



(51) International Patent Classification:
H04N 7/26 (2006.01)

(21) International Application Number:
PCT/CN2010/000901

(22) International Filing Date:
21 June 2010 (21.06.2010)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: METHOD AND APPARATUS FOR ENCODING/DECODING IMAGE DATA

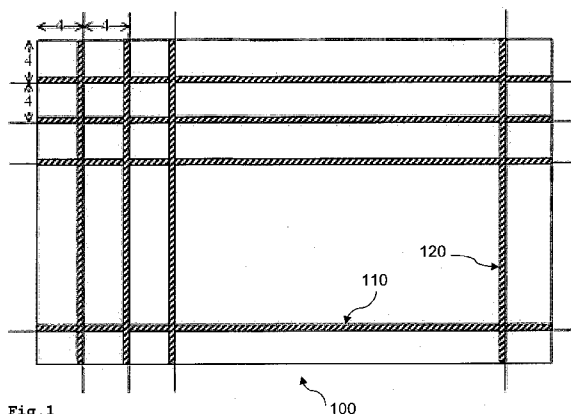


Fig. 1

(57) Abstract: Several attempts have been tried to improve the performance of intra-prediction in video encoding and decoding, which are targeting at pixel level parallelization. However, the prior art methods provide no solution for implementing an improved intra-prediction method on a parallel processing platform. The present invention uses estimated predictors instead of pre-constructed exact predictors. This enables faster estimation of predictors, and allows an encoder to perform intra-prediction for all blocks of at least a portion of an image simultaneously. A method for encoding image data, a device for encoding image data, a method for decoding image data and a device for decoding image data are disclosed.



METHOD AND APPARATUS FOR ENCODING/DECODING IMAGE DATAField of the invention

5 This invention relates to a method and an apparatus for encoding image data, and a method and an apparatus for decoding image data.

Background

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This section is intended to introduce the reader to various aspects of art, which may be related to various aspects of the present invention that are described and/or claimed below. This discussion is believed to be helpful in

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providing the reader with background information to facilitate a better understanding of the various aspects of the present invention. Accordingly, it should be understood that the statements in this section are to be read in this light, and not as admissions of prior art.

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Various video coding standards, e.g. MPEG-4 Part 10/AVC, apply a spatial based intra prediction algorithm for taking advantage of spatial redundancy within images. The intra prediction is done for various block sizes (e.g. 4x4, 8x8 and 16x16). Taking 4x4 block intra prediction as an example, there are in AVC nine pre-defined spatial predictors and the prediction directions for predicting. One of the biggest issues of intra prediction schemes employed in AVC is its complexity. In order to make a correct prediction of the current block, the blocks that are located on the left and upper side of a current block are reconstructed first, after their own encoding and before serving as predictors. Therefore, image encoding can only be performed sequentially, in left-to-right and up-down directions.

30

Nowadays, the processing architectures are evolving from high performance sequential processor architecture to parallel processor architectures (e.g. IBM's cell processor, Intel's Larabee processor, and nVidia or AMD's GPUs etc.)

5 The introduction of these processors is changing the way computation is done with computers. The more parallelism an application has, the better the application will perform on the processors. However, in AVC encoding, intra prediction cannot be efficiently be performed using these processors,
10 due to the fact that intra prediction is a natural born sequential processing problem.

Several attempts have been tried to improve the performance of intra prediction in video encoding and decoding, which
15 are targeted at pixel level parallelization. This approach can make prediction for a line of pixels according to the prediction mode. These methods are efficient on DSP or FPGA implementations, but the above-mentioned parallel processor architectures cannot take advantage of those proposed
20 schemes.

Summary of the Invention

In light of the above, a solution for implementing an
25 improved intra prediction method on a parallel processing platform remains a problem to be solved. The present invention provides such solution, and is suitable for improving the efficiency of intra prediction at least on the encoder side. In various embodiments, also an improvement on
30 the decoder side is achieved.

The present invention is based on the recognition of the fact that image prediction can be based on estimated predictors instead of exactly reconstructed predictors,

while yielding good prediction results and therefore high compression efficiency.

In principle, a method for encoding image data where the
5 image data are structured in blocks comprises for each block in (at least a portion of) the image a first prediction step of predicting the pixels of two edges of a block, based on original pixels of neighbouring blocks, wherein estimated predictor pixels are obtained, and a second prediction step
10 of predicting remaining pixels of the block from the predicted predictor pixels of at least neighbouring blocks.

According to one embodiment of the invention, a method for encoding image data, the image data being structured in
15 blocks, comprises for each block in (at least a portion of) the image steps of predicting the pixels of two edges of a block in a first prediction step, wherein the prediction is based on pixels of neighbouring blocks from the original image, and wherein estimated predictor pixels are obtained,
20 determining residual data for the estimated predictor pixels, performing quantization and inverse quantization on the determined residual data for the estimated predictor pixels, wherein reconstructed residual data for estimated predictor pixels are obtained, reconstructing predictor pixels,
25 wherein the difference between original pixels and reconstructed residual data for estimated predictor pixels is obtained, in a second prediction step, predicting remaining pixels of the block from the predicted predictor pixels of at least neighbouring blocks, determining residual
30 data for each predicted pixel resulting from the first or second prediction step, the residual data being the difference between the predicted pixel and its corresponding original pixel, and entropy encoding the residual data.

Further, according to another embodiment of the invention, a device for encoding image data, which are structured in blocks, comprises first and second prediction means, first and second residual determining means, quantizer and inverse quantizer means, reconstruction means, and entropy coding means. The apparatus performs for each block in at least a portion of the image the steps of

in the first prediction means, predicting the pixels of two edges of a block in a first prediction step, wherein the prediction is based on pixels of neighbouring blocks from the original image, and wherein estimated predictor pixels are obtained;

in the residual determining means, determining residual data for the estimated predictor pixels;

in the quantizer and inverse quantizer, performing quantization and inverse quantization on the determined residual data for the estimated predictor pixels, wherein reconstructed residual data for estimated predictor pixels are obtained;

in the reconstruction means, reconstructing predictor pixels, wherein the difference between original pixels and reconstructed residual data for estimated predictor pixels is obtained;

in the second prediction means, in a second prediction step, predicting remaining pixels of the block from the predicted predictor pixels of at least neighbouring blocks;

in the second residual determining means, determining residual data for each predicted pixel resulting from the first or second prediction step, the residual data being the difference between the predicted pixel and its corresponding original pixel; and

in the entropy coding means, entropy encoding the residual data.

