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Method of recording images at reduced data rate and device for implementing it

The present invention relates to a method of recording images at reduced data rate and a device for implementing it. It has applications particularly to digital recorders for high-definition television.

Known methods for transmitting and recording video signals and particularly television images use image coding and decoding devices called CODECs, an abbreviation for coder-decoder.

These devices use known techniques of image coding exploiting the principle of data rate compression.

A large part of the information contained in an image is redundant. Redundancy may be defined as the part of a message which is not necessary in the sense that if it were missing, the message could not [sic] be reconstructed. The majority of digitizing systems, for example of PCM type, an abbreviation for Pulse Code Modulation, take no account of the intrinsic properties of the image sender, or source, nor those of the visual receiver, for example the eye.

Except [sic], the signal sent is not random. Correlation properties exist between each image sample, representing one or more pixels. Moreover, the eye does not perceive all the information in the same way.

Among the coding techniques using data rate compression, psychovisual codings take account of the properties relating to the visual receiver, that is to say the eye of the observer. They consist in optimally deceiving the eye, reproducing a signal different to the original signal, but containing the pertinent information for the observer. This type of coding is irreversible.

The results obtained correspond to reconstituted images of high quality, which can be used, for example, by television studios for image

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processing.

In the psychovisual coding techniques, the adaptive differential coding consists not in coding the video signal itself, but the difference between this signal and a prediction signal which is known to the receiver.

A known type of architecture of an adaptive differential coding device for image transmission uses two inter-image prediction loops, also called inter loops, at the input and output of the main coding and decoding circuit.

The purpose of each loop is to reconstitute an estimated image on the basis of the current image picked up by each loop. The reconstituted image is then compared with the following image at the moment where the latter is sent to the input and to the output of the transmission device. The input inter loop generally includes, from the input to the output, a decoder, called local decoder, an addition operator and an image prediction device.

The image picked up by the input loop is decoded by the local decoder then added to the prediction signal estimated on the basis of a preceding image in order to reconstitute an image which is compared with the current image present at the input of the transmission device. The image prediction device includes an image memory and possibly an image estimator with movement compensation.

The signal transmitted to the input of the transmission channel thus corresponds to a coded error signal resulting from the difference between the current image present at the input of the device and the prediction signal. At the output of the transmission channel, the error signal is decoded by a second decoder, called remote decoder, then injected into the second loop which adds, to the decoded error signal, a prediction signal which is identical to that delivered by the first loop. The prediction signal of

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the second loop is estimated on the basis of the preceding transmitted image, reconstituted at the output of the device, picked up by the second loop.

In order to record or store one or more images, it is known to insert, into the transmission channel, a digital image recorder, for example a digital video recorder or an image memory for image storage in the medical field, etc..

The image transmission devices generally include, at the input and at the output of the transmission channel, a device for data rate matching between the main coding/decoding circuit and the transmission channel, which also incorporates a function of correcting the errors which are due to transmission through the transmission channel. Likewise, digital recorders are generally equipped with error correction devices at their input and output.

However, errors due to the recording technology used by the recorder, being expressed, for example, in a loss of digital information, or bytes, are not taken into account by the type of error correction devices mentioned above. This type of architecture for image recording is thus not robust in terms of errors due to the recording. Moreover, the hardware used for the recording rapidly becomes very bulky and the error correction devices, based mainly on the introduction of digital information redundancy, consume a great deal of data rate.

The purpose of the invention is to alleviate the abovementioned drawbacks.

To this end, the subject of the invention is a method of recording images at reduced data rate, using differential coding and decoding with inter-image adaptive prediction, characterized in that it consists, after having introduced means of recording and of reading digital information in a main image coding and decoding circuit, in recording a prediction error signal arising from the comparison between an image to

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be recorded and an image predicted on the basis of the preceding image read on at least one recording medium, and in reading, after the recording, the prediction error recorded on the recording medium, and in that it consists in reconstituting an image on the basis of the prediction error signal, read and decoded at the output of the main circuit and of an image arising from a single prediction delivered by a single prediction loop picking up the reconstituted preceding image, and in comparing the image arising from the same prediction with the following image to be recorded at the input of the main circuit, taking account of the recording errors in order to avoid them being propagated from one image to the other.

Other features and advantages of the invention will emerge more clearly in the following description given by way of non-limiting example and given with regard to the attached figures which represent:

- Figure 1, a theoretical diagram of an embodiment of a device for implementing the method according to the invention, and
- Figure 2, an example of a transmission means in an embodiment of the device for implementing the method according to the invention.

