

The invention relates to an adaptive process for encoding and for decoding of a series of images by transformation, and a device for implementation of this process. The aim of such a process is to reduce the quantity of information to be transmitted, or to be stored, when video images have been put into digital form.

Encoding and decoding of a video image, in which use is made of a two-directional transformation of the cosine, Fourier, Hadamard, Haar, or Karhunen-Loeve type are known. The encoding consists of: dividing each image into square blocks; applying the transformation to each block so as to obtain a matrix of values termed block transformation coefficients; and of transmitting these coefficients in an encoded form. The decoding consists of decoding the coefficients and then of reconstituting the digital values representative of each point of a block by applying the inverse transformation to the matrix of the transformation coefficients of this block. The transformations used in practice are transformations for which fast algorithms exist, for example Fourier, Hadamard, Haar transformations and cosine transformation.

The IEEE article "Transaction on Communications", vol. COM-32, no. 3, March 1984, describes an adaptive encoding process consisting of quantifying the transformation coefficients in such an adaptive manner that the blocks of coefficients with a high energy content are quantified with a larger number of quantification levels and a larger number of code bits than the blocks with a low energy content. The image is divided into 16 x 16 blocks. The digital values representative of the points of each block are transformed by cosine transformation and then the transformation coefficients thus obtained are compared with a threshold. The coefficients higher than this threshold are standardised by multiplying them by a parameter supplied by a device for regulation of the transmission flow.

The coefficients thus standardised are next quantified and then encoded by a Huffman code, and are stored in a buffer memory regulating the flow of the transmission. This buffer memory stores the information to be transmitted at a variable rate, this rate depending on the instantaneous energy of the image, and it reconstitutes this

information with a constant flow. The extent to which this buffer memory is filled and the flow at its input are monitored and determine the value of the standardisation parameter.

After the transmission, the information arrives with a constant flow in a buffer memory which restores it with a variable flow to a Huffman decoder. The transformation coefficients are then standardised by a standardisation parameter the reciprocal of that used for the encoding, this inverse parameter being calculated by a flow regulation device which monitors the extent to which the buffer memory is filled. The transformation coefficients are then added to the value of the threshold used for the encoding and are transformed by the inverse transformation of the cosine transformation in order to reconstitute the digital values representative of the points of a block.

The quality of the reconstituted images is very good, in comparison with the other known methods, provided that the images correspond to very animated scenes. The visual quality of the reconstituted images is distinctly poorer when they represent scenes which are slightly animated or completely fixed. In the latter case, two defects appear: there is seen to be a filtering of the high and medium spatial frequencies, this filtering corresponding to elimination of the low energy coefficients which have a value lower than the threshold; and demarcations are seen between the blocks in the uniform zones of the images, since the eye is sensitive to the slight difference in brightness in the uniform zones.

Processes are known which make additional use of the correlation existing between the transformation coefficients of two successive images. This correlation is particularly high when the images represent a slightly animated scene. Patent application EP-A-123,456 describes such a process, consisting of transmitting the transformation coefficients when the scene is very animated, and of transmitting the values of the difference between a transformation coefficient and a prediction when the scene is slightly animated. The prediction is equal to the product of a homologous coefficient for the preceding image, and a prediction coefficient, K , between 0 and 1. This coefficient K is variable depending on the rank of the coefficient to be encoded and

depending on the correlation existing between the transformation coefficients of the two successive images, i.e. depending on how animated the scene is. Thus, the encoding can change gradually from the intra-image type to the inter-image type, depending on the extent of animation of the images. The fixed scenes and the busy scenes can be reconstituted with good quality.

The aim of the invention is to propose a process whereby the amount of compression of the information can be further improved, without degrading the quality of the reconstituted images.

The object of the invention is a process consisting in particular of weighting the coefficients or the differences of coefficients by favouring the low spatial frequencies with respect to the high spatial frequencies.

According to another characteristic, it further consists of standardising the coefficients, and the differences of coefficients by multiplying them by a factor variable as a function of the quantity of information occupying the buffer memory.