One advantage of the invention is that it enables faster estimation of reconstructed predictors. Another advantage is that the encoder can perform intra prediction for all blocks of at least a portion of an image simultaneously, based on the estimated predictors, instead of relying on the reconstructed exact predictors from the conventional sequential encoding process. Thus, encoding is accelerated.

Advantageous embodiments of the invention are disclosed in the dependent claims, the following description and the figures.

Brief description of the drawings

Exemplary embodiments of the invention are described with reference to the accompanying drawings, which show in Fig.1 predictors for all 4x4 blocks in a current frame; Fig.2 predictors for neighbouring blocks in an exemplary 4x4 block; Fig.3 a 4x4 block with its boundary pixels and nine intra prediction modes (9th mode is DC mode, not shown); Fig.4 pixels in the first phase of the encoding procedure; Fig.5 pixels in the second phase of the encoding procedure; Fig.6 a frame that is divided into NxM portions, each of which being predicted independently; Fig.7 a flow-diagram of the encoding procedure; Fig.8 an overview of an encoder structure; and Fig.9 an overview of a decoder structure.

Detailed description of the invention

Fig.1 shows a video frame or image 100, which is structured into blocks of 4x4 pixels each, and the predictors 110,120 for all 4x4 blocks in the current frame. The frame is intra-

predicted, i.e. all prediction is done from other pixel data of the same frame. The predictors 110,120 for all 4x4 blocks in the current coding frame are the lower and right edges of each 4x4 block (only if the edge has a neighbour block), and
5 are shown shaded.

In more detail, four 4x4 blocks B0-B3 and B0's neighbouring pixels X,A-L in the original frame are shown in Fig.2. To make conventional intra prediction to all 4x4 blocks in the
10 current coding frame, reconstructed predictors are required. That is, in a conventional encoder right edge pixels d,h,l,p of a current block B0 are predicted, reconstructed and then used to predict pixels of a horizontally adjacent block B1. Lower edge pixels m,n,o,p of a current block B0 in a conven-
15 tional encoder are predicted, reconstructed and then used to predict pixels of a vertically adjacent block B2. In the AVC coding standard, the predictors are reconstructed and usable not before the macroblocks (MBs) located in the top and left have been reconstructed. According to the present invention,
20 the reconstructed predictors are generated by estimation before actually coding the MBs, i.e. fast approximation of the reconstructed predictors is possible as a separate step. This has the advantage that all predictors are available simultaneously before actually encoding the image. Therefore
25 the actual intra-prediction, which also takes a long time, can be made for some or all blocks of at least a portion of the image, or the complete image, simultaneously.

Instead of using the reconstructed predictors to perform
30 intra prediction, the invention uses the neighbouring pixels in the original frame to make the prediction directly. Then, e.g. for block B0 in Fig.2, the prediction is directly done using original pixels X,A,...,L and using a spatial prediction mode (e.g. one of the nine spatial prediction modes of AVC).

This generates a predicted block per spatial prediction mode. For the AVC example, there are nine candidate predicted blocks B01, B02,, B09 possible, according to the nine prediction modes shown in Fig.3. In one embodiment, more than one prediction mode is checked, and the best mode to perform the prediction is determined by selecting the one with optimal rate-distortion.

$$\text{mode} = i, (i = \min(\text{error_func}(B_0 - B_{0i}))) \quad (\text{Eq.1})$$

error_func is an error measuring method. It can in principle be any known error measuring method (sum-of-absolute-differences SAD, sum-of-absolute-transformed-differences SATD, mean-square-error MSE, etc.).

For the predictor pixels m, n, o, p, d, h, l in a current block B0, its reconstruction can be estimated according to the best prediction mode and selected or given quantization parameters (QP). Taking a pixel m as an example, the estimation reconstruction m' is calculated as follows:

$$m' = m - Q^{-1}(Q(m - m_p), QP), QP) \quad (\text{Eq.2})$$

where $Q(A, QP)$ means the quantization of a value A using a quantization parameter QP, and $Q^{-1}(A, QP)$ means the inverse quantization of a value A using the quantization parameter QP, and m_p means the prediction value of m using the best prediction mode.

In this way, in one embodiment, all the predictors for the blocks are estimated. The predictors are the edge pixels of two edges of each block. Note that this need not necessarily be the lower and right edges of a block: it depends on the possible prediction direction. Using lower and right edge

pixels of a block is suitable for left-to-right and up-to-down prediction directions, e.g. line-wise or column-wise.

In the next step, all chosen best prediction modes for each
5 block and the estimated predictors are used to perform intra prediction for all 4x4 blocks (of at least a portion of the image) simultaneously. That is, the intra prediction within the encoding process is based not on reconstructed pixels, but on estimated reconstructed pixels that are obtained from
10 the original pixels. This simplifies the encoding process and encoder, and accelerates it.

In one embodiment, all possible prediction modes are checked in order to decide the best prediction mode.

15

However, the complexity of this approach can be reduced. In block B0, the pixels m,n,o,p,d,h and l that shall be used as estimated predictors are relatively far away from their own predictor pixels X,A,B,...,L. Therefore, the mode selection
20 can be simplified by using only major prediction directions to perform a prediction specifically for m,n,o,p,d,h and l to make the below-described estimation. In the simplified mode selection, only the DC mode, vertical intra-prediction mode and horizontal intra-prediction mode are used to estimate
25 m,n,o,p,d,h and l. Then, the prediction error $ERROR_{DC}$, $ERROR_{ver}$ and $ERROR_{hor}$ between these pixels and the estimated pixels is calculated. The ERROR function can be any known error measurement function (SAD, SATD, MSE, etc.) Choose the smallest ERROR from all major directions to estimate the
30 reconstructed predictors, using equation (2).

