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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.

5 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

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Current video coders (MPEG, H.264, etc.) use a block-wise representation of the video sequence. The images are divided into macro-blocks, each macro-block is itself divided 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.

15 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 20 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 25 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:

30 - 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 divided 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,
- 10 - 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.);
  - 15 • the type of partitioning;
  - the type of transform, for example  $4 \times 4$  DCT,  $8 \times 8$  DCT, etc.
  - the motion information if necessary;
  - etc.
- 20 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.
- 25 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.
- 30 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.

5 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  
 10 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  
 15 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  
 20 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.

25 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  
 30 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 5 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 10 art.

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

Correspondingly, the invention relates to a device for decoding a data signal according to claim 4.

15 The invention also relates to a computer program comprising instructions for executing the steps of the decoding method according to claim 7.

#### Brief description of the drawings

20 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.

25 - 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.

30 - 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.

5

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 10 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 15 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 division 20 of an image IE of a sequence of images to be coded in a predetermined order, into a plurality Z of partitions B<sub>1</sub>, B<sub>2</sub>, ..., B<sub>i</sub>, ..., B<sub>z</sub>, 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:

25 [http://phenix.int-evry.fr/jct/doc\\_end\\_user/current\\_document.php?id=3286](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 30 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 split up into sub-blocks which can themselves be sub-split.

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

5 Subsequent to said division 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.

10 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.

15 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  $D_1 = (a_1, a_2, \dots, a_P)$ . 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 20 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 25 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;

30 - 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 5 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 10 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 15 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 20 the list  $D_1$  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 25 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 30 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.

5 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.

10

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

15 decoder, it is necessary that the parity of the sum becomes 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.

20 A modified list  $Dm_1 = (a'_1, a'_2, \dots, a'_P)$  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  $D_1$ .

25 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 30  $Dm_1$  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

5 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**.

10 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  
15 **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  
20 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.  
25 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  $D_1$ .

5 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  $Dm_1 = (a'_1, a'_2, \dots, a'_P)$  is then obtained.

10 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 15 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.

20 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 25 undertaken, prior to the coding proper, a division of an image IE of a sequence of images to be coded in a predetermined order, into a plurality Z of partitions  $B'_1, B'_2, \dots, B'_i, \dots, B'_Z$ , 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 30 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 split up into sub-blocks which can themselves be sub-split.

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

5 Subsequent to said division 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.

10 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.

15 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**.

20 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 25 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  $B'_p$  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 30 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 sub-split, 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  $B'r_1$ .

5        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**.

10      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**.

15      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  $E_1 = (\varepsilon_1, \varepsilon_2, \dots, \varepsilon_L)$  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.

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

25      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;

30      - 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,

5 - 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.**

10 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.

15 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

20 of the coefficient  $\epsilon_2 = +9$ .

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

25 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  $\epsilon'_1, \epsilon'_2, \dots, \epsilon'_M$  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 30 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 5 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, 10 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 15 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  $SE_1$ .

20 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.

25 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  $\epsilon_2$ .

If, still in accordance with the convention adopted in the coder CO1 according to the 30 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  $\epsilon_2$ .

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  $SE_1$ .

5 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**.

10 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,  $\varepsilon_2 = +9$ , 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 15 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.

15 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 20 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 25 macroblock, R represents the cost in bits of the coding of the coding information and  $\lambda$  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  $SE_1$ .

30 A modified sub-list  $SE_{1m} = (+9, +6, 0, 0, +1, 0, -1, +2, 0, 0, +1)$  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  $\varepsilon_2$  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.

5 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  $\epsilon_2$ , 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  $\epsilon_2$  which is not coded, as has been explained hereinabove.

15 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.

20 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.

25 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.

30 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  $0 < \text{TSIG\_1} < \text{TSIG\_2} < \text{TSIG\_3} \dots$ , in such a way that if the number of modifiable coefficients lies 5 between  $\text{TSIG\_N}$  and  $\text{TSIG\_N+1}$ ,  $N$  signs are intended to be hidden.

If the number of modifiable coefficients is less than the first threshold  $\text{TSIG\_1}$ , 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.

10 If the number of modifiable coefficients lies between the threshold  $\text{TSIG\_N}$  and  $\text{TSIG\_N+1}$ , 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 15 example proposed,  $N=2$ , the two signs to be hidden are the first two signs of the first two non-zero coefficients respectively, namely  $\varepsilon_2$  and  $\varepsilon_3$ .

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 20  $SE_1$ .

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: +, +;

25

- 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: -, -.