The device according to the invention has the advantages that it makes it possible, on the one hand, to reduce the overall bulk of the image recording device by using a single decoder, a single prediction loop and by including the record/read channel of a digital recorder in the main coding and decoding circuit. It makes it possible, on the other hand, to correct the recording errors in order to avoid them being propagated from one image to the other.

An embodiment of a device for implementing the method according to the invention is illustrated by Figure 1.

It uses psychovisual coding techniques, and

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particularly differential coding with inter-image prediction. This embodiment includes a main coding and decoding circuit 1 bounded by a broken solid line and a single loop 2 also bounded by a broken solid line which reinjects, onto the input and the output of the main circuit 1, a part of the output signal of the device according to the invention.

A video signal X is injected at the input of the main circuit 1 onto a first operand input of a subtraction operator 3. The video signal X is, for example, a sequence of television images. The output signal e of the subtraction operator 3 is the result of the subtraction of a current image X injected at the input of the main circuit 1 with a prediction P output by the prediction loop 2. The signal e corresponding to a prediction error signal is injected at the input of a coding means 4, or coder, digitally coding the signal e received at the input of the coder 4. The output of the coder 4 is coupled to first variable-length coding and error correction means 5, called VLC from now on, the abbreviation for Variable Length Coding, making it possible to match the digital information data rate output by the coder 4 to that of recording and reading means 6 to the input of which the output of the coder 4 is coupled.

The output of the recording and reading means 6 is coupled to the input of a second VLC 7, performing the function which is the inverse of the first VLC 5, with which an error correction function is also combined. The output of the second VLC 7 is coupled to the input of a decoding means, or decoder 8, at the output of which the error signal e_d is reproduced. The output of the decoder 8 is coupled to a first operand input of an addition operator 9.

The image $\hat{X}$ reconstituted at the output of the addition operator 9 is picked up by the loop 2 and injected at the input of prediction means 10 including an image storage device, not represented, possibly

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combined with an estimation device, also not represented, performing compensation for movement between two consecutive images. The output of the prediction means 10 is coupled both to the input and to the output of the main circuit 1 respectively by a second operand input of the subtraction operator 3 and by a second operand input of the addition operator 9. The image $\hat{x}$ thus reconstituted takes account of the errors in recording between two consecutive images.

An embodiment of the recording and reading means 6 of a device for implementing the method according to the invention is illustrated by Figure 2.

This embodiment includes an input I common to a first channel 11, called direct channel, and to a second channel 12, called record/read channel. The output of the record/read channel 12 and the output of the direct channel 11 are coupled respectively to a first input R/W and to a second input M of a changeover switching means 13 making it possible to select one of the two channels 11 and 12 for recording followed by reading or for direct reading of a signal between the input I and the output O of the recording and reading means 6. The two channels 11 and 12 can each be likened to a small transmission channel belonging to a recording device using only a single decoder, both local and remote. Moreover, the recording device according to the invention including this embodiment makes it possible to integrate the coding and decoding functions in the same box.

Thus the notions of "local" and "remote" decoders known in the transmission devices lose their meaning.

In a video-type recorder, a device currently called a "scanner" generally includes separate write and read heads. This makes it possible, in "Read after Write" operating mode, to check the validity of the recording in progress at any moment. In this operating mode, the read and write heads continuously scan the

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recording medium, for example a magnetic tape, thus allowing near-instantaneous reading of what has just been recorded on the recording medium. In "monitoring" operating mode, the recording function of the video recorder is disconnected. In this operating mode only the function of direct reading via the direct read channel of the video recorder is operational for monitoring the information to be recorded.

The "Read after Write" R/W and "monitoring" M modes are selected by the changeover switching device 13. In the "Read after Write" R/W mode of operation of the recorder, the record/read channel 12 makes it possible to write the digital information onto the recording medium, a magnetic tape for example, then to read this information almost instantaneously after recording on the tape.

The information read on the magnetic tape is then sent through the record/read magnetic channel 12 of the video recorder, used as a transmission channel, at the output O of the recording and reading means 6. The information sent undergoes a simple delay due to the processing which, in the majority of cases, for television images for example, is of the order of the duration of one video frame, i.e. about 20 ms. This delay is compensated for in the loop 2.

With the record/read channel 12 forming part of the main coding/decoding circuit 1, the errors related to recording are taken into account by the device at the moment of reading, i.e. upon sending of the information to the output O of the recording and reading means 6.

In the "monitoring" M operating mode, the record/read channel 12 is disconnected. The direct read channel 11 of the recorder, selected by the changeover switching device 13, is then used as a transmission channel to allow the device according to the invention to continue to operate in closed loop mode.