According to the invention, an adaptive process for encoding and for decoding of a series of images by transformation, each image point being represented by a digital value, the encoding consisting of dividing each image into blocks of points and of applying a two-dimensional transformation to each block so as to obtain a matrix of values termed transformation coefficients of the block; and consisting, for each block of points, of:

- discriminating whether the block represents a very animated or slightly animated scene;
- transmitting the values of the transformation coefficients of the block in the first case, or the difference in value of these coefficients, with respect to the value of the homologous coefficients of the homologous block in the preceding image, in the second case;
- transmitting information indicating whether the block represents a slightly animated or very animated scene;

the decoding consisting of applying to the transmitted values corresponding to one block, a transformation which is the reciprocal of the transformation applied for its encoding if this block represents a very animated scene;

and further consisting, if the block represents a slightly animated scene, of determining a value of the coefficients of this block, by adding to the difference in value of each of its coefficients respectively to the value of the homologous coefficients of the homologous block in the preceding image, before applying the inverse transformation;

is characterised in that the encoding further consists of applying a weighting to the values of the coefficients and of the coefficient differences, before transmitting them, with a greater significance for the coefficients and the coefficient differences corresponding to the low spatial frequencies of the image, with respect to those corresponding to the high spatial frequencies;

and in that the decoding further consists of applying a weighting which is the reciprocal of that of the encoding, to the values of the coefficients and of the differences before applying the inverse transformation to them.

The invention will be better understood and other details will become apparent with the help of the following description and of its accompanying figures;

- figure 1 gives a general diagram of an embodiment of an encoding and decoding system implementing the known process previously described;

- figures 2 to 5 give graphs illustrating the process according to the invention;

- figure 6 gives a general diagram of an example of an embodiment of an encoding device according to the invention;

- figure 7 gives a general diagram of an example of an embodiment of a decoding device according to the invention.

In one example of an embodiment the process according to the invention makes use of the cosine transformation. When this is applied to a series of digital values $f(j,k)$ representative of the points of an image, where j and k vary from 0 to $N-1$ and indicating the line and the column containing the point, the transformation coefficients obtained are :

$$F(u,v) = \frac{4C(u).C(v)}{N^2} \sum_{j=0}^{N-1} \sum_{k=0}^{N-1} f(j,k) \cdot \cos \frac{(2j+1)u\pi}{2N} \cdot \cos \frac{(2k+1)v\pi}{2N} \quad (1)$$

where $u, v = 0, 1, \dots, N-1$, and indicate respectively a line and a column of the matrix of the transformation coefficients, and where:

$$C(w) = \frac{1}{\sqrt{2}} \text{ for } w = 0$$

$$C(w) = 1 \text{ for } w = 1, 2, \dots, N-1$$

The inverse cosine transformation is defined by

$$f(j,k) = \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} C(u).C(v).F(u,v) \cdot \cos \frac{(2j+1)u\pi}{2N} \cdot \cos \frac{(2k+1)v\pi}{2N} \quad (2)$$

where $u, v = 0, 1, \dots, N-1$

Figure 1 gives a general diagram of an encoding and decoding system implementing the process described in the document cited above. The images processed are monochrome video images constituted by two interlaced frames, each frame being processed as an independent image. This example of an embodiment comprises: a cosine transformation device 1; a threshold subtraction device 2; a standardisation device 3; a quantification and encoding device 4; a first flow regulation device 5; a second flow regulation device 6; a decoding device 7; an inverse standardisation device 8; a device 9 for addition of the threshold value; and an inverse cosine transformation device 10.

The device 1 receives a series of values $f(j,k)$ representing the brightness of the points of a frame, via an input terminal 13, and reconstitutes a series of values $F(u,v)$ which are transformation coefficients in turn for each block constituting each frame. The values $F(u,v)$ are applied to an input of the device 2 which calculates the difference between this value and a fixed threshold value T . It reconstitutes a value $F_T(u,v)$ such that:

$$F_T(u,v) = F(u,v) - T \quad \text{if } F(u,v) \geq T$$

$$F_T(u,v) = 0 \quad \text{if } F(u,v) < T \quad (3)$$

The subtraction of this threshold has the effect of reducing most of the coefficients to the value zero and thus limits the number of coefficients to be quantified and therefore the quantity of information to be transmitted.