For the intra-prediction of remaining pixels of a block, the estimated predictors are used to perform intra prediction based on all allowed prediction modes. For example, the nine

above-shown intra-prediction modes of AVC can be used. Note that the intra prediction modes, and corresponding mode selection, for estimating the predictors are in principle independent from the intra prediction modes, and corresponding mode selection, for the actual intra-prediction of all the pixels. Then, all 4x4 blocks can be predicted simultaneously, using the estimated predictors.

In the following, the encoding process is described in more detail. The encoding is a process that has two phases.

The first phase of the encoding procedure is shown in Fig.4. In a first step, lower-edge pixels m_0, n_0, o_0, p_0 and right-edge pixels d_0, h_0, l_0, p_0 of each block are predicted from pixels of neighbouring blocks of the original image A-L. Edge pixels of the leftmost or uppermost blocks can be predicted using the same modes as for conventional intra-coding, e.g. DC mode, since these blocks have no left or upper neighbours. At the end of the first phase, as shown in Fig.4 b), all predictors of all blocks (of at least that portion of the image to which accelerated intra-prediction is applied) are estimated. Thus, each block has estimated predictors in neighbouring blocks in two directions available (left and upper direction in Fig.4), before any block is actually encoded. This is possible because the estimated predictors are predicted from pixels of the original image.

In a second step, which may be considered as part of the first phase or the second phase or as separate intermediate phase, the residuals between the estimated predictors and their original pixels are determined, e.g. $m-m_p, n-n_p$ etc. These residuals are then quantized and inverse quantized, in order to make them more similar to the predictors that will be available at the decoder. This results in reconstructed

predictor residuals for all blocks (in the concerned portion of the image), according to

$$Q^{-1}(Q(m-m_p),QP),QP), Q^{-1}(Q(n-n_p),QP),QP), \text{ etc.}$$

The actual estimated predictors $m', n', \dots$ for each of these

5 blocks are then calculated according to eq.2.

At the end of the first phase and after the quantization and inverse quantization, all predictors of all blocks (of at least that portion of the image to which accelerated intra-
10 prediction is applied) are estimated. Thus, each block has estimated predictors in two neighbouring blocks, as shown in Fig.4 b). Accelerated intra-prediction can be applied to one or more portions of an image simultaneously. Other portions may use other, e.g. conventional, intra prediction. For
15 example, conventional intra prediction may be applied in a region-of-interest (ROI), while accelerated intra prediction according to the invention is used in remaining portions of the image.

20 The second phase of the encoding process is shown in Fig.5. It comprises prediction and reconstruction of remaining pixels, i.e. other than predictor pixels, based on the predictor pixels that result from the first phase. In step 3, pixels $a_3, b_3, \dots, k_3$ of a block B3 are predicted using intra-
25 prediction, which uses the actual estimated predictor pixels of neighbouring blocks B0, B1 and B2. In detail, the following estimated predictors are used: p'_0 from upper left adjacent (i.e. neighbouring) block B0, lower edge pixels $m'_1-p'_1$ from upper adjacent block B1, and right-edge pixels
30 d'_2, h'_2, l'_2, p'_2 from left adjacent block B2. In another embodiment, any combination of upper edge, lower edge, left edge and right edge pixels of adjacent blocks can be used as predictors, depending on the prediction direction.

In step 4, shown in Fig.5, the predicted remaining pixels $a_3, b_3, \dots, k_3$ of a block B3 and the original pixels $A_3, B_3, \dots, K_3$ of said block are used to determine prediction residuals $A_{3,res}, B_{3,res}, \dots, K_{3,res}$ of said block. The prediction residuals
5 are then entropy-encoded, as usual.

Since the estimated predictors are slightly different from the exact predictors that would be used by conventional sequential intra-prediction, the encoded image data
10 resulting from the two methods are slightly different. In other words, encoder and decoder do not use exactly the same predictors, since an encoder uses the estimated predictors and a decoder uses conventionally reconstructed predictors. However, the different predictors of encoder and decoder are
15 so similar that the difference is not visible in the image. It has been found that the simplified prediction based on estimated predictors, as employed by the invention, is not only faster and less computational expensive, but also in terms of quality yields much better results than could be
20 expected.

Embodiments of the present invention comprise at least the following:

25 In one embodiment, a method for encoding image data, the image data being structured in blocks, comprises for each block in at least a portion of the image the steps of predicting the pixels of two edges of a block in a first prediction step, wherein the prediction is based on pixels
30 of neighbouring blocks from the original image, and wherein estimated predictor pixels are obtained; determining residual data for the estimated predictor pixels; performing quantization and inverse quantization on the determined residual data for the estimated predictor pixels,

wherein reconstructed residual data for estimated predictor pixels are obtained, according to $Q^{-1}(Q(m-m_p), QP), QP$;

reconstructing predictor pixels, wherein the difference between original pixels and reconstructed residual data for

5 estimated predictor pixels is obtained, according to

$m' = m - Q^{-1}(Q(m-m_p), QP), QP$;

in a second prediction step, predicting remaining pixels of the block from the predicted predictor pixels of at least neighbouring blocks;

10 determining residual data for each predicted pixel resulting from the first or second prediction step, the residual data being the difference between the predicted pixel and its corresponding original pixel; and entropy encoding the residual data.

15

In one embodiment of the method for encoding, the second prediction step is executed in parallel for at least two blocks of the image simultaneously, and the step of determining residual data is executed in parallel for at

20 least two blocks of the image simultaneously. This is possible because there are no dependency issues among blocks, since the original pixel values are used.

In one embodiment of the method for encoding, the first

25 prediction step is executed in parallel for at least two blocks of the image simultaneously. This is possible because there are no dependency issues among blocks, since the original pixel values are used in the first prediction step.

30 In one embodiment of the method for encoding, the first prediction step further comprises determining for each of the estimated predictor pixels a best prediction mode from a given group of spatial intra prediction modes.

In one embodiment of the method for encoding, the given group of spatial intra prediction modes comprises DC mode, horizontal prediction mode and vertical prediction mode. In one embodiment of the method for encoding, the given group of spatial intra prediction modes consists of only DC mode, horizontal prediction and vertical prediction.

