

ABSTRACT

A system and method for improving prediction error coding performance of various video compression algorithms. Various embodiments combine the energy compaction features of transform coding with localization properties of spatial
5 coding. In various embodiments, the effects of pixel "outliers" are removed from the transform and are coded separately as a spatially coded pixel prediction, thereby improving the coding gain of the transform.

SPATIALLY ENHANCED TRANSFORM CODING

FIELD OF THE INVENTION

[0001] The present invention relates to the coding and decoding of digital video material. More particularly, the present invention relates to prediction error coding in both frequency and spatial domains.

BACKGROUND OF THE INVENTION

[0002] This section is intended to provide a background or context to the invention that is recited in the claims. The description herein may include concepts that could be pursued, but are not necessarily ones that have been previously conceived or pursued. Therefore, unless otherwise indicated herein, what is described in this section is not prior art to the description and claims in this application and is not admitted to be prior art by inclusion in this section.

[0003] A video codec comprises an encoder that transforms input video into a compressed representation suited for storage and/or transmission and a decoder that can uncompress the compressed video representation back into a viewable form. Typically, the encoder discards some information in the original video sequence in order to represent the video in a more compact form, i.e., at a lower bitrate.

[0004] Typical hybrid video codecs, for example ITU-T H.263 and H.264, encode video information in two phases. In the first phase, pixel values in a certain picture area or "block" are predicted. These pixel values can be predicted, for example, by motion compensation mechanisms, which involve finding and indicating an area in one of the previously coded video frames that corresponds closely to the block being coded. Additionally, pixel values can be predicted via spatial mechanisms, which involve using the pixel values around the block to be coded in a specified manner. The second phase involves coding the prediction error, i.e. the difference between the predicted block of pixels and the original block of pixels. This is typically accomplished by transforming the difference in pixel values using a specified transform (e.g., a Discrete Cosine Transform (DCT) or a variant thereof), quantizing

the coefficients, and entropy coding the quantized coefficients. By varying the fidelity of the quantization process, the encoder can control the balance between the accuracy of the pixel representation (i.e., the picture quality) and the size of the resulting coded video representation (i.e., the file size or transmission bitrate).

[0005] The decoder reconstructs output video by applying prediction mechanisms that are similar to those used by the encoder in order to form a predicted representation of the pixel blocks (using motion or spatial information created by the encoder and stored in the compressed representation) and prediction error decoding (the inverse operation of the prediction error coding, recovering the quantized prediction error signal in the spatial pixel domain). After applying prediction and prediction error decoding processes, the decoder sums up the prediction and prediction error signals (i.e., the pixel values) to form the output video frame. The decoder (and encoder) can also apply additional filtering processes in order to improve the quality of the output video before passing it for display and/or storing it as a prediction reference for the forthcoming frames in the video sequence.

[0006] In typical video codecs, the motion information is indicated with motion vectors associated with each motion-compensated image block. Each of these motion vectors represents the displacement of the image block in the picture to be coded (in the encoder side) or decoded (in the decoder side) and the prediction source block in one of the previously coded or decoded pictures. In order to represent motion vectors efficiently, motion vectors are typically coded differentially with respect to block specific predicted motion vectors. In a typical video codec, the predicted motion vectors are created in a predefined way, for example by calculating the median of the encoded or decoded motion vectors of the adjacent blocks.

[0007] Typical video encoders utilize Lagrangian cost functions to find optimal coding modes, e.g., the desired macroblock mode and associated motion vectors. This kind of cost function uses a weighting factor λ to tie together the exact or estimated image distortion due to lossy coding methods and the exact or estimated amount of information that is required to represent the pixel values in an image area:

$$C = D + \lambda R \quad (1)$$

[0008] In Eq. (1), C is the Lagrangian cost to be minimized, D is the image distortion (e.g., the mean squared error) with the mode and motion vectors considered, and R the number of bits needed to represent the required data to reconstruct the image block in the decoder (including the amount of data to represent the candidate motion vectors).

[0009] Transform coding of the prediction error signal in video or image compression system typically comprises DCT-based linear transform, quantization of the transformed DCT coefficients, and context based entropy coding of the quantized coefficients. However, the transform can efficiently pack energy of the prediction error signal only under certain statistics, and the coding performance deteriorates when the prediction error to be transformed becomes less correlated. This causes suboptimal performance, especially in modern video and image coding systems employing advanced motion compensation and spatial prediction processes in order to achieve good quality predictions for the image blocks to be coded (thus, minimizing and decorrelating the prediction error signal).

[0010] To address some of the above issues, a number of hybrid video coding schemes have been developed. These hybrid systems typically comprise a hybrid of two redundancy reduction techniques--prediction and transformation. Prediction can take the form of inter-picture prediction, which is used to remove temporal redundancies in the signal. Intra-picture prediction may also be used in the H.264/Advanced Video Coding (AVC) standard where spatial redundancies are removed by exploiting the similarities between neighboring regions within a picture frame. As a consequence of these inter-picture and intra-picture prediction techniques, a residual/error signal is formed by removing the predicted picture frame from the original. This prediction error signal is then typically block transform coded using an 8x8 DCT transform in order to reduce spatial redundancies in the signal.

SUMMARY OF THE INVENTION

[0011] Various embodiments of the present invention provide a system and method for representing the prediction error signal as a weighted sum of different basis functions of a selected transform and quantized spatial samples. The basis functions

of the selected transform may comprise an orthogonal set of basis vectors, or the basis functions may not comprise an orthogonal set. According to various embodiments, the prediction error signal for a single image block is constructed using both transform basis functions and spatial samples (i.e., pixel values), thereby combining the desired features of both the transform and spatial coding approaches discussed previously. This allows for the utilization of those selected transform basis functions that give good overall representation of the image block with minimal amount of transform coefficients (representing the component of prediction error signal that is well correlated with the basis functions). Additionally, various embodiments of the present invention allow for the efficient spatial representation of those components of the prediction error signal of the same image block that are not well correlated with the basis functions of the applied transform (such as certain types of sensor noise, high frequency texture and edge information).

[0012] According to various embodiments of the present invention, a system and method of encoding a prediction error signal for a block of data comprises calculating a difference signal representing differences between sample values of a predicted block of data and values for an original input block. Transform coding and spatial coding are both performed to the difference signal, thereby creating a first and second representations of first and second components of the difference signal. The first and second representations are then combined to provide the prediction error signal.

[0013] Various embodiments of the present invention also provide a system and method of decoding a prediction error signal for a block of data, comprising receiving a coded prediction error signal, the coded prediction error signal including a plurality of transform coefficients and a plurality of spatial samples. The plurality of transformed coefficients are decoded into decoded transform information, and the plurality of spatial samples are decoded into decoded spatial information. The decoded transform information, the decoded spatial information, and a reconstructed prediction of the block of data are then added, thereby forming a decoded representation of the block of data.

[0014] The implementations of various embodiments of the present invention serve to improve the compression efficiency of modern video and image codecs. Although

a certain amount of increased computational complexity of encoding may be needed, fast algorithms can be applied in order to lower the encoding complexity that approaches the complexity level for traditional transform based coding. Any effect on the complexity for a decoder is negligible when implementing various embodiments of the present invention.

[0015] These and other advantages and features of the invention, together with the organization and manner of operation thereof, will become apparent from the following detailed description when taken in conjunction with the accompanying drawings, wherein like elements have like numerals throughout the several drawings described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 shows an example of basis functions of a Hadamard transform that can be used to encode image data;

[0017] Figure 2(a) is an example of four scalar values that are to be coded or decoded and representing the prediction error signal between the original image and the prediction image; Figure 2(b) shows the four weighted basis functions from Figure 1 being summed to the prediction error signal; and Figure 2(c) shows how the same prediction error signal can be reconstructed by summing up only the first basis function and a single spatial sample represented by an arrow;

[0018] Figure 3 is a block diagram of a video encoder constructed in accordance with one embodiment of the present invention;

[0019] Figure 4 is a flow chart showing one encoder algorithm which may be used in an embodiment of the present invention;

[0020] Figure 5 is a flow chart showing one decoder algorithm which may be used in various embodiments of the present invention;

[0021] Figure 6 is a block diagram of a video decoder constructed in accordance with one embodiment of the present invention;

[0022] Figure 7 is an overview diagram of a system within which various embodiments of the present invention may be implemented;

[0023] Figure 8 is a perspective view of an electronic device that can be used in conjunction with the implementation of various embodiments of the present invention; and

[0024] Figure 9 is a schematic representation of the circuitry which may be included in the electronic device of Figure 8.

DETAILED DESCRIPTION OF VARIOUS EMBODIMENTS

[0025] Various embodiments of the present invention provide a system and method for representing the prediction error signal as a weighted sum of different basis functions of a selected transform and quantized spatial samples. According to various embodiments, the prediction error signal for a single image block is constructed using both transform basis functions and spatial samples (i.e., pixel values), thereby combining the desired features of both the transform and spatial coding approaches discussed previously. This allows for the utilization of those selected transform basis functions that give good overall representation of the image block with minimal amount of transform coefficients (representing the component of prediction error signal that is well correlated with the basis functions). Additionally, various embodiments of the present invention allow for the efficient spatial representation of those components of the prediction error signal of the same image block that are not well correlated with the basis functions of the applied transform (such as certain types of sensor noise, high frequency texture and edge information).

[0026] Figures 1 and 2 show a simplified example of how various embodiments of the present invention are operable in one dimension. Figure 1 shows an example of basis functions of a one-dimensional linear transform that can be used to encode image data (namely a Hadamard transform). The weighted sum of these four basis functions can be used to represent any four samples. Figure 2(a) is an example of four scalar values that are to be coded or decoded and representing the prediction error signal between the original image and the prediction image. In Figure 2(b), the four weighted basis functions from Figure 1 are summed to the prediction error signal (1.5 times the first, 0.5 times the second, -0.5 times the third and -0.5 times the fourth basis function). In Figure 2(c) it is demonstrated how the same prediction error signal

can be reconstructed by summing up only the first basis function and a single spatial sample represented by an arrow. In this example, compression efficiency improvement can be expected, as the signal is represented by a single transform coefficient and a single spatial sample instead of four transform coefficients weighting the four Hadamard basis functions (as shown in Figure 2(b)).

[0027] Figure 3 is a block diagram of a video encoder constructed in accordance with one embodiment of the present invention. More particularly, Figure 3 shows how an image to be encoded 300 undergoes pixel prediction 302, prediction error coding 303 and prediction error decoding 304. For pixel prediction 302, the image 300 undergoes both inter-prediction 306 and intra-prediction 308 which, after mode selection 310, results in prediction representation of an image block 312. A preliminary reconstructed image 314 is also used for intra-prediction 308. Once all of the image blocks are processed, the preliminary reconstructed image 314 undergoes filtering at 316 to create a final reconstructed image 340, which is sent to a reference frame memory 318 and is also used for inter-prediction 306 of future frames.

[0028] The prediction representation of the image block 312, as well as the image to be encoded 300, are used together to define a prediction error signal 320 which is used for prediction error coding 303. In prediction error coding 303, the prediction error signal 320 undergoes feature selection 322 and spatial quantization 324, as well as transform 326 and quantization 328 (both after feature selection 322). The data describing prediction error and predicted representation of the image block 312 (e.g., motion vectors, mode information and quantized DCT+spatial samples) are passed to entropy coding 330. The prediction error decoding 304 is substantially the opposite of the prediction error coding 303, with the prediction error decoding including an inverse spatial quantizer 332, an inverse transform 334 and an inverse quantization 336. The result of the prediction error decoding 304 is a reconstructed prediction error signal 338, which is used in combination with the predicted representation of the image block 312 to create the preliminary reconstructed image 314.

[0029] Figure 4 is a flow chart showing one encoder algorithm which may be used in an embodiment of the present invention. However, as discussed below, a variety of different algorithms may be used according to principles of the present invention. At

400 in Figure 4, the difference between sample values of a predicted block and an original input block is calculated. It should be noted that "values" and "outlier values" as used herein are intended to refer to these difference values. At 410, outlier values are found. In this case, the amplitude depends on the expected accuracy of the coded representation; smaller amplitude representations qualify as outliers if one is targeting high bitrate good quality representation, and only high amplitude representations qualify if one is targeting a lower bitrate, lower quality representation. At 420, the modified prediction error signal is transform coded (involving transform, quantization and entropy coding), with the outlier values being substituted by interpolated representations of those values, e.g., by averaging the neighboring prediction error values. At 430, the modified prediction error signals are transform decoded back to the spatial domain. At 440, spatial coding is applied (involving quantization and entropy coding without transform) to the difference between the original outlier values and the transform decoded outlier values. At 450, the final coded representation of the prediction error signal is formed by joining the transform coded data and the spatial coded data. In an alternative embodiment, the spatial coding occurs before transform coding.

[0030] When considering the one-dimensional example depicted in Figures 2(a)-2(c), the algorithm outlined in Figure 4 would process the relevant data as follows. As discussed previously, Figure 2(a) represents the difference signal [1 1 3 1] to be coded. In this case, [3] is an outlier. Therefore, the prediction error signal is modified by substituting the [3] with an average of the second and fourth samples, making the signal [1 1 1 1]. The difference between the original outlier sample ([3]) and the transform coded outlier value ([1]) is then spatial coded, making the spatial coded signal [0 0 2 0]. The entropy coded representations of the transform coded and spatial coded signals are then written to the bitstream. Thereafter, the decoder can recover the coded signal by adding up the inverse transformed data [1 1 1 1] and the inverse spatial coded data [0 0 2 0] (together with the prediction samples of the image block).

[0031] When considering the above example, it is important to note that the choice of Hadamard basis vectors for the transform is only intended to be exemplary in nature. In fact, the various methods and techniques described herein can be applied to

any transform employing basis functions, and the basis functions do not necessarily need to be orthogonal.

[0032] A video or image codec, according to various embodiments the present invention, can be implemented in various ways. In the case of an encoder, the encoder can use different strategies to find the desired transform coefficients and spatial samples. For example, an encoder can first transform code the signal and apply spatial coding to the residual. The encoder can also first apply spatial coding to the signal, followed by transform coding of the residual. Additionally, some or all of the transform coefficients can be set to zero in order to improve the coding performance. Some or all spatial samples can also be set to zero in order to improve the coding performance. An encoder can also iteratively modify transform coefficients and/or spatial samples in order to improve the coding performance until a desired performance or a maximum defined number of iterations is achieved.

[0033] In terms of quantization and dequantization, the quantization and dequantization of transform coefficients and spatial samples can be tied together (e.g., a quantization step size for both transform coefficients and spatial samples can be derived from a single parameter). Alternatively, different quantizations and dequantizations can be applied to transform coefficients and spatial samples.

[0034] For the coding and decoding of spatial samples, such coding and decoding can depend on transform coefficients and vice versa. Alternatively, the coding and decoding of spatial samples, transform coefficients or both can depend on the prediction signal, on the other transform coefficients and spatial samples in the same image or in other images.

[0035] In addition to the above, it can be indicated that there are no transform coefficients or spatial samples for a specific image area or image. It can also be indicated that only spatial coding or only transform coding is used for a specific image area or image. The number of spatial samples can be coded and decoded as one unit, for example representing certain patterns of textures. Pre- and/or post-processing mechanisms can be applied to the prediction signal, prediction error signal reconstructed signal or any combination thereof. The method can be used to code and decode other information instead or in addition to the prediction error signals. The

codec can limit the usage of either transform coefficients (e.g., allow only low frequency transform coefficients to be present in the coded representation of the signal) or spatial samples.

[0036] Figure 5 shows a decoding process according to various embodiments of the present invention. At 500 in Figure 5, a video decoder receives a coded prediction error signal which comprises both transformed coefficients and spatial samples. At 510, both the transformed coefficients and the spatial samples are decoded. At 520, the decoded transform information, the decoded spatial information and reconstructed prediction of the image block are added together to form decoded representation of the image block.

[0037] Figure 6 is a block diagram of a video decoder constructed in accordance with one embodiment of the present invention. As shown in Figure 6, entropy decoding 600 is followed by both prediction error decoding 602 and pixel prediction 604. In prediction error decoding 602, in addition to an inverse transform 606 and inverse quantization 608, an inverse spatial quantizer 610 is used as discussed herein, ultimately resulting in a reconstructed prediction error signal 612. For pixel prediction 604, either intra-prediction or inter-prediction occurs at 614 to create a predicted representation of an image block 616. The predicted representation of the image block 616 is used in conjunction with the reconstructed prediction error signal 612 to create a preliminary reconstructed image 618, which in turn can be used both for prediction 614. Once all of the image blocks have been processed, the preliminary reconstructed image 618 is passed for filtering 620. The filtered image can also be stored in reference frame memory 624, making it usable for prediction 614 as well.

[0038] Figure 7 shows a system 10 in which various embodiments of the present invention can be utilized, comprising multiple communication devices that can communicate through one or more networks. The system 10 may comprise any combination of wired or wireless networks including, but not limited to, a mobile telephone network, a wireless Local Area Network (LAN), a Bluetooth personal area network, an Ethernet LAN, a token ring LAN, a wide area network, the Internet, etc. The system 10 may include both wired and wireless communication devices.

[0039] For exemplification, the system 10 shown in Figure 7 includes a mobile telephone network 11 and the Internet 28. Connectivity to the Internet 28 may include, but is not limited to, long range wireless connections, short range wireless connections, and various wired connections including, but not limited to, telephone lines, cable lines, power lines, and the like.

[0040] The exemplary communication devices of the system 10 may include, but are not limited to, an electronic device 50, a combination personal digital assistant (PDA) and mobile telephone 14, a PDA 16, an integrated messaging device (IMD) 18, a desktop computer 20, a notebook computer 22, etc. The communication devices may be stationary or mobile as when carried by an individual who is moving. The communication devices may also be located in a mode of transportation including, but not limited to, an automobile, a truck, a taxi, a bus, a train, a boat, an airplane, a bicycle, a motorcycle, etc. Some or all of the communication devices may send and receive calls and messages and communicate with service providers through a wireless connection 25 to a base station 24. The base station 24 may be connected to a network server 26 that allows communication between the mobile telephone network 11 and the Internet 28. The system 10 may include additional communication devices and communication devices of different types.

[0041] The communication devices may communicate using various transmission technologies including, but not limited to, Code Division Multiple Access (CDMA), Global System for Mobile Communications (GSM), Universal Mobile Telecommunications System (UMTS), Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), Transmission Control Protocol/Internet Protocol (TCP/IP), Short Messaging Service (SMS), Multimedia Messaging Service (MMS), e-mail, Instant Messaging Service (IMS), Bluetooth, IEEE 802.11, etc. A communication device involved in implementing various embodiments of the present invention may communicate using various media including, but not limited to, radio, infrared, laser, cable connection, and the like.

[0042] Figures 8 and 9 show one representative electronic device 50 within which the present invention may be implemented. It should be understood, however, that the present invention is not intended to be limited to one particular type of device. The

electronic device 50 of Figures 8 and 9 includes a housing 30, a display 32 in the form of a liquid crystal display, a keypad 34, a microphone 36, an ear-piece 38, a battery 40, an infrared port 42, an antenna 44, a smart card 46 in the form of a UICC according to one embodiment of the invention, a card reader 48, radio interface circuitry 52, codec circuitry 54, a controller 56 and a memory 58. Individual circuits and elements are all of a type well known in the art, for example in the Nokia range of mobile telephones.

[0043] The various embodiments of the present invention described herein is described in the general context of method steps or processes, which may be implemented in one embodiment by a computer program product, embodied in a computer-readable medium, including computer-executable instructions, such as program code, executed by computers in networked environments. Generally, program modules may include routines, programs, objects, components, data structures, etc. that perform particular tasks or implement particular abstract data types. Computer-executable instructions, associated data structures, and program modules represent examples of program code for executing steps of the methods disclosed herein. The particular sequence of such executable instructions or associated data structures represents examples of corresponding acts for implementing the functions described in such steps or processes.

[0044] Software and web implementations of various embodiments of the present invention can be accomplished with standard programming techniques with rule-based logic and other logic to accomplish various database searching steps or processes, correlation steps or processes, comparison steps or processes and decision steps or processes. It should be noted that the words “component” and “module,” as used herein and in the following claims, is intended to encompass implementations using one or more lines of software code, and/or hardware implementations, and/or equipment for receiving manual inputs.

[0045] The foregoing description of embodiments of the present invention have been presented for purposes of illustration and description. The foregoing description is not intended to be exhaustive or to limit embodiments of the present invention to the precise form disclosed, and modifications and variations are possible in light of

the above teachings or may be acquired from practice of various embodiments of the present invention. The embodiments discussed herein were chosen and described in order to explain the principles and the nature of various embodiments of the present invention and its practical application to enable one skilled in the art to utilize the present invention in various embodiments and with various modifications as are suited to the particular use contemplated.

WHAT IS CLAIMED IS:

- 1 1. A method of encoding a prediction error signal for a block of data,
2 comprising:
3 calculating a difference signal representing differences between sample
4 values of a predicted block of data and values for an original input block;
5 performing transform coding to the difference signal, thereby creating
6 a first representation of a first component of the difference signal;
7 performing spatial coding to the difference signal, thereby creating a
8 second representation of a first component of the difference signal; and
9 joining the first and second representations.
- 1 2. The method of claim 1, further comprising, before performing
2 transform coding and spatial coding, substituting outlier values in the difference
3 signal with non-outlier values to create a modified prediction error signal.
- 1 3. The method of claim 2, wherein transform coding is applied to the
2 modified prediction error signal and spatial coding is applied to a residual thereof.
- 1 4. The method of claim 2, wherein spatial coding is applied to the
2 modified prediction error signal and transform coding is applied to a residual thereof.
- 1 5. The method of claim 1, wherein, for transform coding, at least one
2 transform coefficient is set to zero.
- 1 6. The method of claim 1, wherein, for spatial coding, at least one spatial
2 sample is set to zero.
- 1 7. The method of claim 2, wherein the non-outlier values used to replace
2 the outlier values comprise an average of neighboring prediction error values.
- 1 8. The method of claim 1, further comprising providing an indication that
2 no transform coefficients exist in the block of data if appropriate.

1 9. The method of claim 1, further comprising providing an indication that
2 no spatial samples exist in the block of data if appropriate.

1 10. The method of claim 1, wherein for the transform coding, a transform
2 coefficient is formed, the transform coefficient comprising a weighting coefficient of
3 a discrete transform basis vector.

1 11. The method of claim 10, wherein the discrete transform comprises a
2 discrete orthogonal transform.

1 12. A computer program product, embodied in a computer-readable
2 medium, comprising computer code configured to perform the implemented the
3 processes of claim 1.

1 13. An apparatus, comprising:
2 a processor; and
3 a memory unit communicatively connected to a controller and
4 comprising:
5 computer code for performing transform coding to the
6 difference signal, thereby creating a first representation of a first component of the
7 difference signal;
8 computer code for performing spatial coding to the difference
9 signal, thereby creating a second representation of a first component of the difference
10 signal; and
11 computer code for joining the first and second representations.

1 14. The apparatus of claim 13, wherein the memory unit further comprises
2 computer code for, before performing transform coding and spatial coding,
3 substituting outlier values in the difference signal with non-outlier values to create a
4 modified prediction error signal.

1 15. The apparatus of claim 14, wherein transform coding is applied to the
2 modified prediction error signal and spatial coding is applied to a residual thereof.

1 16. The apparatus of claim 14, wherein spatial coding is applied to the
2 modified prediction error signal and transform coding is applied to a residual thereof.

1 17. The apparatus of claim 13, wherein, for transform coding, at least one
2 transform coefficient is set to zero.

1 18. The apparatus of claim 13, wherein, for spatial coding, at least one
2 spatial sample is set to zero.

1 19. The apparatus of claim 13, wherein the non-outlier values used to
2 replace the outlier values comprise an average of neighboring prediction error values.

1 20. The apparatus of claim 13, further comprising providing an indication
2 that no transform coefficients exist in the block of data if appropriate.

1 21. The apparatus of claim 13, further comprising providing an indication
2 that no spatial samples exist in the block of data if appropriate.

1 22. A method of decoding a prediction error signal for a block of data,
2 comprising:
3 receiving a coded prediction error signal, the coded prediction error
4 signal including a plurality of transform coefficients and a plurality of spatial samples;
5 decoding the plurality of transformed coefficients into decoded
6 transform information;
7 decoding the plurality of spatial samples into decoded spatial
8 information; and
9 adding the decoded transform information, the decoded spatial
10 information, and a reconstructed prediction of the block of data, thereby forming a
11 decoded representation of the block of data.

1 23. The method of claim 22, wherein an indication is provided that no
2 transform coefficients exist in the block of data if appropriate.

1 24. The method of claim 22, wherein an indication is provided that that no
2 spatial samples exist in the block of data if appropriate.

1 25. The method of claim 22, wherein the decoding of the plurality of
2 transformed coefficients and spatial samples includes dequantization of each, and
3 wherein the dequantization of transformed coefficients and spatial samples are related
4 to each other.

1 26. The method of claim 22, wherein the decoding of the plurality of
2 transformed coefficients and spatial samples includes dequantization of each, and
3 wherein the dequantization of transformed coefficients and spatial samples are
4 different from each other.

1 27. The method of claim 22, wherein the decoding of the spatial samples is
2 dependent upon the decoding of the transformed coefficients.

1 28. The method of claim 22, wherein the decoding of the transformed
2 coefficients is dependent upon the decoding of the spatial samples.

1 29. The method of claim 22, wherein at least some of the plurality of
2 spatial samples are decoded as a single unit.

1 30. A computer program product, embodied in a computer-readable
2 medium, comprising computer code configured to perform the processes of claim 19.

1 31. An apparatus, comprising:
2 a processor; and
3 a memory unit communicatively connected to the processor and
4 including:
5 computer code for processing a received coded prediction error
6 signal, the coded prediction error signal including a plurality of transformed
7 coefficients and a plurality of spatial samples;
8 computer code for decoding the plurality of transformed
9 coefficients into decoded transform information;

10 computer code for decoding the plurality of spatial samples into
11 decoded spatial information; and
12 computer code for adding the decoded transform information,
13 the decoded spatial information, and a reconstructed prediction of the block of data,
14 thereby forming a decoded representation of the block of data.

1 32. The apparatus of claim 31, wherein an indication is provided that no
2 transform coefficients exist in the block of data if appropriate.

1 33. The apparatus of claim 31, wherein an indication is provided that that
2 no spatial samples exist in the block of data if appropriate.

1 34. The apparatus of claim 31, wherein the decoding of the plurality of
2 transformed coefficients and spatial samples includes dequantization of each, and
3 wherein the dequantization of transformed coefficients and spatial samples are related
4 to each other.

1 35. The apparatus of claim 31, wherein the decoding of the plurality of
2 transformed coefficients and spatial samples includes dequantization of each, and
3 wherein the dequantization of transformed coefficients and spatial samples are
4 different from each other.

1 36. The apparatus of claim 31, wherein the decoding of the spatial samples
2 is dependent upon the decoding of the transformed coefficients.

1 37. The apparatus of claim 31, wherein the decoding of the transformed
2 coefficients is dependent upon the decoding of the spatial samples.

1 38. The apparatus of claim 31, wherein at least some of the plurality of
2 spatial samples are decoded as a single unit.