30

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  $\varepsilon_2$

and of the coefficient  $\varepsilon_3$ , 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 5 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 10 aforementioned list  $Em_1$ , with the exception of the sign of the coefficient  $\varepsilon_2$  and of the sign of the coefficient  $\varepsilon_3$ , which signs are hidden in the parity of the sum modulo  $2^N$  of the coefficients.

#### Detailed description of the decoding part

15 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**.

20 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 25 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.

30 Each block or macroblock may moreover itself be split up into sub-blocks which can themselves be sub-split.

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.

5 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**.

10 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 15 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  $D_1 = (a_1, a_2, \dots, a_p)$ , 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, 20 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  $Dm_1 = (a'_1, a'_2, \dots, a'_p)$ , 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 25 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 30 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

5 of the first non-zero datum  $a_2$  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 10 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

15 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  $N \geq 2$ .

20 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 25  $Dm_1$ . 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  $a_2$  and  $a_3$ , according to the convention used on coding.

Once these two signs have been reconstructed, there is undertaken the implementation of 30 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**,

5 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

10 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 split up into sub-blocks which can themselves be sub-split.

15 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'\_1 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.

20 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 25 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

30 corresponding to the amplitude of each of the coded coefficients of the list E1 or of the modified list Em1. At this juncture, only the signs of the coefficients of the list E1 or of the modified list Em1 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  $\epsilon_2 = +9$ .

10 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  $\epsilon'_1, \epsilon'_2, \dots, \epsilon'_M$  where  $M < L$  liable to have 15 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:

20 - 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  $SEm_1$  25 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.

30 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 5 signs of the coefficients of the list  $E_{m1}$ , with the exception of the sign of the first non-zero coefficient  $\epsilon_2$ .

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  $SE_{m1}$  so as to determine whether the computed value is even or odd.

10 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  $SE_{m1}$ .

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  $SE_{m1}$  signifies that the sign of the first non-zero coefficient of the modified list  $E_{m1}$  is positive, while an odd value of the sum of the 15 coefficients of the sub-list  $SE_{m1}$  signifies that the sign of the first non-zero coefficient of the modified list  $E_{m1}$  is negative.

In the exemplary embodiment where  $SE_{m1} = (+9, -6, 0, 0, +1, 0, -1, +2, 0, 0, +1)$ , 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 20 coefficient  $\epsilon_2$  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 25 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 30 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

5 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

10 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 15 intra) and, if appropriate, the mode of intra prediction, the type of partitioning of a block or macroblock if the latter has been sub-split, 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  $B'p_1$ .

20 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  $F'$ .

25 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  $1 \leq i \leq Z$ .

30 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  $N \geq 2$ .

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  $0 < \text{TSIG\_1} < \text{TSIG\_2} < \text{TSIG\_3} \dots$ , in such a way that if the number of said coefficients lies between

5  $\text{TSIG\_N}$  and  $\text{TSIG\_N+1}$ ,  $N$  signs have been hidden.

If the number of said coefficients is less than the first threshold  $\text{TSIG\_1}$ , 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.

10 If the number of said coefficients lies between the threshold  $\text{TSIG\_N}$  and  $\text{TSIG\_N+1}$ , 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  $E_1$ , with the exception of the  $N$  respective signs of the first non-zero coefficients of said modified list  $E_{1,1}$ , said  $N$  signs being hidden.

In this other embodiment, the processing module MTR\_DO1 computes, in the course of step 15 D5, the value of the function  $f$  which is the remainder modulo  $2^N$  of the sum of the coefficients of the sub-list  $SE_{1,1}$ . 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  $\varepsilon_2$  and  $\varepsilon_3$ , according to the convention used on coding.

20 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.

25 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  $N' \geq 1$ , 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

30  $N'$  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.** Fremgangsmåde til afkodning af et datasignal, der repræsenterer mindst et i partitioner opdelt billede, som tidligere er blevet kodet, idet en aktuel partition (Bi), der skal afkodes, omfatter koefficienter til en direkte transformation af den aktuelle partition (Bi) samt koefficienternes fortegn med undtagelse af fortegnet for den aktuelle partitions (Bi) første fra nul forskellige koefficient, der kan være skjult, hvilken fremgangsmåde til afkodning for den aktuelle partition (Bi) omfatter følgende trin:

10        - at afkode (SD2, SD3) den aktuelle partitions (Bi) data bortset fra fortegnet;

      - at bestemme fortegnets værdi, idet bestemmelsen af fortegnets værdi omfatter følgende trin:

15               hvis antallet af koefficienter mellem den første og den sidste fra nul forskellige koefficient, herunder den første og den sidste fra nul forskellige koefficient, er mindre end en specificeret tærskelværdi (TSIG), at bestemme, at fortegnet ikke er skjult, men at det er indeholdt i den aktuelle partitions (Bi) data, eller

20               hvis antallet af koefficienter mellem den første og den sidste fra nul forskellige koefficient, herunder den første og den sidste fra nul forskellige koefficient er større end eller lig med den specificerede tærskelværdi (TSIG), at bestemme, at fortegnet er skjult, og at pariteten af summen af koefficienterne mellem den første og den sidste fra nul forskellige koefficient angiver værdien af det skjulte fortegn, og

25               hvis summen af koefficienterne mellem den første og den sidste fra nul forskellige koefficient er lige, at bestemme, at det skjulte fortegn er positivt, eller

             hvis summen af koefficienterne mellem den første og den sidste fra nul forskellige koefficient er ulige, at bestemme, at det skjulte fortegn er negativt.

30

**2.** Fremgangsmåde til afkodning ifølge krav 1, ved hvilken pariteten af summen af koefficienterne er pariteten af summen af koefficienternes absolutte værdier.

**3. Fremgangsmåde til afkodning ifølge krav 1 eller 2, ved hvilken tærskelværdien (TSIG) er specifieret til 5.**

4. Apparat (DO) til afkodning af et datasignal, der repræsenterer mindst et i 5 partitioner opdelt billede, som tidligere er blevet kodet, idet en aktuel partition (Bi), der skal afkodes, omfatter koefficienter til en direkte transformation af den aktuelle partition (Bi) samt koefficienternes fortegn med undtagelse af fortegnet for den aktuelle partitions (Bi) første fra nul forskellige koefficient, der kan være skjult, idet apparatet til afkodning for den aktuelle partition (Bi), der skal afkodes, 10 omfatter forarbejdningssmidler (MTR\_DO), der er egnede til:

at afkode den aktuelle partitions (Bi) data bortset fra fortegnet,

at bestemme fortegnets værdi, idet bestemmelsen af fortegnets værdi omfatter:

hvis antallet af koefficenter mellem den første og den sidste fra nul

15 forskellige koefficient, herunder den første og den sidste fra nul  
forskellige koefficient, er mindre end en specificeret tærskelværdi  
(TSIG), at bestemme, at fortegnet ikke er skjult, men at det er  
indeholdt i den aktuelle partitions ( $B_i$ ) data, eller

hvis antallet af koefficienter mellem den første og den sidste fra nul forskellige koefficient, herunder den første og den sidste fra nul forskellige koefficient, er større end eller lig med den specificerede tærskelværdi (TSIG), at bestemme, at fortegnet er skjult, og at pariteten af summen af koefficienterne mellem den første og den sidste fra nul forskellige koefficient angiver værdien af det skjulte fortegn, og

hvis summen af koefficienterne mellem den første og den sidste fra nul forskellige koefficient er lige, at bestemme, at det skjulte fortegn er positivt, eller

hvis summen af koefficienterne mellem den første og den sidste fra nul forskellige koefficient er ulige, at bestemme, at det skjulte fortegn er negativt

5. Apparat (DO) til afkodning ifølge krav 4, i hvilket pariteten af summen af koefficienterne er pariteten af summen koefficienternes absolutte værdier.

- 6.** Apparat (DO) til afkodning ifølge krav 4 eller 5, i hvilket tærskelværdien (TSIG) er specifieret til 5.
  
- 7.** Computerprogram omfattende instruktioner til udførelse af fremgangsmåden til 5 afkodning ifølge et af kravene 1 til 3, når fremgangsmåden til afkodning udføres på en computer.