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CLAIMS

1. Method of recording images at reduced data rate, using differential coding and decoding with inter-image adaptive prediction, characterized in that it consists, after having introduced means of recording and of reading digital information in a main image coding and decoding circuit (1), in recording a prediction error signal (e) arising from the comparison between an image (X) to be recorded and an image predicted on the basis of the preceding image read on at least one recording medium, and in reading, after the recording, the prediction error (e_d) recorded on the recording medium, and in that it consists in reconstituting an image on the basis of the prediction error signal (e_d), read and decoded at the output of the main circuit (1) and of an image arising from a single prediction (P) delivered by a single prediction loop (2) picking up the reconstituted preceding image, and in comparing the image arising from the same prediction (P) with the following image to be recorded at the input of the main circuit (1), taking account of the recording errors in order to avoid them being propagated from one image to the other.

2. Device for implementing the method according to Claim 1, characterized in that it includes a main circuit (1) including, in order, an image coding means (4) coupled to first error correction and data rate matching means (5) coupled to the input of digital information recording and reading means (6) coupled at the output to second error correction and data rate matching means (7) and a decoding means (8), and in that it includes a single inter-image prediction loop (2) picking up a reconstituted image ($\hat{x}$) at the output of the device and including prediction means (10) for predicting the following image on the basis of the reconstituted image ($\hat{x}$) picked up by the loop (2), means (3) for subtracting the image arising from the

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prediction (P) from the real image to be recorded, and means (9) for adding the image arising from the same prediction (P) to the prediction error (e_d), after decoding.

3. Device according to Claim 2, characterized in that the prediction means (10) include an image storage device.

4. Recorder according to Claim 3, characterized in that the prediction means (10) further include a movement estimation device for compensating for the movements between two consecutive images to be recorded.

5. Device according to any one of Claims 2 to 4, characterized in that the recording and reading means (6) include an input common to at least a first channel (11), called direct reading channel of a digital recorder, and to at least a second channel (12) called record/read channel of a digital recorder, the output of each channel (11 and 12) is coupled respectively to a first input and to a second input of a changeover switching means (13) making it possible to select one of the two channels (11 and 12).

6. Device according to Claim 5, characterized in that the first channel (11) is a direct reading channel of a digital video recorder, in that the second channel (12) is a record/read magnetic channel of the digital video recorder using a magnetic tape as recording medium, and in that the changeover switching means (13) is a switch making it possible to select a first operating mode of the digital video recorder, called "monitoring" (M) mode using the direct channel (11), or a second operating mode of the digital recorder, called "Read after Write" (R/W) mode, using the magnetic record/read channel (12).

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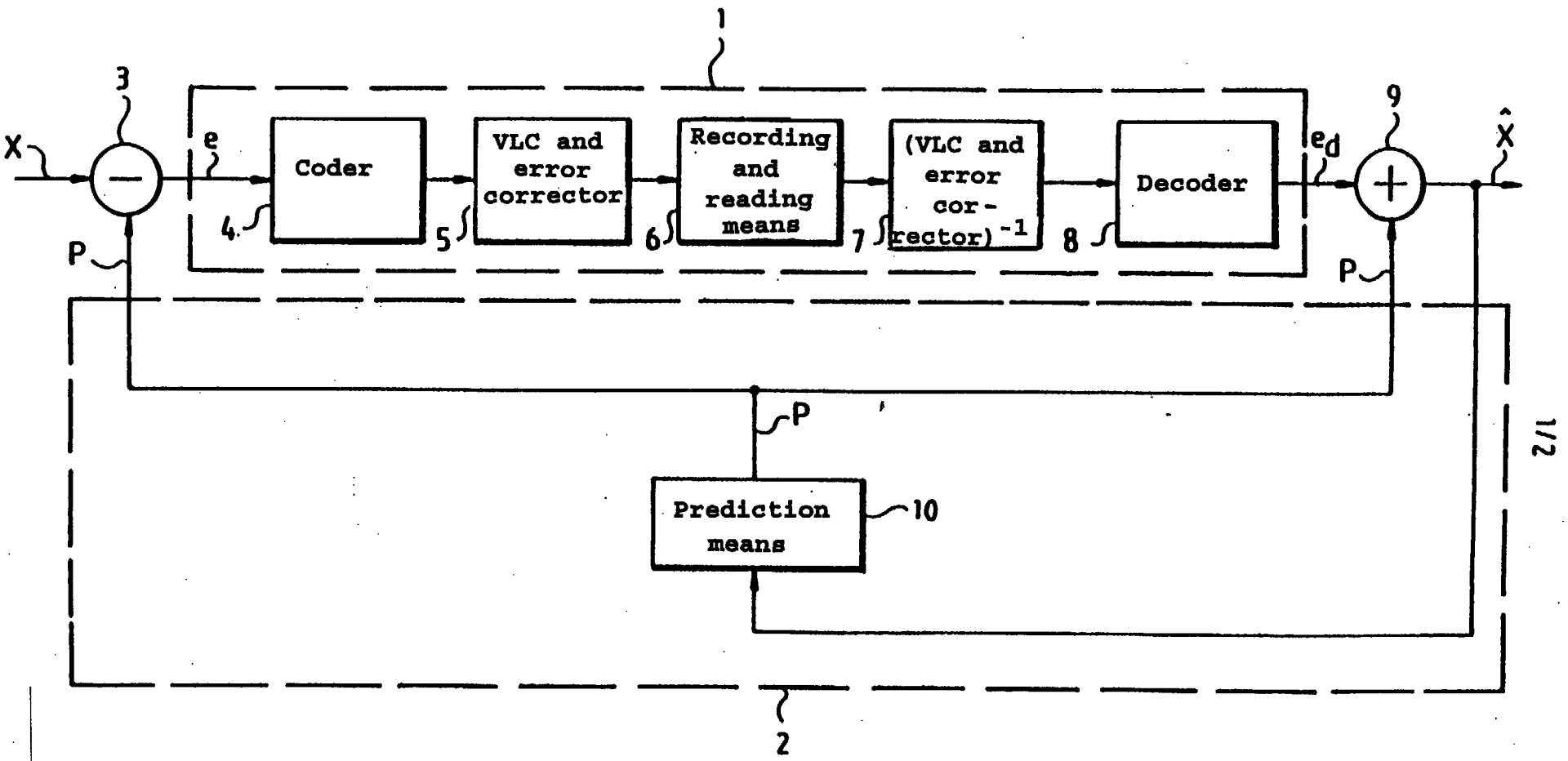