In one embodiment of the method for encoding, the image is structured into at least two portions, wherein the method is executed in parallel for at least two portions of the image simultaneously and independently.

In one embodiment of the method for encoding, the at least one portion of the image is not square, wherein if there is more than one portion, all portions have the same shape and same amount of blocks.

In one embodiment a method for decoding image data, the image data being structured in blocks and having at least two portions, comprises, in all portions of the image independently and simultaneously, the steps of reconstructing pixels of the blocks from received pixel data; predicting pixels in the blocks from said reconstructed pixels of the block or from reconstructed pixels of neighboring blocks; and reconstructing the predicted pixels based on received residual data.

In one embodiment, a device for encoding image data, the image data being structured in blocks, comprises first and second prediction means; first and second residual determining means; quantizer and inverse quantizer; reconstruction means; and entropy coding means;

wherein the apparatus performs for each block in at least a portion of the image the steps of

in the first prediction means, predicting the pixels of two edges of a block in a first prediction step, wherein the prediction is based on pixels of neighbouring blocks from the original image, and wherein estimated predictor pixels are obtained;

in the residual determining means, determining residual data for the estimated predictor pixels;

in the quantizer and inverse quantizer, performing quantization and inverse quantization on the determined residual data for the estimated predictor pixels, wherein reconstructed residual data for estimated predictor pixels are obtained, according to $Q^{-1}(Q(m-m_p), QP), QP$, $Q^{-1}(Q(n-n_p), \dots$;

in the reconstruction means, reconstructing predictor pixels m' , wherein the difference between original pixels and reconstructed residual data for estimated predictor pixels is obtained, according to $m' = m - Q^{-1}(Q(m-m_p), QP), QP$, $n' = \dots$;

in the second prediction means, in a second prediction step, predicting remaining pixels of the block from the predicted predictor pixels of at least neighbouring blocks;

in the second residual determining means, determining residual data for each predicted pixel resulting from the first or second prediction step, the residual data being the difference between the predicted pixel and its corresponding original pixel; and in the entropy coding means, entropy encoding the residual data.

In one embodiment, the encoding device further comprises at least a second set of second prediction means and residual determining means, wherein the second prediction step is executed in parallel in the at least two second prediction means for at least two blocks of the image simultaneously, and the step of determining residual data is executed in

parallel in the at least two residual prediction means for at least two blocks of the image simultaneously.

In one embodiment, the encoding device further comprises at least two of the first prediction means, wherein the first prediction step is executed in the at least two first prediction means in parallel for at least two blocks of the image simultaneously.

In one embodiment of the encoding device, the first prediction means comprises a prediction mode selector for determining for each of the estimated predictor pixels a best prediction mode from a given group of spatial intra prediction modes.

In one embodiment of the encoding device, the image is structured into at least two portions, and the device operates in parallel for at least two portions of the image simultaneously and independently.

For most of the above embodiments, the resulting data stream can be decoded conventionally. However, where the image is split into portions, it is also possible to decode each portion independently, and thus in parallel simultaneously.

In one embodiment, as shown in Fig.9, a device for decoding image data is concerned: The device for decoding image data, the image data being structured in blocks and having at least two independent portions, comprises decoder data receiving means DDR, decoder pixel reconstruction means DPR, and decoder pixel prediction means DPP. After receiving pixel data, prediction mode data and residual data in the decoder data receiving means DDR, the device performs in all portions of the image independently and simultaneously the following steps: in the decoder pixel reconstruction means

DPR, reconstructing pixels based on received pixel data; in the decoder pixel prediction means DPP, predicting pixels in the blocks from said reconstructed pixels of the block or from reconstructed pixels of neighbouring blocks; and
5 further in the decoder pixel reconstruction means DPR, reconstructing the predicted pixels based on reconstructed predictors and received residual data. For parallel decoding two or more sets of decoder pixel reconstruction means DPR and decoder pixel prediction means DPP may be employed in
10 the decoder.

In the above illustrative embodiments, intra 4x4 prediction is used as an example. It is clear that the same mechanism can seamlessly be applied to other intra predictions, e.g.
15 intra 16x16 prediction. Usually, the processing of a block is independent from its relative position in a MB.

In one embodiment of the encoding device or the decoding device, the at least one portion of the image is not square,
20 and if there is more than one portion, all portions have the same shape and same amount of blocks.

Different embodiments described above can be used in combination. For example, the dividing images into more than one portion and processing the portions simultaneously has
25 the lowest measurable impact on prediction quality. The usage of estimated predictors with limited set of prediction directions yields the highest performance improvement. Thus, it is possible to choose among different combinations of the disclosed features, depending on different requirements and
30 conditions.

Further, the spirit of the idea can be extended to design an efficient loop filter implementation, where the pixel values to be filtered can be predicted using the methods described

above. Also any product that uses parallel intra prediction mode decisions may use features described above.

It will be understood that the present invention has been described purely by way of example, and modifications of detail can be made without departing from the scope of the invention. While there has been shown, described, and pointed out fundamental novel features of the present invention as applied to preferred embodiments thereof, it will be understood that various omissions and substitutions and changes in the apparatus and method described, in the form and details of the devices disclosed, and in their operation, may be made by those skilled in the art without departing from the spirit of the present invention. Although the present invention has been disclosed with regard to AVC, one skilled in the art would recognize that the method and devices described herein may be applied to any coding standard that uses intra-prediction. It is expressly intended that all combinations of those elements that perform substantially the same function in substantially the same way to achieve the same results are within the scope of the invention. Substitutions of elements from one described embodiment to another are also intended and contemplated.

Each feature disclosed in the description and (where appropriate) the claims and drawings may be provided independently or in any appropriate combination. Features may, where appropriate be implemented in hardware, software, or a combination of the two. Reference numerals appearing in the claims are by way of illustration only and shall have no limiting effect on the scope of the claims.