The value $F_T(u,v)$ is applied to one input of the standardisation device 3 which receives on another input a value $\frac{1}{D}$ termed standardisation parameter. The device 3 possesses an output supplying the standardised value $\frac{F_T(u,v)}{D}$. The standardisation thus obtained by the device 3 enables the range of values of the coefficients to be adjusted so that optimum use can be made of the number of bits fixed for the subsequent encoding.

The standardised value of each transformation coefficient is applied to an input of the quantification and encoding device 4. The quantification consists simply of converting a value expressed with a floating point into a whole value. Thus a certain number of values between 0 and 1 are replaced by the value 0, and this reduces the number of significant coefficients to be transmitted.

The coefficient $F(0,0)$ which corresponds to the first coefficient of the first line of the matrix of the transformation coefficients of a block, is encoded in a special manner so as to prevent the differences in brightness from one block to another from being perceived by the eye. This coefficient is quantified linearly and is then encoded by a code of nine bits. The other non-zero coefficients are encoded, as far as their values and their addresses in the matrix are concerned, by reading respectively from two tables of the values encoded according to a Huffman code.

The encoded values of such a code have a variable length but are selected so that they are identifiable without necessitating separation information. Furthermore, the encoded values of shortest length are allocated to the coefficients having the respective

addresses which appear most frequently when a statistical study of the transformation coefficients is made.

The address of each coefficient is not encoded by the index of its line and the index of its column in the matrix of the block but by an encoding by ranges consisting of taking as address the length of a range where the coefficients have a single value, the matrix of the coefficients being run through in a well-determined order.

Figure 2 represents the upper left corner of the matrix of transformation coefficients of a block and represents the zigzag path defining the order in which the coefficients are considered for this encoding by ranges. This order is also the order in which the coefficients $F(u,v)$ are supplied by the output from the cosine transformation device 1. Such a path has the advantage that it encounters long ranges of zero values and this makes it possible to reduce the quantity of information to be transmitted.

The first flow regulation device 5 receives the values encoded by the device 4 with a variable flow and reconstitutes these same encoded values with a constant flow on a transmission line 12. The device 5 comprises an offset register used as buffer and comprises control means for monitoring the filling of the register and for determining a standardisation value D to be supplied to the device 3.

An input of the second flow regulation device 6 is connected to the transmission line 12 so as to receive the encoded values and to store them in an offset register used as buffer. An output from the device 6 is connected to an input of the decoding device 7. An output from the device 7 is connected to an input of the inverse standardisation device 8. The decoding device 7 supplies decoded values at irregular intervals because of the variable length of the values encoded according to a Huffman code. The filling of the buffer registers in the regulation devices 5 and 6 is constantly balanced. Control means integrated into the device 6 generate the same value D which is supplied to an input of the inverse standardisation device 8. The device 8 receives on another input a value supplied by the decoding device 7 and it multiplies this value by D so as to reconstitute a transformation coefficient value.

An output from the device 8 is connected to an input of the device 9 for addition of the threshold value and an output from the device 9 is connected to an input of the inverse cosine transformation device 10. An output from the device 10 is connected to an output terminal 11 and supplies a series of decoded brightness values. The device 9 adds the threshold value T to the values of the coefficients from which a value T was subtracted by the device 2 at the moment of the encoding. Lastly the device 10 performs the inverse cosine transformation which reconstitutes the brightness values of each point of each block.

The process according to the invention differs from the known process by the use of an inter-image encoding for the images representing slightly animated or fixed scenes, while retaining an intra-image encoding similar to that described previously, for the images representing strongly animated scenes. The use of an inter-image encoding for the slightly animated scenes enables the correlation existing between two successive images to be exploited.