FIG.1

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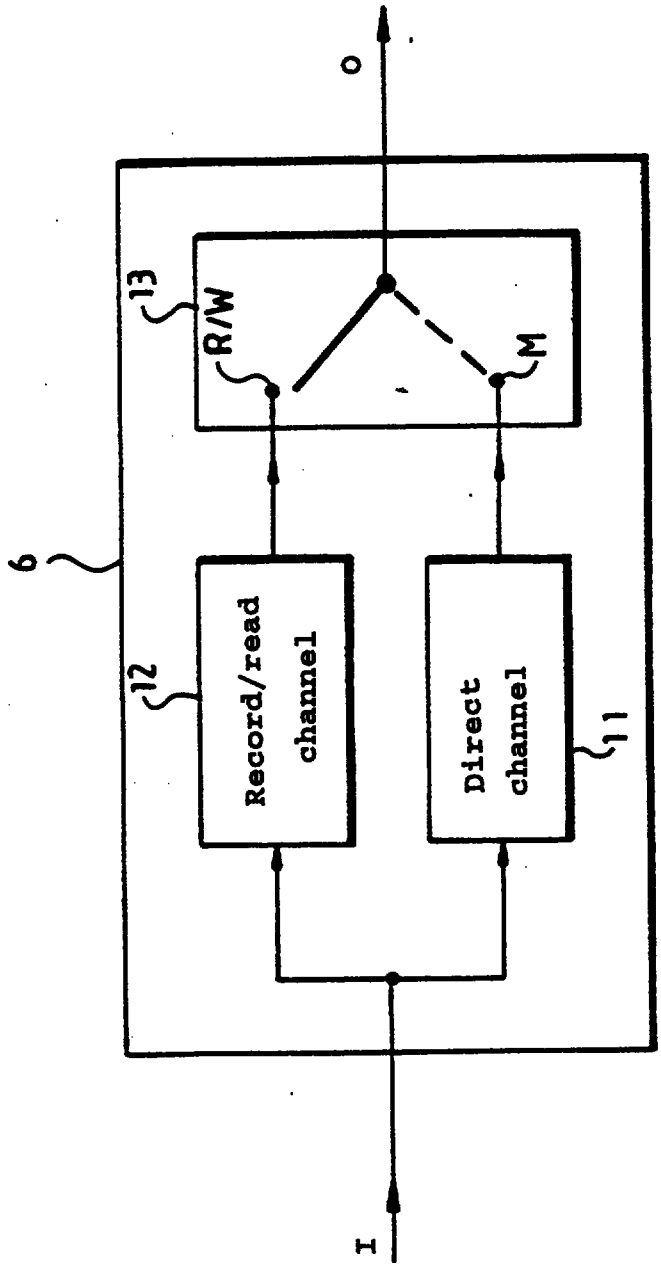


FIG.2

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Except [sic], the signal sent is not random. Correlation properties exist between each image sample, representing one or more pixels. Moreover, the eye does not perceive all the information in the same way.