1 39. A method of encoding a prediction error signal for a block of data,
2 comprising:
3 calculating a difference signal representing differences between sample
4 values of a predicted block of data and values for an original input block;

5 substituting outlier values in the difference signal with non-outlier
6 values to create a modified prediction error signal;
7 performing one of transform coding and spatial coding to the modified
8 prediction error signal, creating one of a transform coded data and spatial coded data
9 performing an inverse of the one of transform coding and spatial
10 coding;
11 applying the other of transform coding and spatial coding to a residual
12 from the inverse transform or spatial decoding, creating the other of transform coded
13 data and spatial coded data; and
14 joining the transform coded data and the spatial coded data.

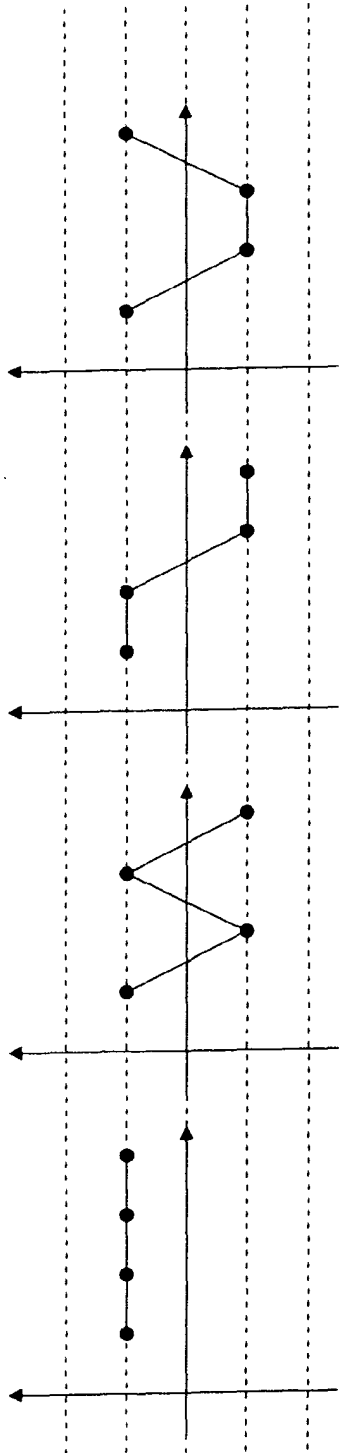


FIG. 1

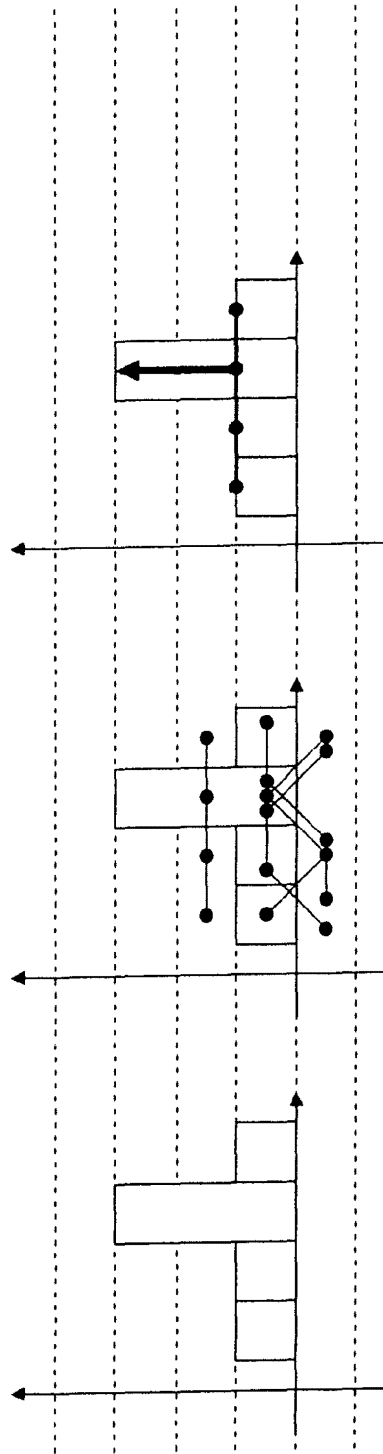


FIG. 2(a) FIG. 2(b) FIG. 2(c)

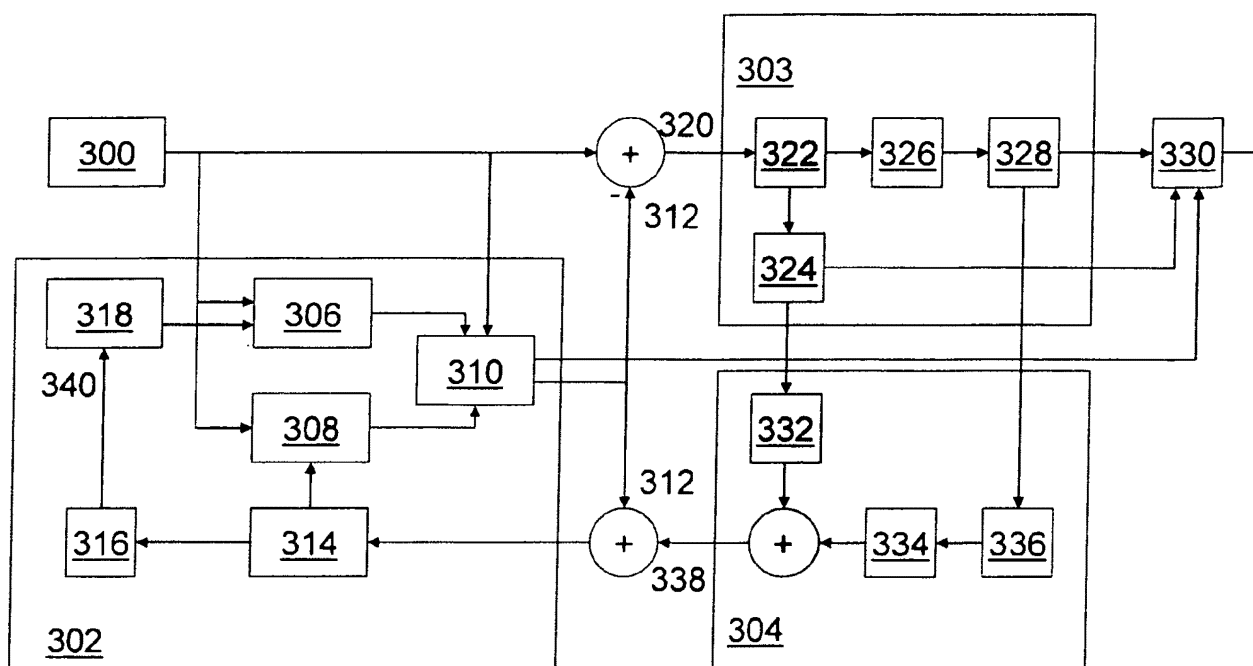


FIG. 3

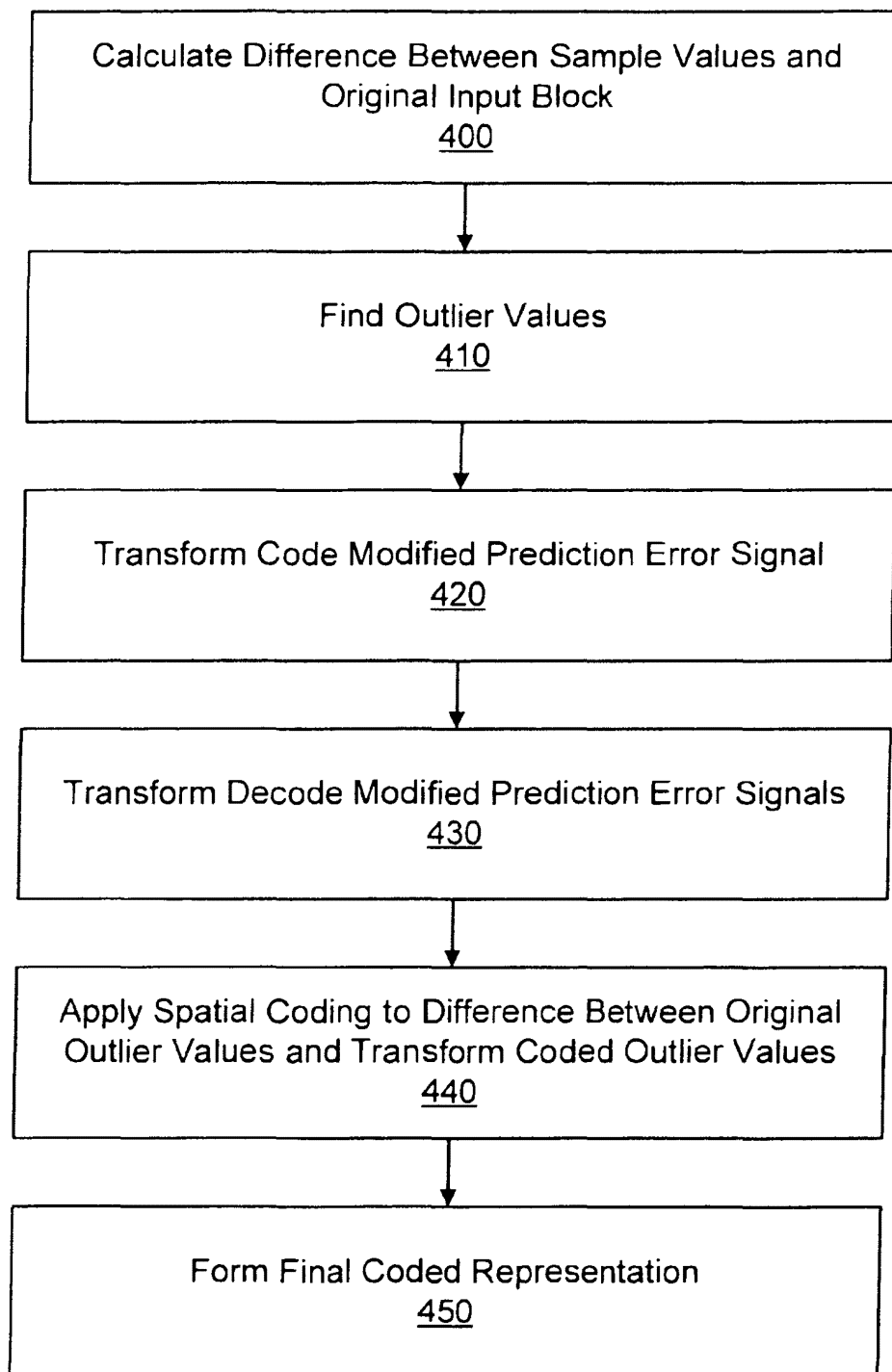


FIG. 4

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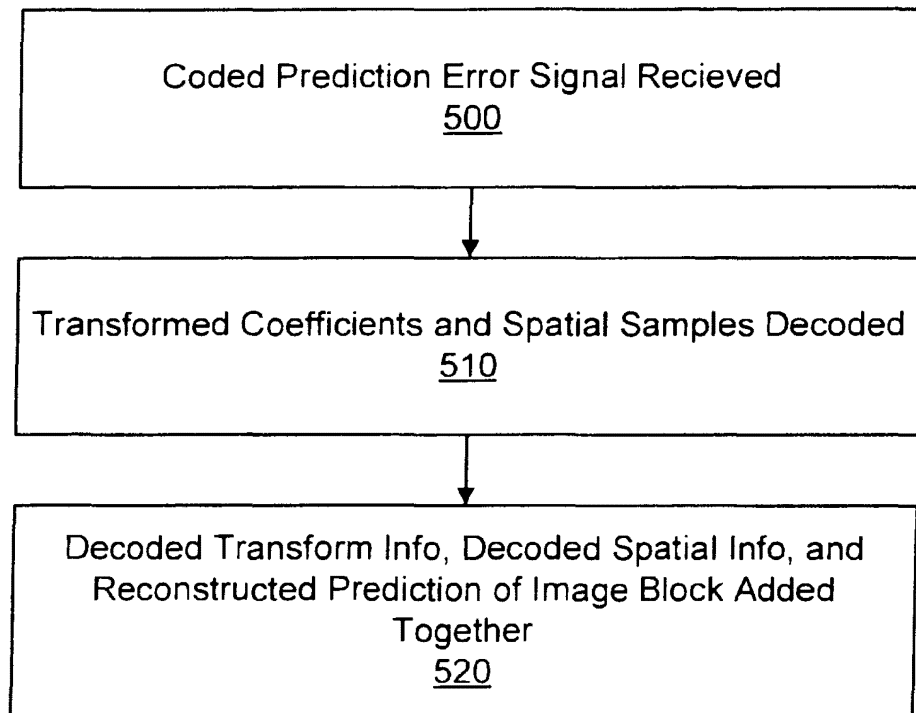


FIG. 5

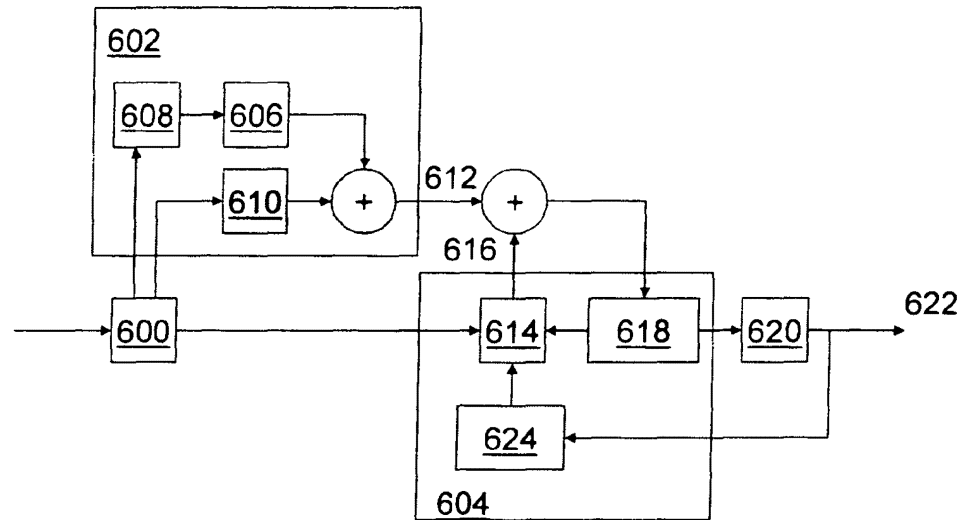


FIG. 6

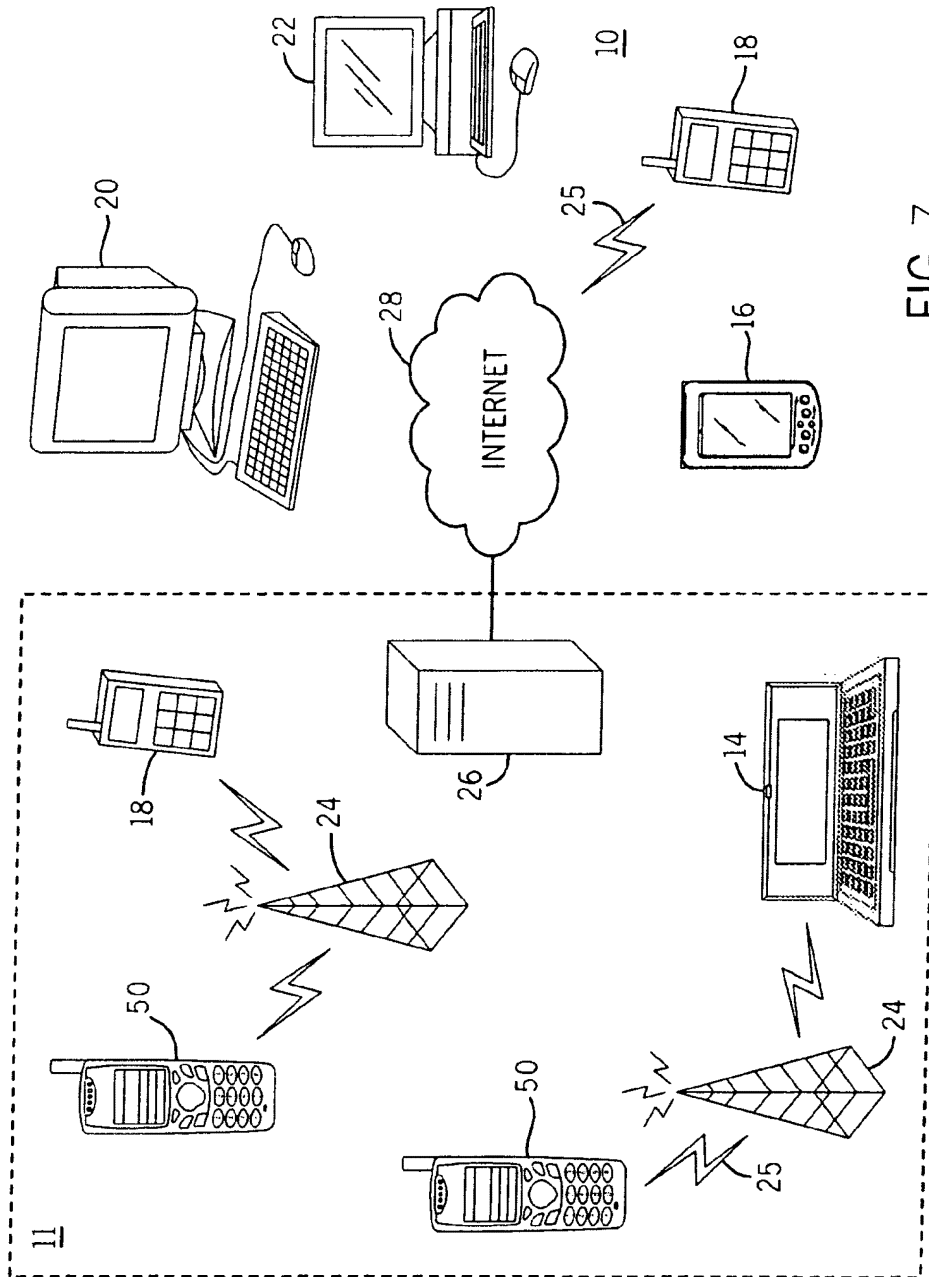


FIG. 7

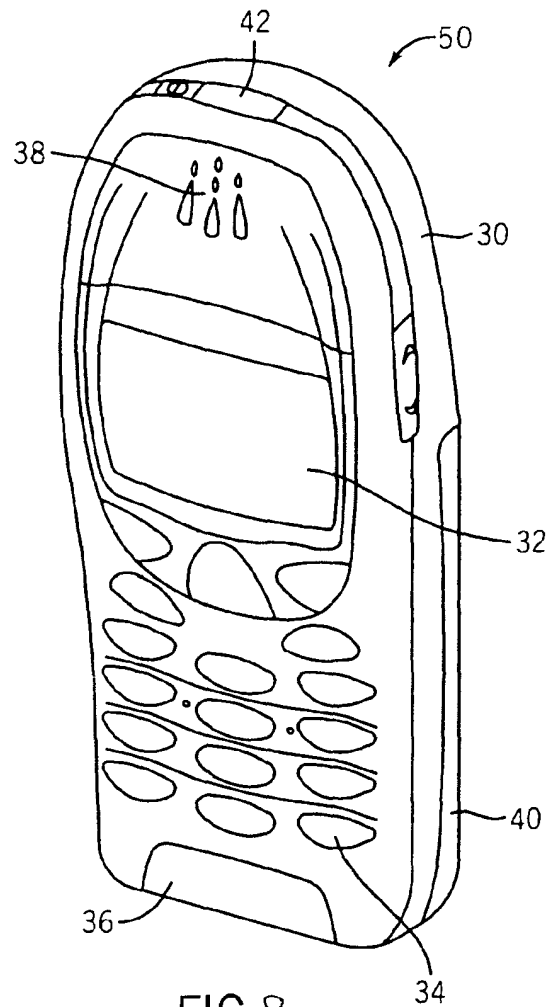


FIG. 8

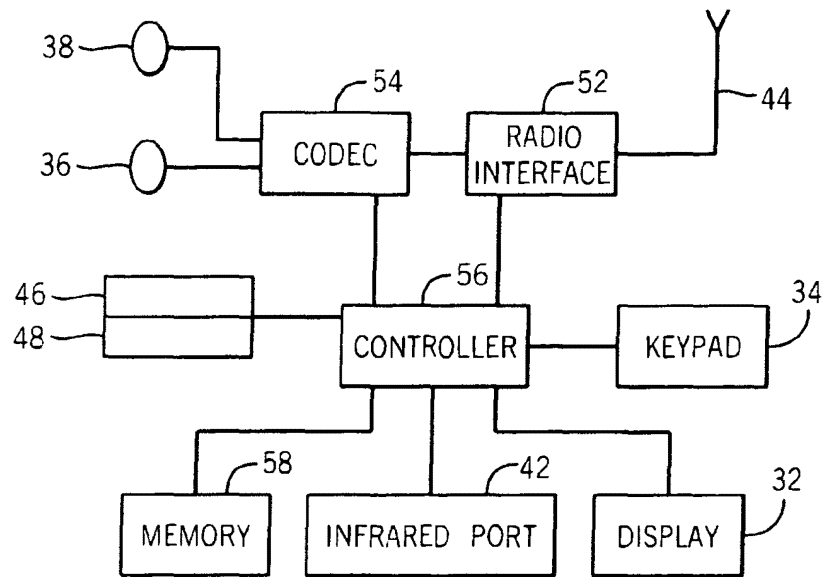


FIG. 9

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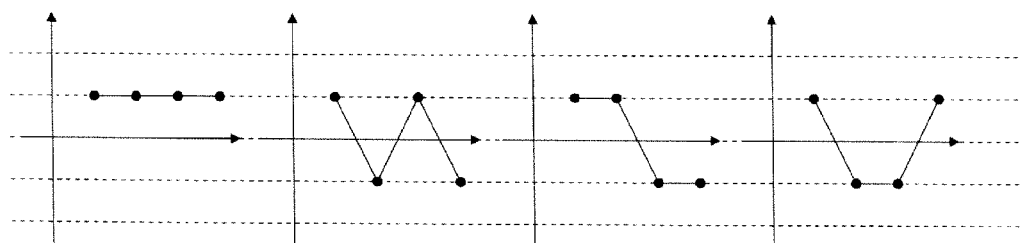


FIG. 1

(57) Abstract: A system and method for improving prediction error coding performance of various video compression algorithms. Various embodiments combine the energy compaction features of transform coding with localization properties of spatial coding. In various embodiments, the effects of pixel "outliers" are removed from the transform and are coded separately as a spatially coded pixel prediction, thereby improving the coding gain of the transform.

SPATIALLY ENHANCED TRANSFORM CODING

FIELD OF THE INVENTION

[0001] The present invention relates to the coding and decoding of digital video material. More particularly, the present invention relates to prediction error coding in both frequency and spatial domains.

BACKGROUND OF THE INVENTION

[0002] This section is intended to provide a background or context to the invention that is recited in the claims. The description herein may include concepts that could be pursued, but are not necessarily ones that have been previously conceived or pursued. Therefore, unless otherwise indicated herein, what is described in this section is not prior art to the description and claims in this application and is not admitted to be prior art by inclusion in this section.

[0003] A video codec comprises an encoder that transforms input video into a compressed representation suited for storage and/or transmission and a decoder that can uncompress the compressed video representation back into a viewable form. Typically, the encoder discards some information in the original video sequence in order to represent the video in a more compact form, i.e., at a lower bitrate.

[0004] Typical hybrid video codecs, for example ITU-T H.263 and H.264, encode video information in two phases. In the first phase, pixel values in a certain picture area or "block" are predicted. These pixel values can be predicted, for example, by motion compensation mechanisms, which involve finding and indicating an area in one of the previously coded video frames that corresponds closely to the block being coded. Additionally, pixel values can be predicted via by spatial mechanisms, which involve using the pixel values around the block to be coded in a specified manner. The second phase involves coding the prediction error, i.e. the difference between the predicted block of pixels and the original block of pixels. This is typically accomplished by transforming the difference in pixel values using a specified transform (e.g., a Discrete Cosine Transform (DCT) or a variant thereof), quantizing

the coefficients, and entropy coding the quantized coefficients. By varying the fidelity of the quantization process, the encoder can control the balance between the accuracy of the pixel representation (i.e., the picture quality) and the size of the resulting coded video representation (i.e., the file size or transmission bitrate).

[0005] The decoder reconstructs output video by applying prediction mechanisms that are similar to those used by the encoder in order to form a predicted representation of the pixel blocks (using motion or spatial information created by the encoder and stored in the compressed representation) and prediction error decoding (the inverse operation of the prediction error coding, recovering the quantized prediction error signal in the spatial pixel domain). After applying prediction and prediction error decoding processes, the decoder sums up the prediction and prediction error signals (i.e., the pixel values) to form the output video frame. The decoder (and encoder) can also apply additional filtering processes in order to improve the quality of the output video before passing it for display and/or storing it as a prediction reference for the forthcoming frames in the video sequence.

[0006] In typical video codecs, the motion information is indicated with motion vectors associated with each motion-compensated image block. Each of these motion vectors represents the displacement of the image block in the picture to be coded (in the encoder side) or decoded (in the decoder side) and the prediction source block in one of the previously coded or decoded pictures. In order to represent motion vectors efficiently, motion vectors are typically coded differentially with respect to block specific predicted motion vectors. In a typical video codec, the predicted motion vectors are created in a predefined way, for example by calculating the median of the encoded or decoded motion vectors of the adjacent blocks.

[0007] Typical video encoders utilize Lagrangian cost functions to find optimal coding modes, e.g., the desired macroblock mode and associated motion vectors. This kind of cost function uses a weighting factor λ to tie together the exact or estimated image distortion due to lossy coding methods and the exact or estimated amount of information that is required to represent the pixel values in an image area:

$$C = D + \lambda R \quad (1)$$

[0008] In Eq. (1), C is the Lagrangian cost to be minimized, D is the image distortion (e.g., the mean squared error) with the mode and motion vectors considered, and R the number of bits needed to represent the required data to reconstruct the image block in the decoder (including the amount of data to represent the candidate motion vectors).

[0009] Transform coding of the prediction error signal in video or image compression system typically comprises DCT-based linear transform, quantization of the transformed DCT coefficients, and context based entropy coding of the quantized coefficients. However, the transform can efficiently pack energy of the prediction error signal only under certain statistics, and the coding performance deteriorates when the prediction error to be transformed becomes less correlated. This causes suboptimal performance, especially in modern video and image coding systems employing advanced motion compensation and spatial prediction processes in order to achieve good quality predictions for the image blocks to be coded (thus, minimizing and decorrelating the prediction error signal).

[0010] To address some of the above issues, a number of hybrid video coding schemes have been developed. These hybrid systems typically comprise a hybrid of two redundancy reduction techniques--prediction and transformation. Prediction can take the form of inter-picture prediction, which is used to remove temporal redundancies in the signal. Intra-picture prediction may also be used in the H.264/Advanced Video Coding (AVC) standard where spatial redundancies are removed by exploiting the similarities between neighboring regions within a picture frame. As a consequence of these inter-picture and intra-picture prediction techniques, a residual/error signal is formed by removing the predicted picture frame from the original. This prediction error signal is then typically block transform coded using an 8x8 DCT transform in order to reduce spatial redundancies in the signal.