The essential visual information of an image corresponds to the lowest spatial frequencies and the latter correspond to the first coefficients of the matrix of the transformation coefficients of this image when this matrix is run through following the zigzag path defined in figure 2. These first coefficients therefore in general have a high energy whereas the following coefficients have a low energy. In order to obtain a decoded image having a minimal quality the encoding and the decoding must therefore give priority to transmission of the first coefficients of the transformation coefficient matrix.

When a series of images represents a slightly animated or fixed scene, it is useless to transmit the values of the first coefficients of the matrix for each image since these values vary very little from one image to the next; however it is regrettable not to transmit the values of the following coefficients which enable the fine details of each image to be reconstituted, details which the eye has ample time to perceive precisely when the scene is slightly animated or fixed.

The process according to the invention therefore consists of transmitting the values of the transformation coefficients of an image

when the latter represents a very animated scene, by weighting with a low significance the coefficients corresponding to the average and high spatial frequencies; and of transmitting the variations of the transformation coefficients of an image with respect to the preceding image when these images represent a slightly animated or fixed scene, the reduction in the quantity of information thus obtained being used in order to transmit with more bits the values of the coefficients corresponding to the average and high spatial frequencies.

The animation of the scenes represented by the series of images can be estimated by comparing the values of the transformation coefficients of the homologous blocks of each of the images of the series. The process according to the invention consists of calculating the difference between the first transformation coefficients of each block and the corresponding coefficients of the homologous block in the preceding image and of comparing the absolute values of these differences with a threshold, and of changing over from inter-image encoding to intra-image encoding when at least one of the differences is greater than the threshold fixed. The values of homologous coefficients used in order to calculate the differences are not the precise values calculated according to the theoretical formulae (1) but those reconstituted by an encoding and then a decoding, since it is the latter which are actually available in the decoding device.

Figures 3 to 5 illustrate the process according to the invention, applied to the encoding of three successive images representing a fixed scene, the encoded information being transmitted with a constant flow. Each of these figures represents a graph having in the Y axis the quantity of information actually transmitted and in the X axis the rank of the coefficients of the transformation matrix of each of these images, this rank being determined on the zigzag path shown in figure 2. Figures 3 to 5 consider the quantities of information actually transmitted after: a calculation of the difference between the transformation coefficients of the image in question and the transformation coefficients of the image preceding it; a weighting; a standardisation; and a quantification.

The image corresponding to figure 3 being different from any images which may have preceded it, the values of the transformation coefficients of this image are therefore very different from those of the transformation coefficients of the image preceding it. The distribution of the quantities of information transmitted is similar to the distribution of the quantities of information which would have to be transmitted by an intra-image encoding. This is why the quantities of information transmitted for the coefficients of low rank are high and the quantities of information for the coefficients of higher rank decrease as a function of this rank.

The quantities of information transmitted for the coefficients of very high rank are zero because the values of the transformation coefficient differences further undergo a weighting favouring the coefficients of low rank with respect to the coefficients of high rank, and then a standardisation commanded by a flow regulation device, and lastly a quantification.

Figure 4 corresponds to the following image which is assumed to be identical to the preceding image. The transformation coefficients of this second image are therefore theoretically strictly identical to those of the preceding image. However the weighting calculation, standardisation, and quantification operations cause encoding errors which show themselves through a non-zero difference between the transformation coefficients before encoding and the transformation coefficients after encoding and then decoding. There are therefore non-zero differences between the encoded and then decoded coefficients for the first image and the coefficients which will be encoded for the second image.

Figure 4 shows the quantity of information corresponding to these differences after these differences have undergone a weighting, a standardisation, and a quantification. The quantity of information constituted by these differences is small; the regulation device then commands the standardisation device so as to amplify their values. Figure 4 therefore shows the quantity of information resulting from this amplification. The quantity of information is maximum for the coefficients of medium rank, because the encoding errors for the first image

are substantial as far as the coefficients of medium rank and of high rank are concerned. The encoding of the difference values of the coefficients of high rank for the second image is itself also erroneous because the coefficients of high rank are less favoured than the coefficients of medium rank, because of the weighting operation.

