coding unit. The latter terminology is in particular used in the HEVC/H.265 standard currently being formulated, for example in the document accessible at the following Internet address: http://phenix.int-evry.fr/jct/doc_end_user/current_document.php?id=3286.

In particular, such a coding unit groups together sets of pixels of rectangular or square shape, also called blocks, macroblocks, or else sets of pixels exhibiting other geometric shapes.

In the example represented in **Figure 2**, said partitions are blocks which have a square shape and all have the same size. As a function of the size of the image which is not necessarily a multiple of the size of the blocks, the last blocks on the left and the last blocks at the bottom may not be square. In an alternative embodiment, the blocks may be for example of rectangular size and/or not aligned one with another.

Each block or macroblock may moreover itself be divided into sub-blocks which are themselves subdividable.

Such a splitting is performed by a partitioning module PCO represented in **Figure 2** which uses for example a partitioning algorithm well known as such.

Subsequent to said splitting step, there is undertaken the coding of each of the current partitions B_i (i being an integer such that $1 \leq i \leq Z$) of said image IE.

In the example represented in **Figure 2**, such a coding is applied successively to each of the blocks B_1 to B_Z of the current image IE. The blocks are coded for example according to a path such as the "raster scan" path well known to the person skilled in the art.

The coding according to the invention is implemented in a coding software module MC_CO of the coder CO, such as represented in **Figure 2**.

In the course of a step S1 represented in **Figure 1**, the coding module MC_CO of **Figure 2** selects as current block B_i the first block B_1 to be coded of the current image IE. As represented in **Figure 2**, this is the first left block of the image IE.

In the course of a step S2 represented in **Figure 1**, there is undertaken the extraction of data of the current block B_1 in the form of a list $D_1 = (a_1, a_2, ..., a_P)$. Such an extraction is performed by a software module EX_CO such as represented in **Figure 2**. Such data are for example pixel data, the non-zero pixel data each being assigned either a positive sign, or a negative sign.

Each of the data of the list D_1 is associated with various items of digital information which are intended to undergo an entropy coding. Items of digital information such as these are described hereinbelow by way of example:

- for each datum situated before the last non-zero datum of the list D_1, a digital item of information, such as a bit, is intended to be coded entropically to indicate whether the datum is or is not zero: if the datum is zero, it is for example the bit of value 0 which will be coded, while if the datum is non-zero, it is the bit of value 1 which will be coded;
- for each non-zero datum, a digital item of information, such as a bit, is intended to be coded entropically to indicate whether the absolute value of the datum is or is not equal to one: if it is equal to 1 , it is for example the bit of value 1 which will be coded, while if it is equal to 0, it is the bit of value 0 which will be coded;
- for each non-zero datum whose absolute value is not equal to one and which is situated before the last non-zero datum, an amplitude item of information is coded entropically,
- for each non-zero datum, the sign which is assigned to it is coded by a digital item of information, such as a bit for example set to '0' (for the + sign) or to '1' (for the - sign).

The specific coding steps according to the invention will now be described with reference to **Figure 1**.

In accordance with the invention, it is decided to avoid entropically coding at least one sign of one of said data of the list D_1.

In accordance with the preferred embodiment, it is the sign of the first non-zero datum which is intended to be hidden. Such a sign is for example positive and assigned to the first non-zero datum, such as for example the datum a_2.

In the course of a step S3 represented in **Figure 1**, the processing module MTR_CO computes the value of a function f which is representative of the data of the list D_1.

In the preferred embodiment where a single sign is intended to be hidden in the signal to be transmitted to the decoder, the function f is the parity of the sum of the data of the list D_1.

In the course of a step S4 represented in **Figure 1**, the processing module MTR_CO verifies whether the parity of the value of the sign to be hidden corresponds to the parity of the sum of the data of the list D_1, by virtue of a convention defined previously at the coder CO.

In the example proposed, said convention is such that a positive sign is associated with a bit of value equal to zero, while a negative sign is associated with a bit of value equal to one.

If, in accordance with the convention adopted in the coder CO according to the invention, the sign is positive, thereby corresponding to a zero coding bit value, and if the sum of the data of the list D1 is even, there is undertaken a step S20 of entropy coding of the data of the aforementioned list D_1, with the exception of the sign of the first non-zero datum a_2. Such a step S20 is represented in **Figure 1**.

If, still in accordance with the convention adopted in the coder CO according to the invention, the sign is negative, thereby corresponding to a one coding bit value, and if the sum of the data of the list D_1 is odd, there is also undertaken the step S20 of entropy coding of the data of the aforementioned list D_1, with the exception of the sign of the first non-zero datum a_2.

If, in accordance with the convention adopted in the coder CO according to the invention, the sign is positive, thereby corresponding to a zero coding bit value, and if the sum of the data of the list D_1 is odd, there is undertaken, in the course of a step S5 represented in **Figure 1**, a modification of at least one modifiable datum of the list D_1.

If, still in accordance with the convention adopted in the coder CO according to the invention, the sign is negative, thereby corresponding to a one coding bit value, and if the sum of the data of the list D_1 is even, there is also undertaken step S5 of modifying at least one modifiable datum of the list D_1.

According to the invention, a datum is modifiable if the modification of its value does not cause any desynchronization at the decoder, once this modified datum is processed by the decoder. Thus, the processing module MTR_CO is configured initially so as not to modify:

- the zero datum or data situated before the first non-zero datum, in such a way that the decoder does not assign the value of the hidden sign to this or these zero data,
- and for computation complexity reasons, the zero datum or data situated after the last non-zero datum.

Such a modification operation is performed by the processing module MTR_CO of **Figure 2**.

In the proposed exemplary embodiment, it is assumed that the total sum of the data of the list D_1 is equal to 5, and is therefore odd. So that the decoder can reconstruct the positive sign assigned to the first non-zero datum a_2, without the coder CO having to transmit this datum to the decoder, it is necessary that the parity of the sum become even. Consequently, the processing module MTR_CO tests, in the course of said step S5, various modifications of data of the list D_1, all aimed at changing the parity of the sum of the data. In the preferred embodiment, there is undertaken the addition of +1 or −1 to each modifiable datum and the selection, according to a predetermined criterion, of a modification from among all those performed.

A modified list $Dm_1 = (a'_1, a'_2, ..., a'_P)$ is then obtained, on completion of step S5.

It should be noted that, in the course of this step, certain modifications are prohibited. Thus, in the case where the first non-zero datum equals +1, it would not be possible to add −1 to it, since it would become zero, and it would then lose its characteristic of first non-zero datum of the list D_1. The decoder would then subsequently allocate the decoded sign (by computation of the parity of the sum of the data) to another datum, and there would then be a decoding error.

There is thereafter undertaken step S20 of entropy coding of the data of the aforementioned list Dm_1, with the exception of the positive sign of the first non-zero datum a_2, which sign is hidden in the parity of the sum of the data.

It should be noted that the set of amplitudes of the data of the list D_1 or of the modified list Dm_1 is coded before the set of signs, with the exclusion of the sign of the first non-zero datum which is not coded, as was explained hereinabove.

In the course of a following step S30 represented in **Figure 1**, the coding module MC_CO of **Figure 2** tests whether the coded current block is the last block of the image IE.

If the current block is the last block of the image IE, in the course of a step S40 represented in **Figure 1**, the coding method is terminated.

If such is not the case, there is undertaken the selection of the following block B_i which is then coded in accordance with the aforementioned raster scan order of path, by iteration of steps S1 to S20, for $1 \leq i \leq Z$.

Once the entropy coding of all the blocks B_1 to B_Z has been carried out, there is undertaken the construction of a signal F representing, in binary form, said coded blocks.

The construction of the binary signal F is implemented in a stream construction software module CF, such as represented in **Figure 2**.

The stream F is thereafter transmitted by a communication network (not represented), to a remote terminal. The latter includes a decoder which will be described in greater detail in the subsequent description.

Another embodiment of the invention will now be described, mainly with reference to **Figure 1**.

This other embodiment is distinguished from the previous one solely by the number of signs to be hidden which is N, N being an integer such that $N \geq 2$.

For this purpose, the function f is the remainder modulo 2^N of the sum of the data of the list D_1. It is assumed that in the example proposed, N = 2, the two signs to be hidden are the first two signs of the first two non-zero data of the list D_1, for example a_2 and a_3.

In the course of step S4 represented in **Figure 1**, the processing module MTR_CO verifies whether the configuration of the N signs, i.e. 2^N possible configurations, corresponds to the value of the remainder modulo 2^N of the sum of the data of the list D_1.

In the example proposed where N = 2, there exist $2^2 = 4$ different configurations of signs.

These four configurations obey a convention at the coder CO, which is for example determined in the following manner:

- a remainder equal to zero corresponds to two consecutive positive signs: +, +;
- a remainder equal to one corresponds to consecutive positive sign and negative sign: +, -;
- a remainder equal to two corresponds to consecutive negative sign and positive sign: -, +;
- a remainder equal to three corresponds to two consecutive negative signs: -, -.

If the configuration of the N signs corresponds to the value of the remainder modulo 2^N of the sum of the data of the list D_1, there is undertaken step S20 of entropy coding of the data of the aforementioned list D_1, with the exception of the respective sign of the first two non-zero data a_2 and a_3, which signs are hidden in the parity of the sum modulo 2^N of the data of the list D_1.