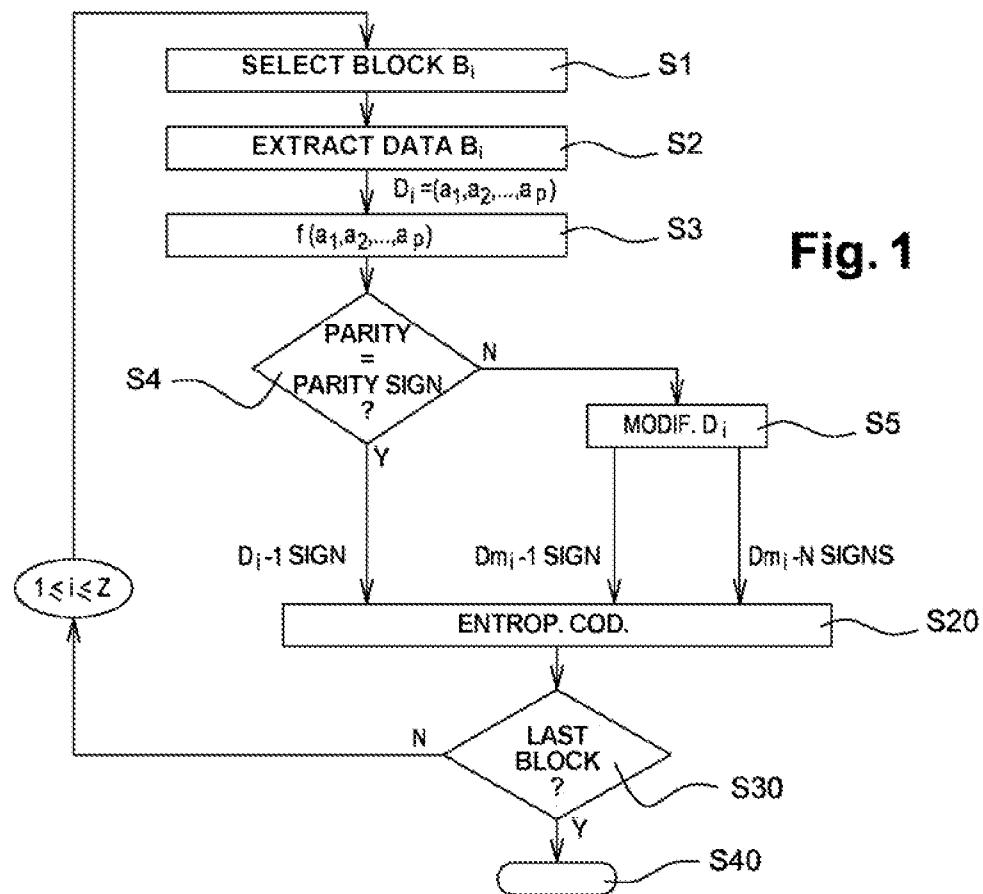


Fig. 1

