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(54) **Title**: ESTIMATION OF THE PREDICTION MODE FOR THE INTRA CODING MODE

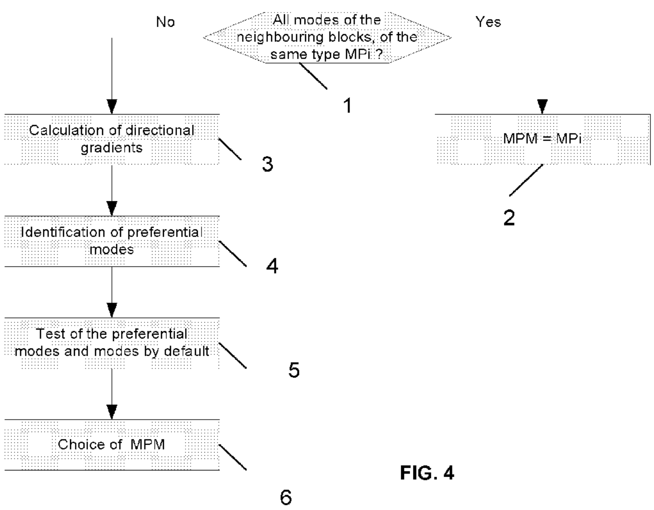

FIG. 4

(57) **Abstract**: The method for the calculation of the prediction mode comprises the following steps: - calculation of the spatial gradients (3) according to different filtering operations for an already coded reconstructed zone of the image located in the neighbouring area of the current block, pre-selection of preferred prediction modes (4) from among coding modes based on predictors obtained from pixels at the immediate edge of the current block in the already coded reconstructed zone of the image, pre-selection based on a minimization of an energy level associated with each filtering relative to a spatial gradient. selection of the prediction mode (6), at least from among the pre-selected prediction modes, minimizing an energy level (5) corresponding to the prediction error on said zone located in the neighbouring area of the current block. Application to video data compression.

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ESTIMATION OF THE PREDICTION MODE FOR THE INTRA CODING MODE

The invention is situated in the domain of video coding and decoding. It relates to a method and device for coding and decoding a block of an image of a video sequence, more specifically based on an intra predictive coding using a mode prediction for its coding.

The H.264 standard, described for example in the document H.264/AVC *Advanced Video Coding for Generic Audiovisual Services*, ITU-T Rec. H.264 and ISO/IEC 14496-10 (MPEG-4 AVC), ITU-T and ISO/IEC JTC 1, Version 1: May 2003, Version 2: May 2004, Version 3: March 2005, Version 4: Sept. 2005, Version 5 and Version 6: June 2006, Version 7: Apr. 2007, Version 8 (including SVC extension): Consented in July 2007 proposes several intra prediction modes. The coding of the mode is based on the prior calculation of the MPM (Most Probable Mode), determined according to modes that were selected prior to the coding of the current entity to be coded. In the H.264 standard, this entity represents a block of the image to be coded. The calculation of this MPM is of interest.

In the H.264 standard, intra spatial prediction is based on already coded neighbouring pixels of the same slice. For example, for the luminance there are 8 directional prediction modes plus an averaged mode (DC) for the coding of 4x4 and 8x8 blocks. Thus for the H.264 standard the spatial prediction is carried out in the pixel domain that consists in predicting the set of pixels of a block using a combination of left column and/or upper line neighbouring pixels, reconstructed from the partition to be predicted. This combination of prediction pixels will for example enable a contour to be prolonged if there is one. In the case of a uniform zone the prediction retained will be more representative of the average of the surrounding pixels.

If the intra 4x4 coding mode described in the H.264 standard is considered, the initial intra predictor selection method corresponds for each 4x4 and 8x8 block to a spatial prediction zone that is limited to the reconstructed neighbouring pixels. Figure 1 shows a current block blc and its spatial prediction zone:

- blc corresponds to the current block during coding,
- the shaded zone represents the reconstructed part of the image, the rest of the image to be coded is not shaded,
- the column and line of pixels in dots around the causal neighbouring area of block blc show, as an example, the neighbouring area used in the context of 4x4 and 8x8 intra prediction.