Among the coding techniques using data rate compression, psychovisual codings take account of the properties relating to the visual receiver, that is to say the eye of the observer. They consist in optimally deceiving the eye, reproducing a signal different to the original signal, but containing the pertinent information for the observer. This type of coding is irreversible.

The results obtained correspond to reconstituted images of high quality, which can be used, for example, by television studios for image

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In the psychovisual coding techniques, the adaptive differential coding consists not in coding the video signal itself, but the difference between this signal and a prediction signal which is known to the receiver.

A known type of architecture of an adaptive differential coding device for image transmission uses two inter-image prediction loops, also called inter loops, at the input and output of the main coding and decoding circuit.

The purpose of each loop is to reconstitute an estimated image on the basis of the current image picked up by each loop. The reconstituted image is then compared with the following image at the moment where the latter is sent to the input and to the output of the transmission device. The input inter loop generally includes, from the input to the output, a decoder, called local decoder, an addition operator and an image prediction device.

The image picked up by the input loop is decoded by the local decoder then added to the prediction signal estimated on the basis of a preceding image in order to reconstitute an image which is compared with the current image present at the input of the transmission device. The image prediction device includes an image memory and possibly an image estimator with movement compensation.

The signal transmitted to the input of the transmission channel thus corresponds to a coded error signal resulting from the difference between the current image present at the input of the device and the prediction signal. At the output of the transmission channel, the error signal is decoded by a second decoder, called remote decoder, then injected into the second loop which adds, to the decoded error signal, a prediction signal which is identical to that delivered by the first loop. The prediction signal of

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the second loop is estimated on the basis of the preceding transmitted image, reconstituted at the output of the device, picked up by the second loop.

In order to record or store one or more images, it is known to insert, into the transmission channel, a digital image recorder, for example a digital video recorder or an image memory for image storage in the medical field, etc..

The image transmission devices generally include, at the input and at the output of the transmission channel, a device for data rate matching between the main coding/decoding circuit and the transmission channel, which also incorporates a function of correcting the errors which are due to transmission through the transmission channel. Likewise, digital recorders are generally equipped with error correction devices at their input and output.

However, errors due to the recording technology used by the recorder, being expressed, for example, in a loss of digital information, or bytes, are not taken into account by the type of error correction devices mentioned above. This type of architecture for image recording is thus not robust in terms of errors due to the recording. Moreover, the hardware used for the recording rapidly becomes very bulky and the error correction devices, based mainly on the introduction of digital information redundancy, consume a great deal of data rate.

The purpose of the invention is to alleviate the abovementioned drawbacks.

To this end, the subject of the invention is a method of recording images at reduced data rate, using differential coding and decoding with inter-image adaptive prediction, characterized in that it consists, after having introduced means of recording and of reading digital information in a main image coding and decoding circuit, in recording a prediction error signal arising from the comparison between an image to

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be recorded and an image predicted on the basis of the preceding image read on at least one recording medium, and in reading, after the recording, the prediction error recorded on the recording medium, and in that it consists in reconstituting an image on the basis of the prediction error signal, read and decoded at the output of the main circuit and of an image arising from a single prediction delivered by a single prediction loop picking up the reconstituted preceding image, and in comparing the image arising from the same prediction with the following image to be recorded at the input of the main circuit, taking account of the recording errors in order to avoid them being propagated from one image to the other.

Other features and advantages of the invention will emerge more clearly in the following description given by way of non-limiting example and given with regard to the attached figures which represent:

- Figure 1, a theoretical diagram of an embodiment of a device for implementing the method according to the invention, and
- Figure 2, an example of a transmission means in an embodiment of the device for implementing the method according to the invention.

The device according to the invention has the advantages that it makes it possible, on the one hand, to reduce the overall bulk of the image recording device by using a single decoder, a single prediction loop and by including the record/read channel of a digital recorder in the main coding and decoding circuit. It makes it possible, on the other hand, to correct the recording errors in order to avoid them being propagated from one image to the other.

An embodiment of a device for implementing the method according to the invention is illustrated by Figure 1.

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particularly differential coding with inter-image prediction. This embodiment includes a main coding and decoding circuit 1 bounded by a broken solid line and a single loop 2 also bounded by a broken solid line which reinjects, onto the input and the output of the main circuit 1, a part of the output signal of the device according to the invention.