SUMMARY OF THE INVENTION

[0011] Various embodiments of the present invention provide a system and method for representing the prediction error signal as a weighted sum of different basis functions of a selected transform and quantized spatial samples. The basis functions

of the selected transform may comprise an orthogonal set of basis vectors, or the basis functions may not comprise an orthogonal set. According to various embodiments, the prediction error signal for a single image block is constructed using both transform basis functions and spatial samples (i.e., pixel values), thereby combining the desired features of both the transform and spatial coding approaches discussed previously. This allows for the utilization of those selected transform basis functions that give good overall representation of the image block with minimal amount of transform coefficients (representing the component of prediction error signal that is well correlated with the basis functions). Additionally, various embodiments of the present invention allow for the efficient spatial representation of those components of the prediction error signal of the same image block that are not well correlated with the basis functions of the applied transform (such as certain types of sensor noise, high frequency texture and edge information).

[0012] According to various embodiments of the present invention, a system and method of encoding a prediction error signal for a block of data comprises calculating a difference signal representing differences between sample values of a predicted block of data and values for an original input block. Transform coding and spatial coding are both performed to the difference signal, thereby creating a first and second representations of first and second components of the difference signal. The first and second representations are then combined to provide the prediction error signal.

[0013] Various embodiments of the present invention also provide a system and method of decoding a prediction error signal for a block of data, comprising receiving a coded prediction error signal, the coded prediction error signal including a plurality of transform coefficients and a plurality of spatial samples. The plurality of transformed coefficients are decoded into decoded transform information, and the plurality of spatial samples are decoded into decoded spatial information. The decoded transform information, the decoded spatial information, and a reconstructed prediction of the block of data are then added, thereby forming a decoded representation of the block of data.

[0014] The implementations of various embodiments of the present invention serve to improve the compression efficiency of modern video and image codecs. Although

a certain amount of increased computational complexity of encoding may be needed, fast algorithms can be applied in order to lower the encoding complexity that approaches the complexity level for traditional transform based coding. Any effect on the complexity for a decoder is negligible when implementing various embodiments of the present invention.

[0015] These and other advantages and features of the invention, together with the organization and manner of operation thereof, will become apparent from the following detailed description when taken in conjunction with the accompanying drawings, wherein like elements have like numerals throughout the several drawings described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 shows an example of basis functions of a Hadamard transform that can be used to encode image data;

[0017] Figure 2(a) is an example of four scalar values that are to be coded or decoded and representing the prediction error signal between the original image and the prediction image; Figure 2(b) shows the four weighted basis functions from Figure 1 being summed to the prediction error signal; and Figure 2(c) shows how the same prediction error signal can be reconstructed by summing up only the first basis function and a single spatial sample represented by an arrow;

[0018] Figure 3 is a block diagram of a video encoder constructed in accordance with one embodiment of the present invention;

[0019] Figure 4 is a flow chart showing one encoder algorithm which may be used in an embodiment of the present invention;

[0020] Figure 5 is a flow chart showing one decoder algorithm which may be used in various embodiments of the present invention;

[0021] Figure 6 is a block diagram of a video decoder constructed in accordance with one embodiment of the present invention;

[0022] Figure 7 is an overview diagram of a system within which various embodiments of the present invention may be implemented;

[0023] Figure 8 is a perspective view of an electronic device that can be used in conjunction with the implementation of various embodiments of the present invention; and

[0024] Figure 9 is a schematic representation of the circuitry which may be included in the electronic device of Figure 8.

DETAILED DESCRIPTION OF VARIOUS EMBODIMENTS

[0025] Various embodiments of the present invention provide a system and method for representing the prediction error signal as a weighted sum of different basis functions of a selected transform and quantized spatial samples. According to various embodiments, the prediction error signal for a single image block is constructed using both transform basis functions and spatial samples (i.e., pixel values), thereby combining the desired features of both the transform and spatial coding approaches discussed previously. This allows for the utilization of those selected transform basis functions that give good overall representation of the image block with minimal amount of transform coefficients (representing the component of prediction error signal that is well correlated with the basis functions). Additionally, various embodiments of the present invention allow for the efficient spatial representation of those components of the prediction error signal of the same image block that are not well correlated with the basis functions of the applied transform (such as certain types of sensor noise, high frequency texture and edge information).

[0026] Figures 1 and 2 show a simplified example of how various embodiments of the present invention are operable in one dimension. Figure 1 shows an example of basis functions of a one-dimensional linear transform that can be used to encode image data (namely a Hadamard transform). The weighted sum of these four basis functions can be used to represent any four samples. Figure 2(a) is an example of four scalar values that are to be coded or decoded and representing the prediction error signal between the original image and the prediction image. In Figure 2(b), the four weighted basis functions from Figure 1 are summed to the prediction error signal (1.5 times the first, 0.5 times the second, -0.5 times the third and -0.5 times the fourth basis function). In Figure 2(c) it is demonstrated how the same prediction error signal

can be reconstructed by summing up only the first basis function and a single spatial sample represented by an arrow. In this example, compression efficiency improvement can be expected, as the signal is represented by a single transform coefficient and a single spatial sample instead of four transform coefficients weighting the four Hadamard basis functions (as shown in Figure 2(b)).

[0027] Figure 3 is a block diagram of a video encoder constructed in accordance with one embodiment of the present invention. More particularly, Figure 3 shows how an image to be encoded 300 undergoes pixel prediction 302, prediction error coding 303 and prediction error decoding 304. For pixel prediction 302, the image 300 undergoes both inter-prediction 306 and intra-prediction 308 which, after mode selection 310, results in prediction representation of an image block 312. A preliminary reconstructed image 314 is also used for intra-prediction 308. Once all of the image blocks are processed, the preliminary reconstructed image 314 undergoes filtering at 316 to create a final reconstructed image 340, which is sent to a reference frame memory 318 and is also used for inter-prediction 306 of future frames.

[0028] The prediction representation of the image block 312, as well as the image to be encoded 300, are used together to define a prediction error signal 320 which is used for prediction error coding 303. In prediction error coding 303, the prediction error signal 320 undergoes feature selection 322 and spatial quantization 324, as well as transform 326 and quantization 328 (both after feature selection 322). The data describing prediction error and predicted representation of the image block 312 (e.g., motion vectors, mode information and quantized DCT+spatial samples) are passed to entropy coding 330. The prediction error decoding 304 is substantially the opposite of the prediction error coding 303, with the prediction error decoding including an inverse spatial quantizer 332, an inverse transform 334 and an inverse quantization 336. The result of the prediction error decoding 304 is a reconstructed prediction error signal 338, which is used in combination with the predicted representation of the image block 312 to create the preliminary reconstructed image 314.

[0029] Figure 4 is a flow chart showing one encoder algorithm which may be used in an embodiment of the present invention. However, as discussed below, a variety of different algorithms may be used according to principles of the present invention. At

400 in Figure 4, the difference between sample values of a predicted block and an original input block is calculated. It should be noted that "values" and "outlier values" as used herein are intended to refer to these difference values. At 410, outlier values are found. In this case, the amplitude depends on the expected accuracy of the coded representation; smaller amplitude representations qualify as outliers if one is targeting high bitrate good quality representation, and only high amplitude representations qualify if one is targeting a lower bitrate, lower quality representation. At 420, the modified prediction error signal is transform coded (involving transform, quantization and entropy coding), with the outlier values being substituted by interpolated representations of those values, e.g., by averaging the neighboring prediction error values. At 430, the modified prediction error signals are transform decoded back to the spatial domain. At 440, spatial coding is applied (involving quantization and entropy coding without transform) to the difference between the original outlier values and the transform decoded outlier values. At 450, the final coded representation of the prediction error signal is formed by joining the transform coded data and the spatial coded data. In an alternative embodiment, the spatial coding occurs before transform coding.

[0030] When considering the one-dimensional example depicted in Figures 2(a)-2(c), the algorithm outlined in Figure 4 would process the relevant data as follows. As discussed previously, Figure 2(a) represents the difference signal [1 1 3 1] to be coded. In this case, [3] is an outlier. Therefore, the prediction error signal is modified by substituting the [3] with an average of the second and fourth samples, making the signal [1 1 1 1]. The difference between the original outlier sample ([3]) and the transform coded outlier value ([1]) is then spatial coded, making the spatial coded signal [0 0 2 0]. The entropy coded representations of the transform coded and spatial coded signals are then written to the bitstream. Thereafter, the decoder can recover the coded signal by adding up the inverse transformed data [1 1 1 1] and the inverse spatial coded data [0 0 2 0] (together with the prediction samples of the image block).

[0031] When considering the above example, it is important to note that the choice of Hadamard basis vectors for the transform is only intended to be exemplary in nature. In fact, the various methods and techniques described herein can be applied to

any transform employing basis functions, and the basis functions do not necessarily need to be orthogonal.

[0032] A video or image codec, according to various embodiments the present invention, can be implemented in various ways. In the case of an encoder, the encoder can use different strategies to find the desired transform coefficients and spatial samples. For example, an encoder can first transform code the signal and apply spatial coding to the residual. The encoder can also first apply spatial coding to the signal, followed by transform coding of the residual. Additionally, some or all of the transform coefficients can be set to zero in order to improve the coding performance. Some or all spatial samples can also be set to zero in order to improve the coding performance. An encoder can also iteratively modify transform coefficients and/or spatial samples in order to improve the coding performance until a desired performance or a maximum defined number of iterations is achieved.

[0033] In terms of quantization and dequantization, the quantization and dequantization of transform coefficients and spatial samples can be tied together (e.g., a quantization step size for both transform coefficients and spatial samples can be derived from a single parameter). Alternatively, different quantizations and dequantizations can be applied to transform coefficients and spatial samples.

[0034] For the coding and decoding of spatial samples, such coding and decoding can depend on transform coefficients and vice versa. Alternatively, the coding and decoding of spatial samples, transform coefficients or both can depend on the prediction signal, on the other transform coefficients and spatial samples in the same image or in other images.

[0035] In addition to the above, it can be indicated that there are no transform coefficients or spatial samples for a specific image area or image. It can also be indicated that only spatial coding or only transform coding is used for a specific image area or image. The number of spatial samples can be coded and decoded as one unit, for example representing certain patterns of textures. Pre- and/or post-processing mechanisms can be applied to the prediction signal, prediction error signal reconstructed signal or any combination thereof. The method can be used to code and decode other information instead or in addition to the prediction error signals. The

codec can limit the usage of either transform coefficients (e.g., allow only low frequency transform coefficients to be present in the coded representation of the signal) or spatial samples.

[0036] Figure 5 shows a decoding process according to various embodiments of the present invention. At 500 in Figure 5, a video decoder receives a coded prediction error signal which comprises both transformed coefficients and spatial samples. At 510, both the transformed coefficients and the spatial samples are decoded. At 520, the decoded transform information, the decoded spatial information and reconstructed prediction of the image block are added together to form decoded representation of the image block.

[0037] Figure 6 is a block diagram of a video decoder constructed in accordance with one embodiment of the present invention. As shown in Figure 6, entropy decoding 600 is followed by both prediction error decoding 602 and pixel prediction 604. In prediction error decoding 602, in addition to an inverse transform 606 and inverse quantization 608, an inverse spatial quantizer 610 is used as discussed herein, ultimately resulting in a reconstructed prediction error signal 612. For pixel prediction 604, either intra-prediction or inter-prediction occurs at 614 to create a predicted representation of an image block 616. The predicted representation of the image block 616 is used in conjunction with the reconstructed prediction error signal 612 to create a preliminary reconstructed image 618, which in turn can be used both for prediction 614. Once all of the image blocks have been processed, the preliminary reconstructed image 618 is passed for filtering 620. The filtered image can also be stored in reference frame memory 624, making it usable for prediction 614 as well.

[0038] Figure 7 shows a system 10 in which various embodiments of the present invention can be utilized, comprising multiple communication devices that can communicate through one or more networks. The system 10 may comprise any combination of wired or wireless networks including, but not limited to, a mobile telephone network, a wireless Local Area Network (LAN), a Bluetooth personal area network, an Ethernet LAN, a token ring LAN, a wide area network, the Internet, etc. The system 10 may include both wired and wireless communication devices.

[0039] For exemplification, the system 10 shown in Figure 7 includes a mobile telephone network 11 and the Internet 28. Connectivity to the Internet 28 may include, but is not limited to, long range wireless connections, short range wireless connections, and various wired connections including, but not limited to, telephone lines, cable lines, power lines, and the like.

[0040] The exemplary communication devices of the system 10 may include, but are not limited to, an electronic device 50, a combination personal digital assistant (PDA) and mobile telephone 14, a PDA 16, an integrated messaging device (IMD) 18, a desktop computer 20, a notebook computer 22, etc. The communication devices may be stationary or mobile as when carried by an individual who is moving. The communication devices may also be located in a mode of transportation including, but not limited to, an automobile, a truck, a taxi, a bus, a train, a boat, an airplane, a bicycle, a motorcycle, etc. Some or all of the communication devices may send and receive calls and messages and communicate with service providers through a wireless connection 25 to a base station 24. The base station 24 may be connected to a network server 26 that allows communication between the mobile telephone network 11 and the Internet 28. The system 10 may include additional communication devices and communication devices of different types.

[0041] The communication devices may communicate using various transmission technologies including, but not limited to, Code Division Multiple Access (CDMA), Global System for Mobile Communications (GSM), Universal Mobile Telecommunications System (UMTS), Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), Transmission Control Protocol/Internet Protocol (TCP/IP), Short Messaging Service (SMS), Multimedia Messaging Service (MMS), e-mail, Instant Messaging Service (IMS), Bluetooth, IEEE 802.11, etc. A communication device involved in implementing various embodiments of the present invention may communicate using various media including, but not limited to, radio, infrared, laser, cable connection, and the like.

[0042] Figures 8 and 9 show one representative electronic device 50 within which the present invention may be implemented. It should be understood, however, that the present invention is not intended to be limited to one particular type of device. The

electronic device 50 of Figures 8 and 9 includes a housing 30, a display 32 in the form of a liquid crystal display, a keypad 34, a microphone 36, an ear-piece 38, a battery 40, an infrared port 42, an antenna 44, a smart card 46 in the form of a UICC according to one embodiment of the invention, a card reader 48, radio interface circuitry 52, codec circuitry 54, a controller 56 and a memory 58. Individual circuits and elements are all of a type well known in the art, for example in the Nokia range of mobile telephones.

[0043] The various embodiments of the present invention described herein is described in the general context of method steps or processes, which may be implemented in one embodiment by a computer program product, embodied in a computer-readable medium, including computer-executable instructions, such as program code, executed by computers in networked environments. Generally, program modules may include routines, programs, objects, components, data structures, etc. that perform particular tasks or implement particular abstract data types. Computer-executable instructions, associated data structures, and program modules represent examples of program code for executing steps of the methods disclosed herein. The particular sequence of such executable instructions or associated data structures represents examples of corresponding acts for implementing the functions described in such steps or processes.

[0044] Software and web implementations of various embodiments of the present invention can be accomplished with standard programming techniques with rule-based logic and other logic to accomplish various database searching steps or processes, correlation steps or processes, comparison steps or processes and decision steps or processes. It should be noted that the words "component" and "module," as used herein and in the following claims, is intended to encompass implementations using one or more lines of software code, and/or hardware implementations, and/or equipment for receiving manual inputs.

[0045] The foregoing description of embodiments of the present invention have been presented for purposes of illustration and description. The foregoing description is not intended to be exhaustive or to limit embodiments of the present invention to the precise form disclosed, and modifications and variations are possible in light of

the above teachings or may be acquired from practice of various embodiments of the present invention. The embodiments discussed herein were chosen and described in order to explain the principles and the nature of various embodiments of the present invention and its practical application to enable one skilled in the art to utilize the present invention in various embodiments and with various modifications as are suited to the particular use contemplated.

WHAT IS CLAIMED IS:

- 1 1. A method of encoding a prediction error signal for a block of data,
2 comprising:
3 calculating a difference signal representing differences between sample
4 values of a predicted block of data and values for an original input block;
5 performing transform coding to the difference signal, thereby creating
6 a first representation of a first component of the difference signal;
7 performing spatial coding to the difference signal, thereby creating a
8 second representation of a first component of the difference signal; and
9 joining the first and second representations.
- 1 2. The method of claim 1, further comprising, before performing
2 transform coding and spatial coding, substituting outlier values in the difference
3 signal with non-outlier values to create a modified prediction error signal.
- 1 3. The method of claim 2, wherein transform coding is applied to the
2 modified prediction error signal and spatial coding is applied to a residual thereof.
- 1 4. The method of claim 2, wherein spatial coding is applied to the
2 modified prediction error signal and transform coding is applied to a residual thereof.
- 1 5. The method of claim 1, wherein, for transform coding, at least one
2 transform coefficient is set to zero.
- 1 6. The method of claim 1, wherein, for spatial coding, at least one spatial
2 sample is set to zero.
- 1 7. The method of claim 2, wherein the non-outlier values used to replace
2 the outlier values comprise an average of neighboring prediction error values.
- 1 8. The method of claim 1, further comprising providing an indication that
2 no transform coefficients exist in the block of data if appropriate.

1 9. The method of claim 1, further comprising providing an indication that
2 no spatial samples exist in the block of data if appropriate.

1 10. The method of claim 1, wherein for the transform coding, a transform
2 coefficient is formed, the transform coefficient comprising a weighting coefficient of
3 a discrete transform basis vector.

1 11. The method of claim 10, wherein the discrete transform comprises a
2 discrete orthogonal transform.

1 12. A computer program product, embodied in a computer-readable
2 medium, comprising computer code configured to perform the implemented the
3 processes of claim 1.

1 13. An apparatus, comprising:
2 a processor; and
3 a memory unit communicatively connected to a controller and
4 comprising:
5 computer code for performing transform coding to the
6 difference signal, thereby creating a first representation of a first component of the
7 difference signal;
8 computer code for performing spatial coding to the difference
9 signal, thereby creating a second representation of a first component of the difference
10 signal; and
11 computer code for joining the first and second representations.

1 14. The apparatus of claim 13, wherein the memory unit further comprises
2 computer code for, before performing transform coding and spatial coding,
3 substituting outlier values in the difference signal with non-outlier values to create a
4 modified prediction error signal.

1 15. The apparatus of claim 14, wherein transform coding is applied to the
2 modified prediction error signal and spatial coding is applied to a residual thereof.

1 16. The apparatus of claim 14, wherein spatial coding is applied to the
2 modified prediction error signal and transform coding is applied to a residual thereof.

1 17. The apparatus of claim 13, wherein, for transform coding, at least one
2 transform coefficient is set to zero.

1 18. The apparatus of claim 13, wherein, for spatial coding, at least one
2 spatial sample is set to zero.

1 19. The apparatus of claim 13, wherein the non-outlier values used to
2 replace the outlier values comprise an average of neighboring prediction error values.

1 20. The apparatus of claim 13, further comprising providing an indication
2 that no transform coefficients exist in the block of data if appropriate.

1 21. The apparatus of claim 13, further comprising providing an indication
2 that no spatial samples exist in the block of data if appropriate.

1 22. A method of decoding a prediction error signal for a block of data,
2 comprising:
3 receiving a coded prediction error signal, the coded prediction error
4 signal including a plurality of transform coefficients and a plurality of spatial samples;
5 decoding the plurality of transformed coefficients into decoded
6 transform information;
7 decoding the plurality of spatial samples into decoded spatial
8 information; and
9 adding the decoded transform information, the decoded spatial
10 information, and a reconstructed prediction of the block of data, thereby forming a
11 decoded representation of the block of data.

1 23. The method of claim 22, wherein an indication is provided that no
2 transform coefficients exist in the block of data if appropriate.

1 24. The method of claim 22, wherein an indication is provided that that no
2 spatial samples exist in the block of data if appropriate.

1 25. The method of claim 22, wherein the decoding of the plurality of
2 transformed coefficients and spatial samples includes dequantization of each, and
3 wherein the dequantization of transformed coefficients and spatial samples are related
4 to each other.

1 26. The method of claim 22, wherein the decoding of the plurality of
2 transformed coefficients and spatial samples includes dequantization of each, and
3 wherein the dequantization of transformed coefficients and spatial samples are
4 different from each other.

1 27. The method of claim 22, wherein the decoding of the spatial samples is
2 dependent upon the decoding of the transformed coefficients.

1 28. The method of claim 22, wherein the decoding of the transformed
2 coefficients is dependent upon the decoding of the spatial samples.

1 29. The method of claim 22, wherein at least some of the plurality of
2 spatial samples are decoded as a single unit.

1 30. A computer program product, embodied in a computer-readable
2 medium, comprising computer code configured to perform the processes of claim 19.

1 31. An apparatus, comprising:
2 a processor; and
3 a memory unit communicatively connected to the processor and
4 including:
5 computer code for processing a received coded prediction error
6 signal, the coded prediction error signal including a plurality of transformed
7 coefficients and a plurality of spatial samples;
8 computer code for decoding the plurality of transformed
9 coefficients into decoded transform information;

10 computer code for decoding the plurality of spatial samples into
11 decoded spatial information; and
12 computer code for adding the decoded transform information,
13 the decoded spatial information, and a reconstructed prediction of the block of data,
14 thereby forming a decoded representation of the block of data.

1 32. The apparatus of claim 31, wherein an indication is provided that no
2 transform coefficients exist in the block of data if appropriate.

1 33. The apparatus of claim 31, wherein an indication is provided that that
2 no spatial samples exist in the block of data if appropriate.

1 34. The apparatus of claim 31, wherein the decoding of the plurality of
2 transformed coefficients and spatial samples includes dequantization of each, and
3 wherein the dequantization of transformed coefficients and spatial samples are related
4 to each other.

1 35. The apparatus of claim 31, wherein the decoding of the plurality of
2 transformed coefficients and spatial samples includes dequantization of each, and
3 wherein the dequantization of transformed coefficients and spatial samples are
4 different from each other.

1 36. The apparatus of claim 31, wherein the decoding of the spatial samples
2 is dependent upon the decoding of the transformed coefficients.

1 37. The apparatus of claim 31, wherein the decoding of the transformed
2 coefficients is dependent upon the decoding of the spatial samples.

1 38. The apparatus of claim 31, wherein at least some of the plurality of
2 spatial samples are decoded as a single unit.

1 39. A method of encoding a prediction error signal for a block of data,
2 comprising:
3 calculating a difference signal representing differences between sample
4 values of a predicted block of data and values for an original input block;

5 substituting outlier values in the difference signal with non-outlier
6 values to create a modified prediction error signal;
7 performing one of transform coding and spatial coding to the modified
8 prediction error signal, creating one of a transform coded data and spatial coded data
9 performing an inverse of the one of transform coding and spatial
10 coding;
11 applying the other of transform coding and spatial coding to a residual
12 from the inverse transform or spatial decoding, creating the other of transform coded
13 data and spatial coded data; and
14 joining the transform coded data and the spatial coded data.

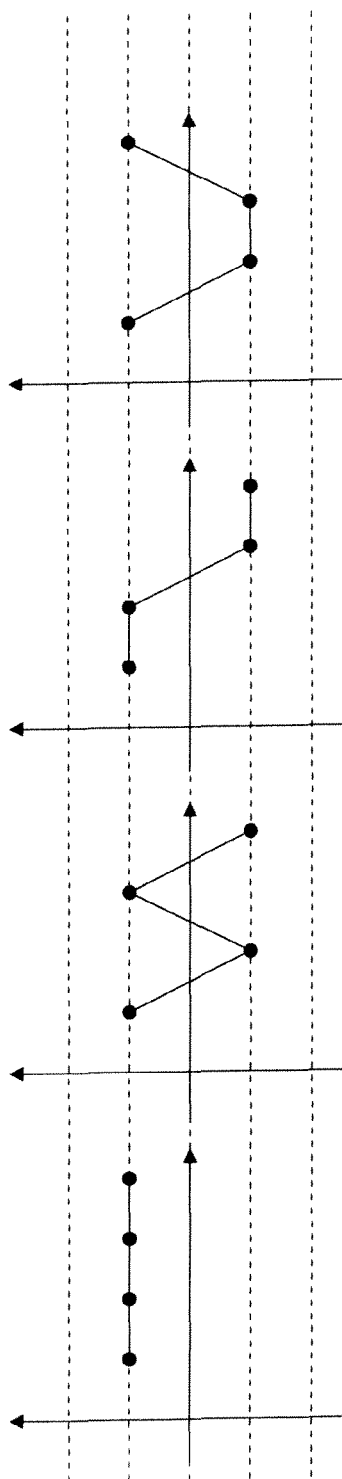


FIG. 1

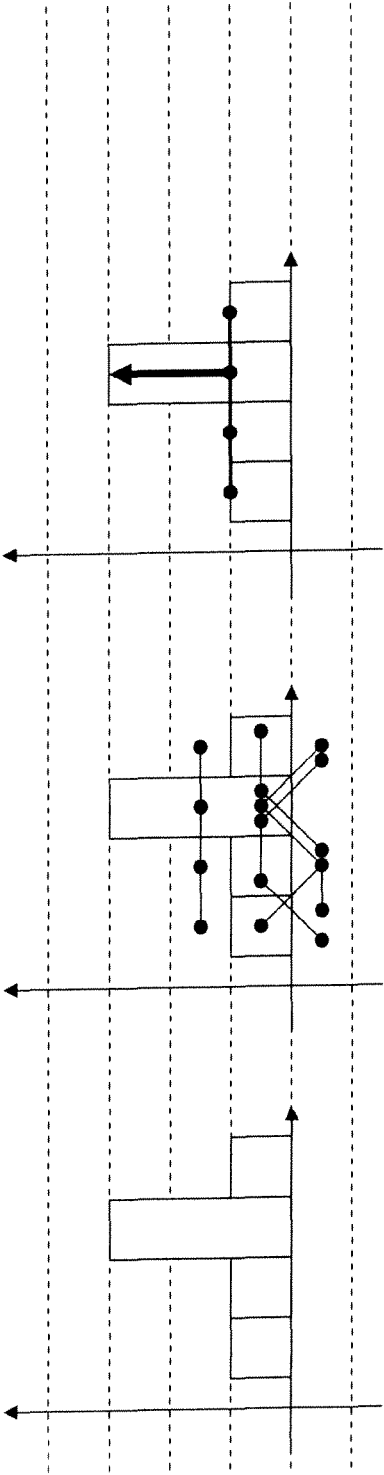


FIG. 2(c)

FIG. 2(b)

FIG. 2(a)