Claims

1. A method for encoding image data, the image data being structured in blocks, the method comprising for each block in at least a portion of the image the steps of

- predicting the pixels of two edges of a block in a first prediction step, wherein the prediction is based on pixels of neighbouring blocks from the original image (X,A-L), and wherein estimated predictor pixels ($d_p, h_p, l_p, m_p, n_p, o_p, p_p$) are obtained;
- determining residual data ($m - m_p$) for the estimated predictor pixels;
- performing quantization (Q) and inverse quantization (Q^{-1}) on the determined residual data for the estimated predictor pixels, wherein reconstructed residual data for estimated predictor pixels are obtained, according to $Q^{-1}(Q(m - m_p), QP), QP$;
- reconstructing predictor pixels (m'), wherein the difference between original pixels and reconstructed residual data for estimated predictor pixels is obtained, according to $m' = m - Q^{-1}(Q(m - m_p), QP), QP$;
- in a second prediction step, predicting remaining pixels ($a_3, b_3, \dots, k_3$) of the block from the predicted predictor pixels ($p'_0, d'_2, h'_2, l'_2, p'_2, m'_1, \dots, p'_1$) of at least neighbouring blocks;
- determining residual data for each predicted pixel resulting from the first or second prediction step, the residual data being the difference between the predicted pixel and its corresponding original pixel;
- and
- entropy encoding the residual data.

2. Method according to claim 1, wherein the second prediction step is executed in parallel for at least two blocks of

the image simultaneously, and the step of determining residual data is executed in parallel for at least two blocks of the image simultaneously.

- 5 3. Method according to claim 1 or 2, wherein the first prediction step is executed in parallel for at least two blocks of the image simultaneously.
4. Method according to any of claims 1-3, wherein the first
10 prediction step further comprises determining for each of the estimated predictor pixels ($d_p, h_p, l_p, m_p, n_p, o_p, p_p$) a best prediction mode from a given group of spatial intra prediction modes.
- 15 5. Method according to claim 4, wherein the given group of spatial intra prediction modes comprises DC mode, horizontal prediction and vertical prediction.
6. Method according to claim 4 or 5, wherein the given group
20 of spatial intra prediction modes consists of DC mode, horizontal prediction and vertical prediction only.
7. Method according to one of the claims 1-6, wherein the
25 image is structured into at least two portions, and wherein the method is executed in parallel for at least two portions of the image simultaneously and independently.
8. Method according to any of the claims 1-7, wherein the at
least one portion of the image is not square, and wherein
30 if there is more than one portion, all portions have the same shape and same amount of blocks.
9. Method for decoding image data, the image data being structured in blocks and having at least two portions, the

method comprising, in all portions of the image independently and simultaneously, the steps of

- reconstructing pixels of the blocks from received pixel data;
- 5 - predicting pixels in the blocks from said reconstructed pixels of the block or from reconstructed pixels of neighboring blocks; and
- reconstructing the predicted pixels based on received residual data.

10

10. A device for encoding image data, the image data being structured in blocks, the device comprising

- first and second prediction means (P_1, P_2);
- first and second residual determining means (RD_1, RD_2);
- 15 - quantizer (Q) and inverse quantizer (Q^{-1});
- reconstruction means (RE); and
- entropy coding means (EC);

wherein the apparatus performs for each block in at least a portion of the image the steps of

- 20 - in the first prediction means, predicting the pixels of two edges of a block in a first prediction step, wherein the prediction is based on pixels of neighbouring blocks from the original image ($X, A-L$), and wherein estimated predictor pixels ($d_p, h_p, l_p, m_p, n_p, o_p, p_p$) are obtained;
- 25 - in the first residual determining means (RD_1), determining residual data ($m-m_p$) for the estimated predictor pixels;
- in the quantizer (Q) and inverse quantizer (Q^{-1}),
- 30 performing quantization and inverse quantization on the determined residual data for the estimated predictor pixels, wherein reconstructed residual data for

estimated predictor pixels are obtained, according to
 $Q^{-1}(Q(m-m_p), QP), QP)$;

- in the reconstruction means (RE), reconstructing
 predictor pixels (m'), wherein the difference between
 5 original pixels and reconstructed residual data for
 estimated predictor pixels is obtained, according to
 $m' = m - Q^{-1}(Q(m-m_p), QP), QP)$;
- in the second prediction means (P_2), in a second
 prediction step, predicting remaining pixels ($a_3, b_3, \dots,$
 10 k_3) of the block from the predicted predictor pixels
 ($p'_0, d'_2, h'_2, l'_2, p'_2, m'_1, \dots, p'_1$) of at least neighbouring
 blocks;
- in the second residual determining means (RD_2),
 determining residual data for each predicted pixel
 15 resulting from the first or second prediction step, the
 residual data being the difference between the
 predicted pixel and its corresponding original pixel;
 and
- in the entropy coding means (EC), entropy encoding the
 20 residual data.

11. Device according to claim 10, further comprising at
 least a second set of second prediction means (P_2, P_2') and
 second residual determining means (RD_2, RD_2'), wherein the
 25 second prediction step is executed in parallel in the at
 least two second prediction means for at least two blocks
 of the image simultaneously, and the step of determining
 residual data is executed in parallel in the at least two
 residual prediction means for at least two blocks of the
 30 image simultaneously.

12. Device according to claim 10 or 11, further comprising
 at least two of the first prediction means (P_1, P_1'),

wherein the first prediction step is executed in the at least two first prediction means in parallel for at least two blocks of the image simultaneously.

- 5 13. Device according to any of claims 10-12, wherein the first prediction means comprises a prediction mode selector (PS,PS') for determining for each of the estimated predictor pixels ($d_p, h_p, l_p, m_p, n_p, o_p, p_p$) a best prediction mode from a given group of spatial intra
10 prediction modes.
14. Device according to one of the claims 10-12, wherein the image is structured into at least two portions, and wherein the device operates in parallel for at least two
15 portions of the image simultaneously and independently.
15. Device according to any of the claims 10-14, wherein the at least one portion of the image is not square, and wherein if there is more than one portion, all portions
20 have the same shape and same amount of blocks.