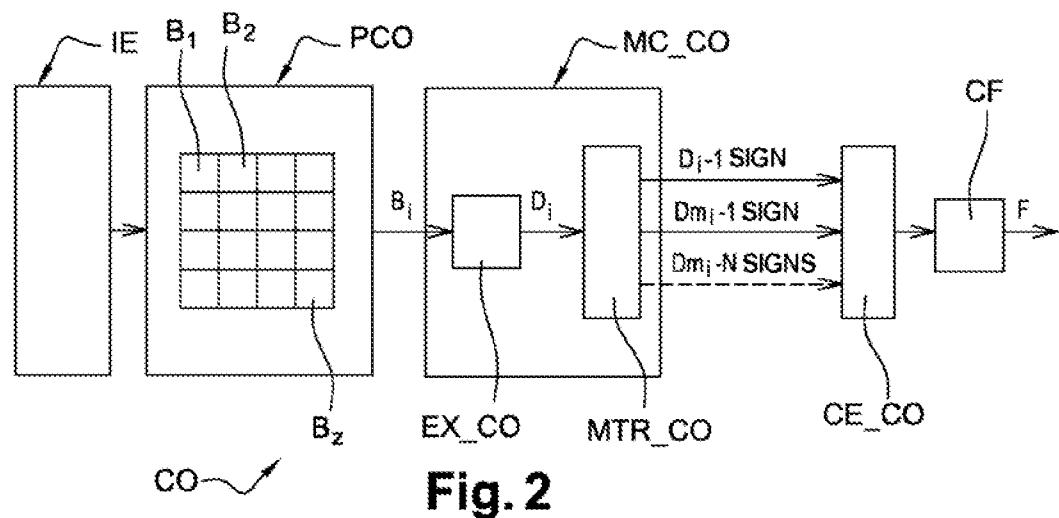
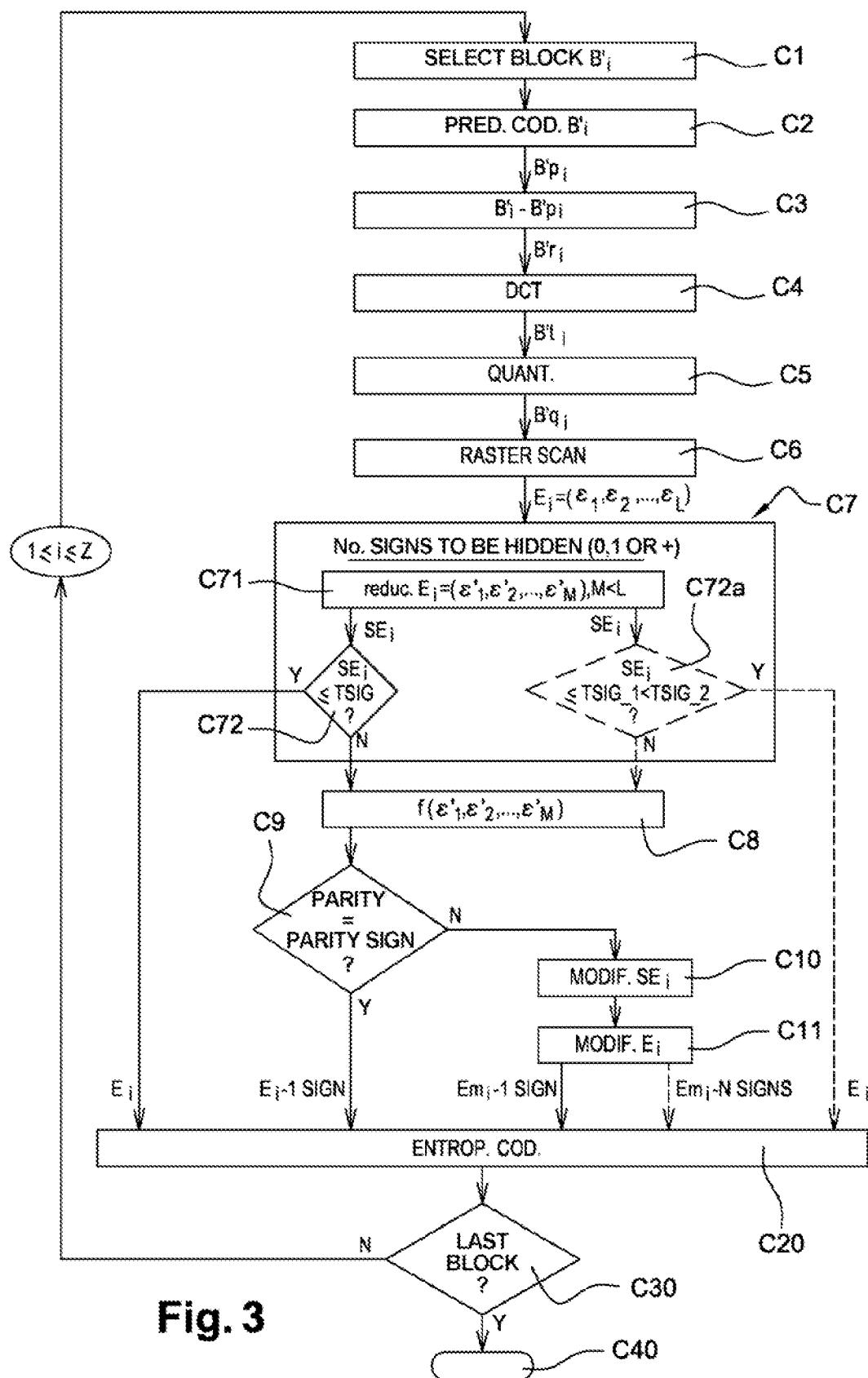