A video signal X is injected at the input of the main circuit 1 onto a first operand input of a subtraction operator 3. The video signal X is, for example, a sequence of television images. The output signal e of the subtraction operator 3 is the result of the subtraction of a current image X injected at the input of the main circuit 1 with a prediction P output by the prediction loop 2. The signal e corresponding to a prediction error signal is injected at the input of a coding means 4, or coder, digitally coding the signal e received at the input of the coder 4. The output of the coder 4 is coupled to first variable-length coding and error correction means 5, called VLC from now on, the abbreviation for Variable Length Coding, making it possible to match the digital information data rate output by the coder 4 to that of recording and reading means 6 to the input of which the output of the coder 4 is coupled.

The output of the recording and reading means 6 is coupled to the input of a second VLC 7, performing the function which is the inverse of the first VLC 5, with which an error correction function is also combined. The output of the second VLC 7 is coupled to the input of a decoding means, or decoder 8, at the output of which the error signal e_d is reproduced. The output of the decoder 8 is coupled to a first operand input of an addition operator 9.

The image $\hat{x}$ reconstituted at the output of the addition operator 9 is picked up by the loop 2 and injected at the input of prediction means 10 including an image storage device, not represented, possibly

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combined with an estimation device, also not represented, performing compensation for movement between two consecutive images. The output of the prediction means 10 is coupled both to the input and to the output of the main circuit 1 respectively by a second operand input of the subtraction operator 3 and by a second operand input of the addition operator 9. The image $\hat{x}$ thus reconstituted takes account of the errors in recording between two consecutive images.

An embodiment of the recording and reading means 6 of a device for implementing the method according to the invention is illustrated by Figure 2.

This embodiment includes an input I common to a first channel 11, called direct channel, and to a second channel 12, called record/read channel. The output of the record/read channel 12 and the output of the direct channel 11 are coupled respectively to a first input R/W and to a second input M of a changeover switching means 13 making it possible to select one of the two channels 11 and 12 for recording followed by reading or for direct reading of a signal between the input I and the output O of the recording and reading means 6. The two channels 11 and 12 can each be likened to a small transmission channel belonging to a recording device using only a single decoder, both local and remote. Moreover, the recording device according to the invention including this embodiment makes it possible to integrate the coding and decoding functions in the same box.

Thus the notions of "local" and "remote" decoders known in the transmission devices lose their meaning.

In a video-type recorder, a device currently called a "scanner" generally includes separate write and read heads. This makes it possible, in "Read after Write" operating mode, to check the validity of the recording in progress at any moment. In this operating mode, the read and write heads continuously scan the

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recording medium, for example a magnetic tape, thus allowing near-instantaneous reading of what has just been recorded on the recording medium. In "monitoring" operating mode, the recording function of the video recorder is disconnected. In this operating mode only the function of direct reading via the direct read channel of the video recorder is operational for monitoring the information to be recorded.

The "Read after Write" R/W and "monitoring" M modes are selected by the changeover switching device 13. In the "Read after Write" R/W mode of operation of the recorder, the record/read channel 12 makes it possible to write the digital information onto the recording medium, a magnetic tape for example, then to read this information almost instantaneously after recording on the tape.

The information read on the magnetic tape is then sent through the record/read magnetic channel 12 of the video recorder, used as a transmission channel, at the output O of the recording and reading means 6. The information sent undergoes a simple delay due to the processing which, in the majority of cases, for television images for example, is of the order of the duration of one video frame, i.e. about 20 ms. This delay is compensated for in the loop 2.

With the record/read channel 12 forming part of the main coding/decoding circuit 1, the errors related to recording are taken into account by the device at the moment of reading, i.e. upon sending of the information to the output O of the recording and reading means 6.

In the "monitoring" M operating mode, the record/read channel 12 is disconnected. The direct read channel 11 of the recorder, selected by the changeover switching device 13, is then used as a transmission channel to allow the device according to the invention to continue to operate in closed loop mode.

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CLAIMS

1. Method of recording images at reduced data rate, using differential coding and decoding with inter-image adaptive prediction, characterized in that it consists, after having introduced means of recording and of reading digital information in a main image coding and decoding circuit (1), in recording a prediction error signal (e) arising from the comparison between an image (X) to be recorded and an image predicted on the basis of the preceding image read on at least one recording medium, and in reading, after the recording, the prediction error (e_d) recorded on the recording medium, and in that it consists in reconstituting an image on the basis of the prediction error signal (e_d), read and decoded at the output of the main circuit (1) and of an image arising from a single prediction (P) delivered by a single prediction loop (2) picking up the reconstituted preceding image, and in comparing the image arising from the same prediction (P) with the following image to be recorded at the input of the main circuit (1), taking account of the recording errors in order to avoid them being propagated from one image to the other.