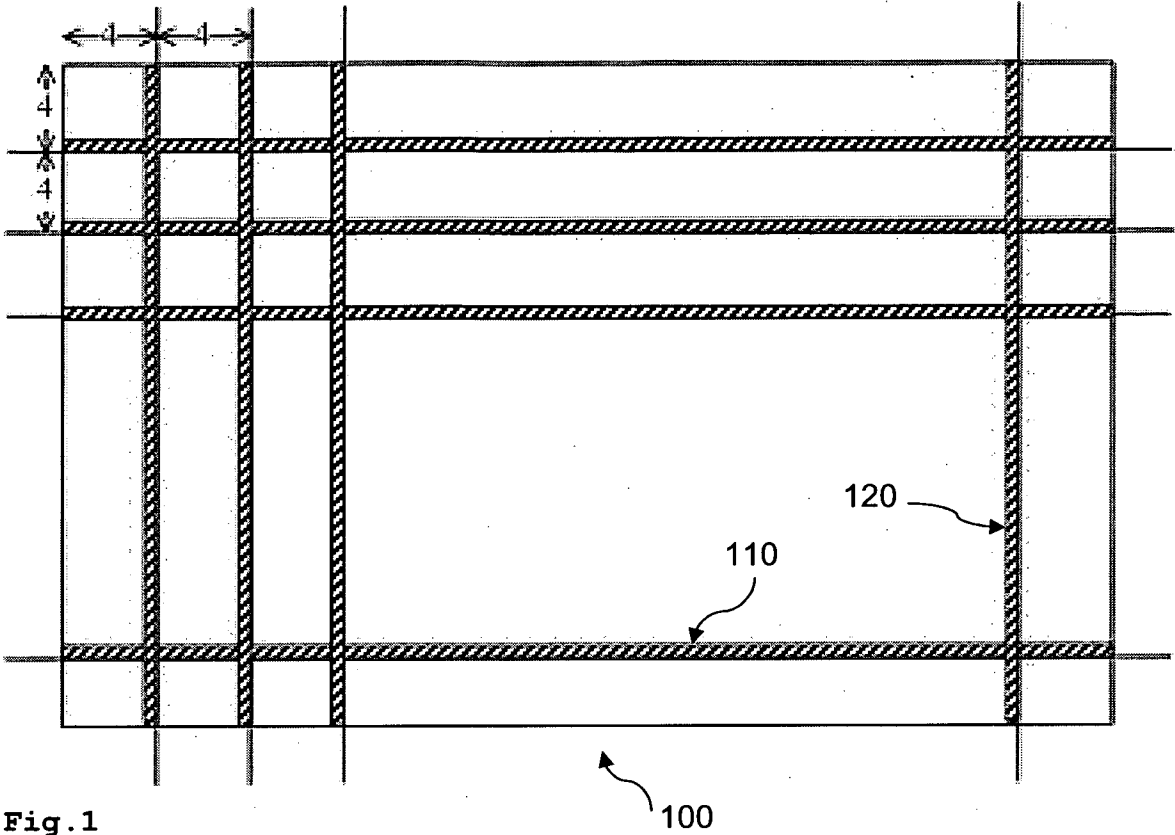


Fig. 1

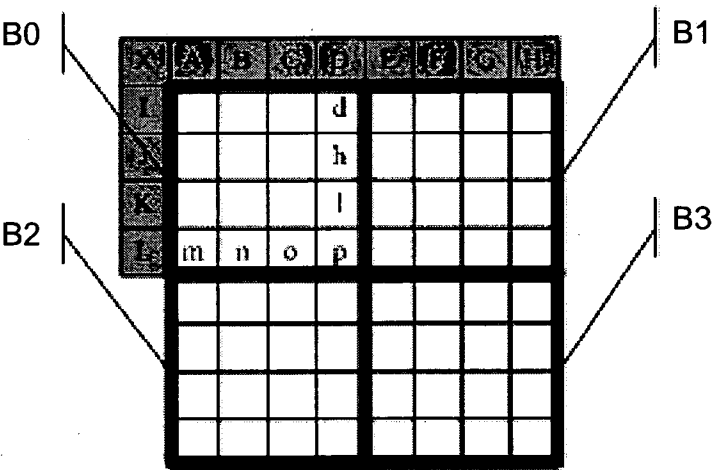


Fig. 2

X	A	B	C	D	E	F	G	H
I	a	b	c	d				
J	e	f	g	h				
K	i	j	k	l				
L	m	n	o	p				

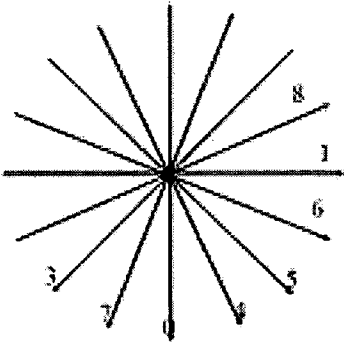


Fig. 3

Encoding: 1st phase: prediction of predictors

X	A	B	C	D	E	F	G	H
I				d_0				
J				h_0				
K				l_0				
L	m_0	n_0	o_0	p_0				

a) Step 1: predict $d_0, h_0, l_0, m_0, n_0, o_0, p_0$ from original A-L

			d_0				d_1
			h_0				h_1
			l_0				l_1
m_0	n_0	o_0	p_0	m_1	n_1	o_1	p_1
			d_2				d_3
			h_2				h_3
			l_2				l_3
m_2	n_2	o_2	p_2	m_3	n_3	o_3	p_3

b) End of 1st phase: all predictors are predicted

Step 2:

determine the residuals between the estimated predictors and their original pixels, and perform quantization and inv. quantization of the residuals (m' from eq.(2))

Fig.4

Encoding 2nd phase: prediction and reconstruction of remaining pixels (parallel, simultaneously in all blocks) based on the predicted, quantized/inverse quantized predictors and original pixels

	X	A	B	C	D	E	F	G	H	
B0	I	a ₀	b ₀	c ₀	d' ₀				d' ₁	B1
	J	e ₀	f ₀	g ₀	h' ₀				h' ₁	
	K	i ₀	j ₀	k ₀	l' ₀				l' ₁	
	L	m' ₀	n' ₀	o' ₀	p' ₀	m' ₁	n' ₁	o' ₁	p' ₁	
B2					d' ₂	a ₃	b ₃	c ₃	d' ₃	B3
					h' ₂	e ₃	f ₃	g ₃	h' ₃	
					l' ₂	i ₃	j ₃	k ₃	l' ₃	
		m' ₂	n' ₂	o' ₂	p' ₂	m' ₃	n' ₃	o' ₃	p' ₃	