Concerning the blocks of dimensions 4x4 and 8x8, the predictors used for the MPEG4/AVC standard are represented in figure 2, the different prediction modes using the pixels A, B, C, D of the upper line and the pixels I, J, K, L of the left column.

For example, if mode 1 or the horizontal mode is retained, the pixels e, f, g and h are predicted using the reconstructed neighbouring pixel J, in the left column.

If mode 5 is selected, the pixel a is predicted by (Q+A+1)/2, the pixels g and p are predicted by (A+2B+C+2)/4.

The intra prediction mode must be signalled in the bitstream. The H.264 standard implements a method of prediction of this mode that aims to reduce its coding cost. For a current block to be coded, the coder and decoder calculate the most probable prediction mode, as being the minimum of numbers (0 to 8 according to figure 2) of the prediction modes used for the two top left neighbouring blocks. If a neighbouring block is not available, either it is located outside of the current sector, referred to as a slice in the standard, or if it is not in intra, the mode that is assigned to it is mode number 2, corresponding to the DC prediction mode which is based on the average value of reconstructed neighbouring pixels.

This very simple calculation of the MPM (Most Probable Mode) is not always suited to the content of the image particularly in terms of the signal, which results in an MPM that differs more or less noticeably from the actual mode and thus in a more or less high mode coding cost. Thus in the H.264 standard, apart from the modes taken into account in the comparison of indexes of coding modes of high and low blocks, it can be noted that the selection is based on pure logic (admittedly based on global statistics). In no case for example is the energy associated with the concerned prediction directions considered and the compression rate is not therefore optimised for this coding.

The intention here is, by a better estimation of MPM, to reduce the coding cost of the current mode while retaining a reasonable degree of complexity.

One of the purposes of the invention is to overcome the aforementioned disadvantages. The purpose of the invention is a method for coding a current block of an image of a sequence of video images comprising an intra predictive coding mode and a differential coding of this mode from a prediction mode, characterized in that the calculation of the prediction mode comprises the following steps:

- calculation of the spatial gradients according to different filtering operations for an already coded reconstructed zone of the image located in the neighbouring area of the current block.

- pre-selection of preferred prediction modes from among coding modes based on predictors obtained from pixels at the immediate edge of the current block in the already coded reconstructed zone of the image, pre-selection based on a minimization of an energy level associated with each filtering relative to a spatial gradient.

- selection of the prediction mode, at least from among the pre-selected prediction modes, minimizing an energy level corresponding to the prediction error on said zone located in the neighbouring area of the current block.

According to a particular embodiment, the method is characterized in that the selection is also made from among at least one prediction mode obtained by template matching, by correlation of said zone located in the neighbouring area of the current block with a zone of the already reconstructed image.

According to a particular embodiment, said zone in the neighbouring area is a zone adjacent to the current block on the left part and on the top part of this block.

According to a particular embodiment, the pre-selection comprises a calculation phase of an additional energy level associated with a DC mode and based on the energy levels of the spatial gradients.

According to a particular embodiment, the method is characterized in that it comprises a preliminary comparison step of coding modes of neighbouring blocks of the current block and in that, if these modes are of the same type, this common mode is selected as the prediction mode for the coding mode of the current block and in that, if these modes are of different types, the prediction mode is obtained according to said steps for calculating spatial gradients, pre-selection and selection.

The invention also relates to a method for decoding a current block of an image coded according to an intra predictive coding mode, the coding mode being itself coded from a prediction mode, characterized in that the calculation of the prediction mode comprises the following steps:

- calculation of spatial gradients according to different filtering operations for a zone of the decoded image located in the neighbouring area of the current block.