If such is not the case, there is undertaken step S5 of modifying at least one modifiable datum of the list D_1. Such a modification is performed by the processing module MTR_CO of **Figure 2** in such a way that the remainder modulo 2^N of the sum of the modifiable data of the list D_1 attains the value of each of the two signs to be hidden.

A modified list $Dm_1 = (a'_1, a'_2, ..., a'_P)$ is then obtained.

There is thereafter undertaken step S20 of entropy coding of the data of the aforementioned list Dm_1, with the exception of the sign of the first non-zero datum a_2 and of the sign of the second non-zero datum a_3, which signs are hidden in the parity of the sum modulo 2^N of the data.

A particular embodiment of the invention will now be described, in which the coding method according to the invention is still used to code a sequence of images according to a binary stream close to that which is obtained by a coding according to the H.264/MPEG-4 AVC standard. In this embodiment, the coding method according to the invention is for example implemented in a software or hardware manner by modifications of a coder initially complying with the H.264/MPEG-4 AVC standard.

The coding method according to the invention is represented in the form of an algorithm comprising steps C1 to C40, such as represented in **Figure 3**.

According to the embodiment of the invention, the coding method is implemented in a coding device or coder CO1 of which an embodiment is represented in **Figure 4**.

In accordance with the invention, and as described in the previous examples, there is undertaken, prior to the coding proper, a splitting of an image IE of a sequence of images to be coded in a predetermined order, into a plurality Z of partitions B'_1, B'_2, ..., B'_i, ..., B'_Z, as represented in **Figure 4**.

In the example represented in **Figure 4**, said partitions are blocks which have a square shape and all have the same size. As a function of the size of the image which is not necessarily a multiple of the size of the blocks, the last blocks on the left and the last blocks at the bottom may not be square. In an alternative embodiment, the blocks may be for example of rectangular size and/or not aligned one with another.

Each block or macroblock may moreover itself be divided into sub-blocks which are themselves subdividable.

Such a splitting is performed by a partitioning software module PCO1 represented in **Figure 4** which is identical to the partitioning module PCO represented in **Figure 2**.

Subsequent to said splitting step, there is undertaken the coding of each of the current partitions B'_i (i being an integer such that $1 \leq i \leq Z$) of said image IE.

In the example represented in **Figure 4**, such a coding is applied successively to each of the blocks B'_1 to B'_Z of the current image IE. The blocks are coded according to a path such as for example the “raster scan” path well known to the person skilled in the art.

The coding according to the invention is implemented in a coding software module MC_CO1 of the coder CO1, such as represented in **Figure 4**.

In the course of a step C1 represented in **Figure 3**, the coding module MC_CO1 of **Figure 4** selects as current block B'_i the first block B'_1 to be coded of the current image IE. As represented in **Figure 4**, this is the first left block of the image IE.

In the course of a step C2 represented in **Figure 3**, there is undertaken the predictive coding of the current block B'_1 by known techniques of intra and/or inter prediction, in the course of which the block B'_1 is predicted with respect to at least one previously coded and decoded block. Such a prediction is performed by a prediction software module PRED_CO1 such as represented in **Figure 4**.

It goes without saying that other modes of intra prediction, such as are proposed in the H.264 standard, are possible.

The current block B'_1 can also be subjected to a predictive coding in inter mode, in the course of which the current block is predicted with respect to a block arising from a previously coded and decoded image. Other types of prediction are of course conceivable. Among the possible predictions for a current block, the optimal prediction is chosen according to a bitrate distortion criterion well known to the person skilled in the art.

Said aforementioned predictive coding step makes it possible to construct a predicted block $B'p_1$ which is an approximation of the current block B'_1. The information relating to this predictive coding is intended to be inscribed in a signal to be transmitted to the decoder. Such information includes in particular the type of prediction (inter or intra) and, if appropriate, the mode of intra prediction, the type of partitioning of a block or macroblock if the latter has been subdivided, the reference image index and the displacement vector used in the mode of inter prediction. This information is compressed by the coder CO1.

In the course of a following step C3 represented in **Figure 3**, the prediction module PRED_CO1 compares the data relating to the current block B'_1 with the data of the predicted block $B'p_1$. More precisely, in the course of this step, there is undertaken conventionally the subtraction of the predicted block $B'p_1$ from the current block B'_1 to produce a residual block $B'r_1$.

In the course of a following step C4 represented in **Figure 3**, there is undertaken the transformation of the residual block $B'r_1$, according to a conventional direct transformation operation, such as for example a discrete cosine transformation DCT, to produce a transformed block $B't_1$. Such an operation is performed by a transform software module MT_CO1, such as represented in **Figure 4**.

In the course of a following step C5 represented in **Figure 3**, there is undertaken the quantification of the transformed block $B't_1$, according to a conventional quantification operation, such as for example a scalar quantification. A block $B'q_1$ of quantified coefficients is then obtained. Such a step is performed by means of a quantification software module MQ_CO1, such as represented in **Figure 4**.

In the course of a following step C6 represented in **Figure 3**, there is undertaken a path, in a predefined order, of the quantified coefficients of the block $B'q_1$. In the example represented this entails a conventional zig-zag path. Such a step is performed by a reading software module ML_CO1, such as represented in **Figure 4**. On completion of step C6, a one-dimensional list $E_1 = (\varepsilon 1, \varepsilon 2, ..., \varepsilon L)$ of coefficients is obtained, better known by the term “quantified residual”, where L is an integer greater than or equal to 1. Each of the coefficients of the list E_1 is associated with various items of digital information which are intended to undergo an entropy coding. Such items of digital information are described hereinbelow by way of example.

Let us assume that, in the example represented, L = 16 and that the list E_1 contains the following sixteen coefficients: $E_1 = (0, +9, -7, 0, 0, +1, 0, -1, +2, 0, 0, +1, 0, 0, 0, 0)$.

In this instance:

- for each coefficient situated before the last non-zero coefficient of the list E_1, a digital item of information, such as a bit, is intended to be coded entropically to indicate whether the coefficient is or is not zero: if the coefficient is zero, it is for example the bit of value 0 which will be coded, while if the coefficient is non-zero, it is the bit of value 1 which will be coded;

- for each non-zero coefficient +9, −7, +1, −1, +2, +1, a digital item of information, such as a bit, is intended to be coded entropically to indicate whether the absolute value of the coefficient is or is not equal to one: if it is equal to 1, it is for example the bit of value 1 which will be coded, while if it is equal to 0, it is the bit of value 0 which will be coded;

- for each non-zero coefficient whose absolute value is not equal to one and situated before the last non-zero coefficient, such as the coefficients of value +9, −7, +2, an amplitude item of information (absolute value of the coefficient from which the value two is deducted) is coded entropically,

- for each non-zero coefficient, the sign which is assigned to it is coded by a digital item of information, such as a bit for example set to '0' (for the + sign) or to '1' (for the - sign).

The specific coding steps according to the invention will now be described with reference to **Figure 3**.

In accordance with the invention, it is decided to avoid entropically coding at least one of the aforementioned items of digital information, which is at least one sign of one of said coefficients of the list E_1.

For this purpose, in the course of a step C7 represented in **Figure 3**, there is undertaken the choice of the number of signs to be hidden in the course of the subsequent entropy coding step. Such a step is performed by a processing software module MTR_CO1, such as represented in **Figure 4**.

In the preferred embodiment, the number of signs to be hidden is one or zero. Furthermore, in accordance with the said preferred embodiment, it is the sign of the first non-zero coefficient which is intended to be hidden. In the example represented, this therefore entails hiding the sign of the coefficient $\varepsilon 2 = +9$.

In an alternative embodiment, the number of signs to be hidden is either zero, or one, or two, or three, or more.

In accordance with the preferred embodiment of step C7, there is undertaken, in the course of a first sub-step C71 represented in **Figure 3**, the determination, on the basis of said list E_1, of a sub-list SE_1 containing coefficients able to be modified ε'1, ε'2, ..., ε'M where M<L. Such coefficients will be called modifiable coefficients in the subsequent description.

According to the invention, a coefficient is modifiable if the modification of its quantified value does not cause any desynchronization at the decoder, once this modified coefficient is processed by the decoder. Thus, the processing module MTR_CO1 is configured initially so as not to modify:

- the zero coefficient or coefficients situated before the first non-zero coefficient, in such a way that the decoder does not assign the value of the hidden sign to this or these zero coefficients,
- and for computation complexity reasons, the zero coefficient or coefficients situated after the last non-zero coefficient.

In the example represented, on completion of sub-step C71, the sub-list SE_1 obtained is such that $SE_1 = (9,-7,0,0,1,0,-1,2,0,0,1)$. Consequently, eleven modifiable coefficients are obtained.

In the course of a following sub-step C72 represented in **Figure 3**, the processing module MTR_CO1 undertakes the comparison of the number of modifiable coefficients with a predetermined threshold TSIG. In the preferred embodiment, TSIG equals 4.

If the number of modifiable coefficients is less than the threshold TSIG, there is undertaken, in the course of a step C20 represented in **Figure 3**, a conventional entropy coding of the coefficients of the list E_1, such as that carried out for example in a CABAC coder, designated by the reference CE_CO1 in **Figure 4**. For this purpose, the sign of each non-zero coefficient of the list E_1 is coded entropically.