Step 3: predict $a_3, b_3, \dots, k_3$ from original neighbour pixels and predicted/quantized/ inverse quantized $p'_0, d'_2, h'_2, l'_2, m'_1, n'_1, o'_1, p'_1$

X	A	B	C	D	E	F	G	H
I	A ₀	B ₀	C ₀	D ₀				D ₁
J	E ₀	F ₀	G ₀	H ₀				H ₁
K	I ₀	J ₀	K ₀	L ₀				L ₁
L	M ₀	N ₀	O ₀	P ₀	M ₁	N ₁	O ₁	P ₁
				D ₂	A ₃	B ₃	C ₃	D ₃
				H ₂	E ₃	F ₃	G ₃	H ₃
				L ₂	I ₃	J ₃	K ₃	L ₃
	M ₂	N ₂	O ₂	P ₂	M ₃	N ₃	O ₃	P ₃

Step 4: reconstruct pixels $A_3, B_3, \dots, P_3$ from predicted $a_3, b_3, \dots, p_3$ and encode the residuals

Fig. 5

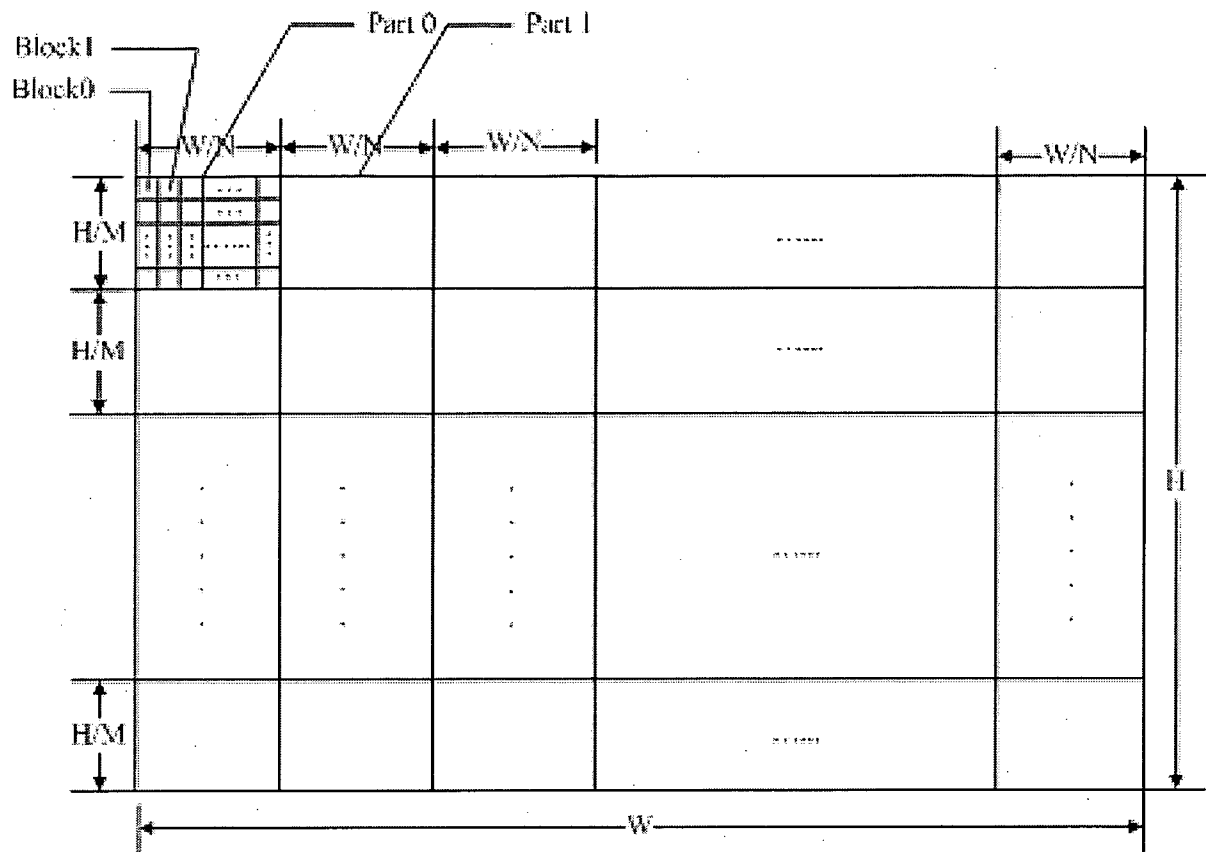


Fig. 6

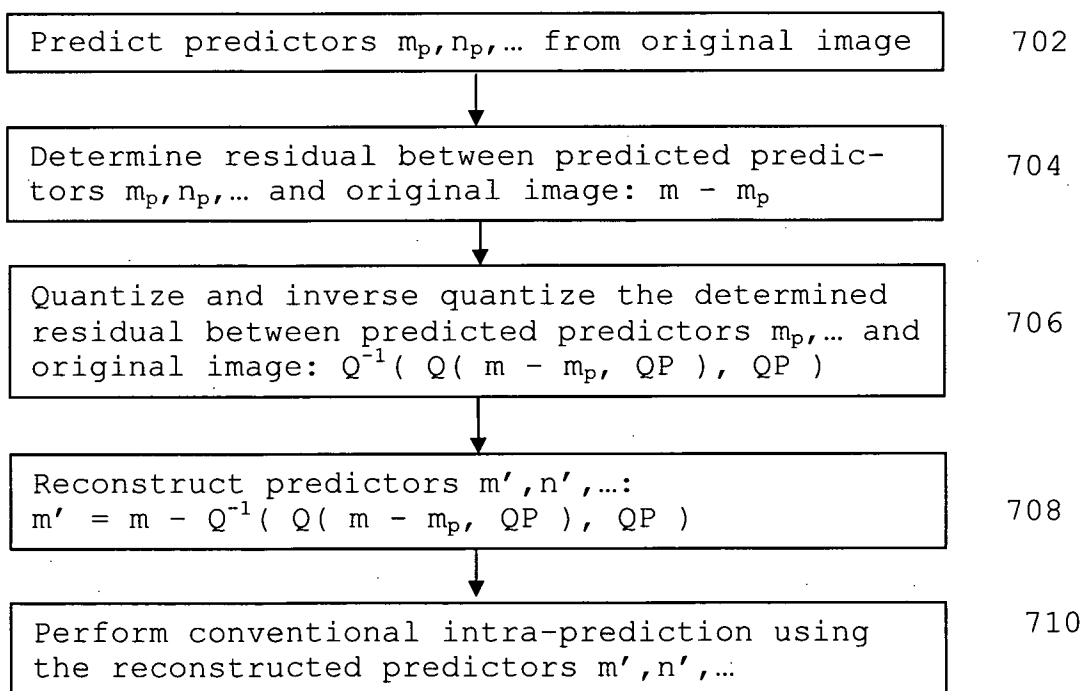


Fig. 7

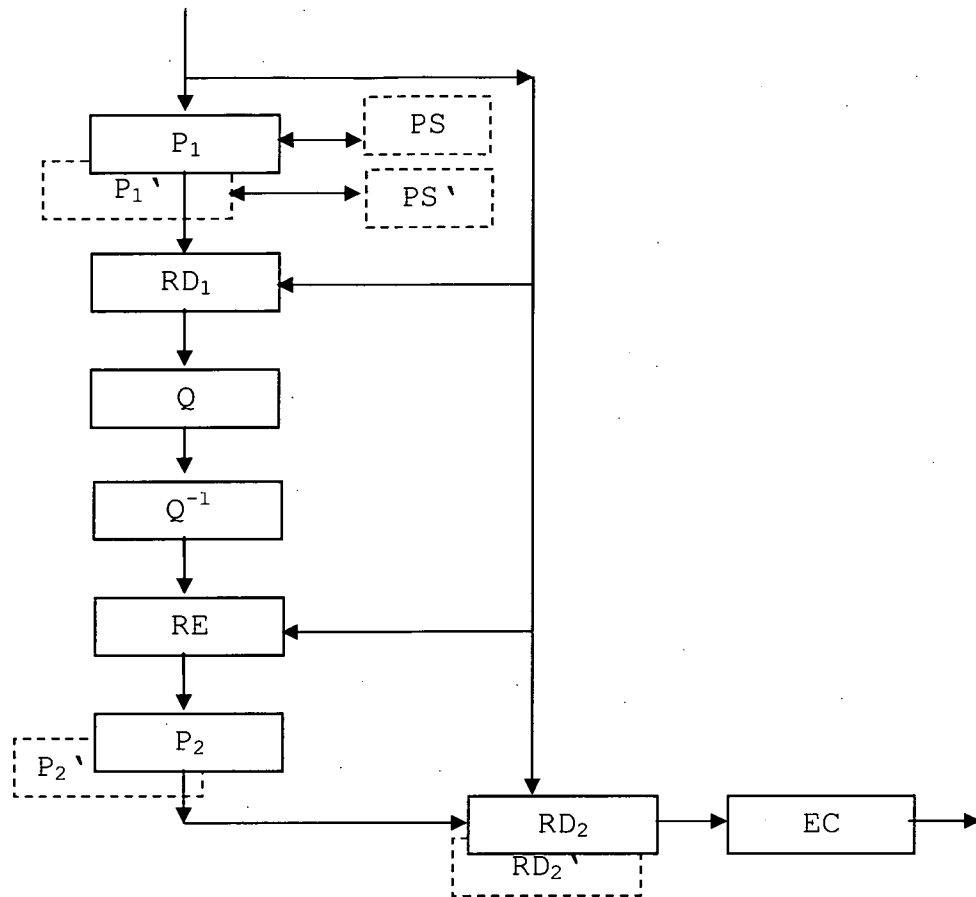


Fig. 8

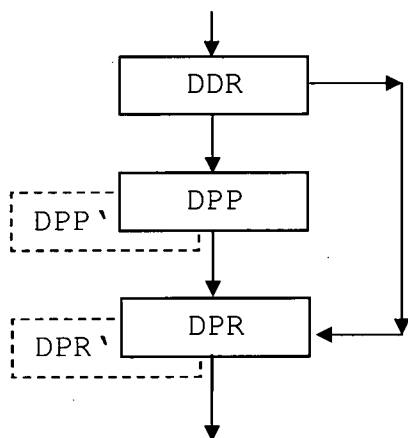


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2010/000901

A. CLASSIFICATION OF SUBJECT MATTER

H04N 7/26 (2006.01)i

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)

IPC: H04N 7/-

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 practicable, search terms used)

EPODOC,WPI,CNPAT: image, encod???, decod???, entropy, reconstruct+, data, block?, portion?, pixel?, edge?, neighbour+, predict+, estimate+, residual, remain+, quantiz+, parallel+, simultaneous+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN101383972A (UNIV BEIJING AERONAUTICS&ASTRONAUTICS) 11 Mar. 2009 (11.03.2009) see the abstract and the claim 1	9
A		1-8, 10-15
A	CN1127855C (THOMSON CONSUMER ELECTRONICS INC) 12 Nov. 2003 (12.11.2003) see the whole document	1-15
A	US2008219576 A1(SAMSUNG ELECTRONICS CO LTD) 11 Sep. 2008 (11.09.2008) see the whole document	1-15
A	EP2081386A1(PANASONIC CORP) 22 Jul. 2009 (22.07.2009) see the whole document	1-15

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 28 Oct. 2010 (28.10.2010)	Date of mailing of the international search report 17 Mar. 2011 (17.03.2011)
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer WANG, Xuerui Telephone No. (86-10)62411852

INTERNATIONAL SEARCH REPORT Information on patent family members			International application No. PCT/CN2010/000901
Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN101383972A	11.03.2009	none	
CN1127855C	12.11.2003	EP0779744A2	18.06.1997
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