- pre-selection of preferred prediction modes from among the modes for which the predictors are obtained from pixels at the immediate edge of the current block in the decoded zone of the image, pre-selection based on a minimization of an energy level associated with each filtering relative to a spatial gradient,

- selection of the prediction mode, at least from among the pre-selected prediction modes, minimizing an energy level corresponding to the prediction error on said zone located in the neighbouring area of the current block to be decoded.

According to a particular embodiment, the method comprises a preliminary step of comparison of coding modes of blocks neighbouring the current block and in that, if these modes are of the same type, this common mode is selected as the prediction mode for the coding mode of the current block and in that, if these modes are of different types, the prediction mode is obtained according to said following steps of calculation of spatial gradients, pre-selection and selection.

Other specific features and advantages will emerge clearly from the following description, the description provided as a non-restrictive example and referring to the annexed drawings wherein:

- figure 1, a current image block and its spatial prediction zone in the image,
- figure 2, the predictors used in the MPEG4 standard,
- figure 3, the principle of template matching,
- figure 4, a flow chart of the method according to the invention.

The MPM calculation method, according to the invention, implements the following steps:

- analysis of the coding modes of the neighbouring blocks already coded,
- analysis of the already coded neighbouring luminance (or chrominance) signal of the current block in order to determine preferred modes,
- evaluation over the neighbouring area of the current block of different modes including the preferred modes determined beforehand.

The invention renders the calculation of the MPM more effective in images having different texture zones. Thus the coding cost can be reduced for an equivalent visual quality.

It is considered that the available intra coding modes include directional prediction modes (similar to those of the H.264 standard), as well as default coding modes that will be referred to hereafter as MPi type modes, i indicating the index of the mode.

For example, these default modes can correspond to TPM (Template Matching Prediction) modes as described for example in the document, by authors Y. Suzuki, C. S. Boon, T.K. Tan, entitled *Inter Frame Coding with Template Matching Averaging*, reference Proc. IEEE Int. Conf. Image Processing ICIP '07, San Antonio, Tx, USA, Sept 2007 or in the International patent application, of inventors D. Thoreau, L Porta, A Orhand, O Le Meur, referenced WO2007/093629, entitled Process for coding images using intra prediction mode.

Template Matching is a method employed in texture synthesis to generate continuous textures. It consists in drawing on the causal neighbouring area of the current block, where it is attempted to find, in the image part or slice already coded, a patch of texture that resembles it. The prediction block is thus the block attached to this patch. Figure 3 illustrates this principle. The zone X_0 in the neighbouring area of the current block is used to determine one or more correlated zones X_1 and X_2 in the reconstructed part of the image. The blocks P_1 and P_2 associated with these zones are the prediction blocks.

The algorithm for calculating the most probable mode, according to the invention, is shown in figure 4. It operates potentially in three phases:

- analysis of the coding modes of already decoded neighbouring blocks,

- analysis of the already decoded neighbouring luminance or chrominance signal of the current block in order to determine preferred modes,

- evaluation over the neighbouring area of the current block of different modes including the preferred modes determined beforehand.

Phase 1 consists of a purely logical analysis of the coding modes used for the neighbouring blocks:

- if the three neighbouring blocks to the left, top and top left of the current block are coded according to an MPi type mode, step referenced as 1 in the figure, then the MPM is equal to the MPi mode and the current block is coded, step referenced as 2,

- otherwise, phase 2 is reached.

According to a variant, the comparison of coding modes relates to the set of these modes, thus equally to the AVC intra predictive coding modes and, when the three neighbouring blocks use the same predictive coding mode, this mode is selected as the prediction mode for the coding mode of the current block.