Fig. 2



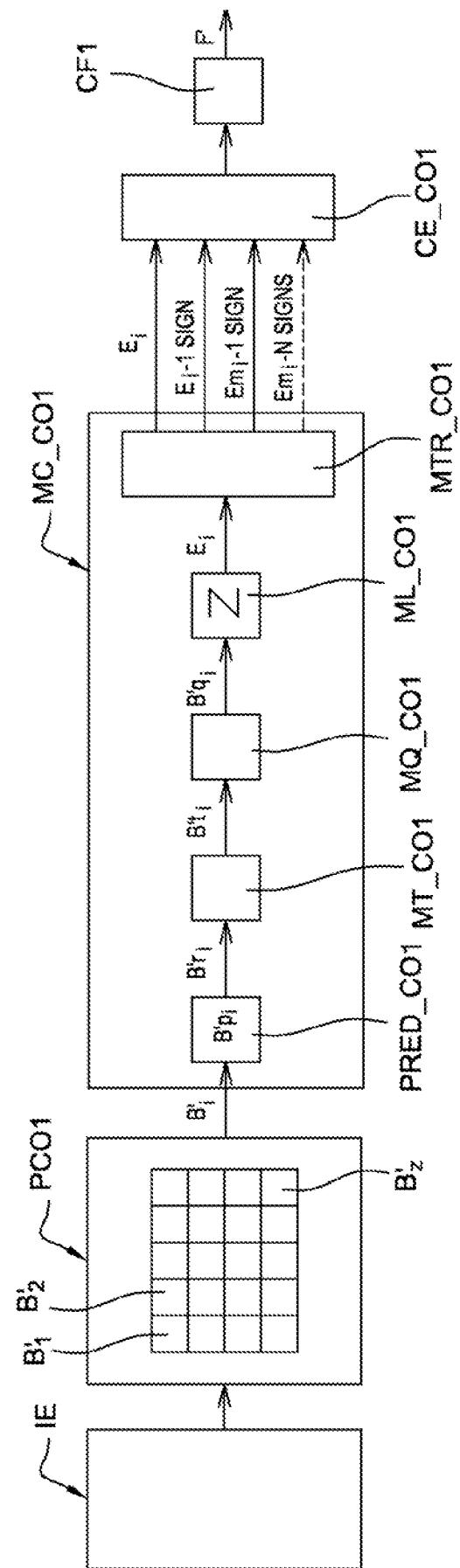


Fig. 4

CO1

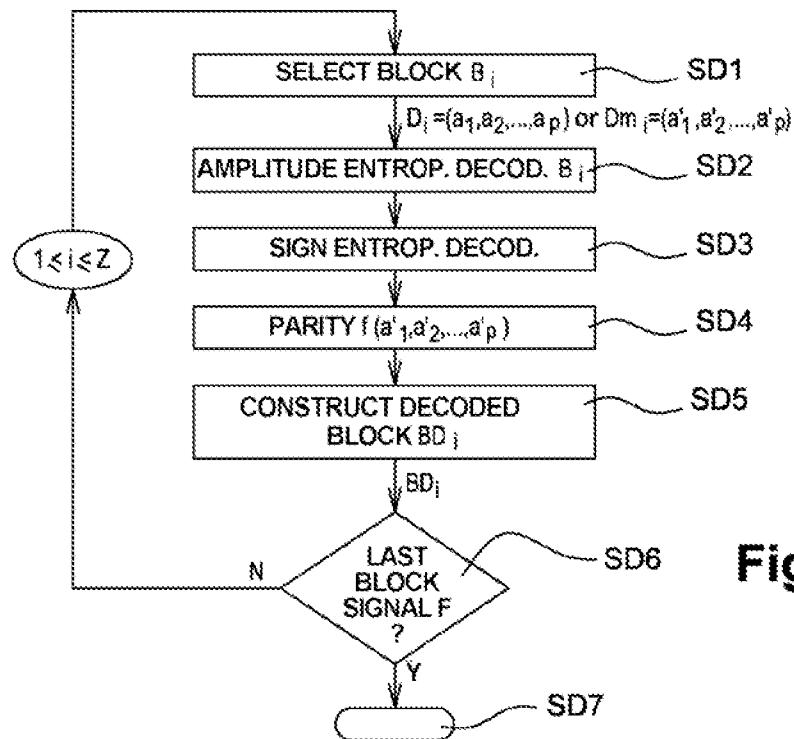