If the number of modifiable coefficients is greater than the threshold TSIG, in the course of a step C8 represented in **Figure 3**, the processing module MTR_CO1 computes the value of a function f which is representative of the coefficients of the sub-list SE_1.

In the preferred embodiment where a single sign is intended to be hidden in the signal to be transmitted to the decoder, the function f is the parity of the sum of the coefficients of the sub-list SE_1.

In the course of a step C9 represented in **Figure 3**, the processing module MTR_CO1 verifies whether the parity of the value of the sign to be hidden corresponds to the parity of the sum of the coefficients of the sub-list SE_1, by virtue of a convention defined previously at the coder CO1.

In the example proposed, said convention is such that a positive sign is associated with a bit of value equal to zero, while a negative sign is associated with a bit of value equal to one.

If, in accordance with the convention adopted in the coder CO1 according to the invention, the sign is positive, thereby corresponding to a zero coding bit value, and if the sum of the coefficients of the sub-list SE_1 is even, there is undertaken the step C20 of entropy coding of the coefficients of the aforementioned list E_1, with the exception of the sign of the coefficient ε2.

If, still in accordance with the convention adopted in the coder CO1 according to the invention, the sign is negative, thereby corresponding to a one coding bit value, and if the sum of the coefficients of the sub-list SE_1 is odd, there is also undertaken the step C20 of entropy coding of the coefficients of the aforementioned list E_1, with the exception of the sign of the coefficient ε2.

If, in accordance with the convention adopted in the coder CO1 according to the invention, the sign is positive, thereby corresponding to a zero coding bit value, and if the sum of the coefficients of the sub-list SE_1 is odd, there is undertaken, in the course of a step C10 represented in **Figure 3**, a modification of at least one modifiable coefficient of the sub-list SE_1.

If, still in accordance with the convention adopted in the coder CO1 according to the invention, the sign is negative, thereby corresponding to a one coding bit value, and if the sum of the coefficients of the sub-list SE_1 is even, there is also undertaken step C10 of modifying at least one modifiable coefficient of the sub-list SE_1.

Such a modification operation is performed by the processing module MTR_CO1 of **Figure 4.**

In the exemplary embodiment where $SE_1 = (+9,-7,0,0,+1,0,-1,+2,0,0,+1)$, the total sum of the coefficients is equal to 5, and is therefore odd. So that the decoder can reconstruct the positive sign assigned to the first non-zero coefficient, ε2 = +9, without the coder CO1 having to transmit this coefficient to the decoder, the parity of the sum must become even. Consequently, the processing module MTR_CO1 tests, in the course of said step C10, various modifications of coefficients of the sub-list SE_1, all aimed at changing the parity of the sum of the coefficients. In the preferred embodiment, there is undertaken the addition of +1 or −1 to each modifiable coefficient and the selection of a modification from among all those performed.

In the preferred embodiment, such a selection constitutes the optimal prediction according to a performance criterion which is for example the bitrate distortion criterion well known to the person skilled in the art. Such a criterion is expressed by equation (1) hereinbelow:

$$(1)\ J = D + \lambda R \text{ where}$$

D represents the distortion between the original macroblock and the reconstructed macroblock, R represents the cost in bits of the coding of the coding information and λ represents a Lagrange multiplier, the value of which can be fixed prior to the coding.

In the example proposed, the modification which gives rise to an optimal prediction according to the aforementioned bitrate-distortion criterion is the addition of the value 1 to the second coefficient −7 of the sub-list SE_1.

A modified sub-list SEm_1 = (+9,+6,0,0,+1,0,−1,+2,0,0,+1) is then obtained on completion of step C10.

It should be noted that in the course of this step, certain modifications are prohibited. Thus, in the case where the first non-zero coefficient ε2 would have been equal to +1, it would not have been possible to add −1 to it, since it would have become zero, and it would then have lost its characteristic of first non-zero coefficient of the list E_1. The decoder would then have subsequently allocated the decoded sign (by computation of the parity of the sum of the coefficients) to another coefficient, and there would then have been a decoding error.

In the course of a step C11 represented in **Figure 3**, the processing module MTR_CO1 undertakes a corresponding modification of the list E_1. The following modified list Em_1 = (0,+9,−6,0,0,+1,0,−1,+2,0,0,+1,0,0,0,0) is then obtained.

There is thereafter undertaken the step C20 of entropy coding of the coefficients of the aforementioned list Em_1, with the exception of the sign of the coefficient ε2, which is the + sign of the coefficient 9 in the example proposed, which sign is hidden in the parity of the sum of the coefficients.

It should be noted that the set of amplitudes of the coefficients of the list E_1 or of the modified list Em_1 is coded before the set of signs, with the exclusion of the sign of the first non-zero coefficient ε2 which is not coded, as has been explained hereinabove.

In the course of a following step C30 represented in **Figure 3**, the coding module MC_CO1 of **Figure 4** tests whether the coded current block is the last block of the image IE.

If the current block is the last block of the image IE, in the course of a step C40 represented in **Figure 3**, the coding method is terminated.

If such is not the case, there is undertaken the selection of the following block B'_i which is then coded in accordance with the aforementioned raster scan order of path, by iteration of steps C1 to C20, for $1 \leq i \leq Z$.

Once the entropy coding of all the blocks B'_1 to B'_z has been carried out, there is undertaken the construction of a signal F' representing, in binary form, said coded blocks.

The construction of the binary signal F' is implemented in a stream construction software module CF1, such as represented in **Figure 4**.

The stream F' is thereafter transmitted by a communication network (not represented), to a remote terminal. The latter includes a decoder which will be described in greater detail in the subsequent description.

Another embodiment of the invention will now be described, mainly with reference to **Figure 3**.

This other embodiment is distinguished from the previous one solely by the number of coefficients to be hidden which is either 0, or N, N being an integer such that $N \geq 2$.

For this purpose, the aforementioned comparison sub-step C72 is replaced with sub-step C72a represented dashed in **Figure 3**, in the course of which there is undertaken the comparison of the number of modifiable coefficients with several predetermined thresholds $0 < TSIG\_1 < TSIG\_2 < TSIG\_3$ ..., in such a way that if the number of modifiable coefficients lies between TSIG_N and TSIG_N+1, N signs are intended to be hidden.

If the number of modifiable coefficients is less than the first threshold TSIG_1, there is undertaken, in the course of the aforementioned step C20, the conventional entropy coding of the coefficients of the list E_1. For this purpose, the sign of each non-zero coefficient of the list E_1 is coded entropically.

If the number of modifiable coefficients lies between the threshold TSIG_N and TSIG_N+1, in the course of a step C8 represented in **Figure 3**, the processing module MTR_CO1 computes the value of a function f which is representative of the coefficients of the sub-list SE_1.

In this other embodiment, the decision at the coder being to hide N signs, the function f is the remainder modulo 2^N of the sum of the coefficients of the sub-list SE_1. It is assumed that in the example proposed, N=2, the two signs to be hidden are the first two signs of the first two non-zero coefficients respectively, namely ε2 and ε3.

In the course of the following step C9 represented in **Figure 3**, the processing module MTR_CO1 verifies whether the configuration of the N signs, i.e. 2^N possible configurations, corresponds to the value of the remainder modulo 2^N of the sum of the coefficients of the sub-list SE_1.

In the example proposed where N=2, there exist 2^2=4 different configurations of signs.

These four configurations obey a convention at the coder CO1, which is for example determined in the following manner:

- a remainder equal to zero corresponds to two consecutive positive signs: +, +;
- a remainder equal to one corresponds to consecutive positive sign and negative sign: +, -;
- a remainder equal to two corresponds to consecutive negative sign and positive sign: -, +;
- a remainder equal to three corresponds to two consecutive negative signs: -, -.

If the configuration of the N signs corresponds to the value of the remainder modulo 2^N of the sum of the coefficients of the sub-list SE_1, there is undertaken the step C20 of entropy coding of the coefficients of the aforementioned list E_1, with the exception of the sign of the coefficient ε2 and of the coefficient ε3, which signs are hidden in the parity of the sum modulo 2^N of the coefficients.

If such is not the case, there is undertaken step C10 of modifying at least one modifiable coefficient of the sub-list SE_1. Such a modification is performed by the processing module MTR_CO1 of **Figure 4**, in such a way that the remainder modulo 2^N of the sum of the modifiable coefficients of the sub-list SE_1 attains the value of each of the two signs to be hidden.

In the course of the aforementioned step C11, the processing module MTR_CO1 undertakes a corresponding modification of the list E_1. A modified list Em_1 is then obtained.

There is thereafter undertaken step C20 of entropy coding of the coefficients of the aforementioned list Em_1, with the exception of the sign of the coefficient ε2 and of the sign of the coefficient ε3, which signs are hidden in the parity of the sum modulo 2^N of the coefficients.

Detailed description of the decoding part

A general embodiment of the decoding method according to the invention will now be described, in which the decoding method is implemented in a software or hardware manner by modifications of a decoder initially complying with the H.264/MPEG-4 AVC standard.

The decoding method according to the invention is represented in the form of an algorithm comprising steps SD1 to SD7 represented in **Figure 5**.