Phase 2 consists in analysing the luminance signal located in the neighbouring area of the current block. Typically this neighbouring area corresponds to the zone to the left and top of the current block forming an "L" turned on its axis (zone X0 of figure 3). This zone will therefore be referred to as the “L-zone”. This analysis consists in detecting the directions having spatial gradients with lower energy levels. Here, the lowest energy level is considered as the gradients are calculated in a collinear manner to the potential contours. It is noted that an approach based on maximum gradients with gradients calculated according to directions orthogonal to the potential contours is also possible.

The step for calculating the energy level of the spatial gradients, a step referenced as 3, is carried out on the L-zone from a 2D convolution window moving about in the zone. Typically, the convolution windows, for the different spatial directions, are the following:

$$D_0 = \begin{bmatrix} 0 & -1 & 0 \\ 0 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix} \quad D_1 = \begin{bmatrix} 0 & 0 & 0 \\ -1 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix} \quad D_3 = \begin{bmatrix} 0 & 0 & -1 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix}$$

$$D_4 = \begin{bmatrix} -1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$D_5 = \begin{bmatrix} 0 & -1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad D_6 = \begin{bmatrix} 0 & 0 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad D_7 = \begin{bmatrix} 0 & -1 & 0 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix}$$

$$D_8 = \begin{bmatrix} 0 & 0 & 1 \\ -1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

8 filtered versions plus one (mode 2) of the L-zone are thus generated, on which will be determined the directional energy levels E0 to E8 that are calculated according to the expression:

$$E_d = \sum_{p \in L-zone} |(Y * D_d)(p)|$$

where

p represents the position of a pixel contained in the L-zone,

Y is the luminance value,

d is the index corresponding to the different prediction directions, 0 to 8,

* is the convolution operator,

| | corresponds to the absolute value operation, the elevation of the square is also possible such that:

- $$E_d = \sum_{p \in L-zone} ((Y * D_d)(p))^2$$

On the pixel p of the L-zone, the convolution mask 3x3 is positioned, such that this pixel corresponds to its centre, to calculate the value D relative to this mask. The pixels p are those enabling the mask to be positioned on the single L-zone, that is to say without overlapping the current block, the pixels p on the edge of the current block are thus excluded for this positioning.

Ed corresponds therefore to the energy assigned to the directional prediction mode d.

An additional energy level is calculated in terms of estimation, for the DC mode according to the following formula:

$$E_2 = \lambda.\sum_{d=0}^{d=8}(E_d) \text{ with d} \neq 2$$

where λ is a predetermined coefficient enabling an estimated value to be associated with the DC mode that enables this mode to be retained in the selection when the energy level of the gradients is noticeably uniform in all of the directions tested. According to a particular embodiment, this value is taken to be equal to 0.825/8.

The N_p preferred modes (N_p being a number retained of modes that can take for example the value 3) selected following this analysis, step 4, are the Ed modes having the lowest energy levels.

Phase 3 intervenes only if phase 2 has been applied, and consists in selecting the best mode from among a set S={m_0, ..., m_n} of several candidates including the preferred modes selected in phase 2. These modes are thus considered preferred, to which are added a set of systematic modes, as they are always tested. For example, one or more MPi modes can be added to the N_p preferred modes. These preferred modes are for example prediction modes based on “matching”, for example the TMP mode described above or the inter image prediction modes, which of course also use motion estimation. In a simplified version, only the N_p preferred modes are retained.

For each of these modes m_i of S, an energy level on the L-zone will be calculated, step 5, an energy level distinct from the one calculated in phase 2. For example, this energy level will be calculated according to the following method:

- prediction of pixels of the L-zone according to the mode mi from pixels coded before those of the L-zone,

- the energy level of the mode is the energy level of the prediction error on the L-zone, calculated for example according to the following formula:

$$SSE_i = \sum_{p \in L-zone}(Y(p) - P(p))^2$$

where

p represents the position of a pixel contained in the L-zone,

Y is the luminance value,

P is the value of the prediction.

The MPM selected during step 6 is the mode m_i generating the minimal SSE_i prediction energy level, on the basis of gradients calculated in a collinear manner (see convolution masks D_0 to D_9).