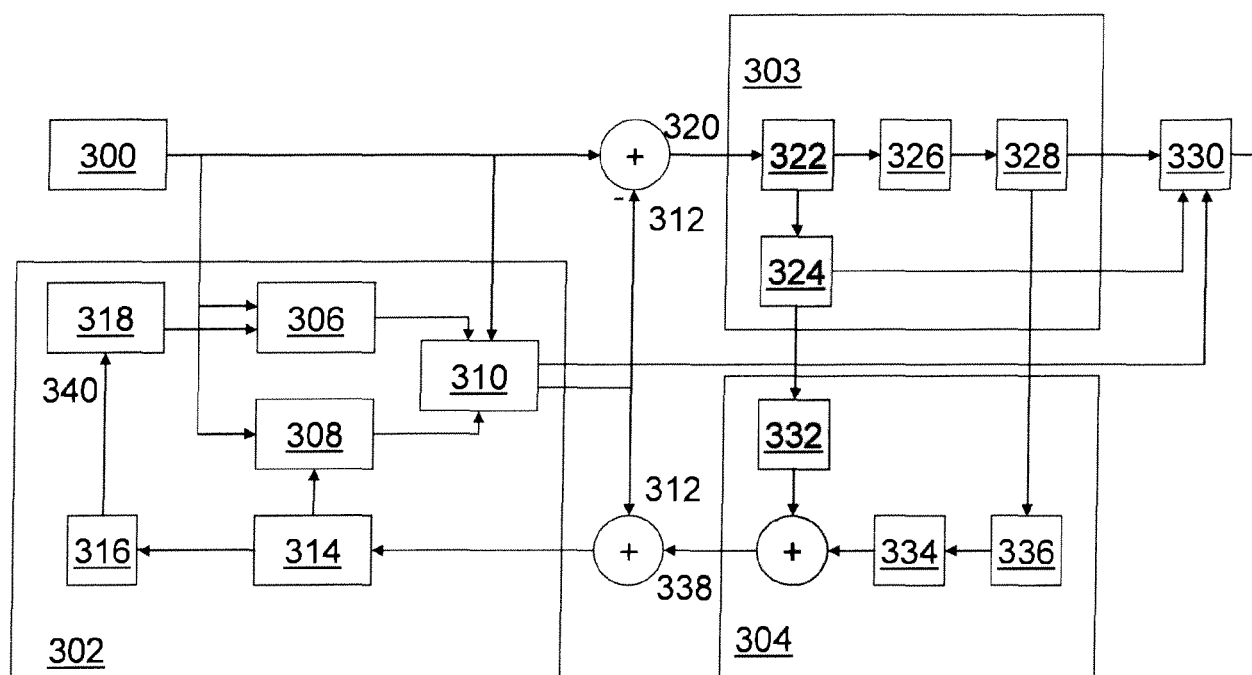


FIG. 3

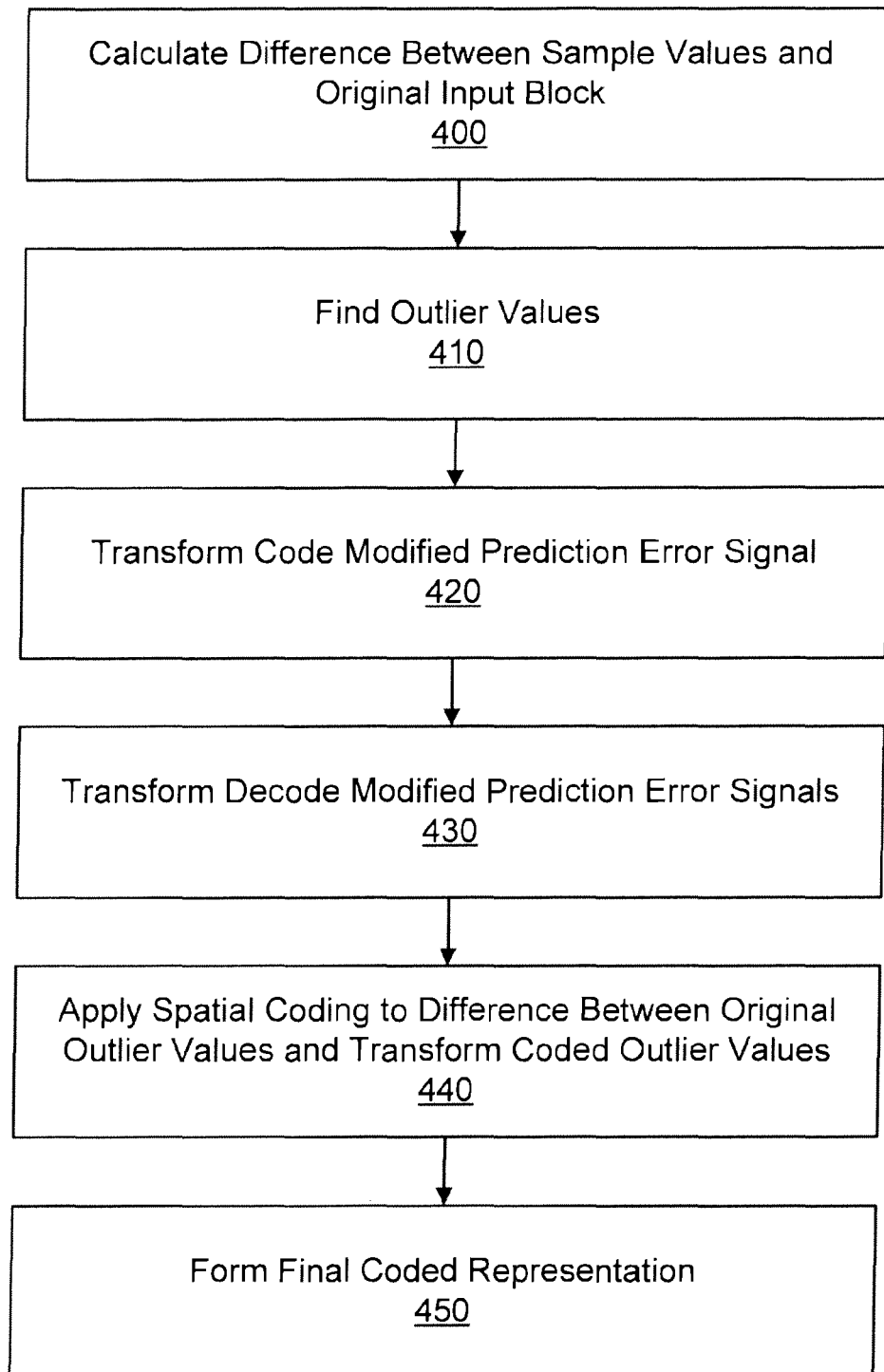


FIG. 4

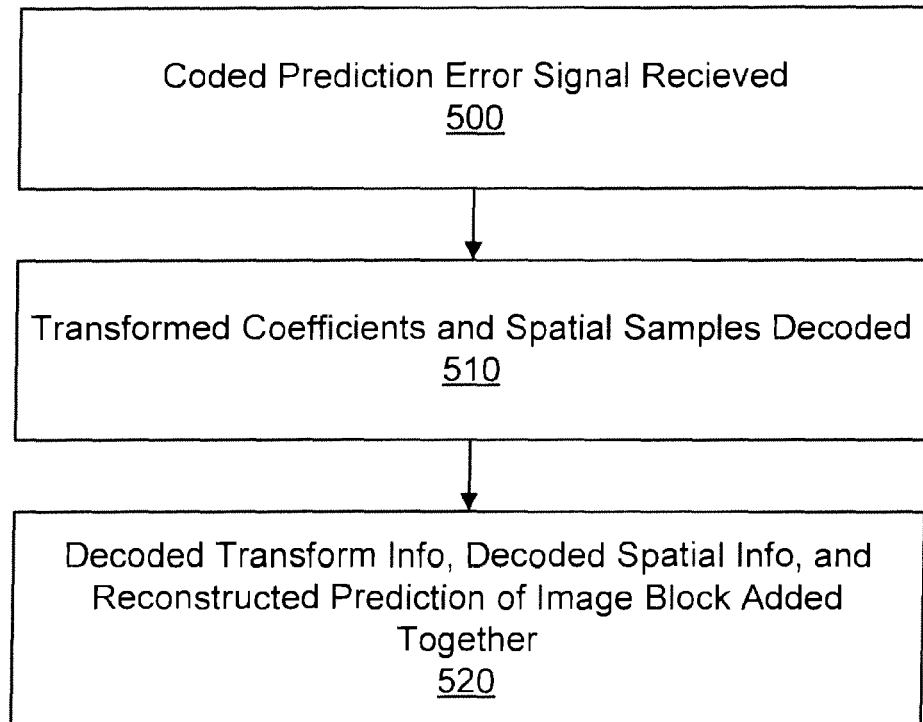


FIG. 5

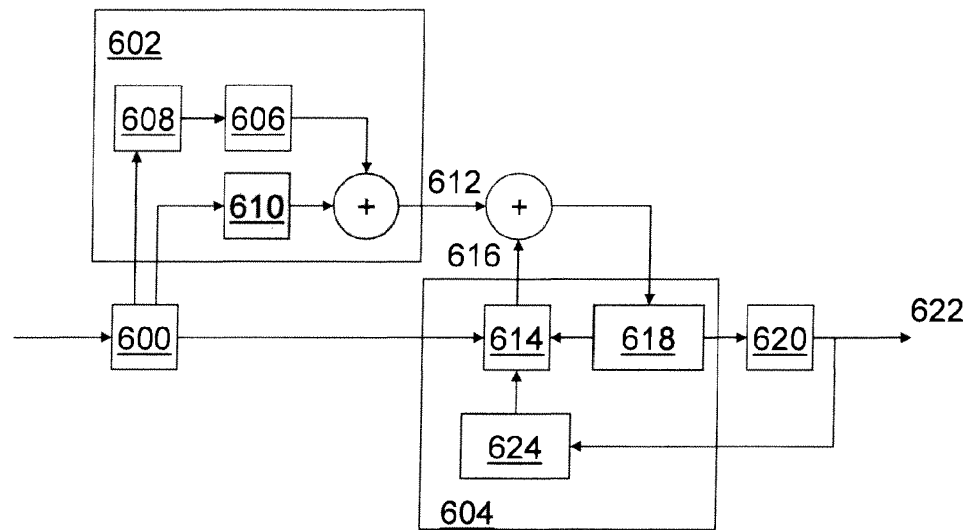


FIG. 6

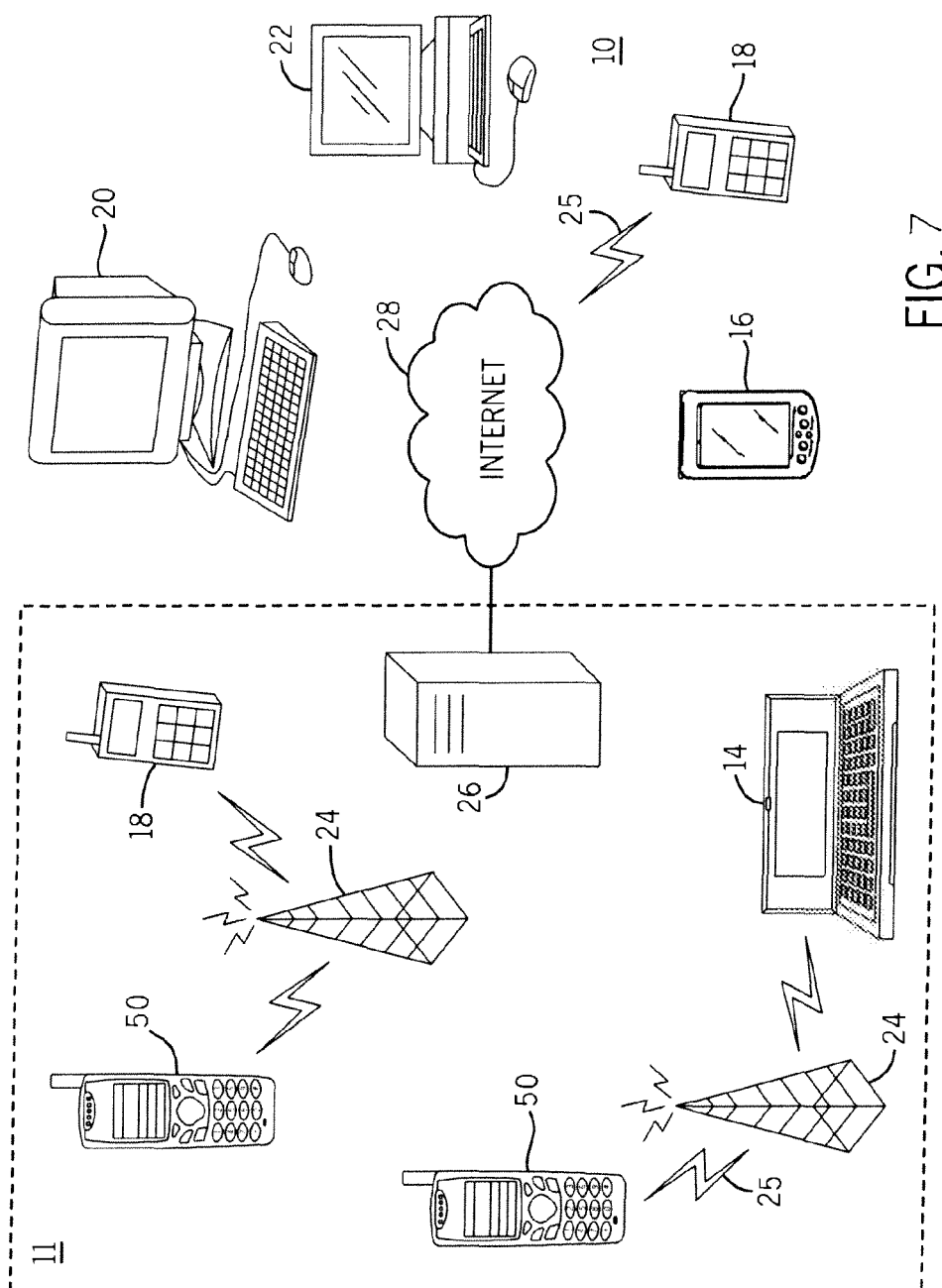
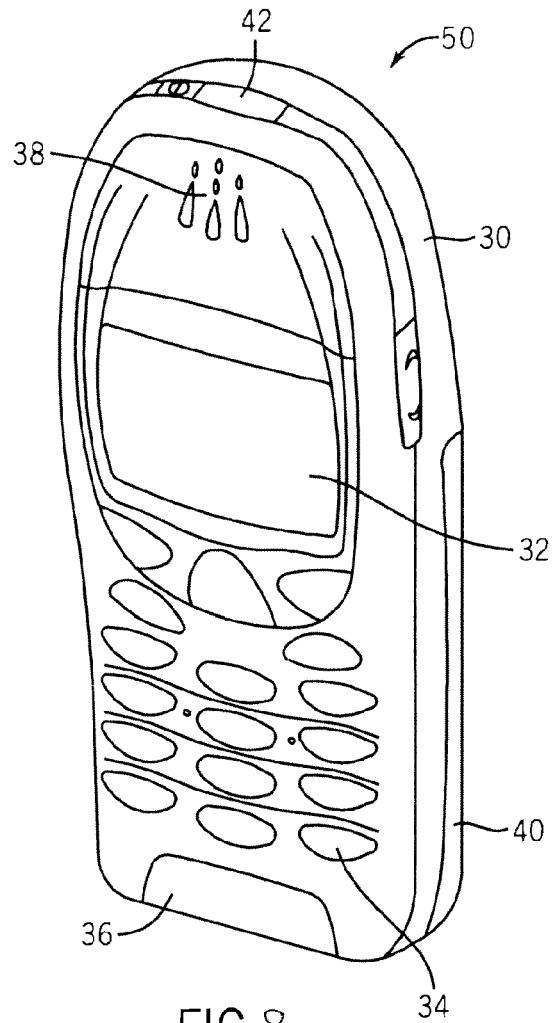


FIG. 7



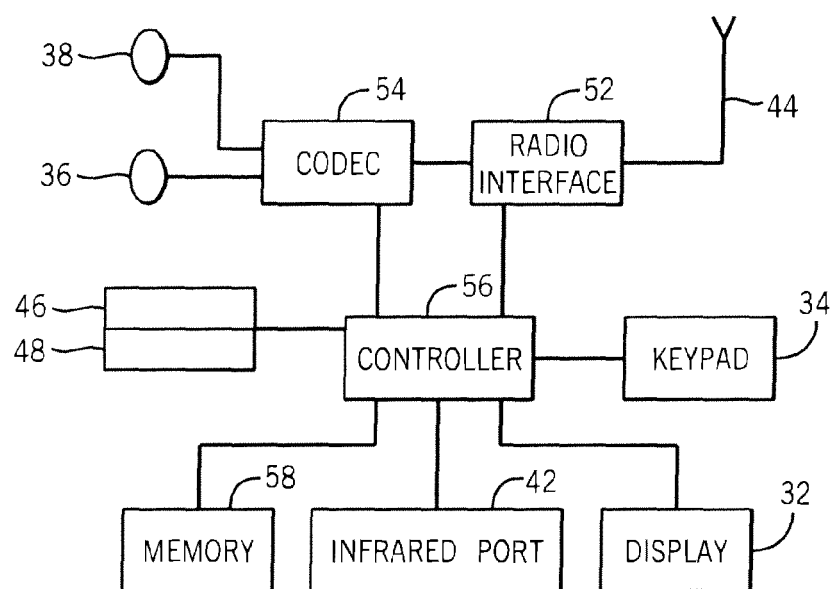


FIG. 9

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APPLICATION NUMBER: 60/911,480

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By Authority of the
Under Secretary of Commerce for Intellectual Property
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Applicant: Jani Lainema
Title: SPATIALLY ENHANCED
TRANSFORM CODING
Appl. No.: Unknown
Filing Date: Herewith

PROVISIONAL PATENT APPLICATION
TRANSMITTAL

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Transmitted herewith for filing under 37 C.F.R. § 1.53(c) is the provisional patent application of:

Jani Lainema
Kisakentäkatu 12 B 6
Tampere
FIN-33230
Finland

☐ Applicant claims small entity status under 37 CFR 1.27(c)(1).

Enclosed are:

- ☒ Description, Claim(s), and Abstract (20 pages).
- ☒ Formal drawings (9 sheets, Figures 1-9).
- ☐ Assignment of the invention to Nokia Corporation.
- ☐ Assignment Recordation Cover Sheet.

- ☐ Small Entity statement(s).
- ☒ Application Data Sheet (37 CFR 1.76).

The adjustment to the number of sheets for EFS-Web filing follows:

Number of Sheets	EFS-Web Adjustment	Number of Sheets for EFS-Web
29	x 75%	22

The filing fee is calculated below:

	Rate	Fee Totals
Basic Fee	\$200.00	\$200.00
Size Fee 22 - 100 = 0 x \$250.00		\$0.00
Surcharge under 37 CFR 1.16(e) for late payment of filing fee + \$50.00 =		\$0.00
SUBTOTAL: =		\$200.00
☐ Small Entity Fees Apply (subtract ½ of above): =		\$0.00
TOTAL FILING FEE: =		\$200.00
Assignment Recordation Fee: + \$40.00 =		\$0.00
TOTAL FEE =		\$200.00

The above-identified fees of \$200.00 are being paid by credit card via EFS-Web.

The Commissioner is hereby authorized to charge any additional fees which may be required regarding this application under 37 C.F.R. §§ 1.16-1.17, or credit any overpayment, to Deposit Account No. 50-0872. Should no proper payment be enclosed herewith, as by the credit card payment instructions in EFS-Web being incorrect or absent, resulting in a rejected or incorrect credit card transaction, the Commissioner is authorized to charge the unpaid amount to Deposit Account No. 50-0872.

Further, Applicant, by and through his attorney of record, hereby expressly abandons the application as of the filing date of this letter. This is an abandonment of the application only, and is not to be construed as an abandonment of the invention disclosed in the

application. It is respectfully requested that the Office acknowledge abandonment of the application as of the filing date of this letter in a communication mailed to the undersigned.

Please direct all correspondence to the undersigned attorney or agent at the address indicated below.

Respectfully submitted,

Date: April 12, 2007

By /G. Peter Albert Jr./

FOLEY & LARDNER LLP
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Electronic Acknowledgement Receipt

EFS ID:	1679373
Application Number:	60911480
International Application Number:	
Confirmation Number:	1635
Title of Invention:	SPATIALLY ENHANCED TRANSFORM CODING
First Named Inventor/Applicant Name:	Jani Lainema
Customer Number:	30542
Filer:	Glenn Peter Albert Jr./Marisol Moretto
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Application Type:	Provisional

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Deposit Account	

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Document Number	Document Description	File Name	File Size(Bytes)	Multi Part .zip	Pages (if appl.)
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1	Transmittal of New Application	7825-Transmittal-04-12-2007.pdf	107205	no	3
Warnings:					
Information:					
2	Application Data Sheet	7825-ADS-04-12-2007.pdf	56952	no	2
Warnings:					
Information:					
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Warnings:					
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4	Claims	7825-Claims-04-12-2007.pdf	96528	no	6
Warnings:					
Information:					
5	Abstract	7825-Abstract-04-12-2007.pdf	59918	no	1
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If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

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Application Data Sheet

Application Information

Application Type::	Provisional
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Suggested Group Art Unit::	
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Computer Readable Form (CRF)?::	No
Title::	SPATIALLY ENHANCED TRANSFORM CODING
Attorney Docket Number::	037145-7825
Request for Early Publication?::	No
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Total Drawing Sheets::	9
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Petition included?::	No
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Applicant Information

Applicant Authority Type::	Inventor
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Representative Information

Representative Customer Number::	30542	
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Domestic Priority Information

Application::	Continuity Type::	Parent Application::	Parent Filing Date::

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Country::	Application number::	Filing Date::	Priority Claimed::

Assignee Information

Assignee Name:: Nokia Corporation

SPATIALLY ENHANCED TRANSFORM CODING

FIELD OF THE INVENTION

[0001] The present invention relates to the coding and decoding of digital video material. More particularly, the present invention relates to prediction error coding in both frequency and spatial domains.

BACKGROUND OF THE INVENTION

[0002] This section is intended to provide a background or context to the invention that is recited in the claims. The description herein may include concepts that could be pursued, but are not necessarily ones that have been previously conceived or pursued. Therefore, unless otherwise indicated herein, what is described in this section is not prior art to the description and claims in this application and is not admitted to be prior art by inclusion in this section.

[0003] A video codec comprises an encoder that transforms input video into a compressed representation suited for storage and/or transmission and a decoder that can uncompress the compressed video representation back into a viewable form. Typically, the encoder discards some information in the original video sequence in order to represent the video in a more compact form, i.e., at a lower bitrate.

[0004] Typical hybrid video codecs, for example ITU-T H.263 and H.264, encode video information in two phases. In the first phase, pixel values in a certain picture area or "block" are predicted. These pixel values can be predicted, for example, by motion compensation mechanisms, which involve finding and indicating an area in one of the previously coded video frames that corresponds closely to the block being coded. Additionally, pixel values can be predicted via by spatial mechanisms, which involve using the pixel values around the block to be coded in a specified manner. The second phase involves coding the prediction error, i.e. the difference between the predicted block of pixels and the original block of pixels. This is typically

accomplished by transforming the difference in pixel values using a specified transform (e.g., a Discrete Cosine Transform (DCT) or a variant thereof), quantizing the coefficients, and entropy coding the quantized coefficients. By varying the fidelity of the quantization process, the encoder can control the balance between the accuracy of the pixel representation (i.e., the picture quality) and the size of the resulting coded video representation (i.e., the file size or transmission bitrate).

[0005] The decoder reconstructs output video by applying prediction mechanisms that are similar to those used by the encoder in order to form a predicted representation of the pixel blocks (using motion or spatial information created by the encoder and stored in the compressed representation) and prediction error decoding (the inverse operation of the prediction error coding, recovering the quantized prediction error signal in the spatial pixel domain). After applying prediction and prediction error decoding processes, the decoder sums up the prediction and prediction error signals (i.e., the pixel values) to form the output video frame. The decoder (and encoder) can also apply additional filtering processes in order to improve the quality of the output video before passing it for display and/or storing it as a prediction reference for the forthcoming frames in the video sequence.

[0006] In typical video codecs, the motion information is indicated with motion vectors associated with each motion-compensated image block. Each of these motion vectors represents the displacement of the image block in the picture to be coded (in the encoder side) or decoded (in the decoder side) and the prediction source block in one of the previously coded or decoded pictures. In order to represent motion vectors efficiently, motion vectors are typically coded differentially with respect to block specific predicted motion vectors. In a typical video codec, the predicted motion vectors are created in a predefined way, for example by calculating the median of the encoded or decoded motion vectors of the adjacent blocks.

[0007] Typical video encoders utilize Lagrangian cost functions to find optimal coding modes, e.g., the desired macroblock mode and associated motion vectors. This kind of cost function uses a weighting factor λ to tie together the exact or

estimated image distortion due to lossy coding methods and the exact or estimated amount of information that is required to represent the pixel values in an image area:

$$C = D + \lambda R \quad (1)$$

[0008] In Eq. (1), C is the Lagrangian cost to be minimized, D is the image distortion (e.g., the mean squared error) with the mode and motion vectors considered, and R the number of bits needed to represent the required data to reconstruct the image block in the decoder (including the amount of data to represent the candidate motion vectors).

[0009] Transform coding of the prediction error signal in video or image compression system typically comprises DCT-based linear transform, quantization of the transformed DCT coefficients, and context based entropy coding of the quantized coefficients. However, the transform can efficiently pack energy of the prediction error signal only under certain statistics, and the coding performance deteriorates when the prediction error to be transformed becomes less correlated. This causes suboptimal performance, especially in modern video and image coding systems employing advanced motion compensation and spatial prediction processes in order to achieve good quality predictions for the image blocks to be coded (thus, minimizing and decorrelating the prediction error signal).

[0010] To address some of the above issues, a number of hybrid video coding schemes have been developed. These hybrid systems typically comprise a hybrid of two redundancy reduction techniques--prediction and transformation. Prediction can take the form of inter-picture prediction, which is used to remove temporal redundancies in the signal. Intra-picture prediction may also be used in the H.264/Advanced Video Coding (AVC) standard where spatial redundancies are removed by exploiting the similarities between neighboring regions within a picture frame. As a consequence of these inter-picture and intra-picture prediction techniques, a residual/error signal is formed by removing the predicated picture frame from the original. This prediction error signal is then typically block transform coded using an 8x8 DCT transform in order to reduce spatial redundancies in the signal.

SUMMARY OF THE INVENTION

[0011] Various embodiments of the present invention provide a system and method for representing the prediction error signal as a weighted sum of different basis functions of a selected transform and quantized spatial samples. The basis functions of the selected transform may comprise an orthogonal set of basis vectors, or the basis functions may not comprise an orthogonal set. According to various embodiments, the prediction error signal for a single image block is constructed using both transform basis functions and spatial samples (i.e., pixel values), thereby combining the desired features of both the transform and spatial coding approaches discussed previously. This allows for the utilization of those selected transform basis functions that give good overall representation of the image block with minimal amount of transform coefficients (representing the component of prediction error signal that is well correlated with the basis functions). Additionally, various embodiments of the present invention allow for the efficient spatial representation of those components of the prediction error signal of the same image block that are not well correlated with the basis functions of the applied transform (such as certain types of sensor noise, high frequency texture and edge information).

[0012] According to various embodiments of the present invention, a system and method of encoding a prediction error signal for a block of data comprises calculating a difference signal representing differences between sample values of a predicted block of data and values for an original input block. Transform coding and spatial coding are both performed to the difference signal, thereby creating a first and second representations of first and second components of the difference signal. The first and second representations are then combined to provide the prediction error signal.

[0013] Various embodiments of the present invention also provide a system and method of decoding a prediction error signal for a block of data, comprising receiving a coded prediction error signal, the coded prediction error signal including a plurality of transform coefficients and a plurality of spatial samples. The plurality of transformed coefficients are decoded into decoded transform information, and the plurality of spatial samples are decoded into decoded spatial information. The

decoded transform information, the decoded spatial information, and a reconstructed prediction of the block of data are then added, thereby forming a decoded representation of the block of data.

[0014] The implementations of various embodiments of the present invention serve to improve the compression efficiency of modern video and image codecs. Although a certain amount of increased computational complexity of encoding may be needed, fast algorithms can be applied in order to lower the encoding complexity that approaches the complexity level for traditional transform based coding. Any effect on the complexity for a decoder is negligible when implementing various embodiments of the present invention.