According to the general embodiment of the invention, the decoding method according to the invention is implemented in a decoding device or decoder DO, such as represented in **Figure 6**, which is suitable for receiving the stream F delivered by the coder CO of **Figure 2**.

In the course of a preliminary step, not represented in **Figure 5**, there is undertaken the identification, in the data signal F received, of the partitions B_1 to B_Z which have been coded previously by the coder CO. In the preferred embodiment, said partitions are blocks which have a square shape and all have the same size. As a function of the size of the image which is not necessarily a multiple of the size of the blocks, the last blocks on the left and the last blocks at the bottom may not be square. In an alternative embodiment, the blocks may be for example of rectangular size and/or not aligned one with another.

Each block or macroblock may moreover itself be divided into sub-blocks which are themselves subdividable.

Such an identification is performed by a stream analysis software module EX_DO, such as represented in **Figure 6**.

In the course of a step SD1 represented in **Figure 5**, the module EX_DO of **Figure 6** selects as current block B_i the first block B_1 to be decoded. Such a selection consists for example in placing a pointer for reading in the signal F at the start of the data of the first block B_1.

There is thereafter undertaken the decoding of each of the selected coded blocks.

In the example represented in **Figure 5**, such a decoding is applied successively to each of the coded blocks B_1 to B_Z. The blocks are decoded according to for example a "raster scan" path well known to the person skilled in the art.

The decoding according to the invention is implemented in a decoding software module MD_DO of the decoder DO, such as represented in **Figure 6**.

In the course of a step SD2 represented in **Figure 5**, there is firstly undertaken the entropy decoding of the first current block B_1 which has been selected. Such an operation is performed by an entropy decoding module DE_DO represented in **Figure 6**, for example of CABAC type. In the course of this step, the module DE_DO performs an entropy decoding of the items of digital information corresponding to the amplitude of each of the coded data of the list D_1 or of the modified list Dm_1. At this juncture, only the signs of the data of the list D_1 or of the modified list Dm_1 are not decoded.

In the case where the processing module MTR_DO receives the list $D_1 = (a_1, a_2, ..., a_P)$, there is undertaken, in the course of a step SD3 represented in **Figure 5**, a conventional entropy decoding of all the signs of the data of the list D_1. Such a decoding is performed by the CABAC decoder, designated by the reference DE_DO in **Figure 6**. For this purpose, the sign of each non-zero datum of the list D_1 is decoded entropically.

In the case where the processing module MTR_DO receives the modified list $Dm_1 = (a'_1, a'_2, ..., a'_P)$, there is undertaken, in the course of said step SD3, the conventional entropy decoding of all the signs of the data of the list Dm_1, with the exception of the sign of the first non-zero datum a2.

In the course of a step SD4 represented in **Figure 5**, the processing module MTR_DO computes the value of a function f which is representative of the data of the list Dm_1, so as to determine whether the computed value is even or odd.

In the preferred embodiment where a single sign is hidden in the signal F, the function f is the parity of the sum of the data of the list Dm_1.

In accordance with the convention used at the coder CO, which is the same at the decoder DO, an even value of the sum of the data of the list Dm_1 signifies that the sign of the first non-zero datum of the modified list Dm_1 is positive, while an odd value of the sum of the data of the list Dm_1 signifies that the sign of the first non-zero datum of the modified list Dm_1 is negative.

In the exemplary embodiment, the total sum of the data is even. Consequently, on completion of step SD4, the processing module MTR_DO deduces therefrom that the hidden sign of the first non-zero datum a2 is positive.

In the course of a step SD5 represented in **Figure 5**, there is undertaken the construction of the decoded block BD_1. Such an operation is performed by a reconstruction software module MR_DO represented in **Figure 6**.

In the course of a step SD6 represented in **Figure 5**, the decoding module MD_DO tests whether the decoded current block is the last block identified in the signal F.

If the current block is the last block of the signal F, in the course of a step SD7 represented in **Figure 5**, the decoding method is terminated.

If such is not the case, there is undertaken the selection of the following block B_i to be decoded, in accordance with the aforementioned raster scan order of path, by iteration of steps SD1 to SD5, for $1 \leq i \leq Z$.

Another embodiment of the invention will now be described, mainly with reference to **Figure 5**.

This other embodiment is distinguished from the previous one solely by the number of hidden signs which is now equal to N, N being an integer such that $N \geq 2$.

For this purpose, in the course of the aforementioned step SD3, there is undertaken the conventional entropy decoding of all the signs of the data of the list Dm_1, with the exception of the N respective signs of the first non-zero data of said modified list Dm_1, said N signs being hidden.

In this other embodiment, the processing module MTR_DO computes, in the course of step SD4, the value of the function f which is the remainder modulo 2^N of the sum of the data of the list Dm_1. It is assumed that in the example proposed, N = 2.

The processing module MTR_DO then deduces therefrom the configuration of the two hidden signs which are assigned respectively to each of the first two non-zero data a2 and a3, according to the convention used on coding.

Once these two signs have been reconstructed, there is undertaken the implementation of steps SD5 to SD7 described hereinabove.

A particular embodiment of the decoding method according to the invention will now be described, in which the decoding method is implemented in a software or hardware manner by modifications of a decoder initially complying with the H.264/MPEG-4 AVC standard.

The decoding method according to the invention is represented in the form of an algorithm comprising steps D1 to D12 represented in **Figure 7**.

According to the embodiment of the invention, the decoding method according to the invention is implemented in a decoding device or decoder DO1, such as represented in **Figure 8**, which is able to process the signal F′ delivered by the coder CO1 of **Figure 4**.

In the course of a preliminary step, not represented in **Figure 7**, there is undertaken the identification, in the data signal F′ received, of the partitions B'_1 to B'_Z which have been coded previously by the coder CO1. In the preferred embodiment, said partitions are blocks which have a square shape and all have the same size. As a function of the size of the image which is not necessarily a multiple of the size of the blocks, the last blocks on the left and the last blocks at the bottom may not be square. In an alternative embodiment, the blocks may be for example of rectangular size and/or not aligned one with another.

Each block or macroblock may moreover itself be divided into sub-blocks which are themselves subdividable.

Such an identification is performed by a stream analysis software module EX_DO1, such as represented in **Figure 8**.

In the course of a step D1 represented in **Figure 7**, the module EX_DO1 of **Figure 8** selects as current block B'_i the first block B'_1 to be decoded. Such a selection consists for example in placing a pointer for reading in the signal F′ at the start of the data of the first block B'_1.

There is thereafter undertaken the decoding of each of the selected coded blocks.

In the example represented in **Figure 7**, such a decoding is applied successively to each of the coded blocks B'_1 to B'_Z. The blocks are decoded according to for example a "raster scan" path well known to the person skilled in the art.

The decoding according to the invention is implemented in a decoding software module MD_DO1 of the decoder DO1, such as represented in **Figure 8**.

In the course of a step D2 represented in **Figure 7**, there is firstly undertaken the entropy decoding of the first current block B'_1 which has been selected. Such an operation is performed by an entropy decoding module DE_DO1 represented in **Figure 8**, for example of CABAC type. In the course of this step, the module DE_DO1 performs an entropy decoding of the digital information corresponding to the amplitude of each of the coded coefficients of the list E_1 or of the modified list Em_1. At this juncture, only the signs of the coefficients of the list E_1 or of the modified list Em_1 are not decoded.

In the course of a step D3 represented in **Figure 7**, there is undertaken the determination of the number of signs liable to have been hidden in the course of the previous step of entropy coding C20. Such a step D3 is performed by a processing software module MTR_DO1, such as represented in **Figure 8**. Step D3 is similar to the aforementioned step C7 of determining the number of signs to be hidden.

In the preferred embodiment, the number of hidden signs is one or zero. Furthermore, in accordance with the said preferred embodiment, it is the sign of the first non-zero coefficient which is hidden. In the example represented, this therefore entails the positive sign of the coefficient $\varepsilon 2 = +9$.

In an alternative embodiment, the number of hidden signs is either zero, or one, or two, or three, or more.

In accordance with the preferred embodiment of step D3, there is undertaken, in the course of a first sub-step D31 represented in **Figure 7**, the determination, on the basis of said list E_1 or of the modified list Em_1, of a sub-list containing coefficients $\varepsilon'1$, $\varepsilon'2$, ..., $\varepsilon'M$ where $M<L$ liable to have been modified on coding.

Such a determination is performed in the same manner as in the aforementioned coding step C7.

Like the aforementioned processing module MTR_CO1, the processing module MTR_DO1 is configured initially so as not to modify:

- the zero coefficient or coefficients situated before the first non-zero coefficient,

- and for computation complexity reasons, the zero coefficient or coefficients situated after the last non-zero coefficient.

In the example represented, on completion of sub-step D31, this entails the sub-list SEm_1 such that $SEm_1 = (9, -6, 0, 0, 1, 0, -1, 2, 0, 0, 1)$. Consequently, eleven coefficients liable to have been modified are obtained.

In the course of a following sub-step D32 represented in **Figure 7**, the processing module MTR_DO1 undertakes the comparison of the number of coefficients liable to have been modified with a predetermined threshold TSIG. In the preferred embodiment, TSIG equals 4.