Fig. 5

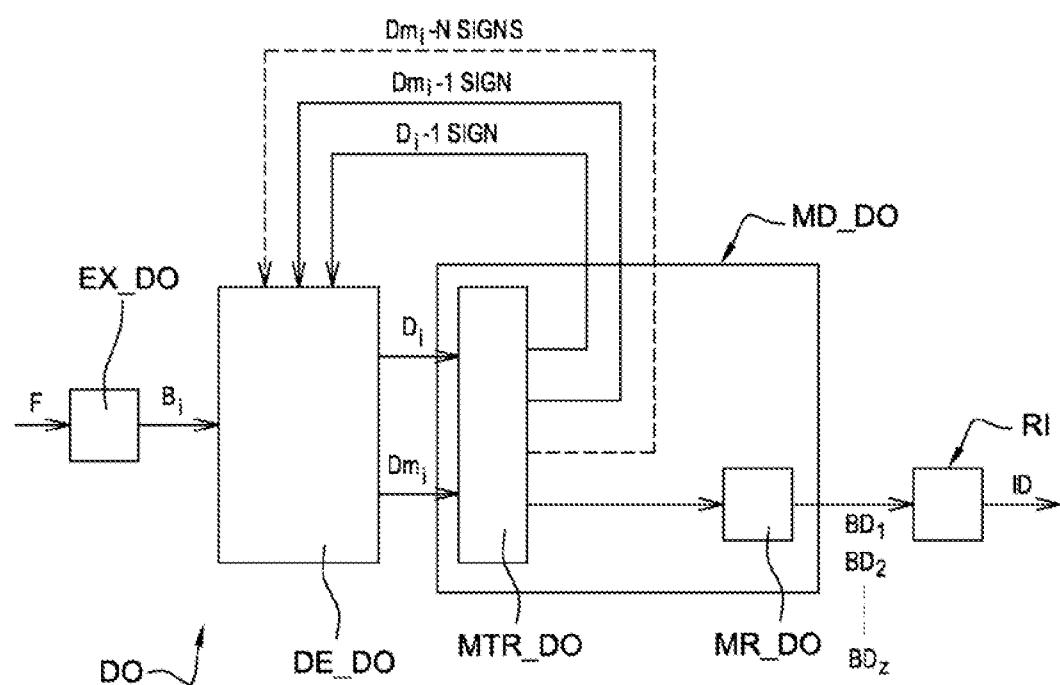
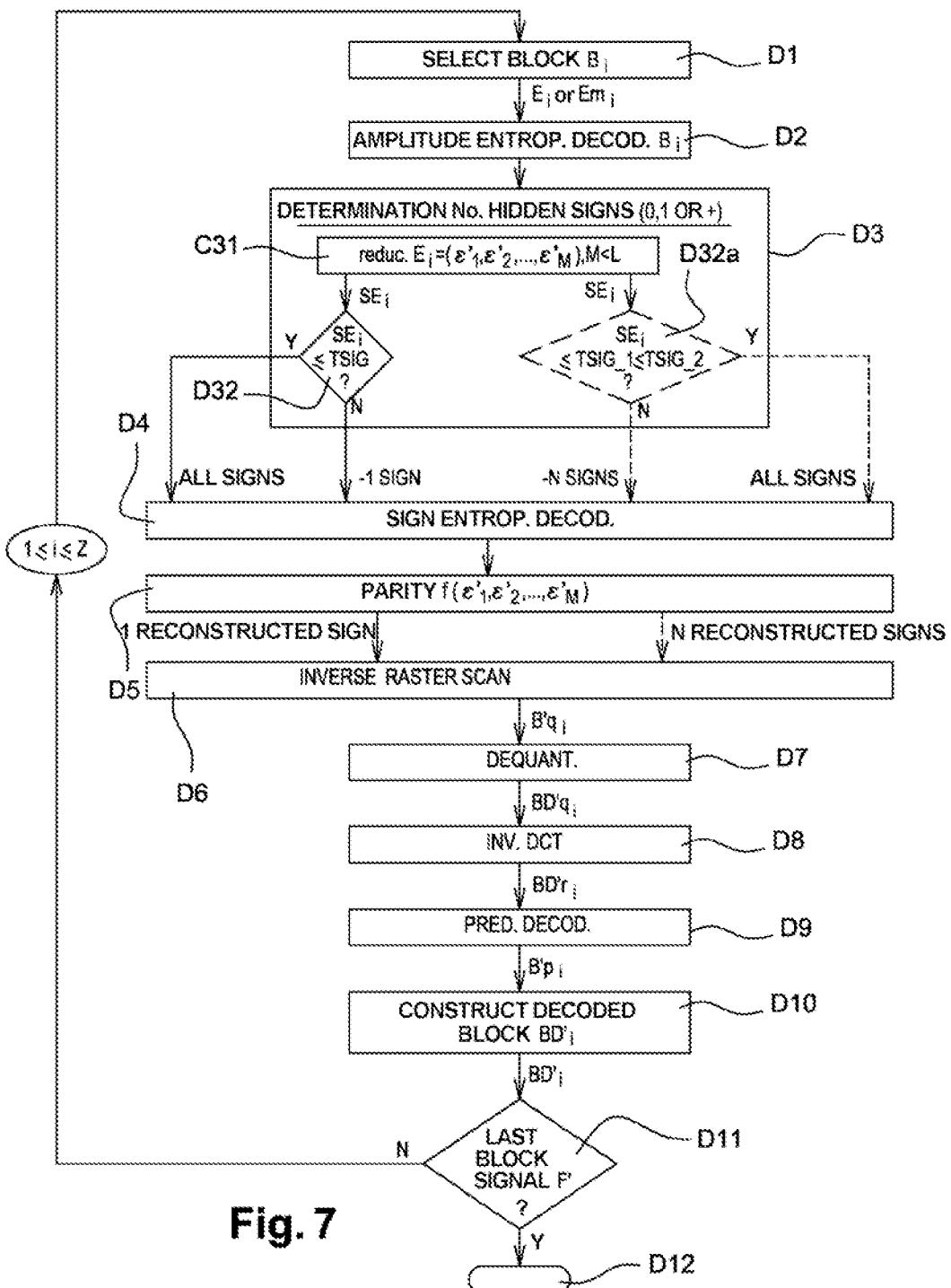