[0015] These and other advantages and features of the invention, together with the organization and manner of operation thereof, will become apparent from the following detailed description when taken in conjunction with the accompanying drawings, wherein like elements have like numerals throughout the several drawings described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 shows an example of basis functions of a Hadamard transform that can be used to encode image data;

[0017] Figure 2(a) is an example of four scalar values that are to be coded or decoded and representing the prediction error signal between the original image and the prediction image; Figure 2(b) shows the four weighted basis functions from Figure 1 being summed to the prediction error signal; and Figure 2(c) shows how the same prediction error signal can be reconstructed by summing up only the first basis function and a single spatial sample represented by an arrow;

[0018] Figure 3 is a block diagram of a video encoder constructed in accordance with one embodiment of the present invention;

[0019] Figure 4 is a flow chart showing one encoder algorithm which may be used in an embodiment of the present invention;

[0020] Figure 5 is a flow chart showing one decoder algorithm which may be used in various embodiments of the present invention;

[0021] Figure 6 is a block diagram of a video decoder constructed in accordance with one embodiment of the present invention;

[0022] Figure 7 is an overview diagram of a system within which various embodiments of the present invention may be implemented;

[0023] Figure 8 is a perspective view of an electronic device that can be used in conjunction with the implementation of various embodiments of the present invention; and

[0024] Figure 9 is a schematic representation of the circuitry which may be included in the electronic device of Figure 8.

DETAILED DESCRIPTION OF VARIOUS EMBODIMENTS

[0025] Various embodiments of the present invention provide a system and method for representing the prediction error signal as a weighted sum of different basis functions of a selected transform and quantized spatial samples. According to various embodiments, the prediction error signal for a single image block is constructed using both transform basis functions and spatial samples (i.e., pixel values), thereby combining the desired features of both the transform and spatial coding approaches discussed previously. This allows for the utilization of those selected transform basis functions that give good overall representation of the image block with minimal amount of transform coefficients (representing the component of prediction error signal that is well correlated with the basis functions). Additionally, various embodiments of the present invention allow for the efficient spatial representation of those components of the prediction error signal of the same image block that are not well correlated with the basis functions of the applied transform (such as certain types of sensor noise, high frequency texture and edge information).

[0026] Figures 1 and 2 show a simplified example of how various embodiments of the present invention are operable in one dimension. Figure 1 shows an example of basis functions of a one-dimensional linear transform that can be used to encode

image data (namely a Hadamard transform). The weighted sum of these four basis functions can be used to represent any four samples. Figure 2(a) is an example of four scalar values that are to be coded or decoded and representing the prediction error signal between the original image and the prediction image. In Figure 2(b), the four weighted basis functions from Figure 1 are summed to the prediction error signal (1.5 times the first, 0.5 times the second, -0.5 times the third and -0.5 times the fourth basis function). In Figure 2(c) it is demonstrated how the same prediction error signal can be reconstructed by summing up only the first basis function and a single spatial sample represented by an arrow. In this example, compression efficiency improvement can be expected, as the signal is represented by a single transform coefficient and a single spatial sample instead of four transform coefficients weighting the four Hadamard basis functions (as shown in Figure 2(b)).

[0027] Figure 3 is a block diagram of a video encoder constructed in accordance with one embodiment of the present invention. More particularly, Figure 3 shows how an image to be encoded 300 undergoes pixel prediction 302, prediction error coding 303 and prediction error decoding 304. For pixel prediction 302, the image 300 undergoes both inter-prediction 306 and intra-prediction 308 which, after mode selection 310, results in prediction representation of an image block 312. A preliminary reconstructed image 314 is also used for intra-prediction 308. Once all of the image blocks are processed, the preliminary reconstructed image 314 undergoes filtering at 316 to create a final reconstructed image 340, which is sent to a reference frame memory 318 and is also used for inter-prediction 306 of future frames.

[0028] The prediction representation of the image block 312, as well as the image to be encoded 300, are used together to define a prediction error signal 320 which is used for prediction error coding 303. In prediction error coding 303, the prediction error signal 320 undergoes feature selection 322 and spatial quantization 324, as well as transform 326 and quantization 328 (both after feature selection 322). The data describing prediction error and predicted representation of the image block 312 (e.g., motion vectors, mode information and quantized DCT+spatial samples) are passed to entropy coding 330. The prediction error decoding 304 is substantially the opposite of the prediction error coding 303, with the prediction error decoding including an

inverse spatial quantizer 332, an inverse transform 334 and an inverse quantization 336. The result of the prediction error decoding 304 is a reconstructed prediction error signal 338, which is used in combination with the predicted representation of the image block 312 to create the preliminary reconstructed image 314.

[0029] Figure 4 is a flow chart showing one encoder algorithm which may be used in an embodiment of the present invention. However, as discussed below, a variety of different algorithms may be used according to principles of the present invention. At 400 in Figure 4, the difference between sample values of a predicted block and an original input block is calculated. It should be noted that "values" and "outlier values" as used herein are intended to refer to these difference values. At 410, outlier values are found. In this case, the amplitude depends on the expected accuracy of the coded representation; smaller amplitude representations qualify as outliers if one is targeting high bitrate good quality representation, and only high amplitude representations qualify if one is targeting a lower bitrate, lower quality representation. At 420, the modified prediction error signal is transform coded (involving transform, quantization and entropy coding), with the outlier values being substituted by interpolated representations of those values, e.g., by averaging the neighboring prediction error values. At 430, the modified prediction error signals are transform decoded back to the spatial domain. At 440, spatial coding is applied (involving quantization and entropy coding without transform) to the difference between the original outlier values and the transform decoded outlier values. At 450, the final coded representation of the prediction error signal is formed by joining the transform coded data and the spatial coded data. In an alternative embodiment, the spatial coding occurs before transform coding.

[0030] When considering the one-dimensional example depicted in Figures 2(a)-2(c), the algorithm outlined in Figure 4 would process the relevant data as follows. As discussed previously, Figure 2(a) represents the difference signal [1 1 3 1] to be coded. In this case, [3] is an outlier. Therefore, the prediction error signal is modified by substituting the [3] with an average of the second and fourth samples, making the signal [1 1 1 1]. The difference between the original outlier sample ([3]) and the transform coded outlier value ([1]) is then spatial coded, making the spatial coded

signal [0 0 2 0]. The entropy coded representations of the transform coded and spatial coded signals are then written to the bitstream. Thereafter, the decoder can recover the coded signal by adding up the inverse transformed data [1 1 1 1] and the inverse spatial coded data [0 0 2 0] (together with the prediction samples of the image block).

[0031] When considering the above example, it is important to note that the choice of Hadamard basis vectors for the transform is only intended to be exemplary in nature. In fact, the various methods and techniques described herein can be applied to any transform employing basis functions, and the basis functions do not necessarily need to be orthogonal.

[0032] A video or image codec, according to various embodiments the present invention, can be implemented in various ways. In the case of an encoder, the encoder can use different strategies to find the desired transform coefficients and spatial samples. For example, an encoder can first transform code the signal and apply spatial coding to the residual. The encoder can also first apply spatial coding to the signal, followed by transform coding of the residual. Additionally, some or all of the transform coefficients can be set to zero in order to improve the coding performance. Some or all spatial samples can also be set to zero in order to improve the coding performance. An encoder can also iteratively modify transform coefficients and/or spatial samples in order to improve the coding performance until a desired performance or a maximum defined number of iterations is achieved.

[0033] In terms of quantization and dequantization, the quantization and dequantization of transform coefficients and spatial samples can be tied together (e.g., a quantization step size for both transform coefficients and spatial samples can be derived from a single parameter). Alternatively, different quantizations and dequantizations can be applied to transform coefficients and spatial samples.

[0034] For the coding and decoding of spatial samples, such coding and decoding can depend on transform coefficients and vice versa. Alternatively, the coding and decoding of spatial samples, transform coefficients or both can depend on the prediction signal, on the other transform coefficients and spatial samples in the same image or in other images.

[0035] In addition to the above, it can be indicated that there are no transform coefficients or spatial samples for a specific image area or image. It can also be indicated that only spatial coding or only transform coding is used for a specific image area or image. The number of spatial samples can be coded and decoded as one unit, for example representing certain patterns of textures. Pre- and/or post-processing mechanisms can be applied to the prediction signal, prediction error signal reconstructed signal or any combination thereof. The method can be used to code and decode other information instead or in addition to the prediction error signals. The codec can limit the usage of either transform coefficients (e.g., allow only low frequency transform coefficients to be present in the coded representation of the signal) or spatial samples.

[0036] Figure 5 shows a decoding process according to various embodiments of the present invention. At 500 in Figure 5, a video decoder receives a coded prediction error signal which comprises both transformed coefficients and spatial samples. At 510, both the transformed coefficients and the spatial samples are decoded. At 520, the decoded transform information, the decoded spatial information and reconstructed prediction of the image block are added together to form decoded representation of the image block.

[0037] Figure 6 is a block diagram of a video decoder constructed in accordance with one embodiment of the present invention. As shown in Figure 6, entropy decoding 600 is followed by both prediction error decoding 602 and pixel prediction 604. In prediction error decoding 602, in addition to an inverse transform 606 and inverse quantization 608, an inverse spatial quantizer 610 is used as discussed herein, ultimately resulting in a reconstructed prediction error signal 612. For pixel prediction 604, either intra-prediction or inter-prediction occurs at 614 to create a predicted representation of an image block 616. The predicted representation of the image block 616 is used in conjunction with the reconstructed prediction error signal 612 to create a preliminary reconstructed image 618, which in turn can be used both for prediction 614. Once all of the image blocks have been processed, the preliminary reconstructed image 618 is passed for filtering 620. The filtered image can also be stored in reference frame memory 624, making it usable for prediction 614 as well.

[0038] Figure 7 shows a system 10 in which various embodiments of the present invention can be utilized, comprising multiple communication devices that can communicate through one or more networks. The system 10 may comprise any combination of wired or wireless networks including, but not limited to, a mobile telephone network, a wireless Local Area Network (LAN), a Bluetooth personal area network, an Ethernet LAN, a token ring LAN, a wide area network, the Internet, etc. The system 10 may include both wired and wireless communication devices.

[0039] For exemplification, the system 10 shown in Figure 7 includes a mobile telephone network 11 and the Internet 28. Connectivity to the Internet 28 may include, but is not limited to, long range wireless connections, short range wireless connections, and various wired connections including, but not limited to, telephone lines, cable lines, power lines, and the like.

[0040] The exemplary communication devices of the system 10 may include, but are not limited to, an electronic device 50, a combination personal digital assistant (PDA) and mobile telephone 14, a PDA 16, an integrated messaging device (IMD) 18, a desktop computer 20, a notebook computer 22, etc. The communication devices may be stationary or mobile as when carried by an individual who is moving. The communication devices may also be located in a mode of transportation including, but not limited to, an automobile, a truck, a taxi, a bus, a train, a boat, an airplane, a bicycle, a motorcycle, etc. Some or all of the communication devices may send and receive calls and messages and communicate with service providers through a wireless connection 25 to a base station 24. The base station 24 may be connected to a network server 26 that allows communication between the mobile telephone network 11 and the Internet 28. The system 10 may include additional communication devices and communication devices of different types.

[0041] The communication devices may communicate using various transmission technologies including, but not limited to, Code Division Multiple Access (CDMA), Global System for Mobile Communications (GSM), Universal Mobile Telecommunications System (UMTS), Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), Transmission Control Protocol/Internet Protocol (TCP/IP), Short Messaging Service (SMS), Multimedia

Messaging Service (MMS), e-mail, Instant Messaging Service (IMS), Bluetooth, IEEE 802.11, etc. A communication device involved in implementing various embodiments of the present invention may communicate using various media including, but not limited to, radio, infrared, laser, cable connection, and the like.

[0042] Figures 8 and 9 show one representative electronic device 50 within which the present invention may be implemented. It should be understood, however, that the present invention is not intended to be limited to one particular type of device. The electronic device 50 of Figures 8 and 9 includes a housing 30, a display 32 in the form of a liquid crystal display, a keypad 34, a microphone 36, an ear-piece 38, a battery 40, an infrared port 42, an antenna 44, a smart card 46 in the form of a UICC according to one embodiment of the invention, a card reader 48, radio interface circuitry 52, codec circuitry 54, a controller 56 and a memory 58. Individual circuits and elements are all of a type well known in the art, for example in the Nokia range of mobile telephones.

[0043] The various embodiments of the present invention described herein is described in the general context of method steps or processes, which may be implemented in one embodiment by a computer program product, embodied in a computer-readable medium, including computer-executable instructions, such as program code, executed by computers in networked environments. Generally, program modules may include routines, programs, objects, components, data structures, etc. that perform particular tasks or implement particular abstract data types. Computer-executable instructions, associated data structures, and program modules represent examples of program code for executing steps of the methods disclosed herein. The particular sequence of such executable instructions or associated data structures represents examples of corresponding acts for implementing the functions described in such steps or processes.

[0044] Software and web implementations of various embodiments of the present invention can be accomplished with standard programming techniques with rule-based logic and other logic to accomplish various database searching steps or processes, correlation steps or processes, comparison steps or processes and decision steps or processes. It should be noted that the words "component" and "module," as

used herein and in the following claims, is intended to encompass implementations using one or more lines of software code, and/or hardware implementations, and/or equipment for receiving manual inputs.

[0045] The foregoing description of embodiments of the present invention have been presented for purposes of illustration and description. The foregoing description is not intended to be exhaustive or to limit embodiments of the present invention to the precise form disclosed, and modifications and variations are possible in light of the above teachings or may be acquired from practice of various embodiments of the present invention. The embodiments discussed herein were chosen and described in order to explain the principles and the nature of various embodiments of the present invention and its practical application to enable one skilled in the art to utilize the present invention in various embodiments and with various modifications as are suited to the particular use contemplated.

WHAT IS CLAIMED IS:

- 1 1. A method of encoding a prediction error signal for a block of data,
2 comprising:
3 calculating a difference signal representing differences between sample
4 values of a predicted block of data and values for an original input block;
5 performing transform coding to the difference signal, thereby creating
6 a first representation of a first component of the difference signal;
7 performing spatial coding to the difference signal, thereby creating a
8 second representation of a first component of the difference signal; and
9 joining the first and second representations.
- 1 2. The method of claim 1, further comprising, before performing
2 transform coding and spatial coding, substituting outlier values in the difference
3 signal with non-outlier values to create a modified prediction error signal.
- 1 3. The method of claim 2, wherein transform coding is applied to the
2 modified prediction error signal and spatial coding is applied to a residual thereof.
- 1 4. The method of claim 2, wherein spatial coding is applied to the
2 modified prediction error signal and transform coding is applied to a residual thereof.
- 1 5. The method of claim 1, wherein, for transform coding, at least one
2 transform coefficient is set to zero.
- 1 6. The method of claim 1, wherein, for spatial coding, at least one spatial
2 sample is set to zero.
- 1 7. The method of claim 2, wherein the non-outlier values used to replace
2 the outlier values comprise an average of neighboring prediction error values.
- 1 8. The method of claim 1, further comprising providing an indication that
2 no transform coefficients exist in the block of data if appropriate.

1 9. The method of claim 1, further comprising providing an indication that
2 no spatial samples exist in the block of data if appropriate.

1 10. The method of claim 1, wherein for the transform coding, a transform
2 coefficient is formed, the transform coefficient comprising a weighting coefficient of
3 a discrete transform basis vector.

1 11. The method of claim 10, wherein the discrete transform comprises a
2 discrete orthogonal transform.

1 12. A computer program product, embodied in a computer-readable
2 medium, comprising computer code configured to perform the implemented the
3 processes of claim 1.

1 13. An apparatus, comprising:
2 a processor; and
3 a memory unit communicatively connected to a controller and
4 comprising:
5 computer code for performing transform coding to the
6 difference signal, thereby creating a first representation of a first component of the
7 difference signal;
8 computer code for performing spatial coding to the difference
9 signal, thereby creating a second representation of a first component of the difference
10 signal; and
11 computer code for joining the first and second representations.

1 14. The apparatus of claim 13, wherein the memory unit further comprises
2 computer code for, before performing transform coding and spatial coding,
3 substituting outlier values in the difference signal with non-outlier values to create a
4 modified prediction error signal.

1 15. The apparatus of claim 14, wherein transform coding is applied to the
2 modified prediction error signal and spatial coding is applied to a residual thereof.

1 16. The apparatus of claim 14, wherein spatial coding is applied to the
2 modified prediction error signal and transform coding is applied to a residual thereof.

1 17. The apparatus of claim 13, wherein, for transform coding, at least one
2 transform coefficient is set to zero.

1 18. The apparatus of claim 13, wherein, for spatial coding, at least one
2 spatial sample is set to zero.

1 19. The apparatus of claim 13, wherein the non-outlier values used to
2 replace the outlier values comprise an average of neighboring prediction error values.

1 20. The apparatus of claim 13, further comprising providing an indication
2 that no transform coefficients exist in the block of data if appropriate.

1 21. The apparatus of claim 13, further comprising providing an indication
2 that no spatial samples exist in the block of data if appropriate.

1 22. A method of decoding a prediction error signal for a block of data,
2 comprising:
3 receiving a coded prediction error signal, the coded prediction error
4 signal including a plurality of transform coefficients and a plurality of spatial samples;
5 decoding the plurality of transformed coefficients into decoded
6 transform information;
7 decoding the plurality of spatial samples into decoded spatial
8 information; and
9 adding the decoded transform information, the decoded spatial
10 information, and a reconstructed prediction of the block of data, thereby forming a
11 decoded representation of the block of data.

1 23. The method of claim 22, wherein an indication is provided that no
2 transform coefficients exist in the block of data if appropriate.

1 24. The method of claim 22, wherein an indication is provided that that no
2 spatial samples exist in the block of data if appropriate.

1 25. The method of claim 22, wherein the decoding of the plurality of
2 transformed coefficients and spatial samples includes dequantization of each, and
3 wherein the dequantization of transformed coefficients and spatial samples are related
4 to each other.

1 26. The method of claim 22, wherein the decoding of the plurality of
2 transformed coefficients and spatial samples includes dequantization of each, and
3 wherein the dequantization of transformed coefficients and spatial samples are
4 different from each other.

1 27. The method of claim 22, wherein the decoding of the spatial samples is
2 dependent upon the decoding of the transformed coefficients.

1 28. The method of claim 22, wherein the decoding of the transformed
2 coefficients is dependent upon the decoding of the spatial samples.

1 29. The method of claim 22, wherein at least some of the plurality of
2 spatial samples are decoded as a single unit.

1 30. A computer program product, embodied in a computer-readable
2 medium, comprising computer code configured to perform the processes of claim 19.

1 31. An apparatus, comprising:
2 a processor; and
3 a memory unit communicatively connected to the processor and
4 including:

5 computer code for processing a received coded prediction error
6 signal, the coded prediction error signal including a plurality of transformed
7 coefficients and a plurality of spatial samples;
8 computer code for decoding the plurality of transformed
9 coefficients into decoded transform information;
10 computer code for decoding the plurality of spatial samples into
11 decoded spatial information; and
12 computer code for adding the decoded transform information,
13 the decoded spatial information, and a reconstructed prediction of the block of data,
14 thereby forming a decoded representation of the block of data.

1 32. The apparatus of claim 31, wherein an indication is provided that no
2 transform coefficients exist in the block of data if appropriate.

1 33. The apparatus of claim 31, wherein an indication is provided that that
2 no spatial samples exist in the block of data if appropriate.

1 34. The apparatus of claim 31, wherein the decoding of the plurality of
2 transformed coefficients and spatial samples includes dequantization of each, and
3 wherein the dequantization of transformed coefficients and spatial samples are related
4 to each other.

1 35. The apparatus of claim 31, wherein the decoding of the plurality of
2 transformed coefficients and spatial samples includes dequantization of each, and
3 wherein the dequantization of transformed coefficients and spatial samples are
4 different from each other.

1 36. The apparatus of claim 31, wherein the decoding of the spatial samples
2 is dependent upon the decoding of the transformed coefficients.

1 37. The apparatus of claim 31, wherein the decoding of the transformed
2 coefficients is dependent upon the decoding of the spatial samples.

1 38. The apparatus of claim 31, wherein at least some of the plurality of
2 spatial samples are decoded as a single unit.

1 39. A method of encoding a prediction error signal for a block of data,
2 comprising:
3 calculating a difference signal representing differences between sample
4 values of a predicted block of data and values for an original input block;
5 substituting outlier values in the difference signal with non-outlier
6 values to create a modified prediction error signal;
7 performing one of transform coding and spatial coding to the modified
8 prediction error signal, creating one of a transform coded data and spatial coded data
9 performing an inverse of the one of transform coding and spatial
10 coding;
11 applying the other of transform coding and spatial coding to a residual
12 from the inverse transform or spatial decoding, creating the other of transform coded
13 data and spatial coded data; and
14 joining the transform coded data and the spatial coded data.

ABSTRACT

A system and method for improving prediction error coding performance of various video compression algorithms. Various embodiments combine the energy compaction features of transform coding with localization properties of spatial
5 coding. In various embodiments, the effects of pixel "outliers" are removed from the transform and are coded separately as a spatially coded pixel prediction, thereby improving the coding gain of the transform.

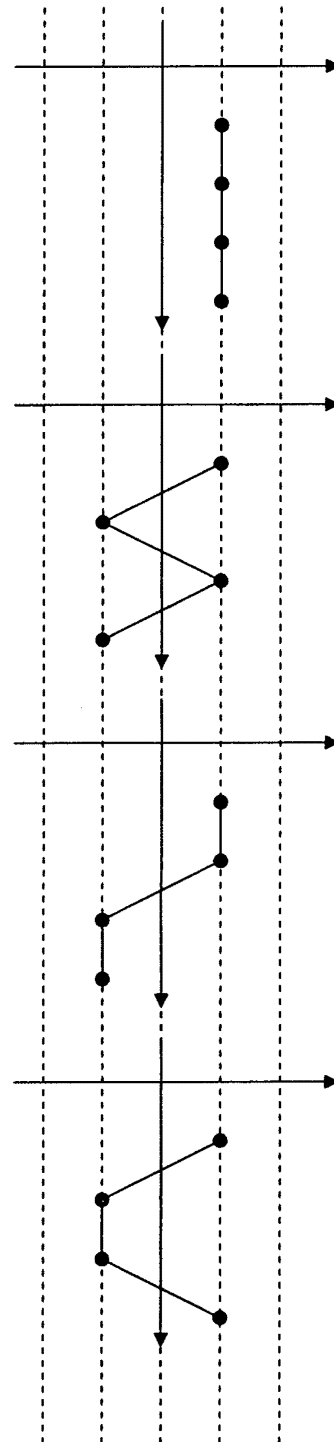


FIG. 1

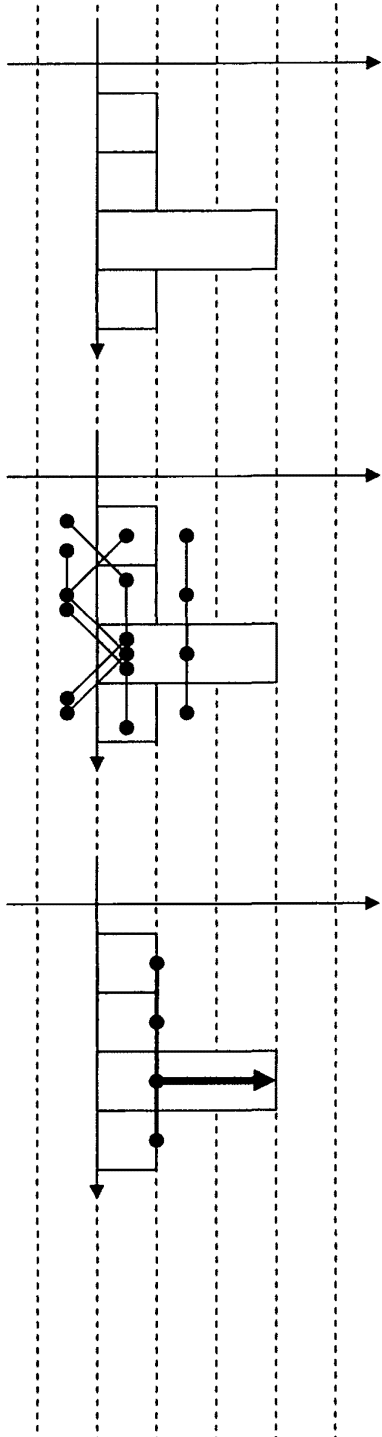


FIG. 2(a)

FIG. 2(b)

FIG. 2(c)