If the number of coefficients liable to have been modified is less than the threshold TSIG, there is undertaken, in the course of a step D4 represented in **Figure 7**, a conventional entropy decoding of all the signs of the coefficients of the list E_1. Such a decoding is performed by the CABAC decoder, designated by the reference DE_DO1 in **Figure 8**. For this purpose, the sign of each non-zero coefficient of the list E_1 is decoded entropically.

If the number of coefficients liable to have been modified is greater than the threshold TSIG, there is undertaken, in the course of said step D4, the conventional entropy decoding of all the signs of the coefficients of the list Em_1, with the exception of the sign of the first non-zero coefficient ε2.

In the course of a step D5 represented in **Figure 7**, the processing module MTR_DO1 computes the value of a function f which is representative of the coefficients of the sub-list SEm_1 so as to determine whether the computed value is even or odd.

In the preferred embodiment where a single sign is hidden in the signal F', the function f is the parity of the sum of the coefficients of the sub-list SEm_1.

In accordance with the convention used at the coder CO1, which is the same at the decoder DO1, an even value of the sum of the coefficients of the sub-list SEm_1 signifies that the sign of the first non-zero coefficient of the modified list Em_1 is positive, while an odd value of the sum of the coefficients of the sub-list SEm_1 signifies that the sign of the first non-zero coefficient of the modified list Em_1 is negative.

In the exemplary embodiment where SEm_1 = (+9,−6,0,0,+1,0,−1,+2,0,0,+1), the total sum of the coefficients is equal to 6, and is therefore even. Consequently, on completion of step D5, the processing module MTR_DO1 deduces therefrom that the hidden sign of the first non-zero coefficient ε2 is positive.

In the course of a step D6 represented in **Figure 7**, and with the aid of all the items of digital information reconstructed in the course of steps D2, D4 and D5, there is undertaken the reconstruction of the quantified coefficients of the block $B'q_1$ in a predefined order. In the example represented, this entails a zig-zag path reverse to the zig-zag path performed in the course of the aforementioned coding step C6. Such a step is performed by a reading software module ML_DO1, such as represented in **Figure 8**. More precisely, the module ML_DO1 undertakes the writing of the coefficients of the list E_1 (one-dimensional) to the block $B'q_1$ (two-dimensional), using said inverse zig-zag order of path.

In the course of a step D7 represented in **Figure 7**, there is undertaken the dequantification of the quantified residual block $B'q_1$ according to a conventional dequantification operation which is the operation inverse to the quantification performed on coding in the aforementioned step C5, so as to produce a decoded dequantified block $BD'q_1$. Such a step is performed by means of a dequantification software module MDQ_DO1, such as represented in **Figure 8**.

In the course of a step D8 represented in **Figure 7**, there is undertaken the inverse transformation of the dequantified block $BD'q_1$ which is the operation inverse to the direct transformation performed on coding in the aforementioned step C4. A decoded residual block $BD'r_1$ is then obtained. Such an operation is performed by an inverse transform software module MTI_DO1, such as represented in **Figure 8**.

In the course of a step D9 represented in **Figure 7**, there is undertaken the predictive decoding of the current block B'_1. Such a predictive decoding is performed conventionally by known techniques of intra and/or inter prediction, in the course of which the block B'_1 is predicted with respect to at least one previously decoded block. Such an operation is performed by a predictive decoding module PRED_DO1 such as represented in **Figure 8**.

It goes without saying that other modes of intra prediction, such as are proposed in the H.264 standard, are possible.

In the course of this step, the predictive decoding is performed with the aid of the syntax elements decoded in the previous step and comprising in particular the type of prediction (inter or intra) and, if appropriate, the mode of intra prediction, the type of partitioning of a block or macroblock if the latter has been subdivided, the reference image index and the displacement vector used in the mode of inter prediction.

Said aforementioned predictive decoding step makes it possible to construct a predicted block $B'p_1$.

In the course of a step D10 represented in **Figure 7**, there is undertaken the construction of the decoded block BD'_1 by adding the decoded residual block $BD'r_1$ to the predicted block $B'p_1$. Such an operation is performed by a reconstruction software module MR_DO1 represented in **Figure 8.**

In the course of a step D11 represented in **Figure 7**, the decoding module MD_DO1 tests whether the decoded current block is the last block identified in the signal F'.

If the current block is the last block of the signal F', in the course of a step D12 represented in **Figure 7**, the decoding method is terminated.

If such is not the case, there is undertaken the selection of the following block B'_i to be decoded in accordance with the aforementioned raster scan order of path, by iteration of steps D1 to D10, for $1 \le i \le Z$.

Another embodiment of the invention will now be described, mainly with reference to **Figure 7**.

This other embodiment is distinguished from the previous one solely by the number of hidden coefficients which is either 0, or N, N being an integer such that $N \ge 2$.

For this purpose, the aforementioned comparison sub-step D32 is replaced with sub-step D32a represented dashed in **Figure 7**, in the course of which there is undertaken the comparison of the number of coefficients liable to have been modified with several predetermined thresholds 0<TSIG_1 <TSIG_2<TSIG_3..., in such a way that if the number of said coefficients lies between TSIG_N and TSIG_N+1, N signs have been hidden.

If the number of said coefficients is less than the first threshold TSIG_1, there is undertaken, in the course of the aforementioned step D4, the conventional entropy decoding of all the signs of the coefficients of the list E_1. For this purpose, the sign of each non-zero coefficient of the list E_1 is decoded entropically.

If the number of said coefficients lies between the threshold TSIG_N and TSIG_N+1, there is undertaken, in the course of the aforementioned step D4, the conventional entropy decoding of all the signs of the coefficients of the list E1, with the exception of the N respective signs of the first non-zero coefficients of said modified list Em_1, said N signs being hidden.

In this other embodiment, the processing module MTR_DO1 computes, in the course of step D5, the value of the function f which is the remainder modulo 2^N of the sum of the coefficients of the sub-list SEm_1. It is assumed that in the example proposed, N = 2.

The processing module MTR_DO1 then deduces therefrom the configuration of the two hidden signs which are assigned respectively to each of the first two non-zero coefficients ε2 and ε3, according to the convention used on coding.

Once these two signs have been reconstructed, steps D6 to D12 described hereinabove are carried out.

It goes without saying that the embodiments which have been described hereinabove have been given purely by way of indication.

The invention is defined by the accompanying claims.

Thus for example, according to a simplified embodiment with respect to that represented in **Figure 4**, the coder CO1 could be configured to hide at least N' predetermined signs, with N'≥1, instead of either zero, or one or N predetermined signs. In this case, the comparison step C72 or C72a would be dispensed with. In a corresponding manner, according to a simplified embodiment with respect to that represented in **Figure 8**, the decoder DO1 would be configured to reconstruct N' predetermined signs instead of either zero, or one or N predetermined signs. In this case, the comparison step D32 or D32a would be dispensed with. Furthermore, the decision criterion applied in the coding step C72 and in the decoding step D32 could be replaced with another type of criterion. For this purpose, instead of comparing with a threshold the number of modifiable coefficients or the number of coefficients liable to have been modified, the processing module MTR_CO1 or MTR_DO1 could apply a decision criterion which is respectively dependent on the sum of the amplitudes of the coefficients that are modifiable or liable to have been modified, or else the number of zeros present among the coefficients that are modifiable or liable to have been modified.

Patentkrav

1. Indretning til afkodning af et datasignal repræsentativt for mindst et billede opdelt i partitioner, som tidligere er kodet, hvilke partitioner omfatter en aktuel partition (Bi), der skal kodes, indeholdende data, hvoraf mindst et data er tildelt et fortegn, idet dataene er koefficienterne af den direkte transformation, hvilken afkodningsindretning er konfigureret til:

- entropisk afkodning (D2) af den første aktuelle partition (Bi),
- bestemmelse af (D3), på basis af de afkodede data forskellig fra nul af den aktuelle partition, hvorvidt fortegnet af mindst et data er skjult,
- beregning (D5) af paritetsværdien af en sum af de afkodede data af den aktuelle partition (Bi),
- opnåelse, fra nævnte paritetsværdi, af værdien af nævnte fortegn, hvis pariteten af summen af dataene har en første værdi, er fortegnet positivt, og hvis pariteten af summen af dataene har en anden værdi, er fortegnet negativt,
- rekonstruktion (D6) på basis deraf, af de kvantificerede koefficienter af den aktuelle partition (Bi) i en foruddefineret rækkefølge, og
- afkvantificering (D7) af de kvantificerede koefficienter af den aktuelle partition (Bi) for at frembringe en afkvantificeret og afkodet blok.

2. Afkodningsindretning ifølge krav 1, hvor opnåelse af værdien af nævnte skjulte fortegn af første koefficient forskellig fra nul (e2) er udledt af et behandlingsmodul (MTR_D01).

3. Afkodningsindretning ifølge krav 2, hvor behandlingsmodulet (MTR_D01) beregner værdien af en funktion f, der er repræsentativ for koefficienter af en underliste af afkodede data fra den aktuelle partition for at bestemme, hvorvidt den beregnede værdi er lige eller ulige.

4. Afkodningsindretning ifølge krav 1, hvor en flerhed af værdier forbundet respektivt med en flerhed (N) af fortegn er opnået fra nævnte beregnede værdi.