The invention described enables the prediction mode to be determined of the coding mode of a block without using the information of the current block. The method described must in fact be applicable to the coder but also to the decoder. Thus the invention also relates to the method for decoding enabling calculation of the prediction mode of the coding mode of the current block to be decoded, and hence the coding mode and decoding mode of the current block. The different steps for calculating the prediction mode for decoding are identical to those previously described for the coder. At the coder, the reconstructed image was the image relative to the local decoder of the coding circuit, at the decoder, it is the image for its decoded part.

CLAIMS

1. Method for coding a current block of an image of a sequence of video images comprising an intra predictive coding mode and a differential coding of this mode from a prediction mode, characterized in that the calculation of the prediction mode comprises the following steps:

- calculation of the spatial gradients (3) according to different filtering operations for an already coded reconstructed zone of the image located in the neighbouring area of the current block,

- pre-selection of preferred prediction modes (4) from among coding modes based on predictors obtained from pixels at the immediate edge of the current block in the already coded reconstructed zone of the image, pre-selection based on a minimization of an energy level associated with each filtering relative to a spatial gradient.

- selection of the prediction mode (6), at least from among the pre-selected prediction modes, minimizing an energy level (5) corresponding to the prediction error on said zone located in the neighbouring area of the current block.

2. Method according to claim 1, characterized in that the selection (6) is also made from among at least one prediction mode obtained by template matching, by correlation of said zone located in the neighbouring area of the current block with a zone of the already reconstructed image.

3. Method according to claim 1 or 2, characterized in that said zone in the neighbouring area is a zone adjacent to the current block on the left part and on the top part of this block.

4. Method according to claim 1, characterized in that the pre-selection (4) comprises a calculation phase of an additional energy level associated with a DC mode and based on the energy levels of the spatial gradients.

5. Coding method according to claim 1, characterized in that it comprises a preliminary step of comparison of coding modes of blocks neighbouring the current block and in that, if these modes are of the same type, this common mode is selected as the prediction mode for the coding mode of the current block and in that, if these modes are of different types, the prediction mode is obtained according to said steps for calculating spatial gradients, pre-selection and selection.

6. Method for decoding a current block of an image coded according to an intra predictive coding mode, the coding mode being itself coded from a prediction mode, characterized in that the calculation of the prediction mode comprises the following steps:

- calculation of spatial gradients according to different filtering operations for a zone of the decoded image located in the neighbouring area of the current block.

- pre-selection of preferred prediction modes from among the modes for which the predictors are obtained from pixels at the immediate edge of the current block in the decoded zone of the image, pre-selection based on a minimization of an energy level associated with each filtering relative to a spatial gradient,

- selection of the prediction mode, at least from among the pre-selected prediction modes, minimizing an energy level corresponding to the prediction error on said zone located in the neighbouring area of the current block to be decoded.

7. Decoding method according to claim 5, characterized in that it comprises a preliminary step of comparison of coding modes of blocks neighbouring the current block and in that, if these modes are of the same type, this common mode is selected as the prediction mode for the coding mode of the current block and in that, if these modes are of different types, the prediction mode is obtained according to said following steps for calculating spatial gradients, pre-selection and selection.