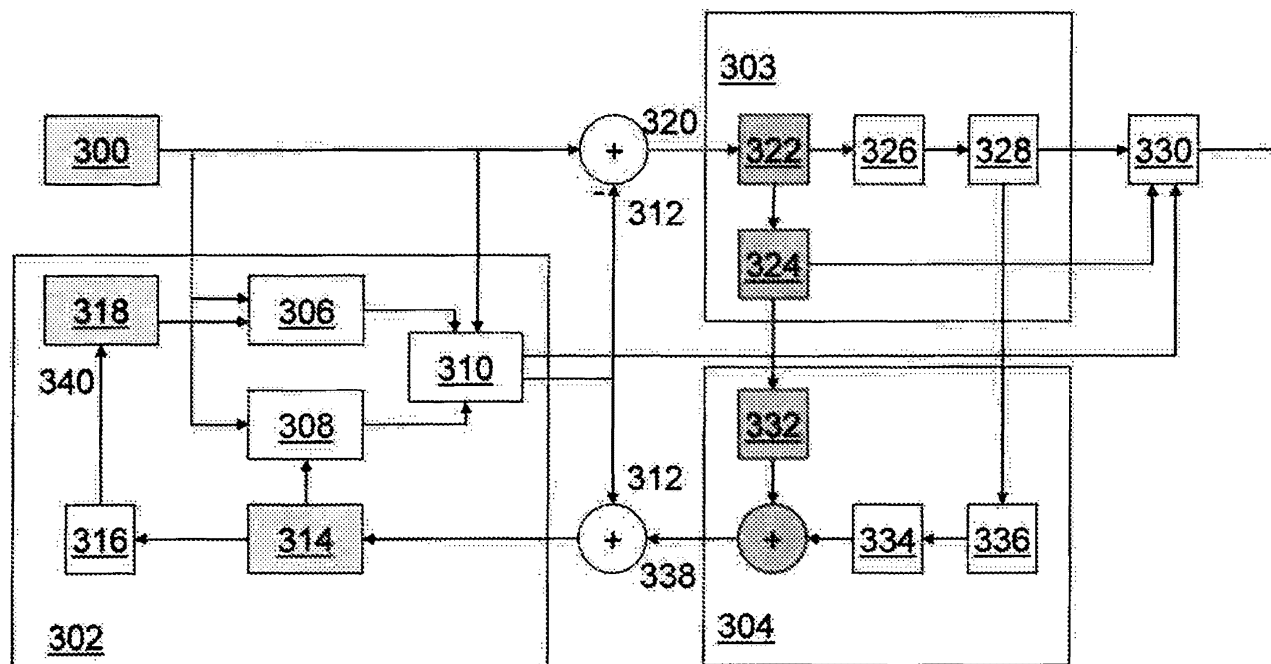


FIG. 3

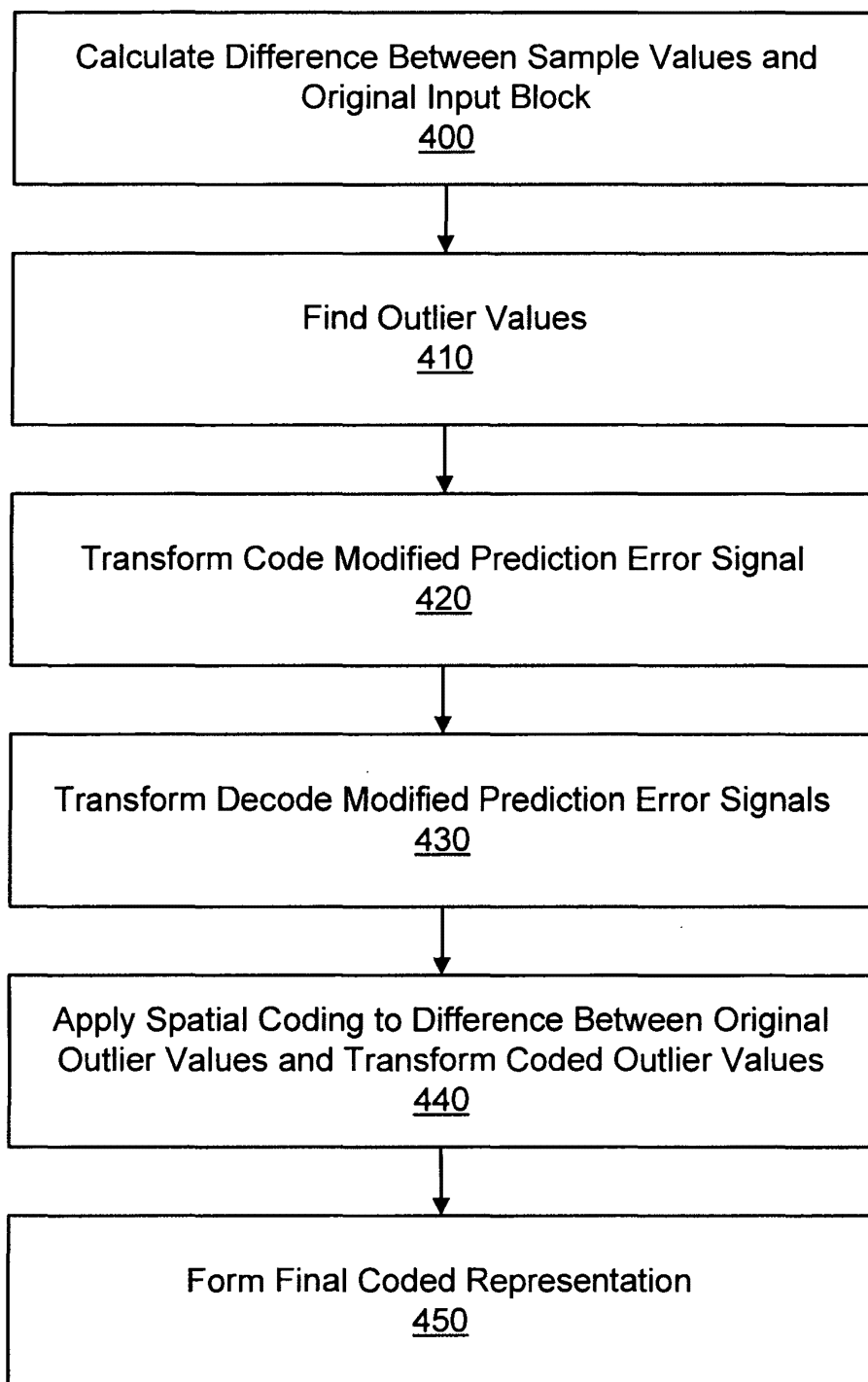


FIG. 4

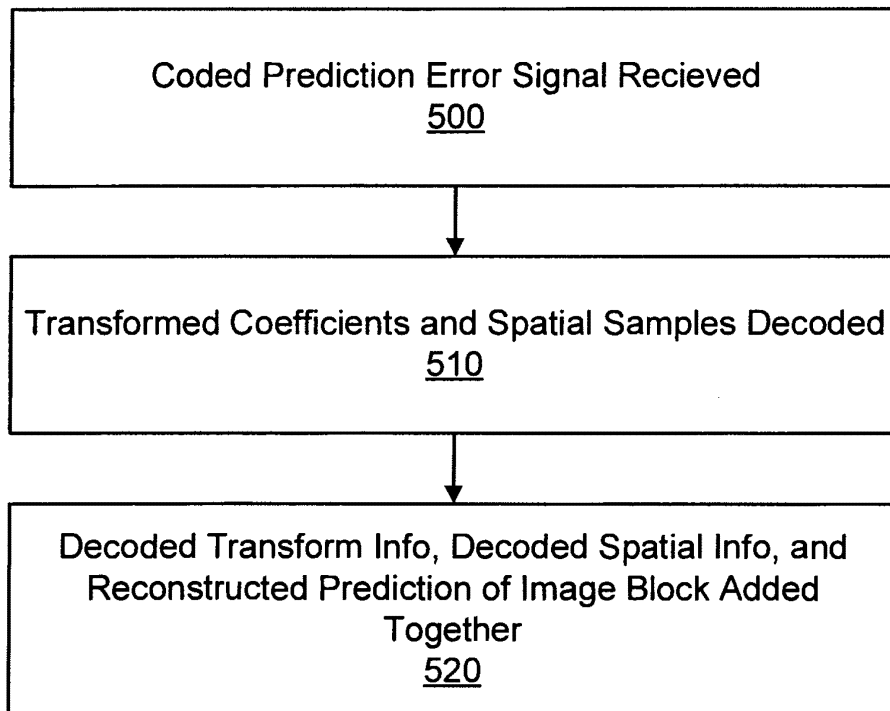


FIG. 5

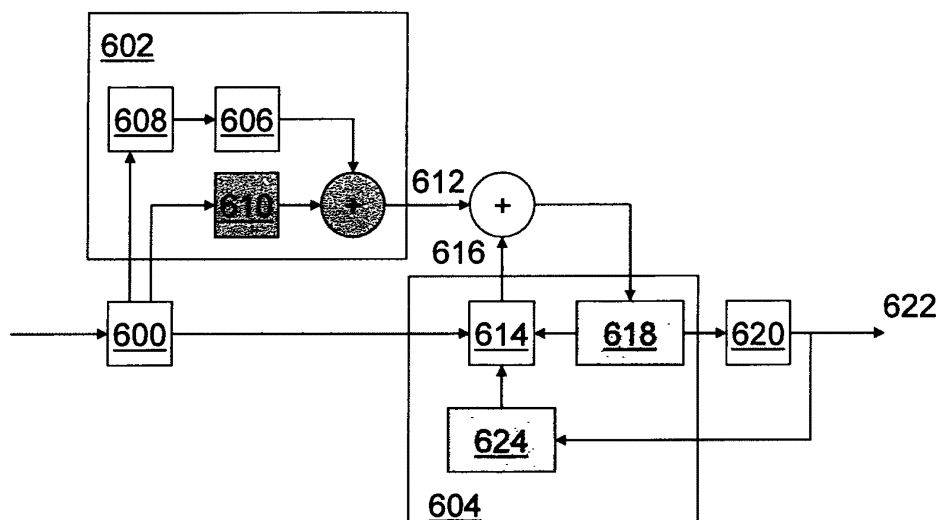


FIG. 6

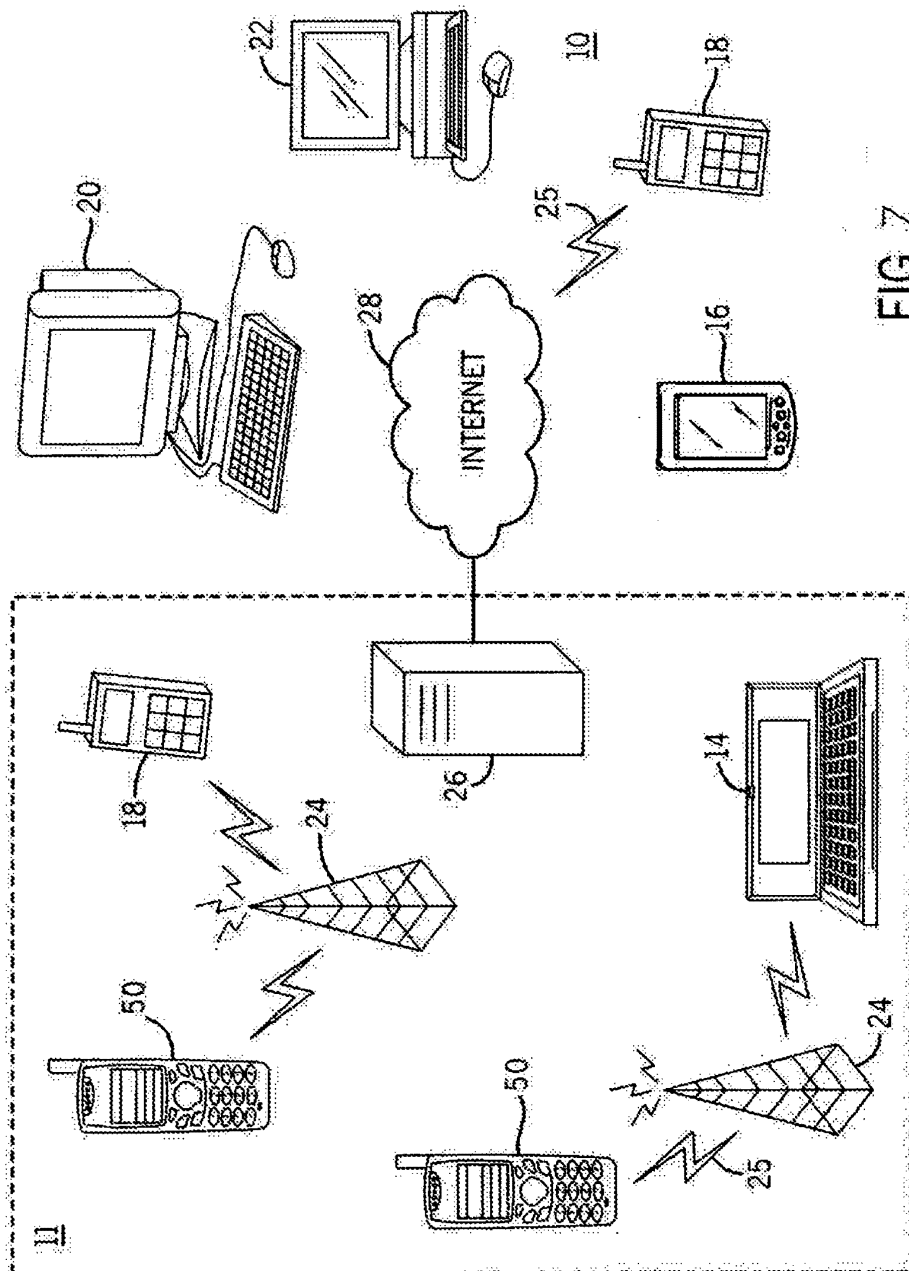


FIG. 7

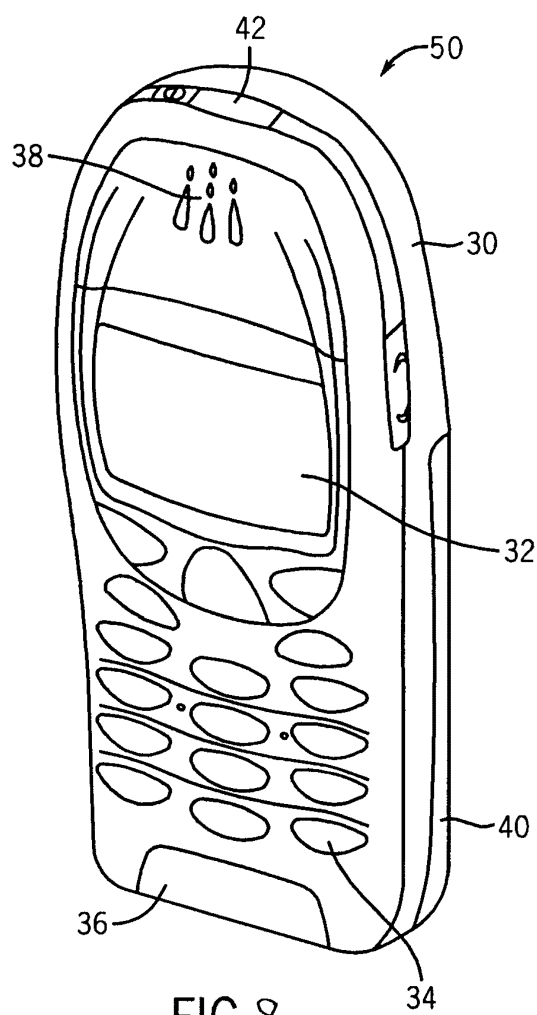


FIG. 8

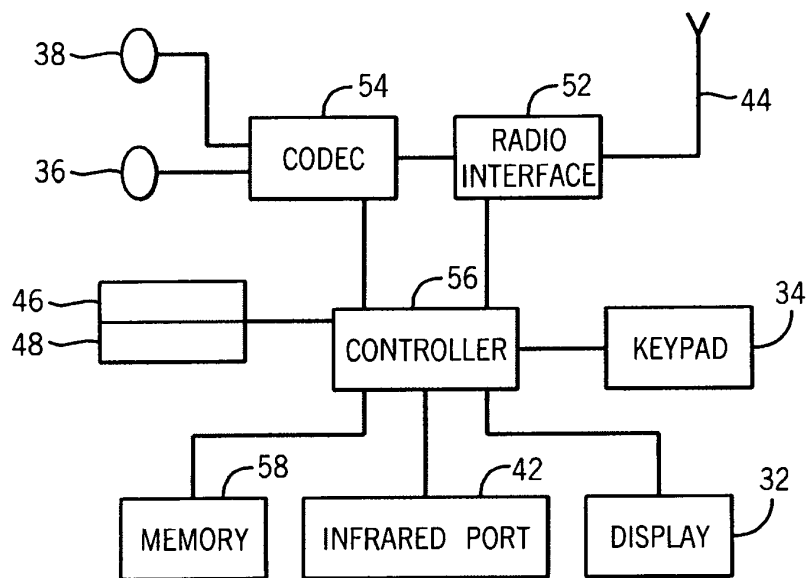


FIG. 9

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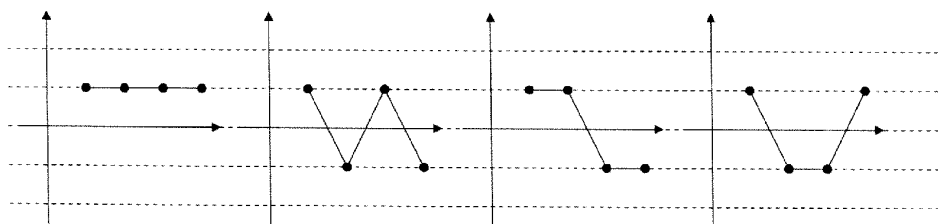


FIG. 1

(57) Abstract: A system and method for improving prediction error coding performance of various video compression algorithms. Various embodiments combine the energy compaction features of transform coding with localization properties of spatial coding. In various embodiments, the effects of pixel "outliers" are removed from the transform and are coded separately as a spatially coded pixel prediction, thereby improving the coding gain of the transform.



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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2008/051351

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04N7/50

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 G06F

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, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SANTAGO P ET AL: "USING CONVEX SET TECHNIQUES FOR COMBINED PIXEL AND FREQUENCY DOMAIN CODING OF TIME-VARYING IMAGES" IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, IEEE SERVICE CENTER, PISCATAWAY, US, vol. SAC-05, no. 7, 1 August 1987 (1987-08-01), pages 1127-1139, XP001053635 ISSN: 0733-8716 paragraph [VII. DESCRIPTION OF THE IMPLEMENTED CODER] ----- -/--	1-39

☒ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:

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Wahrenberg, Annika

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2008/051351

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SMITH J R ET AL: "Joint adaptive space and frequency basis selection" IMAGE PROCESSING, 1997. PROCEEDINGS., INTERNATIONAL CONFERENCE ON SANTA BARBARA, CA, USA 26-29 OCT. 1997, LOS ALAMITOS, CA, USA, IEEE COMPUT. SOC, US, vol. 3, 26 October 1997 (1997-10-26), pages 702-705, XP010253684 ISBN: 978-0-8186-8183-7 the whole document -----	1-39
A	CLARKE R J: "ON TRANSFORM CODING OF MOTION-COMPENSATED DIFFERENCE IMAGES" IEE PROCEEDINGS I. SOLID- STATE & ELECTRON DEVICES, INSTITUTION OF ELECTRICAL ENGINEERS. STEVENAGE, GB, vol. 139, no. 3 PART 01, 1 June 1992 (1992-06-01), pages 372-376, XP000305103 ISSN: 0956-3776 the whole document -----	1-39
A	WIEGAND T ET AL: "Overview of the H.264/AVC video coding standard" IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY, IEEE SERVICE CENTER, PISCATAWAY, NJ, US, vol. 13, no. 7, 1 July 2003 (2003-07-01), pages 560-576, XP011099249 ISSN: 1051-8215 the whole document -----	1-39
A	SEGALL C A ET AL: "Pre- and post-processing algorithms for compressed video enhancement" SIGNALS, SYSTEMS AND COMPUTERS, 2000. CONFERENCE RECORD OF THE THIRTY- FOURTH ASILOMAR CONFERENCE ON OCT. 29 - NOV. 1, 2000, PISCATAWAY, NJ, USA, IEEE, vol. 2, 29 October 2000 (2000-10-29), pages 1369-1373, XP010535224 ISBN: 978-0-7803-6514-8 the whole document -----	1-39



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**For any questions about
this communication:**

Tel.: +31 (0)70 340 45 00

Date

27.08.09

Reference	Application No./Patent No. 08737779.2 - 1247 PCT/IB2008051351
Applicant/Proprietor Nokia Corporation	

Entry into the European phase before the European Patent Office

The following information describes the procedural steps required for entry into the European phase before the European Patent Office (EPO). You are advised to read it carefully because failure to take the necessary action in due time can lead to a loss of rights.

1. The above mentioned international patent application has been given the **European application No. 08737779.2**.
2. Applicants **without a residence or their principal place of business** in an EPC Contracting State may themselves initiate European processing of their international applications, provided they do so before expiry of the 31st month from the priority date.

During the European phase before the EPO as designated or elected Office, however, such applicants **must** be represented by a professional representative (Art. 133(2) and Art. 134(1) and (8) EPC).

Where, at the expiry of the time period laid down in Rule 163(5) EPC, the requirements of Article 133(2) EPC have not been complied with, the European patent application will be **refused**, pursuant to Rule 163(6) EPC.

Please note that a professional representative authorised to act before the EPO and who acted for the applicant during the international phase does not automatically become the representative for the European phase. Applicants are therefore strongly advised to appoint in good time any representative they wish to initiate the European phase for them; otherwise the EPO has to send all communications directly to the applicant.

3. Applicants **with a residence or their principal place of business** in an EPC Contracting State are not obliged to appoint for the European phase a professional representative authorised to act before the EPO. However, in view of the complexity of the procedure it is recommended that they do so.
4. Applicants and professional representatives are also strongly advised to initiate the European phase using **EPO Form 1200**. It is available free of charge from the EPO or via the EPO website at <http://www.epo.org>. Similarly, it can be or generated with the epoline® Online Filing Software, obtainable free of charge from the EPO (<http://www.epoline.org>) The use of the form is not compulsory.

-
5. Where the EPO acts as designated or elected Office (Art. 22(1) and (3) and 39(1) PCT), to enter the European phase before the EPO, the **following acts** must be performed by the applicant within **31 months** from the date of filing of the international application or (where applicable) the earliest priority date:
- a) Supply a translation of the international application into an EPO official language, if the International Bureau did not publish the application in such language (Art. 22(1) PCT and R. 159(1)(a) EPC);
 - b) Specify the application documents, as originally filed or as amended, on which the European grant procedure is to be based (R. 159(1)(c) EPC);
 - c) Pay the filing fee and, where applicable, the additional fee for a European patent application comprising more than 35 pages (R. 159(1)(c) EPC, Art. 2, items 1, 1a Rules relating to Fees);
 - d) Pay the search fee where a supplementary European search report has to be drawn up (R. 159(1)(e) EPC);
 - e) Pay the designation fee if the time limit laid down in Rule 39(1) EPC (i.e. six months after publication of the international search report) has expired before the 31-month period pursuant to Rule 159(1) EPC (R. 159(1)(d) EPC);
 - f) File the written request for examination and pay the examination fee if the time limit laid down in Rule 70(1) EPC has expired before the 31-month period pursuant to Rule 159(1) EPC (R. 159(1)(f) EPC);
 - g) Pay the renewal fee in respect of the third year, if the fee has fallen due (see Rule 51(1) EPC) before expiry of the 31-month period pursuant to Rule 159(1) EPC (R. 159(1)(g) EPC);
 - h) File, where applicable, the certificate of exhibition referred to in Article 55(2) and Rule 25 EPC (R. 159(1)(h) EPC);
 - i) Pay the claims fees for the sixteenth and each subsequent claim when the application documents on which the European grant procedure is to be based comprise more than fifteen claims (R. 162(1) EPC). For applications entering the European phase on or after 1 April 2009, a higher amount is payable for the 51st and each subsequent claim (Decision of the Administrative Council of 14 December 2007 amending the Rules relating to Fees, OJ EPO 2008, 10).

If either the translation of the international application or the request for examination is not filed in time, or if the filing fee, the additional fee, the search fee, the designation fee or the examination fee is not paid in due time, the application shall be deemed to be withdrawn (R. 160(1) EPC).

6. Payment of fees

The amounts of fees are set out in the Schedule of fees and expenses, which is published from time to time as a supplement to the Official Journal of the EPO. Applicants should always check the fee amounts applying at the time of payment.

Payments can be validly made by any person. Permissible methods of payment are laid down in Article 5 RFees. Please note that payment cannot be made by cheque sent to the EPO.

For information on the calculation of the additional fee for applications comprising more than 35 pages, see Notice from the European Patent Office dated 26 January 2009 concerning the 2009 fee structure, OJ EPO 2/2009, 118, and Guidelines for Examination in the EPO, April 2009, A-III, 13.2. For an overview of search and examination fees, see Notice from the European Patent Office of 11 February 2008 (OJ EPO 2008, 130).

The above and further fee-related information is available on the EPO website (<http://www.epo.org>).

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7. If the applicant had appointed a representative during the application's international phase, the present Form will be sent to the representative, asking him to inform the applicant accordingly.

All subsequent communications will be sent to the applicant, or - if the EPO is informed of his appointment in time - to the applicant's European representative.

8. For more details about time limits and procedural acts before the EPO as designated or elected Office, see the EPO brochure "How to get a European patent", Guide for applicants - Part 2, PCT procedure before the EPO - "Euro-PCT".

This brochure, the list of professional representatives before the EPO as well as Form 1200 are available on the Internet under <http://www.epo.org>.

Receiving Section





Entry into the European phase (EPO as designated or elected Office)

To the European Patent Office

European application number	EP08737779.2
PCT application number	PCT/IB2008/051351
PCT publication number	WO2008126019
Applicant's or representative's reference	P-EP62595F
International Filing Date	09.04.2008
International Search Authority (ISA)	EP
International Preliminary Examination Authority (IPEA)	not applicable
1. Applicant Indications concerning the applicant(s) are contained in the international publication or were recorded by the International Bureau after the international publication. ☒ Changes which have not yet been recorded by the International Bureau are set out here: ☐	
2. Representative This is the representative who will be listed in the Register of European Patents and to whom notifications will be made Representative 1 Name: Helino, Mr. Timo Registration No.: 1.8 Company: PAPULA OY Address of place of business: Mechelininkatu 1 a 00180 Helsinki, Finland Telephone: +358 9 348 0060 Fax: +358 9 3480 0630 e-mail: papula@papula.fi Representative 2 Name: Simmelvuori, Mr. Markku Representative 3 Name: Partio, Ms Erja Representative 4 Name: Tanskanen, Mr. Jarmo	
3. Authorisation An individual authorisation is attached. ☐ A general authorisation has been registered under No: ☐ A general authorisation has been filed, but not yet registered. ☐ The authorisation filed with the EPO as PCT receiving Office expressly includes the European phase. ☐	
4. Request for examination Examination of the application under Art. 94 EPC is hereby requested. The examination fee is being (has been, will be) paid. ☒ Request for examination in an admissible non-EPO language: ☒ Täten pyydetään hakemuksen tutkimista artiklan 94 mukaisesti. The applicant waives his right to be asked under Rule 70(2) EPC whether he wishes to proceed further with the application. ☐	
5. Copies	

Additional copies of the documents cited in the supplementary European search report are requested.	☐
Number of additional sets of copies	
6. Documents intended for proceedings before the EPO	
6.1 Proceedings before the EPO as designated Office (PCT I) are to be based on the following documents:	
the application documents published by the International Bureau (with all claims, description and drawings), where applicable with amended claims under Art. 19 PCT	☐
unless replaced by the amendments attached.	☒
<i>Where necessary, clarifications should be attached as 'Other documents'</i>	
6.2 Proceedings before the EPO as elected Office (PCT II) are to be based on the following documents:	
the documents on which the international preliminary examination report is based, including any annexes	☐
unless replaced by the amendments attached.	☐
<i>Where necessary, clarifications should be attached as 'Other documents'</i>	
If the EPO as International Preliminary Examining Authority has been supplied with test reports, these may be used as the basis of proceedings before the EPO.	☐
7. Translations	
Translations in one of the official languages of the EPO (English, French, German) are attached as crossed below:	☐
<i>* In proceedings before the EPO as designated or elected Office (PCT I + II):</i>	
Translation of the international application (description, claims, any text in the drawings) as originally filed, of the abstract as published and of any indication under Rule 13bis.3 and 13bis.4 PCT regarding biological material	☐
Translation of the priority application(s) (to be filed only at the EPO's request, Rule 53(3) EPC)	☐
It is hereby declared that the international application as originally filed is a complete translation of the previous application (Rule 53(3) EPC)	☐
<i>* In addition, in proceedings before the EPO as designated Office (PCT I):</i>	
Translation of amended claims and any statement under Art. 19 PCT, if the claims as amended are to form the basis for the proceedings before the EPO (see Section 6).	☐
<i>* In addition, in proceedings before the EPO as elected Office (PCT II):</i>	
Translation of annexes to the international preliminary examination report	☐
8. Biological material	
The invention uses and/or relates to biological material deposited under Rule 31 EPC.	☐
The particulars referred to in Rule 31(1)(c) EPC (if not yet known, the depositary institution and the identification reference(s)) [number, symbols, etc.] of the depositor) are given in the international publication or in the translation submitted in Section 7 on:	☐
page(s) / line(s)	
The receipt(s) of deposit issued by the depositary institution is (are) enclosed.	☐
will be filed later.	☐
Waiver of the right to an undertaking from the requester pursuant to Rule 33(2) EPC attached.	☐
9. Nucleotide and amino acid sequences	
The items pursuant to Rules 5.2 and 13ter PCT, Rules 30 and 163(3) EPC are already with the EPO.	☐
The sequence listing is attached in PDF format.	☐
The sequence listing does not include matter which goes beyond the content of the application as filed.	☐
The sequence listing data is also attached in computer-readable form in accordance with WIPO Standard 25.	☐

The sequence listing data in computer-readable form in accordance with WIPO Standard 25 is identical to the sequence listing in PDF format.

☐

10. Designation fees

All the contracting states party to the EPC at the time of filing of the international patent application and designated in the international application are deemed to be designated (see Article 79(1) EPC).