5. Afkodningsindretning ifølge krav 1, hvor den foruddefinerede rækkefølge er en zigzagbane.

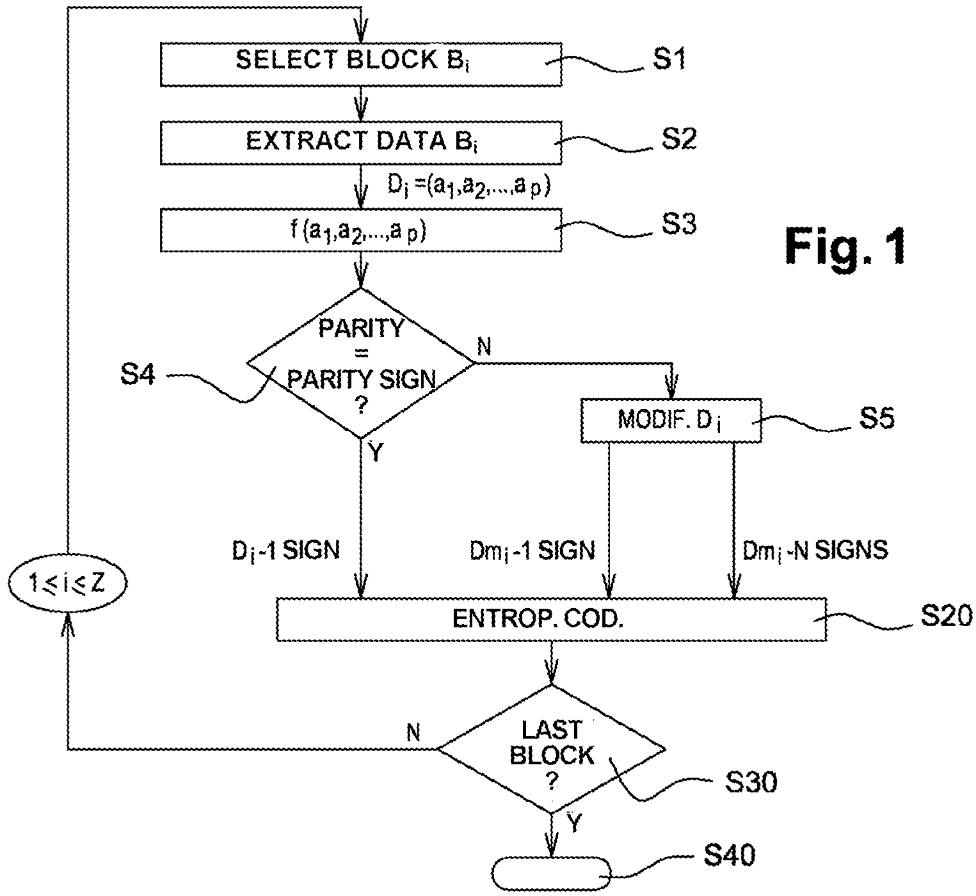
SELECT BLOCK Bi
S1
EXTRACT DATA Bi
S2
Di =(a1,a2,...,a p)
f (a1,a2,...,a p)
S3
PARITY = PARITY SIGN ?
N
S4
MODIF. Di
S5
Y
Di -1 SIGN
Dmi -1 SIGN
Dmi -N SIGNS
1≤i≤Z
ENTROP. COD.
S20
LAST BLOCK ?
N
S30
Y
S40

Fig. 1

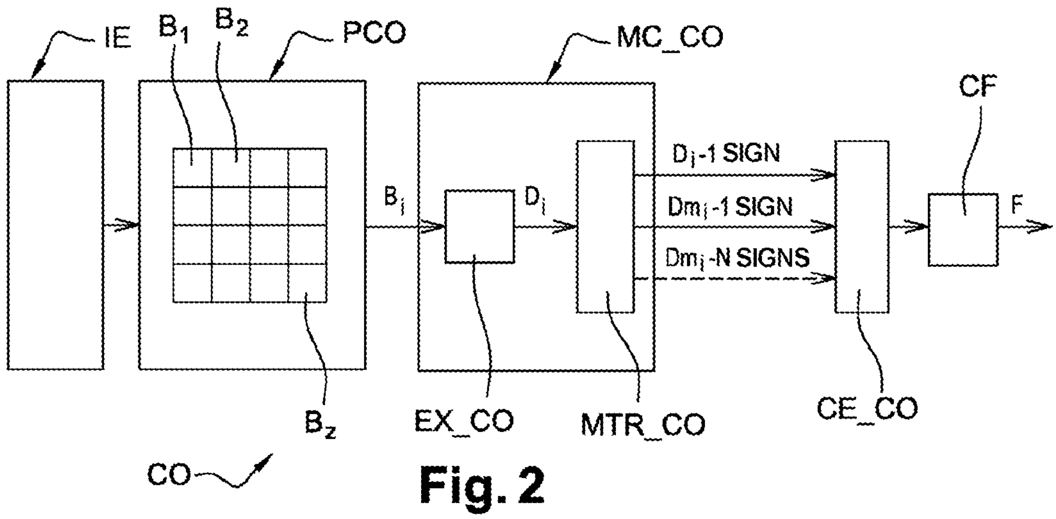
IE
B1
B2
PCO
MC_CO
CF
Bi
Di
Di -1 SIGN
Dmi -1 SIGN
Dmi -N SIGNS
F
Bz
EX_CO
MTR_CO
CE_CO
CO

Fig. 2

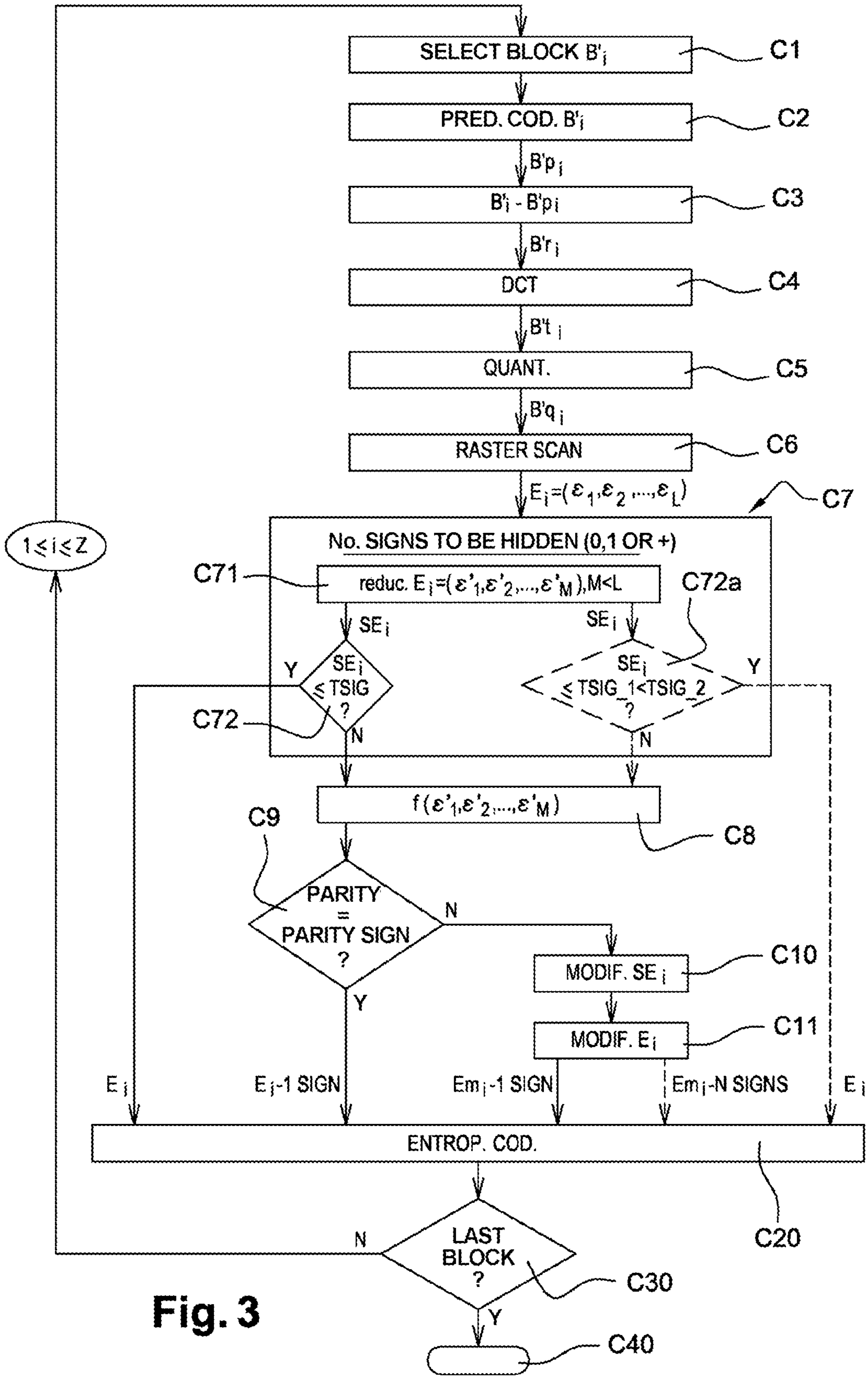
SELECT BLOCK B'i
C1
PRED. COD. B'i
C2
B'pi
B'i - B'pi
C3
B'ri
DCT
C4
B't i
QUANT.
C5
B'q i
RASTER SCAN
C6
Ei=(ε1,ε2,...,εL)
C7
1≤i≤Z
No. SIGNS TO BE HIDDEN (0,1 OR +)
C71
reduc. Ei=(ε'1,ε'2,...,ε'M),M<L
C72a
SEi
SEi ≤ TSIG ?
SEi ≤ TSIG_1<TSIG_2 ?
C72
Y
N
f(ε'1,ε'2,...,ε'M)
C8
C9
PARITY = PARITY SIGN ?
MODIF. SEi
C10
MODIF. Ei
C11
Ei
Ei-1 SIGN
Emi-1 SIGN
Emi-N SIGNS
ENTROP. COD.
C20
LAST BLOCK ?
C30
C40