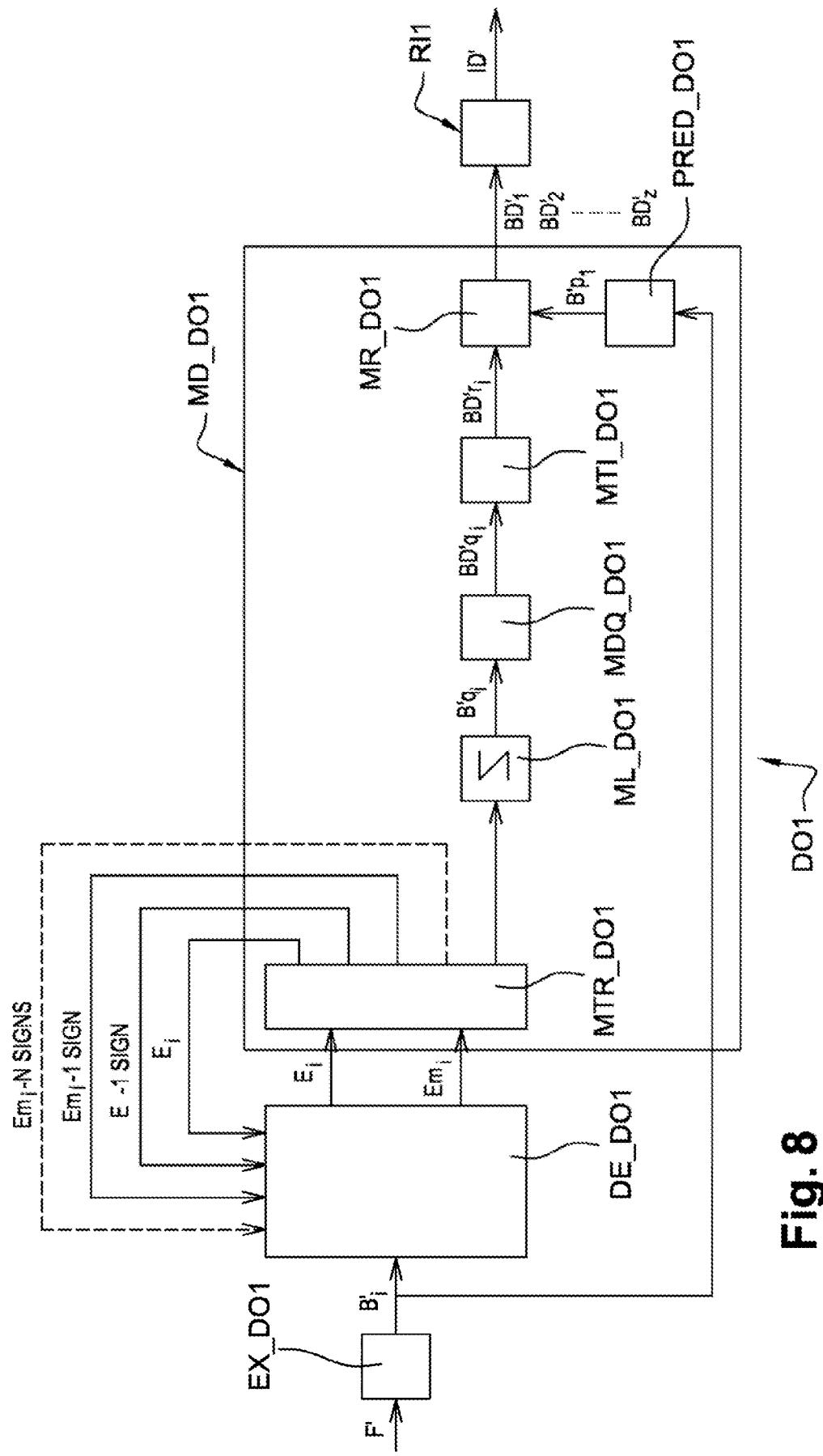


Fig. 6



**Fig. 7**

**Fig. 8**