☒

AT BE BG CH&LI CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LT LU LV MC MT NL NO PL PT RO SE SI SK TR

10.1 It is currently intended to pay fewer than seven designation fees, for the following contracting states:

☐

10.2 If contracting states are indicated in Section 10.1, it is agreed that for the contracting states not thus indicated no communication under Rule 112(1) EPC be issued and further processing be excluded.

☐

11. Extension of the European patent

This application is deemed to be a request to extend the European patent application and the European patent granted in respect of it to all the non-contracting states to the EPC designated in the international application and with which extension agreements are in force on the date on which the international application is filed. However, the extension only takes effect if the prescribed extension fee is paid.

☐

It is currently intended to pay the extension fee for the following states:

Note: Under the automatic debiting procedure, extension fees will only be debited for states indicated here, unless the EPO is instructed otherwise before expiry of the period for payment.

12. List of enclosed documents

	Description of document	Original file name	Assigned file name
1	AMCLMS	P-EP62595F_Amended_Claims_for filing.pdf	AMCLMS.pdf

13. Mode of payment: Debit from deposit account

☒

Currency

EUR

The European Patent Office is hereby authorised, to debit from the deposit account with the EPO any fees and costs indicated on the fees page.

Deposit account number

28150011

Account holder

Papula Oy

14. Any refunds should be made to the following EPO deposit account:

☐

15. Fees

		Factor/reducti on applied	Fee schedule	Amount to be paid
15-1	002 Fee for (supplementary) European search for applications filed on/after 01.07.2005	0	1 050.00	0.00
15-2	005e Designation fee for all Contracting States designated	1	500.00	500.00
15-3	006e Examination fee (Euro-PCT without supplementary European search report)	0.8	1 565.00	1 252.00
15-4	015 Claims fee for 16th up to 50th claim	9	200.00	1 800.00
15-5	020 Filing fee - entry EP phase (Rule 159(1)(c) EPC)	1	100.00	100.00
15-6	033 Renewal fee for the 3rd year	1	400.00	400.00
15-7	520 Additional fee for the 36th and each subsequent page - Euro-PCT application -	0	12.00	0.00
Total:			EUR	4 052.00

16. Annotations

17. Signature(s) of applicant(s) or representative

Place:

Helsinki

Date:

12 November 2009

Signed by:

FI, HELINO TIMO 121624547

Capacity:

(Representative)

CLAIMS

1. A method, comprising:
 - calculating a difference signal representing differences between sample values of a predicted block of data and values for an original input block;
 - 5 performing transform coding to the difference signal, thereby creating a first representation of a first component of the difference signal;
 - performing spatial coding to the difference signal, thereby creating a second representation of a first component of the difference signal; and
 - joining the first and second representations.
- 10 2. The method according to claim 1, further comprising, before performing transform coding and spatial coding, substituting outlier values in the difference signal with non-outlier values to create a modified prediction error signal.
3. The method according to claim 2, wherein transform coding comprises applying transform coding to the modified prediction error signal; and wherein spatial
15 coding comprises applying spatial coding to a residual thereof.
4. The method according to claim 2, wherein spatial coding comprises applying spatial coding to the modified prediction error signal, and wherein transform coding comprises applying transform coding to a residual thereof.
5. The method according to claims 1 to 4, wherein, for transform coding,
20 at least one transform coefficient is set to zero, and wherein, for spatial coding, at least one spatial sample is set to zero.
6. The method according to claims 2, 3 and 4 wherein the non-outlier values used to replace the outlier values comprise an average of neighboring prediction error values.
- 25 7. The method according to claims 1 to 6, further comprising providing at least one of:

an indication that no transform coefficients exist in the block of data; and

an indication that no spatial samples exist in the block of data.

8. A computer program product in which a software code is stored in a computer readable medium, wherein said code realizes the following when being
5 executed by a processor:
- calculating a difference signal representing differences between sample values of a predicted block of data and values for an original input block;
 - performing transform coding to the difference signal, thereby creating a first representation of a first component of the difference signal;
 - 10 performing spatial coding to the difference signal, thereby creating a second representation of a first component of the difference signal; and
 - joining the first and second representations.

9. An apparatus, comprising:
- an encoder configured to:
 - 15 calculate a difference signal representing differences between sample values of a predicted block of data and values for an original input block;
 - perform transform coding to the difference signal, thereby creating a first representation of a first component of the difference signal;
 - perform spatial coding to the difference signal, thereby creating a
 - 20 second representation of a first component of the difference signal; and
 - join the first and second representations.

10. The apparatus according to claim 9, wherein the encoder is further configured to, before performing transform coding and spatial coding, substitute outlier values in the difference signal with non-outlier values to create a modified
25 prediction error signal.

11. The apparatus according to claim 10, wherein the encoder is configured to:

apply transform coding to the modified prediction error signal; and apply spatial coding to a residual thereof.

12. The apparatus according to claim 104, wherein the encoder is configured to:

5 apply spatial coding to the modified prediction error signal; and apply transform coding to a residual thereof.

13. The apparatus according to claims 9 to 12, wherein, for transform coding, at least one transform coefficient is set to zero, and wherein, for spatial coding, at least one spatial sample is set to zero.

10 14. The apparatus according to claims 10, 11, and 12, wherein the non-outlier values used to replace the outlier values comprise an average of neighboring prediction error values.

15. The apparatus according to claims 9 to 14, wherein the encoder is further configured to provide at least one of:

15 an indication that no transform coefficients exist in the block of data; and an indication that no spatial samples exist in the block of data.

16. A method, comprising:
receiving a coded prediction error signal, the coded prediction error signal including a plurality of transform coefficients and a plurality of spatial samples;
20 decoding the plurality of transformed coefficients into decoded transform information;
decoding the plurality of spatial samples into decoded spatial information; and
adding the decoded transform information, the decoded spatial
25 information, and a reconstructed prediction of the block of data, thereby forming a decoded representation of the block of data.

17. The method according to claim 16, wherein an indication is provided that indicates at least one of:

no transform coefficients exist in the block of data; and

no spatial samples exist in the block of data.

5 18. The method according to claims 16 and 17, wherein the decoding of the plurality of transformed coefficients and spatial samples includes dequantization of each, and wherein the dequantization of transformed coefficients and spatial samples are related to each other.

10 19. The method according to claim 16, wherein the decoding of the spatial samples is dependent upon the decoding of the transformed coefficients, and wherein the decoding of the transformed coefficients is based upon the decoding of the spatial samples.

20. A computer program product in which a software code is stored in a computer readable medium, wherein said code realizes the following when being
15 executed by a processor:
receiving a coded prediction error signal, the coded prediction error signal including a plurality of transform coefficients and a plurality of spatial samples;
decoding the plurality of transformed coefficients into decoded transform information;
20 decoding the plurality of spatial samples into decoded spatial information; and
adding the decoded transform information, the decoded spatial information, and a reconstructed prediction of the block of data, thereby forming a decoded representation of the block of data.

25 21. An apparatus, comprising:
a decoder configured to:

receive a coded prediction error signal, the coded prediction error signal including a plurality of transformed coefficients and a plurality of spatial samples;

5 decode the plurality of transformed coefficients into decoded transform information;

 decode the plurality of spatial samples into decoded spatial information; and

 add the decoded transform information, the decoded spatial information, and a reconstructed prediction of the block of data, thereby forming a
10 decoded representation of the block of data.

22. The apparatus of claim 21, wherein the decoder is further configured to decode at least one of:

 an indication indicating that no transform coefficients exist in the block of data; and

15 an indication indicating that no spatial samples exist in the block of data.

23. The apparatus according to claims 21 and 22, wherein the decoding of the plurality of transformed coefficients and spatial samples includes dequantization of each, and wherein the dequantization of transformed coefficients and spatial samples are related to each other.

20 24. The apparatus according to claims 21, 22, and 23, wherein the decoding of the spatial samples is dependent upon the decoding of the transformed coefficients, and wherein the decoding of the transformed coefficients is based upon the decoding of the spatial samples.



Acknowledgement of receipt

We hereby acknowledge receipt of the form for entry into the European phase (EPO as designated or elected Office) as follows:

Submission number	691237	
PCT application number	PCT/IB2008/051351	
EP application number	08737779.2	
Date of receipt	12 November 2009	
Receiving Office	European Patent Office, The Hague	
Your reference	P-EP62595F	
Applicant		
Country		
Documents submitted	package-data.xml application-body.xml AMCLMS.pdf\P-EP62595F_Amended _Claims_for filing.pdf (5 p.)	ep-euro-pct.xml epf1200.pdf (4 p.)
Submitted by	CN=HELINO TIMO 121624547,SN=HELINO,givenName=TIMO,serialNumber=121624547,C=FI	
Method of submission	Online	
Date and time receipt generated	12 November 2009, 15:00 (CET)	
Message Digest	52:46:1C:E0:27:BC:C4:34:7E:AD:81:F5:0D:91:0F:3C:06:61:48:8B	

Correction by the EPO of errors in debit instructions filed by eOLF

Errors in debit instructions filed by eOLF that are caused by the editing of Form 1038E entries or the continued use of outdated software (all forms) may be corrected automatically by the EPO, leaving the payment date unchanged (see decision T 152/82, OJ EPO 1984, 301 and point 6.3 ff ADA, Supplement to OJ EPO 10/2007).

/European Patent Office/

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter I of the Patent Cooperation Treaty)

(PCT Rule 44bis)

Applicant's or agent's file reference 037145-7827	FOR FURTHER ACTION		See item 4 below
International application No. PCT/IB2008/051351	International filing date (<i>day/month/year</i>) 09 April 2008 (09.04.2008)	Priority date (<i>day/month/year</i>) 12 April 2007 (12.04.2007)	
International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237			
Applicant NOKIA CORPORATION			

- This international preliminary report on patentability (Chapter I) is issued by the International Bureau on behalf of the International Searching Authority under Rule 44 *bis*.1(a).
- This REPORT consists of a total of 6 sheets, including this cover sheet.

In the attached sheets, any reference to the written opinion of the International Searching Authority should be read as a reference to the international preliminary report on patentability (Chapter I) instead.
- This report contains indications relating to the following items:

☒	Box No. I	Basis of the report
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application
- The International Bureau will communicate this report to designated Offices in accordance with Rules 44bis.3(c) and 93bis.1 but not, except where the applicant makes an express request under Article 23(2), before the expiration of 30 months from the priority date (Rule 44bis .2).

		Date of issuance of this report 13 October 2009 (13.10.2009)
The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland		Authorized officer Cecile Chatel
Facsimile No. +41 22 338 82 70		e-mail: ro.ib@wipo.int

Form PCT/IB/373 (January 2004)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

PCT

To:

see form PCT/ISA/220

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY (PCT Rule 43bis.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.
PCT/IB2008/051351

International filing date (day/month/year)
09.04.2008

Priority date (day/month/year)
12.04.2007

International Patent Classification (IPC) or both national classification and IPC
INV. H04N7/50

Applicant
NOKIA CORPORATION

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA:



European Patent Office - P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk - Pays Bas
Tel. +31 70 340 - 2040 Tx: 31 651 epo nl
Fax: +31 70 340 - 3016

Date of completion of
this opinion

see form
PCT/ISA/210

Authorized Officer

Wahrenberg, Annika

Telephone No. +31 70 340-4890



**WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY**

International application No.
PCT/IB2008/051351

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:
 - ☒ the international application in the language in which it was filed
 - ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).
2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43bis.1(a))
3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application and necessary to the claimed invention, this opinion has been established on the basis of:
 - a. type of material:
 - ☐ a sequence listing
 - ☐ table(s) related to the sequence listing
 - b. format of material:
 - ☐ on paper
 - ☐ in electronic form
 - c. time of filing/furnishing:
 - ☐ contained in the international application as filed.
 - ☐ filed together with the international application in electronic form.
 - ☐ furnished subsequently to this Authority for the purposes of search.
4. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
5. Additional comments:

**WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY**

International application No.
PCT/IB2008/051351

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	<u>2-11, 14-21, 23-29, 32-39</u>
	No: Claims	<u>1, 12, 13, 22, 30, 31</u>
Inventive step (IS)	Yes: Claims	<u>NONE</u>
	No: Claims	<u>1-39</u>
Industrial applicability (IA)	Yes: Claims	<u>1-39</u>
	No: Claims	<u>NONE</u>

2. Citations and explanations

see separate sheet

Re Item V.

1. Reference is made to the following documents:

D1: SANTAGO P ET AL: "USING CONVEX SET TECHNIQUES FOR COMBINED PIXEL AND FREQUENCY DOMAIN CODING OF TIME-VARYING IMAGES" IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, IEEE SERVICE CENTER, PISCATAWAY, US, vol. SAC-05, no. 7, 1 August 1987 (1987-08-01), pages 1127-1139, XP001053635 ISSN: 0733-8716

D2: SEGALL C A ET AL: "Pre- and post-processing algorithms for compressed video enhancement" SIGNALS, SYSTEMS AND COMPUTERS, 2000. CONFERENCE RECORD OF THE THIRTY- FOURTH ASILOMAR CONFERENCE ON OCT. 29 - NOV. 1, 2000, PISCATAWAY, NJ, USA, IEEE, vol. 2, 29 October 2000 (2000-10-29), pages 1369-1373, XP010535224 ISBN: 978-0-7803-6514-8

2. The term '*spatial coding*' used in claims 1, 13 and 39 is vague and unclear and leaves the reader in doubt as to the meaning of the technical features to which it refers, thereby rendering the definition of the subject-matter of said claims unclear; Article 6 PCT.

For the purpose of establishing this opinion, the aforementioned term has been interpreted as coding/representation of image samples in the spatial domain (see the description, para. [0011]).

3. The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claims 1, 13, 22 and 31 is not new in the sense of Article 33(2) PCT.

- 3.1 The document D1 discloses (the references in parentheses applying to this document):

a method of encoding a prediction error signal for a block of data (page 1129, right-hand column, para. VII, lines 2-3), comprising:

calculating a difference signal representing differences between sample values of a predicted block of data and values for an original input block (*ibid*; para. IX, lines 2-3);

performing transform coding to the difference signal, thereby creating a first representation of a first component of the difference signal (fig. 5 - transform (F));

performing spatial coding to the difference signal, thereby creating a second representation of a first component of the difference signal (fig. 5 - mask coder); and joining the first and second representations (fig. 5 - POCS; para. VII).

The subject-matter of claim 1 is therefore not new.

- 3.2 The same reasoning applies *mutatis mutandis* to claims 13, 22 and 31, which, therefore, lack novelty.
4. Pre-filtering the prediction error signal to remove outlier samples is well known in the art (see e.g. D2, para. 4.1). The additional feature of claim 39, therefore, does not add anything of inventive significance.
5. The dependent claims (2-12, 14-21, 23, 30 and 31-38) are numerous, disparate and vague and it is not at all apparent that they relate to a single general inventive concept. Furthermore, they do not appear to contain subject-matter which makes an inventive contribution over the prior art D1 and D2.



Helino, Timo Kalervo
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00180 Helsinki
FINLANDE

**For any questions about
this communication:**

Tel.: +31 (0)70 340 45 00

Date
25-11-2009

Reference P-EP62595F	Application No./Patent No. 08737779.2 - 1247 PCT/IB2008051351
Applicant/Proprietor Nokia Corporation	

Communication pursuant to Rules 161 and 162 EPC

(1) Amendment of application documents, especially the claims (R. 161 EPC)

The above mentioned international (Euro-PCT) application has entered the European phase.

Under Articles 28, 41 PCT, Rules 52, 78 PCT and Rule 137(2) to (4) EPC, the applicant may amend the application documents after receiving the international search report.

Whether or not he has already done so, he now has a further opportunity to file amended claims or other application documents within a non-extendable period of ONE MONTH after notification of the present communication (R. 161 EPC).

The claims applicable on expiry of the above time limit, i.e. those filed on entry into the European phase or in response to the present communication, will form the basis for the calculation of any claims fee to be paid (see page 2) and for any supplementary search to be carried out under Article 153(7) EPC (R. 161 EPC).

(2) Claims fees under Rule 162 EPC

If the application documents on which the European grant procedure is to be based comprise more than fifteen claims, a claims fee shall be payable for the sixteenth and each subsequent claim within the period provided for in Rule 159(1) EPC.

- ☒ Based on the application documents currently on file, all necessary claims fees have already been paid (or the documents do not comprise more than 15 claims).
- ☐ All necessary fees will be/have been debited automatically according to the automatic debit order.
- ☐ The claims fees due for the claims to were not paid within the above-mentioned period.

Any non-paid claims fee, either based on the current set of claims or on any amended claims to be filed pursuant to Rule 161 EPC (see page 1), may still be validly paid within a non-extendable period of **one month** after notification of this communication (R. 162(2) EPC).

If a payment is made for only some of the claims, it must be indicated for which claims it is intended. If a claims fee is not paid in due time, the claim concerned is deemed to be abandoned (R. 162(4) EPC).

If claims fees have already been paid, but on expiry of the above-mentioned period there is a new set of claims containing fewer fee-incurring claims than previously, the claims fees in excess of those due under Rule 162(2), 2nd sentence EPC will be refunded (R. 162(3) EPC).

You are reminded that any supplementary search under Article 153(7) EPC will relate only to the last set of claims applicable on expiry of the above period AND will be confined to those fee-incurring claims for which fees have been paid in due time.

The present amount of the claims fee is

EUR 200 for the 16th and each subsequent claim up to the limit of 50
EUR 500 for the 51st and each subsequent claim

Note to users of the automatic debiting procedure

Unless the EPO receives prior instructions to the contrary, the fees for all claims incurring fees will be debited on the last day of the period for payment. For further details see the Arrangements for the automatic debiting procedure, Supplement to OJ EPO 3/2009.

Receiving Section



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**For any questions about
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Tel.: +31 (0)70 340 45 00

Date

02.12.09

Reference P-EP62595F	Application No./Patent No. 08737779.2 - 1247 PCT/IB2008051351
Applicant/Proprietor Nokia Corporation	

Refund of fees

The following fee(s) was/were paid in respect of the application 08737779.2:

Fee	Reference	Voucher No	Date	Currency	Amount
Renewal fee	033	00809612	12.11.09	EUR	400,00

According to the present state of the file the refund will be made by:

CREDITING THE DEPOSIT ACCOUNT 28150011 Papula Rein Lahtela OY.

Amount refundable:	Reference	Currency	Amount	Voucher No
	033	EUR	400,00	00028008

Reason for refund: Renewal fee paid too early

The Authorising Officer
Schiavo
(49)(89)23994237





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**For any questions about
this communication:**

Tel.: +31 (0)70 340 45 00

Date

27.01.10

Reference P-EP62595F	Application No./Patent No. 08737779.2 - 2223 / 2156675
Applicant/Proprietor Nokia Corporation	

Communication of European publication number and information on the application of Article 67(3) EPC

The provisional protection under Article 67(1) and (2) EPC in the individual Contracting States becomes effective only when the conditions referred to in Article 67(3) EPC have been fulfilled (for further details, see information brochure of the European Patent Office "National Law relating to the EPC" and additional information in the Official Journal of the European Patent Office).

Pursuant to Article 153(3) EPC the publication under Article 21 PCT of an international application for which the European Patent Office is a designated or elected Office takes the place of the publication of a European patent application.

The bibliographic data of the above-mentioned Euro-PCT application will be published on 24.02.10 in Section I.1 of the European Patent Bulletin. The European publication number is 2156675.

In all future communications to the European Patent Office, please quote the application number plus Directorate number.

Receiving Section





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Application No. 08 737 779.2 - 2223	Ref. P-EP62595F	Date 11.06.2010
Applicant Nokia Corporation		

Communication pursuant to Article 94(3) EPC

The examination of the above-identified application has revealed that it does not meet the requirements of the European Patent Convention for the reasons enclosed herewith. If the deficiencies indicated are not rectified the application may be refused pursuant to Article 97(2) EPC.

You are invited to file your observations and insofar as the deficiencies are such as to be rectifiable, to correct the indicated deficiencies within a period

of 4 months

from the notification of this communication, this period being computed in accordance with Rules 126(2) and 131(2) and (4) EPC. One set of amendments to the description, claims and drawings is to be filed within the said period on separate sheets (R. 50(1) EPC).

If filing amendments, you must identify them and indicate the basis for them in the application as filed. Failure to meet either requirement may lead to a communication from the Examining Division requesting that you correct this deficiency (R. 137(4) EPC).

Failure to comply with this invitation in due time will result in the application being deemed to be withdrawn (Art. 94(4) EPC).



Wahrenberg, Annika
Primary Examiner
For the Examining Division

Enclosure(s): 1 page/s reasons (Form 2906)

The examination is being carried out on the **following application documents**

Description, Pages

1-13 as published

Claims, Numbers

1-24 filed with entry into the regional phase before the EPO

Drawings, Sheets

1/9-9/9 as published

- 1 An International Preliminary Report on Patentability (IPRP) has already been drawn up for the present application in accordance with the PCT.
- 2 On entry into the regional phase, the applicant has amended the claims. The number of claims have been reduced and the dependencies have been changed. Also, the wording of the claims have been slightly amended. However, the subject-matter of at least the independent claims, corresponds, in essence, to the claims on which the IPRP is based. Consequently, the objections raised in the IPRP apply to the newly filed claims:
- 3 Accordingly, claims 1, 8 and 9 lack clarity, contrary to Article 84 EPC (see Item V, point 2 of the IPRP). Claims 1, 8, 9, 16, 20, and 21 lack novelty (Article 54(1) and (2), contrary to Article 52(1) EPC (Item V, point 3). The dependent claims are numerous, disparate and vague and it is not at all apparent that they relate to a single general inventive concept. Furthermore, they do not appear to contain subject-matter which make an inventive contribution over the prior art.

European Patent Office
D-80298 München
Germany

Our ref. P-EP62595Q
Date 11 October 2010

European patent application 08737779.2-2223
Applicant: Nokia Corporation

This is in response to a Communication dated 11 June 2010 pursuant to Article 94(3) EPC concerning the above identified application.

In response to portion 3 of said Communications and point 2 of the corresponding IPRP, the term “spatial coding” has been amended to “spatial domain coding”. Basis for the amendment can be found at least on paragraphs [0001] and [0011] of the originally filed description.

Furthermore, in view of the cited prior art, claims 1, 7 (originally filed claim 8) and 8 (originally filed claim 9) have been amended by incorporating the subject matter of originally filed claims 2 and 10 into them. Accordingly, said originally filed claims 2 and 10 have been deleted. Claim numbering has been amended to reflect these deletions. Additional support for these amendments can be found at least on paragraphs [0043] and [0044] of the originally filed description.

Also, in view of the cited prior art, claims 14 (originally filed claim 16), 17 (originally filed claim 20) and 18 (originally filed claim 21) have been amended by incorporating the subject matter of originally filed claims 17 and 22 into them. Accordingly, said originally filed claims 17 and 22 have been deleted. Claim numbering has been amended to reflect these deletions. Additional support for these amendments can be found at least on paragraphs [0043] and [0044] of the originally filed description.

For your convenience, both marked-up and clean copies of the amended claim set are provided. Additions are highlighted with underlinings, and deletions are highlighted with strikethroughs in the marked-up copies.

The application as amended does not contain subject matter extending beyond the content of the application as filed.

In regards to the cited prior art Santiago P. et al., “USING CONVEX SET TECHNIQUES FOR COMBINED PIXEL AND FREQUENCY DOMAIN CODING OF TIME-VARYING IMAGES” (D1), and Segall C. A.

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et al., “Pre- and Post-Processing Algorithms for Compressed Video Enhancement” (D2), and the alleged lack of novelty, the following comments and observations are submitted.

D1 discloses an image coding technique, in which pixel and frequency domain information is combined in order to improve image quality over standard transform coding at given bit rates. The use of nonintersecting convex sets is shown to be optimum for two sets and a given error measure.

D2 discloses a survey on the fields of pre- and post-processing techniques for video compression, as well as some compression enhancement algorithms.

Both D1 and D2 fail to teach or suggest at least the claimed feature of “creating a modified prediction error signal by substituting outlier values in the difference signal with non-outlier values” in amended claims 1, 7 and 8. No such feature can be found anywhere in either D1 or D2.

Similarly, both D1 and D2 fail to teach or suggest at least the claimed feature of “wherein an indication is provided that indicates at least one of no transform coefficients exist in the block of data; and no spatial samples exist in the block of data” in amended claims 14, 17 and 18. No such feature can be found anywhere in either D1 or D2.

Accordingly, the present invention is novel in view of D1 and D2.

Furthermore, the above features of the present invention have a significant advantage in that they allow e.g. improving the compression efficiency of modern video and image codecs. Fast algorithms can be applied in order to lower the encoding complexity that approaches the complexity level for traditional transform based coding.

Accordingly, the above features of the present invention involve an inventive step over D1 and D2.

It is believed the application is now in compliance with the EPC. Should the Examiner find any incompliance, we are ready to further specify our comments and/or further amend the application in response to any communication pointing such deficiencies under the European Patent Convention. Should the Examining Division take any adverse decision on this application, the applicant hereby requests, in order of preference, a phone conversation, an informal interview and Oral Proceedings before such decision.

Respectfully

PAPULA OY

Timo Helino

ENCS amended claims, marked-up copy
 amended claims, clean copy

MH



Letter accompanying subsequently filed items

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The document(s) listed below is (are) subsequently filed documents pertaining to the following application:

Application number

08737779.2

Applicant's or representative's reference

P-EP62595Q

	Description of document	Original file name	Assigned file name
1	Reply to examination report	P-EP62595Q Letter.pdf	EXRE3-1.pdf
2	Claims	P-EP62595Q Amended Claims Oct2010 Clean.pdf	CLMS-1.pdf
3	Claims	P-EP62595Q Amended Claims Oct2010 Marked.pdf	CLMS-2.pdf

Signatures

Place: **Helsinki**
Date: **11 October 2010**
Signed by: **FI, Papula Oy, T. Helino 23760**
Capacity: **(Representative)**

WHAT IS CLAIMED IS:

1. A method, comprising:
 - calculating a difference signal representing differences between sample values of a predicted block of data and values for an original input block;
 - 5 creating a modified prediction error signal by substituting outlier values in the difference signal with non-outlier values;
 - performing transform coding to the difference signal, thereby creating a first representation of a first component of the difference signal;
 - performing spatial domain coding to the difference signal, thereby
 - 10 creating a second representation of a first component of the difference signal; and
 - joining the first and second representations.
2. The method according to claim 1, wherein transform coding comprises applying transform coding to the modified prediction error signal; and wherein spatial domain coding comprises applying spatial domain coding to a residual
- 15 thereof.
3. The method according to claim 1, wherein spatial domain coding comprises applying spatial domain coding to the modified prediction error signal, and wherein transform coding comprises applying transform coding to a residual thereof.
4. The method according to claims 1 to 3, wherein, for transform coding, at least
- 20 one transform coefficient is set to zero, and wherein, for spatial domain coding, at least one spatial sample is set to zero.
5. The method according to claims 1, 2 and 3, wherein the non-outlier values used to replace the outlier values comprise an average of neighboring prediction error values.
- 25 6. The method according to claims 1 to 5, further comprising providing at least one of:
 - an indication that no transform coefficients exist in the block of data; and

an indication that no spatial samples exist in the block of data.