2. Device for implementing the method according to Claim 1, characterized in that it includes a main circuit (1) including, in order, an image coding means (4) coupled to first error correction and data rate matching means (5) coupled to the input of digital information recording and reading means (6) coupled at the output to second error correction and data rate matching means (7) and a decoding means (8), and in that it includes a single inter-image prediction loop (2) picking up a reconstituted image ($\hat{x}$) at the output of the device and including prediction means (10) for predicting the following image on the basis of the reconstituted image ($\hat{x}$) picked up by the loop (2), means (3) for subtracting the image arising from the

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prediction (P) from the real image to be recorded, and means (9) for adding the image arising from the same prediction (P) to the prediction error (e_d), after decoding.

3. Device according to Claim 2, characterized in that the prediction means (10) include an image storage device.

4. Recorder according to Claim 3, characterized in that the prediction means (10) further include a movement estimation device for compensating for the movements between two consecutive images to be recorded.

5. Device according to any one of Claims 2 to 4, characterized in that the recording and reading means (6) include an input common to at least a first channel (11), called direct reading channel of a digital recorder, and to at least a second channel (12) called record/read channel of a digital recorder, the output of each channel (11 and 12) is coupled respectively to a first input and to a second input of a changeover switching means (13) making it possible to select one of the two channels (11 and 12).

6. Device according to Claim 5, characterized in that the first channel (11) is a direct reading channel of a digital video recorder, in that the second channel (12) is a record/read magnetic channel of the digital video recorder using a magnetic tape as recording medium, and in that the changeover switching means (13) is a switch making it possible to select a first operating mode of the digital video recorder, called "monitoring" (M) mode using the direct channel (11), or a second operating mode of the digital recorder, called "Read after Write" (R/W) mode, using the magnetic record/read channel (12).

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METHOD OF RECORDING IMAGE AT A REDUCED DATA RATE AND DEVICE FOR IMPLEMENTING IT.

ABSTRACT

A method comprising the steps of recording a prediction error signal (e) corresponding to the difference between an actual image (X) to be recorded and an image predicted on the basis of the previous image, by means of a main coding/decoding circuit (1) comprising a digital recorder record and play unit (6); taking the restored image ($\hat{X}$) at the output of the main circuit (1) in a single inter-image prediction loop (2); on the basis of the previous image: and reinjecting the image resulting from the prediction (P) at both the input and output of the main circuit (1) by subtracting the image resulting from the prediction (P) from the actual image (X) to be recorded, and by adding the same image to the error signal read and decoded (e^d) in the main circuit (1), respectively, in order to restore the image ($\hat{X}$) after recording while taking recording errors into account. The method is suitable for digital recorders, particularly high-definition digital VCRs.

Figure 1.

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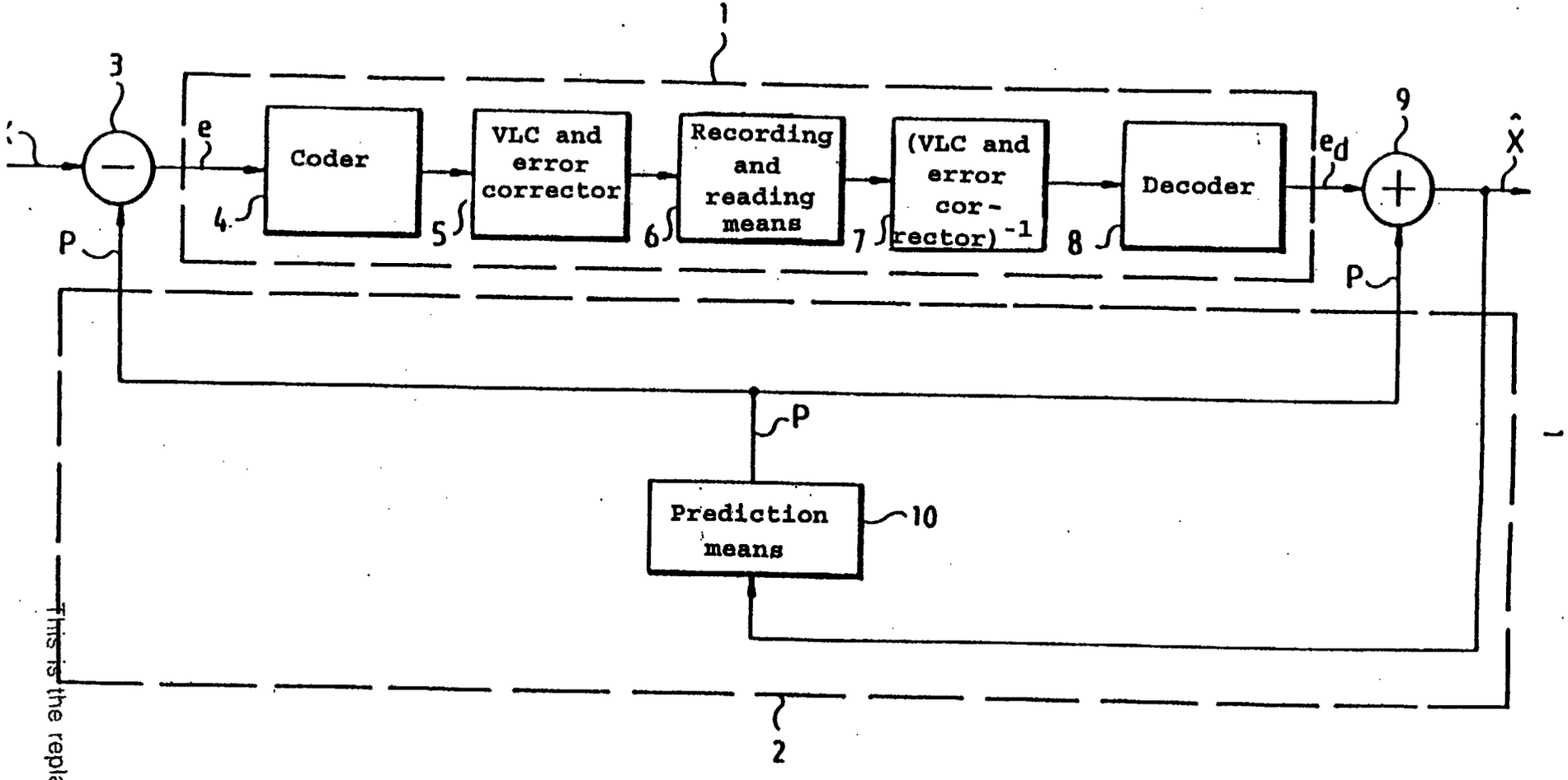