Fig. 3

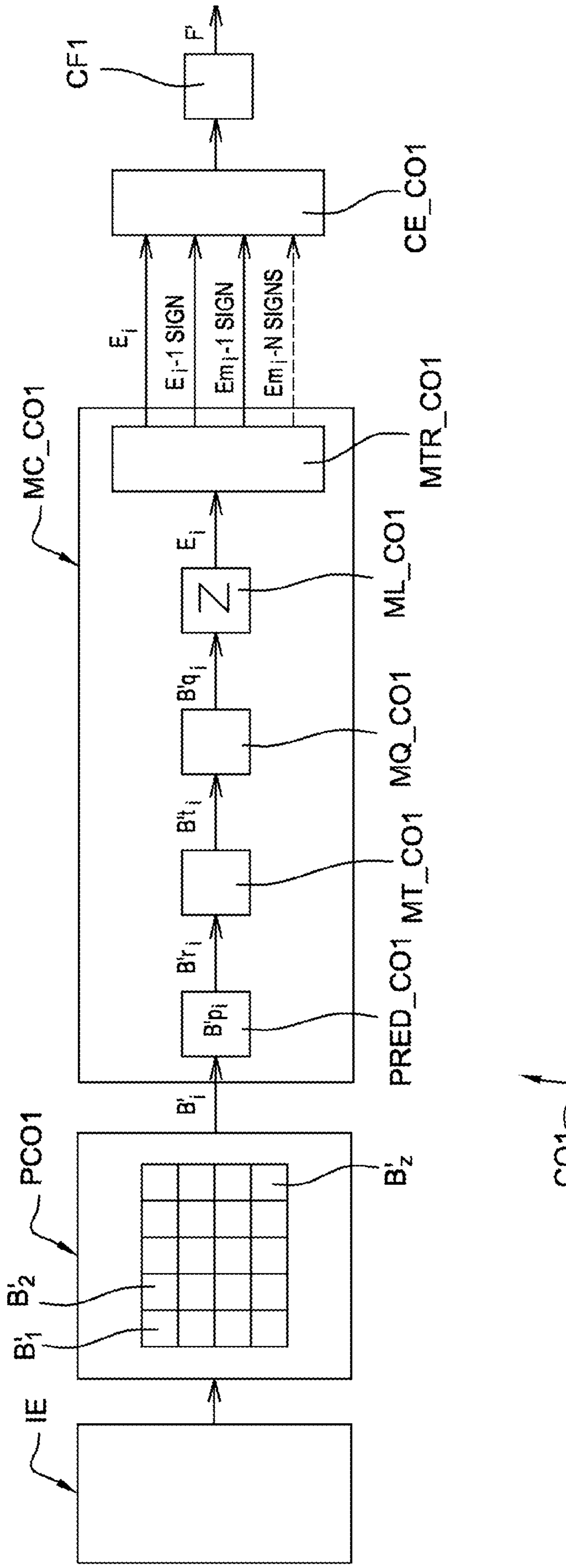
CF1
F'
CE_CO1
Ei
Ei-1 SIGN
Emi-1 SIGN
Emi-N SIGNS
MC_CO1
MTR_CO1
Ei
ML_CO1
Z
B'qi
MQ_CO1
B'ti
MT_CO1
B'ri
PRED_CO1
B'pi
B'i
PCO1
B'z
B'2
B'1
IE
CO1

Fig. 4

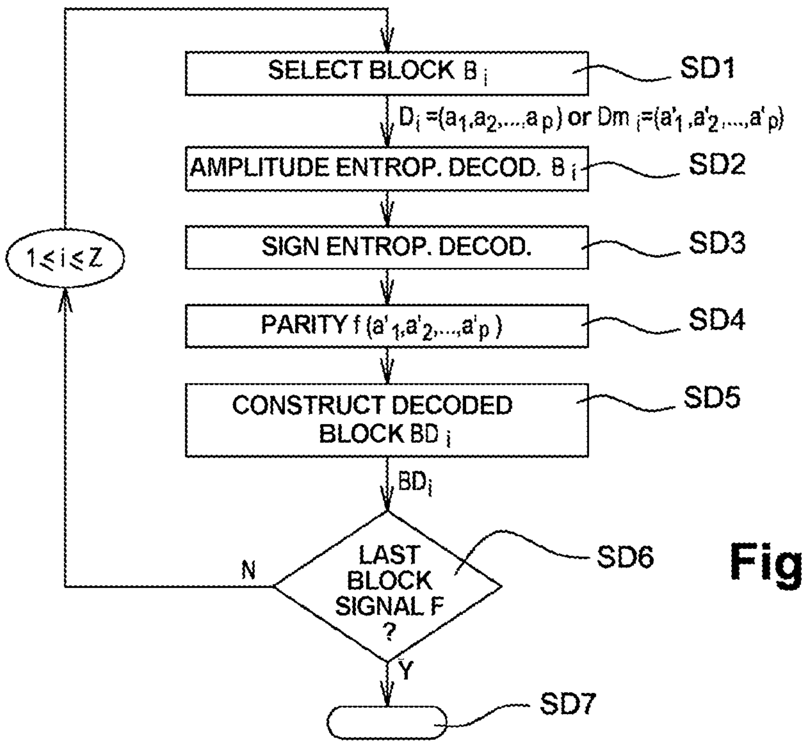
SELECT BLOCK B i
SD1
Di =(a1,a2,...,a p) or Dm i=(a'1 ,a'2,...,a'p)
AMPLITUDE ENTROP. DECOD. B i
SD2
SIGN ENTROP. DECOD.
SD3
1≤i≤Z
PARITY f (a'1,a'2,...,a'p)
SD4
CONSTRUCT DECODED BLOCK BD i
SD5
BDi
LAST BLOCK SIGNAL F ?
N
Y
SD6
SD7

Fig. 5

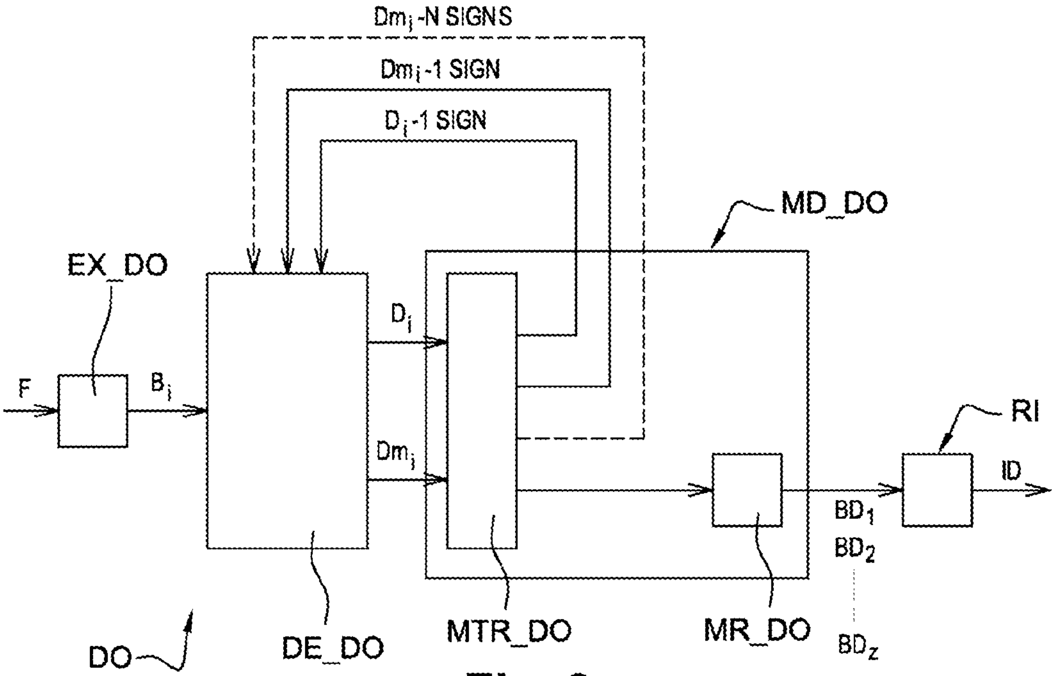
Dmi -N SIGNS
Dmi -1 SIGN
Di -1 SIGN
MD_DO
EX_DO
F
Bi
Di
Dmi
RI
ID
BD1
BD2
BDz
DO
DE_DO
MTR_DO
MR_DO