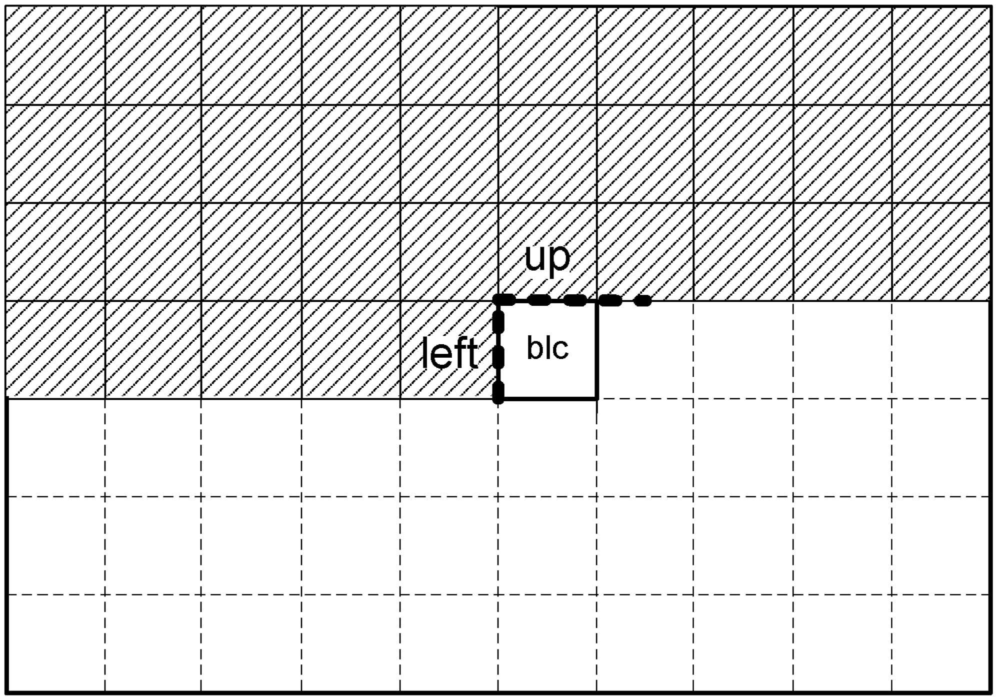
up
left
blc

FIG. 1

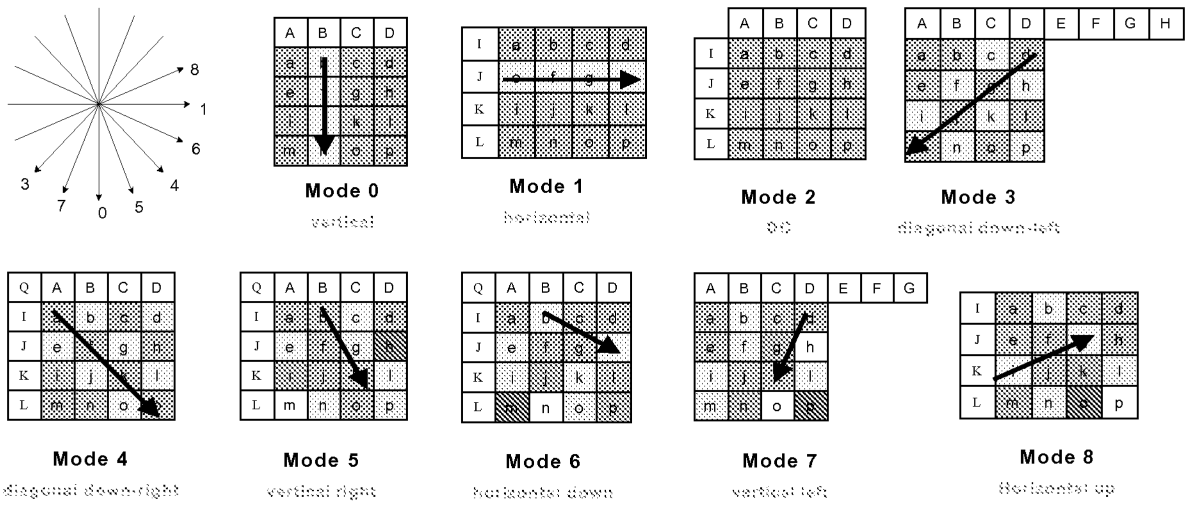
8
1
6
3
7
0
5
4
Mode 0
vertical
Mode 1
horizontal
Mode 2
DC
Mode 3
diagonal down-left
Mode 4
diagonal down-right
Mode 5
vertical right
Mode 6
horizontal down
Mode 7
vertical left
Mode 8
horizontal up