FIG.1

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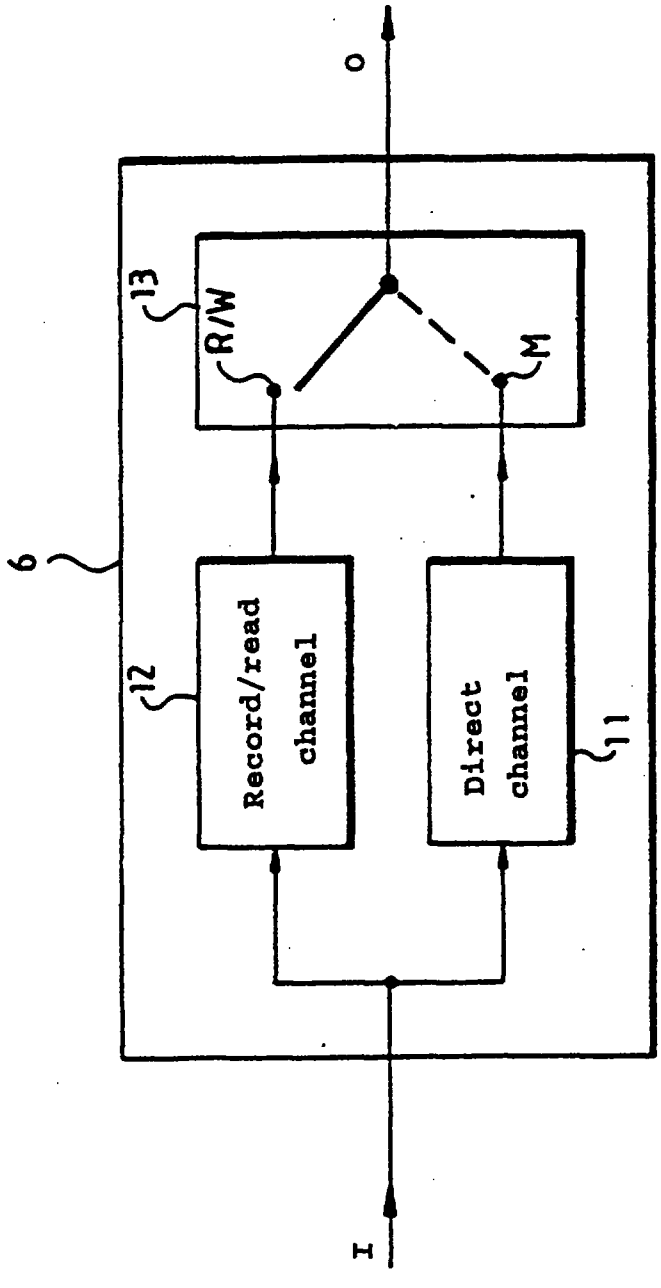


FIG.2

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