7. A computer program product, in which a software code is stored in a computer readable medium, wherein said code realizes the following when being executed by a processor:

- 5 calculating a difference signal representing differences between sample values of a predicted block of data and values for an original input block;
 creating a modified prediction error signal by substituting outlier values in the difference signal with non-outlier values;
 performing transform coding to the difference signal, thereby creating a first
10 representation of a first component of the difference signal;
 performing spatial domain coding to the difference signal, thereby creating a second representation of a first component of the difference signal; and
 joining the first and second representations.

8. An apparatus, comprising:

- 15 an encoder configured to:
 calculate a difference signal representing differences between sample values of a predicted block of data and values for an original input block;
 create a modified prediction error signal by substituting outlier values in the difference signal with non-outlier values;
20 perform transform coding to the difference signal, thereby creating a first representation of a first component of the difference signal;
 perform spatial domain coding to the difference signal, thereby creating a second representation of a first component of the difference signal; and
 join the first and second representations.

25 9. The apparatus according to claim 8, wherein the encoder is configured to:

 apply transform coding to the modified prediction error signal; and apply spatial domain coding to a residual thereof.

10. The apparatus according to claim 8, wherein the encoder is configured to:

apply spatial domain coding to the modified prediction error signal; and apply transform coding to a residual thereof.

11. The apparatus according to claims 8 to 10, wherein, for transform coding, at least one transform coefficient is set to zero, and wherein, for spatial domain coding,
5 at least one spatial sample is set to zero.

12. The apparatus according to claims 8, 9, and 10, wherein the non-outlier values used to replace the outlier values comprise an average of neighboring prediction error values.

13. The apparatus according to claims 8 to 12, wherein the encoder is further
10 configured to provide at least one of:

an indication that no transform coefficients exist in the block of data; and

an indication that no spatial samples exist in the block of data.

14. A method, comprising:
receiving a coded prediction error signal, the coded prediction error signal
15 including a plurality of transform coefficients and a plurality of spatial samples;
decoding the plurality of transformed coefficients into decoded transform information;
decoding the plurality of spatial samples into decoded spatial information; and
adding the decoded transform information, the decoded spatial information,
20 and a reconstructed prediction of the block of data, thereby forming a decoded representation of the block of data,
wherein an indication is provided that indicates at least one of no transform coefficients exist in the block of data; and no spatial samples exist in the block of data.

25 15. The method according to claim 14, wherein the decoding of the plurality of transformed coefficients and spatial samples includes dequantization of each, and

wherein the dequantization of transformed coefficients and spatial samples are related to each other.

16. The method according to claim 14, wherein the decoding of the spatial samples is dependent upon the decoding of the transformed coefficients, and wherein
5 the decoding of the transformed coefficients is based upon the decoding of the spatial samples.

17. A computer program product in which a software code is stored in a computer readable medium, wherein said code realizes the following when being executed by a processor:

10 receiving a coded prediction error signal, the coded prediction error signal including a plurality of transform coefficients and a plurality of spatial samples;
decoding the plurality of transformed coefficients into decoded transform information;
decoding the plurality of spatial samples into decoded spatial information; and
15 adding the decoded transform information, the decoded spatial information, and a reconstructed prediction of the block of data, thereby forming a decoded representation of the block of data,
wherein an indication is provided that indicates at least one of no transform coefficients exist in the block of data; and no spatial samples exist in the block of
20 data.

18. An apparatus, comprising:
a decoder configured to:
receive a coded prediction error signal, the coded prediction error signal including a plurality of transformed coefficients and a plurality of spatial samples;
25 decode the plurality of transformed coefficients into decoded transform information;
decode the plurality of spatial samples into decoded spatial information; and
add the decoded transform information, the decoded spatial information, and a reconstructed prediction of the block of data, thereby forming a decoded
30 representation of the block of data,

wherein the decoder is further configured to decode at least one of: an indication indicating that no transform coefficients exist in the block of data; and an indication indicating that no spatial samples exist in the block of data.

19. The apparatus according to claim 18, wherein the decoding of the plurality of transformed coefficients and spatial samples includes dequantization of each, and
5 wherein the dequantization of transformed coefficients and spatial samples are related to each other.

20. The apparatus according to claims 18 and 19, wherein the decoding of the spatial samples is dependent upon the decoding of the transformed coefficients, and
10 wherein the decoding of the transformed coefficients is based upon the decoding of the spatial samples.

WHAT IS CLAIMED IS:

1. A method, comprising:
 - calculating a difference signal representing differences between sample values of a predicted block of data and values for an original input block;
 - 5 ~~creating a modified prediction error signal by substituting outlier values in the difference signal with non-outlier values;~~
 - performing transform coding to the difference signal, thereby creating a first representation of a first component of the difference signal;
 - performing spatial domain coding to the difference signal, thereby
 - 10 creating a second representation of a first component of the difference signal; and
 - joining the first and second representations.
- ~~2. The method according to claim 1, further comprising, before performing transform coding and spatial coding, substituting outlier values in the difference signal with non-outlier values to create a modified prediction error signal.~~
- 15 ~~3.2.~~ The method according to claim ~~21~~, wherein transform coding comprises applying transform coding to the modified prediction error signal; and wherein spatial domain coding comprises applying spatial domain coding to a residual thereof.
- ~~4.3.~~ The method according to claim ~~21~~, wherein spatial domain coding comprises
- 20 applying spatial domain coding to the modified prediction error signal, and wherein transform coding comprises applying transform coding to a residual thereof.
- ~~5.4.~~ The method according to claims 1 to ~~43~~, wherein, for transform coding, at least one transform coefficient is set to zero, and wherein, for spatial domain coding, at least one spatial sample is set to zero.
- 25 ~~6.5.~~ The method according to claims ~~21~~, ~~3-2~~ and ~~43~~, wherein the non-outlier values used to replace the outlier values comprise an average of neighboring prediction error values.

~~7.6~~.....The method according to claims 1 to ~~65~~, further comprising providing at least one of:

an indication that no transform coefficients exist in the block of data; and

an indication that no spatial samples exist in the block of data.

5 ~~8.7~~.....A computer program product, in which a software code is stored in a computer readable medium, wherein said code realizes the following when being executed by a processor:

calculating a difference signal representing differences between sample values of a predicted block of data and values for an original input block;

10 ~~creating a modified prediction error signal by substituting outlier values in the difference signal with non-outlier values;~~

performing transform coding to the difference signal, thereby creating a first representation of a first component of the difference signal;

performing spatial ~~domain~~ coding to the difference signal, thereby creating a
15 second representation of a first component of the difference signal; and
joining the first and second representations.

~~9.8~~.....An apparatus, comprising:

an encoder configured to:

calculate a difference signal representing differences between sample values
20 of a predicted block of data and values for an original input block;

~~create a modified prediction error signal by substituting outlier values in the difference signal with non-outlier values;~~

perform transform coding to the difference signal, thereby creating a first representation of a first component of the difference signal;

25 perform spatial ~~domain~~ coding to the difference signal, thereby creating a second representation of a first component of the difference signal; and
join the first and second representations.

~~10. The apparatus according to claim 9, wherein the encoder is further configured to, before performing transform coding and spatial coding, substitute outlier values in the difference signal with non-outlier values to create a modified prediction error signal.~~

~~11.9.~~ The apparatus according to claim ~~108~~, wherein the encoder is configured to:

5 apply transform coding to the modified prediction error signal; and apply spatial domain coding to a residual thereof.

~~12.10.~~ The apparatus according to claim ~~108~~, wherein the encoder is configured to:

 apply spatial domain coding to the modified prediction error signal; and apply transform coding to a residual thereof.

10 ~~13.11.~~ The apparatus according to claims ~~9-8~~ to ~~1210~~, wherein, for transform coding, at least one transform coefficient is set to zero, and wherein, for spatial domain coding, at least one spatial sample is set to zero.

~~14.12.~~ The apparatus according to claims ~~108~~, ~~119~~, and ~~1210~~, wherein the non-outlier values used to replace the outlier values comprise an average of neighboring
15 prediction error values.

~~15.13.~~ The apparatus according to claims ~~9-8~~ to ~~1412~~, wherein the encoder is further configured to provide at least one of:

 an indication that no transform coefficients exist in the block of data; and

 an indication that no spatial samples exist in the block of data.

20 ~~16.14.~~ A method, comprising:

 receiving a coded prediction error signal, the coded prediction error signal including a plurality of transform coefficients and a plurality of spatial samples;
 decoding the plurality of transformed coefficients into decoded transform information;

25 decoding the plurality of spatial samples into decoded spatial information; and

adding the decoded transform information, the decoded spatial information, and a reconstructed prediction of the block of data, thereby forming a decoded representation of the block of data,

5 ~~wherein an indication is provided that indicates at least one of no transform coefficients exist in the block of data; and no spatial samples exist in the block of data.~~

~~17. The method according to claim 16, wherein an indication is provided that indicates at least one of:~~

~~no transform coefficients exist in the block of data; and~~
10 ~~no spatial samples exist in the block of data.~~

~~18. 15. The method according to claims 16 and 17 14,~~ wherein the decoding of the plurality of transformed coefficients and spatial samples includes dequantization of each, and wherein the dequantization of transformed coefficients and spatial samples are related to each other.

15 ~~19. 16. The method according to claim 16 14,~~ wherein the decoding of the spatial samples is dependent upon the decoding of the transformed coefficients, and wherein the decoding of the transformed coefficients is based upon the decoding of the spatial samples.

~~20. 17. A computer program product in which a software code is stored in a computer~~
20 ~~readable medium, wherein said code realizes the following when being executed by a processor:~~

receiving a coded prediction error signal, the coded prediction error signal including a plurality of transform coefficients and a plurality of spatial samples;
decoding the plurality of transformed coefficients into decoded transform
25 information;
decoding the plurality of spatial samples into decoded spatial information; and

adding the decoded transform information, the decoded spatial information, and a reconstructed prediction of the block of data, thereby forming a decoded representation of the block of data,

5 ~~wherein an indication is provided that indicates at least one of no transform coefficients exist in the block of data; and no spatial samples exist in the block of data.~~

21-18. An apparatus, comprising:
a decoder configured to:

10 receive a coded prediction error signal, the coded prediction error signal including a plurality of transformed coefficients and a plurality of spatial samples;
 decode the plurality of transformed coefficients into decoded transform information;
 decode the plurality of spatial samples into decoded spatial information; and
 add the decoded transform information, the decoded spatial information, and a
15 reconstructed prediction of the block of data, thereby forming a decoded representation of the block of data,

~~wherein the decoder is further configured to decode at least one of: an indication indicating that no transform coefficients exist in the block of data; and an indication indicating that no spatial samples exist in the block of data.~~

20 ~~22. The apparatus of claim 21, wherein the decoder is further configured to decode at least one of:~~

~~an indication indicating that no transform coefficients exist in the block of data; and~~

~~an indication indicating that no spatial samples exist in the block of data.~~

25 ~~23. 19. The apparatus according to claims 21 and 22 18, wherein the decoding of the plurality of transformed coefficients and spatial samples includes dequantization of each, and wherein the dequantization of transformed coefficients and spatial samples are related to each other.~~

~~24.20~~ The apparatus according to claims ~~21, 22, 18~~ and ~~23~~¹⁹, wherein the decoding of the spatial samples is dependent upon the decoding of the transformed coefficients, and wherein the decoding of the transformed coefficients is based upon the decoding of the spatial samples.



Acknowledgement of receipt

We hereby acknowledge receipt of the following subsequently filed document(s):

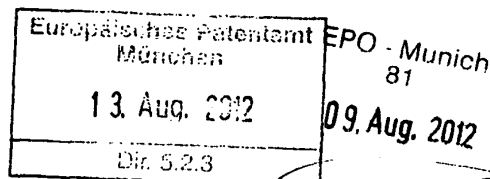
Submission number	968858	
Application number	EP08737779.2	
Date of receipt	11 October 2010	
Receiving Office	European Patent Office, The Hague	
Your reference	P-EP62595Q	
Applicant	All applicants as on file	
Documents submitted	package-data.xml epf1038.pdf (1 p.) CLMS-1.pdfP-EP62595Q Amended Claims Oct2010 Clean.pdf (5 p.)	ep-sfd-request.xml EXRE3-1.pdfP-EP62595Q Letter.pdf (3 p.) CLMS-2.pdfP-EP62595Q Amended Claims Oct2010 Marked.pdf (6 p.)
Submitted by	CN=T. Helino 23760,O=Papula Oy,C=FI	
Method of submission	Online	
Date and time receipt generated	11 October 2010, 13:09 (CEST)	
Message Digest	A8:B8:B4:9D:A7:79:54:B7:43:C1:4C:2C:2D:D4:00:CC:EF:8E:92:6B	

Correction by the EPO of errors in debit instructions filed by eOLF

Errors in debit instructions filed by eOLF that are caused by the editing of Form 1038E entries or the continued use of outdated software (all forms) may be corrected automatically by the EPO, leaving the payment date unchanged (see decision T 152/82, OJ EPO 1984, 301 and point 6.3 ff ADA, Supplement to OJ EPO 10/2007).

/European Patent Office/

European Patent Office
D-80298 München
Germany



Forssén & Salomaa merger and Papula Oy change of address

Please, record the following changes:

- 1) The firm Forssén & Salomaa Oy has merged into Papula Oy. Accordingly, in all active cases where the representative is Esko Salonen or Sirpa Kurra of Forssén & Salomaa, please record change of representative to Papula Oy (Association No. 397). Esko Salonen and Sirpa Kurra have already been added to the association No. 397.

We enclose a copy of an extract from the Finnish trade register, and a translation of it into English, that the firm Forssén & Salomaa Oy has merged into Papula Oy as of 1.6.2012.

- 2) Further, in all active cases where the representative is one of the following:

Timo Helino ✓
Markku Simmelvuori ✓
Jarmo Tanskanen ✓
Erja Partio ✓

with an address to Papula Oy, please record as the new representative the Papula Oy association (Association No. 397).

- 3) To all the above referred cases and all other active cases where the Papula Oy association (Association No. 397) is the representative, please use the address of the association:

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Accordingly, all active cases to Papula Oy should use this address.

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Jukka Wälfors, M.Sc. (CS) •
Jukka Korhonen, M.Sc. (Eng.) •
Jussi Mäkelä, LL.M. •
Teemu Lång, Dr. (Tech.) •
Hannu Kivistö, M.Sc. (Eng.) •
Enk Gusev, M.Sc. (Phys.) •
Nora Pöyhönen, PhD
Satu Lehtoranta, PhD

Russia
A. V. Polikarpov, M.Sc. (Eng.) ••
M. V. Samoylov, M.Sc. (Eng.) •
E. N. Borisova, M.Sc. (Eng.) ••
G. B. Zuev, PhD (Eng.) •
M. V. Sokolova, PhD (Chem.) ••
E. I. Gerasimov, M.Sc. (Eng.) •
T. G. Korotkiy, M.Sc. (Chem.) •
V. N. Prigodny, PhD (Chem.) •
I. M. Muraviev, M.Sc. (Eng.) •
Z. M. Nosova, M.Sc. (Chem.) •
T. A. Semakova, PhD (Chem.) •
E. A. Soloviy, M.Sc. (Chem.) •
V. G. Mamonov, M.Sc. (Chem.) •
G. V. Pavlov, PhD (Chem.) •

Ukraine
M. I. Krylova, M.Sc. (Eng.) •
N. S. Hapenko, PhD (Eng.) •
G. A. Pogorelov, M.Sc. •
W. S. Koval, LL.M. •
T. A. Kuchuk, M.Sc. (Eng.) •
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M. M. Makhlov, M.Sc. (Eng.) •
M. G. Zambalova, M.Sc. (Chem.) •
G. S. Torgoev, M.Sc. (Eng.) •

Belarus
M. G. Zambalova, M.Sc. (Eng.) •
M. G. Zambalova, M.Sc. (Eng.) •
M. G. Zambalova, M.Sc. (Eng.) •

• M. G. Zambalova, M.Sc. (Eng.) •
• M. G. Zambalova, M.Sc. (Eng.) •
• M. G. Zambalova, M.Sc. (Eng.) •
• M. G. Zambalova, M.Sc. (Eng.) •
• M. G. Zambalova, M.Sc. (Eng.) •



Yours sincerely,

PAPULA OY

On behalf of association no. 397

A handwritten signature in black ink, appearing to be "Folke", written in a cursive style.

Folke Johansson, reg. no. 0081680

Legally valid translation from the original in Finnish:

The National Board of Patents and Registration
Trade Register
Arkadiankatu 6 A
00100 Helsinki
Tel. (09) 6939 500
kirjaamo@prh.fi

Page: 1 (1)
Business ID: 0108262-6
Date of excerpt: 07.06.2012 10:56:28

INFORMATION IN THE REGISTER EXTRACT

Company name: Forssén & Salomaa Oy
Business ID: 0108262-6
Date of registration: 28.10.1949
Company form: Limited company
Domicile: Helsinki
Content of extract: Information in the register 07.06.2012 10:56:26.

Register entries:

IMPLEMENTATION OF MERGER (Registered 01.06.2012)
Forssén & Salomaa Oy Business ID 0108262-6 has merged with a company named Papula Oy
Business ID 0236098-2.

DISSOLUTION (Registered 01.06.2012)
The company is dissolved.

ADDITIONAL INFORMATION

Entered in the register as terminated 01.06.2012.

COMPANY NAME HISTORY

Forssén & Salomaa Oy 24.04.1959 – 31.05.2012
Oy. Patentti- ja Insinööritoimisto Forssén Ab. 08.12.1950 – 23.04.1959
O.Y. Insinööritoimisto Forssén A.B. 28.10.1949 – 07.12.1950

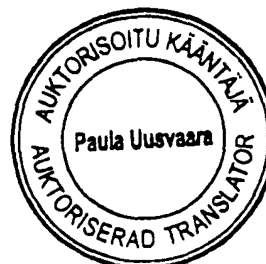
Source: The National Board of Patents and Registration of Finland

I hereby certify the above to be a true and correct translation of the attached document.

Tampere, 8 June 2012

Paula Uusvaara

Paula Uusvaara
Authorized translator (Act 1231/2007 as amended)



Patentti- ja rekisterihallitus
Kaupparekisteri
Arkadiankatu 6 A
00100 Helsinki
puh. (09) 6939 500
kirjaamo@prh.fi

Sivu: 1 (1)
Y-tunnus: 0108262-6
Luontiajankohta: 07.06.2012 10:56:28

REKISTERIOTTEEN TIEDOT

Toiminimi:	Forssén & Salomaa Oy
Y-tunnus:	0108262-6
Yritys rekisteröity:	28.10.1949
Yritysmuoto:	Osakeyhtiö
Kotipaikka:	Helsinki
Otteen sisältö:	07.06.2012 10:56:26 rekisterissä olleet tiedot.

Rekisterimerkinnät:

SULAUTUMISEN TÄYTÄNTÖÖNPANO (Rekisteröity 01.06.2012)
Forssén & Salomaa Oy Y-tunnus 0108262-6 on sulautunut Papula Oy
-nimiseen yhtiöön Y-tunnus 0236098-2.

PURKAUTUMINEN (Rekisteröity 01.06.2012)
Yhtiö on purkautunut.

LISÄTIETOJA

Merkitty rekisteriin lakanneeksi 01.06.2012

TOIMINIMIHISTORIA

Forssén & Salomaa Oy 24.04.1959 - 31.05.2012
Oy. Patentti- ja Insinööritoimisto Forssén Ab. 08.12.1950 - 23.04.1959
O.Y. Insinööritoimisto Forssén A.B. 28.10.1949 - 07.12.1950

Tietolähde: Patentti- ja rekisterihallitus





European Patent Office
80298 MUNICH
GERMANY
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Fax +49 (0)89 2399 - 4465



Papula Oy
P.O. Box 981
00101 Helsinki
FINLANDE

**For any questions about
this communication:**

Tel.: +31 (0)70 340 45 00

Date 31.08.12

Reference P-EP62595F	Application No./Patent No. 08737779.2 - 2223 / 2156675
Applicant/Proprietor Nokia Corporation	

Communication of amended entries concerning the representative (R. 143(1)(h) EPC)

As requested, for the above-mentioned European patent application / European patent the entries concerning the representative have been amended as follows:

Papula Oy
P.O. Box 981
00101 Helsinki
FI

The amendment will be recorded in the Register of European Patents.

For the Examining Division



Client Data Registration Tel.: +49 (0)89 2399 2780
--



Papula Oy
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FINLANDE

Formalities Officer
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Substantive Examiner
Name: Luckett, Paul
Tel: +49 89 2399 - 8965

Application No. 08 737 779.2 - 1908	Ref. P-EP62595F	Date 08.03.2013
Applicant Nokia Corporation		

Communication pursuant to Article 94(3) EPC

The examination of the above-identified application has revealed that it does not meet the requirements of the European Patent Convention for the reasons enclosed herewith. If the deficiencies indicated are not rectified the application may be refused pursuant to Article 97(2) EPC.

You are invited to file your observations and insofar as the deficiencies are such as to be rectifiable, to correct the indicated deficiencies within a period

of 4 months

from the notification of this communication, this period being computed in accordance with Rules 126(2) and 131(2) and (4) EPC. One set of amendments to the description, claims and drawings is to be filed within the said period on separate sheets (R. 50(1) EPC).

If filing amendments, you must identify them and indicate the basis for them in the application as filed. Failure to meet either requirement may lead to a communication from the Examining Division requesting that you correct this deficiency (R. 137(4) EPC).

Failure to comply with this invitation in due time will result in the application being deemed to be withdrawn (Art. 94(4) EPC).



Lockett, Paul
Primary Examiner
For the Examining Division

Enclosure(s): 2 page/s reasons (Form 2906)
 WO-9907154-A1

The examination is being carried out on the **following application documents**

Description, Pages

1-13 as originally filed

Claims, Numbers

1-20 received on 11-10-2010 with letter of 11-10-2010

Drawings, Sheets

1/9-9/9 as originally filed

- 1 The following document is cited by the Examiner. A copy of the document is annexed to the communication and the numbering will be adhered to in the rest of the procedure.
- D6 WO 99/07154 A1 (IDT INT DIGITAL TECHNOLOGIES DEUT GMBH) 11 February 1999 (1999-02-11)
- 2 The features of the independent claims are cast in such broad and vague terms that these claims are not deemed to find adequate technical support in the description nor to be adequately clear to enable a fair determination of their intended scope (Art 84, EPC).
- 3 Obscurity in the independent claims derives from the extremely vague term "joining". The entire description is silent concerning any technical features whatsoever by way of which any form of "joining" could be meaningfully understood.
- 4 Further obscurity in the independent claims is caused by the lack of any clear technical definition of a distinction between "outlier values" and "non-outlier values". This terminology appears to be implying some form of unspecified spatial filtering ?
- 5 In as far as its intended scope can at present be determined, the common subject matter of the various independent claims appears to be rendered obvious by a skilled person's common knowledge taken in combination with the disclosure of :- D6
- 6 The D6 reference discloses (see inter alia abstract) filtering video images so as to improve compressibility. The spatially filtered images are compressed by transform coding into the frequency domain while a "residual" spatial image

component is derived from the difference (error) between the predicted image and the original image. Both the frequency transformed image and the compressed residual image are passed through a communication channel (in which they can be said to be "joined") (see inter alia D6 description w.r.t. fig1).

- 7 None of the independent claims includes any clear distinguishing features which might be considered to involve an inventive step.
- 8 Most of the dependent claims refer directly back to a head claim such that when the latter fails, the former fall apart into a number of disparate concepts all of which appear to constitute routine matters of design normally to be expected of a skilled person. Thus these claims do not relate clearly to a common inventive concept, nor do they in combination lead to any matter upon which an ultimately allowable claim might be based.
- 9 The applicants' attention is drawn to the possibility to request an appealable decision according to the state of the file by way of which the necessity of holding formal oral proceedings (Art 116 EPC) may be avoided.
- 10 However, this option requires the applicants to explicitly withdraw their request for such oral proceedings. Should the applicants not choose this option then, during any ensuing formal oral proceedings (Art 116 EPC), a final decision on the application will be taken subsequent to which the Examining Division will exercise its discretionary power to refuse any further amendment (Rule 137(3) EPC).



European Patent Office
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P.O. Box 981
00101 Helsinki
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Formalities Officer

Name: Eriksson Exner, Karin
Tel.: 2437 -7826
or call:
+31 (0)70 340 45 00

Date

23-08-2013

Reference P-EP62595F	Application No./Patent No. 08737779.2 - 1908 / 2156675
Applicant/Proprietor Nokia Corporation	

Noting of loss of rights pursuant to Rule 112(1) EPC

The European patent application is deemed to be withdrawn under Article 94(4) EPC, because the invitation to file observations on the communication from the Examining Division dated 08.03.13 was not complied with.

Means of redress

Request for a decision (R. 112(2) EPC)

If the applicant considers that the finding of the European Patent Office is inaccurate, he may, within a (non-extendable) period of **two months** after notification of this communication, apply in writing for a decision on the matter. The application can only lead to the finding being reversed if this does not actually correspond to the factual or legal situation.

Further processing (Art. 121 EPC)

The legal consequence of the failure to observe the time limit shall be deemed not to have ensued if, within a (non-extendable) period of **two months** after notification of this communication, further processing is requested by payment of the fee prescribed under Article 2(1)12 of the Rules relating to Fees and the omitted act is completed (R. 135(1) EPC).

Important note to users of the automatic debiting procedure

The fee for further processing will be debited automatically on the day on which the above-mentioned omitted act is completed (see Arrangements for the automatic debiting procedure, Supplement to OJ EPO 3/2009).

For the Examining Division



Registered letter

EPO Form 2021A 12.07 (16/08/13)

ADWI 11

Closure of the procedure in respect of application No. 08737779.2 - 1908

22.11.13

1. The procedure in respect of the above application is closed for the following reason:

ADWI 11/23.08.13 The time limit under Rule 112(2) EPC has expired.
No request for a decision under Rule 112(2), or for further processing under Article 121 EPC or for re-establishment of rights under Article 122 EPC has been filed.

2. The EPASYS situation has been verified in respect of item 1:

DFIL: 09.04.08

NOAP: ///

RDEC: ///

RFPR: //

REES: ///

~~REF~~ 3/ADWI 3 and DEAD 1 coded. Date of legal effect 19.07.2013

3. Position regarding fees:

DEST03	005	00809612	12.11.09	EUR	500,00
EXAM02	006	00809612	12.11.09	EUR	1 252,00
CLMS(2)	015	00809612	12.11.09	EUR	1 800,00
FFEE01	020	00809612	12.11.09	EUR	100,00
RFEE 03	033	00809612	12.11.09	EUR	400,00
RFEE 03	033	00028008	21.11.09	EUR	400,00-
RFEE 03	033	00609336	25.03.10	EUR	400,00
RFEE 04	034	00659252	12.04.11	EUR	525,00
RFEE 05	035	00699181	30.03.12	EUR	735,00
RFEE 06	036	00690550	12.04.13	EUR	995,00

☐ Examination started on _____ (EXDS51).

☐ Refund(s) ordered:

☐ 75% EXAM fee ☐ RFEE(s): _____ ☐ Other fees: _____

Note: Attention is to be paid to potential automated refund proposal(s).

4. Mark "DEAD" on the paper file and:

☒ Check whether a divisional application is pending and if so attach the DEAD file to it.

☐ Any **models** still in the Office's possession were returned on _____
(for dealing with models, please refer to Fil d'Ariane).

☒ Keep paper file in file store (separate place) until next action for file destruction.

22-11-2013
Date

Schalinatus, Dana
Formalities Officer