FIG. 2

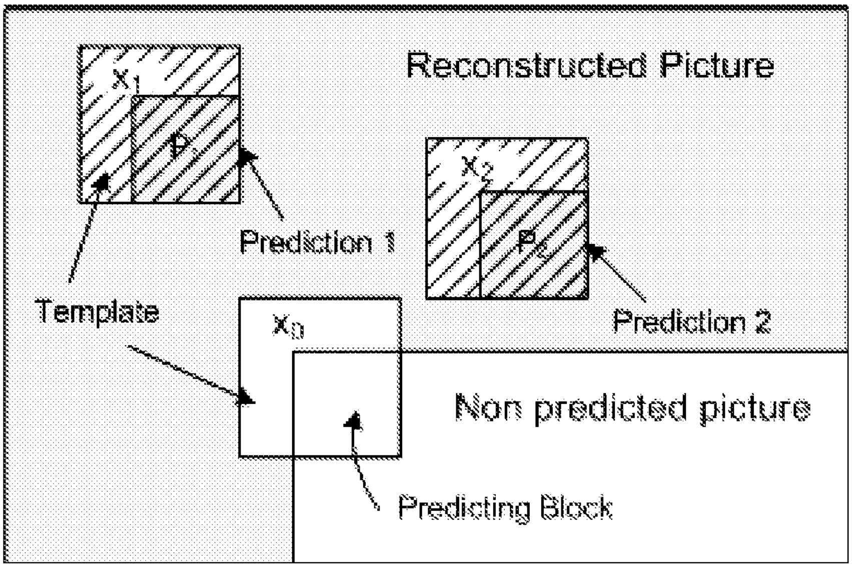
Reconstructed Picture
X_1
P_1
Prediction 1
X_2
P_2
Prediction 2
Template
X_0
Non predicted picture
Predicting Block

FIG. 3

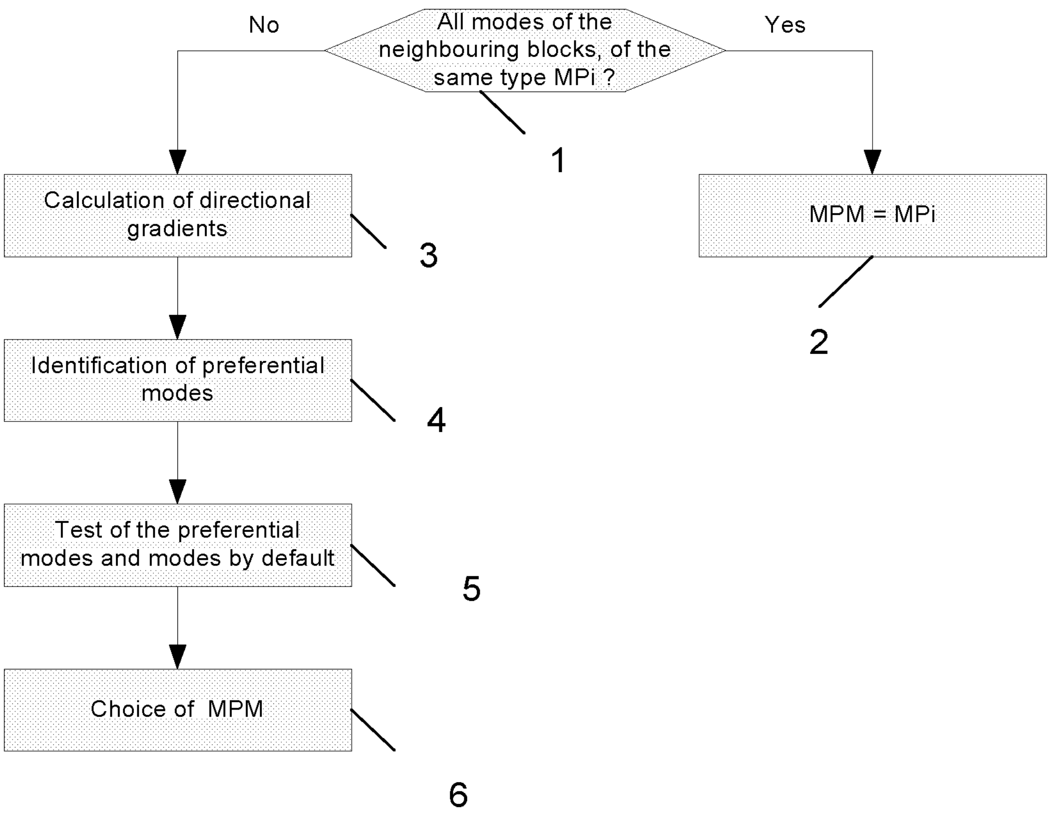
No
All modes of the neighbouring blocks, of the same type MPi ?
Yes
1
Calculation of directional gradients
3
MPM = MPi
2
Identification of preferential modes
4
Test of the preferential modes and modes by default
5
Choice of MPM
6