Fig. 6

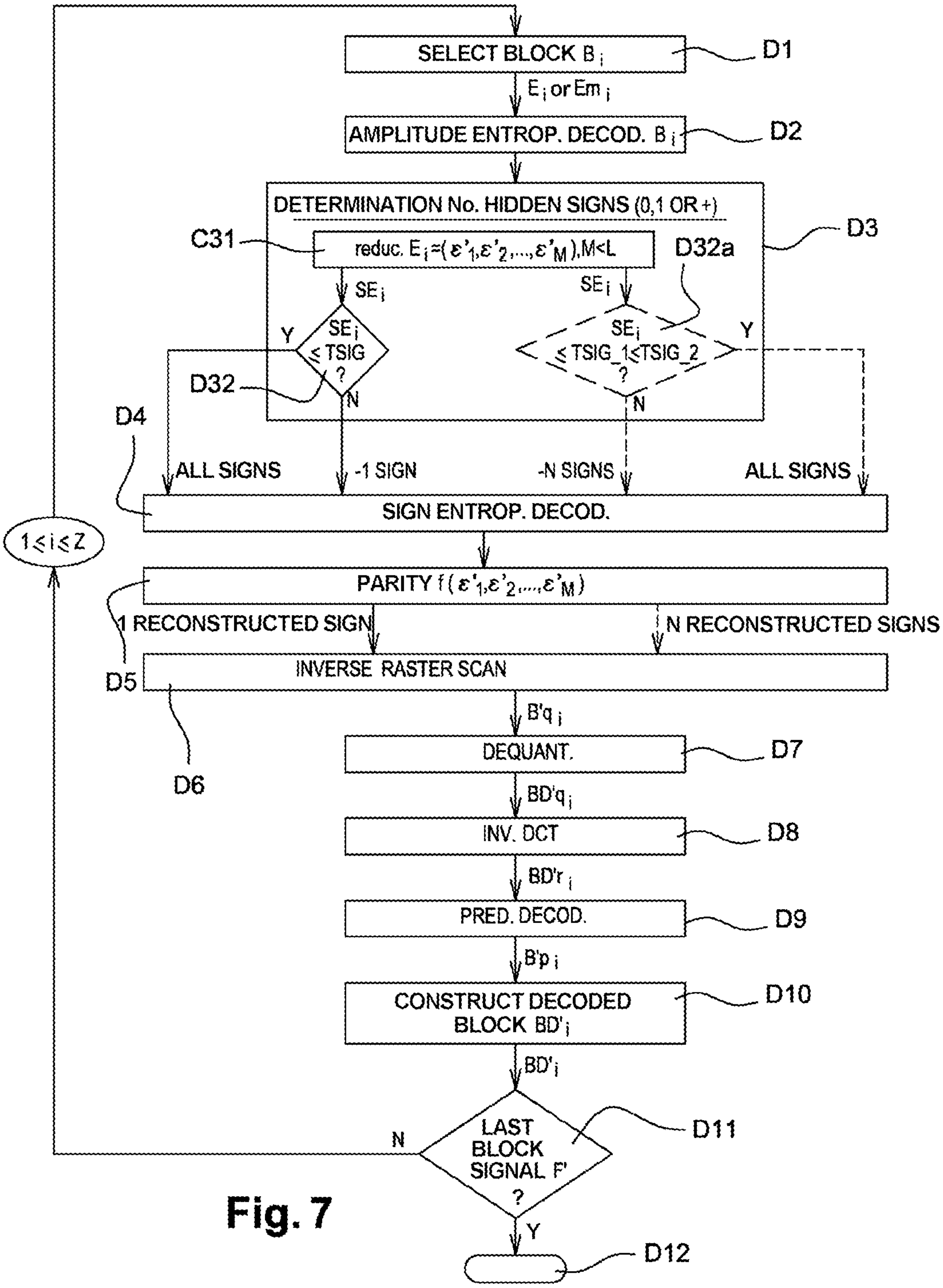
SELECT BLOCK B i
D1
E i or Em i
AMPLITUDE ENTROP. DECOD. B i
D2
DETERMINATION No. HIDDEN SIGNS (0,1 OR +)
D3
C31
reduc. E i =(ε'1,ε'2,...,ε'M),M<L
D32a
SE i
SE i ≤ TSIG ?
SE i ≤ TSIG_1≤TSIG_2 ?
Y
N
D32
D4
ALL SIGNS
-1 SIGN
-N SIGNS
ALL SIGNS
SIGN ENTROP. DECOD.
1≤i≤Z
PARITY f(ε'1,ε'2,...,ε'M)
1 RECONSTRUCTED SIGN
N RECONSTRUCTED SIGNS
D5
INVERSE RASTER SCAN
D6
B'q i
DEQUANT.
D7
BD'q i
INV. DCT
D8
BD'r i
PRED. DECOD.
D9
B'p i
CONSTRUCT DECODED BLOCK BD' i
D10
BD' i
LAST BLOCK SIGNAL F' ?
D11
D12

Fig. 7

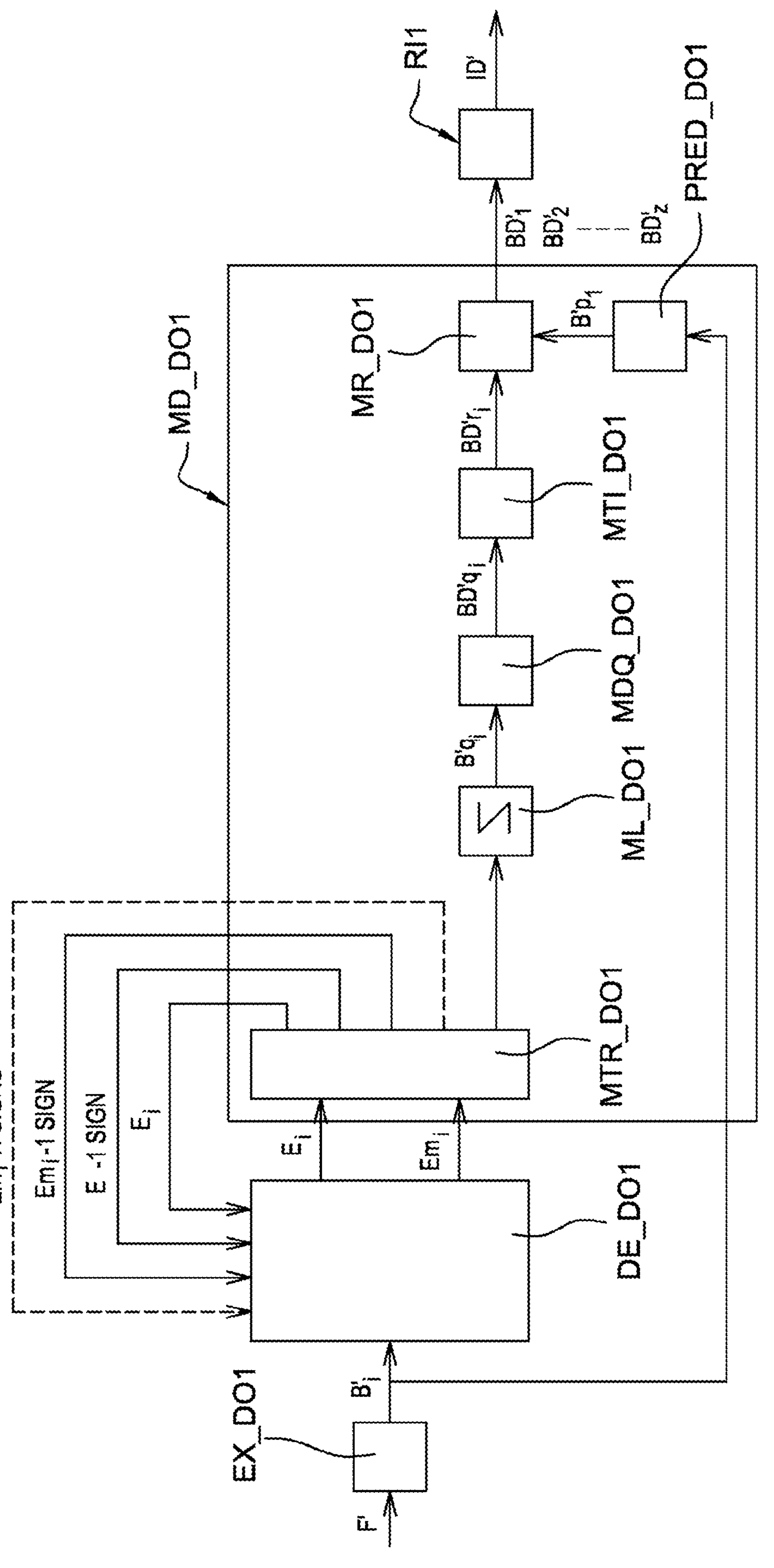
RI1
ID'
BD'1
BD'2
BD'z
PRED_DO1
MD_DO1
MR_DO1
B'p i
BD'r i
MTI_DO1
BD'q i
MDQ_DO1
B'q i
ML_DO1
DO1
MTR_DO1
Em i-N SIGNS
Em i-1 SIGN
E -1 SIGN
E i
E i
Em i
DE_DO1
EX_DO1
B'i
F'

Fig. 8