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/052696

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04N7/26 H04N7/34 H04N7/50
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2008/052950 A1 (THOMSON LICENSING [FR]; HADDAD JULIEN [FR]; THOREAU DOMINIQUE [FR]; GU) 8 May 2008 (2008-05-08) page 1, line 4 - line 5 page 2, line 1 - line 4 page 3, line 27 - line 31 page 4, line 1 - line 3 page 6, line 24 - line 31 page 7, line 23 - line 26 page 8, line 1 - line 3 page 8, line 19 - line 24 page 9, line 17 - line 26 page 10, line 1 - line 10 figure 1 -----	1,4 2,3,5-7

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
8 June 2010	17/06/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Regidor Arenales, R

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/052696

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	YI GUO ET AL: "Priority-based template matching intra prediction" MULTIMEDIA AND EXPO, 2008 IEEE INTERNATIONAL CONFERENCE ON, IEEE, PISCATAWAY, NJ, USA, 23 June 2008 (2008-06-23), pages 1117-1120, XP031312922 ISBN: 978-1-4244-2570-9 section 3 figure 2	2,3
Y	26L TEST MODEL EDITOR (GISLE BJONTEGAARD) H: "H.26L Test Model Long Term Number 2 (TML-2)" ITU STUDY GROUP 16 - VIDEO CODING EXPERTS GROUP -ISO/IEC MPEG & ITU-T VCEG(ISO/IEC JTC1/SC29/WG11 AND ITU-T SG16 Q6), XX, XX, no. q15i57d0, 30 November 1999 (1999-11-30), XP030003026 section 3.4.7	5,7
Y	MATSUO S ET AL: "Intra prediction with spatial gradient" VISUAL COMMUNICATIONS AND IMAGE PROCESSING; 20-1-2009 - 22-1-2009; SAN JOSE,, 20 January 2009 (2009-01-20), XP030081771 abstract page 3, line 1 - line 5	1-7
Y	LI Z G ET AL: "Fast Mode Decision Algorithm for Intraprediction in H.264/AVC Video Coding" IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY, IEEE SERVICE CENTER, PISCATAWAY, NJ, US LNKD- DOI:10.1109/TCSVT.2005.848356, vol. 15, no. 7, 1 July 2005 (2005-07-01), pages 813-822, XP011135306 ISSN: 1051-8215 abstract first paragraph of section III section IV figure 3	1-7

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2010/052696

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2008052950 A1	08-05-2008	CN 101529916 A	09-09-2009
		EP 2078424 A1	15-07-2009
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		JP 2010508684 T	18-03-2010
		US 2010054331 A1	04-03-2010