Figure 5 represents the quantity of information transmitted for a third image. The differences between the coefficients of the third image and the encoded and then decoded coefficients of the second image are small because the coefficients of low rank and then the coefficients of medium rank were previously encoded with a small encoding error. The difference values to be transmitted for the coefficients of low rank and of medium rank are therefore low and necessitate few bits. The flow regulation device then modifies the standardisation parameter so as to amplify still more the values of the coefficient differences, which then correspond almost solely to the coefficients of high rank.

Thus the third decoded image will include the information corresponding to the coefficients of low rank, to the coefficients of medium rank, and to the coefficients of high rank, i.e. will be reproduced with great fineness of detail. This process converges during the period of three or four successive images. The process according to the invention is described above upon the assumption of a constant transmission flow, but it can be applied just as well upon the assumption of a variable transmission flow.

Figure 6 gives the general diagram of an example of an embodiment of an encoding device according to the invention, adapted to process monochrome television images constituted by two interlaced frames. Each pair of frames is considered as two successive images. It comprises: a cosine transformation device 21; a digital subtracter 31; two delay devices 32 and 33; a multiplexer 22 having two inputs and one output; a weighting device 23; a standardisation device 24; a quantification device 25; an encoding device 26; a flow regulation device 27; control means 29; and inter-image decoding means 30.

The cosine transformation device 21 possesses an input connected to an input terminal 20 of the encoding device according to the invention, in order to receive a series of digital values representative of the image points. An output from the device 21 is connected to a first input of the subtracter 31 and to an input of the delay device 33. An output from the means 30 is connected to the second input of the subtracter 31 and the output of the latter is connected to an input of the device 32 and to an input of the means 29.

An input and an output of the weighting device 23 are connected respectively to an output of the multiplexer 22 and to an input of the standardisation device 24. An output from the device 24 is connected to an input of the quantification device 25. An output from the device 25 is connected to an input of the encoding device 26 and to a first input of the means 30. An output from the device 26 is connected to an input of the flow regulation device 27. The device 27 possesses a first output connected to an output terminal 28 of the encoding device according to the invention and a second output connected on the one hand to a control input of the standardisation device 24 and to a second input of the means 30. An output from the means 29 is connected to a control input of the multiplexer 22, to a control input of the encoding device 26, and to a third input of the means 30.

The control means 29 comprise: two comparators, 40 and 42, and a logic circuit 41. The input of the means 29 is connected to a first input of the comparator 40 and to a first input of the comparator 42. These comparators each possess a second input receiving respectively a threshold value $+S$ and a threshold value $-S$. They each possess an output connected respectively to an input of the logic circuit 41. The logic circuit 41 possesses a clock input receiving a signal F_B at the processing frequency of the blocks, and an output constituting the output of the means 29.

The inter-image decoding means 30 comprise: a memory 46 for storage of the transformation coefficients of the block homologous with the block currently being processed; a multiplexer having two inputs and one output, 47; an adder 48; an inverse weighting device,

49; and an inverse standardisation device, 50. The first input, the second input and the third input of the decoding means 30 are connected respectively to a control input of the multiplexer 47, to a first and to a second input of the device 50. An output from the device 50 is connected to an input of the device 49. An output from the latter is connected to a first input of the multiplexer 47 and to a first input of the adder 48.

A second input of the adder 48 and an output are connected respectively to an output from the memory 46, which constitutes the output from the means 30, and to a second input of the multiplexer 47. An output from the multiplexer 47 is connected to a data input of the memory 46. The memory 46 can be constituted by an offset register controlled by a clock signal at the frequency of analysis of the points, this frequency corresponding to the frequency of processing of each transformation coefficient. The number of stages of this register is equal to the number of points per image frame, less ten points to take account of the delay produced by the device 32.

The cosine transformation device 21 performs the dividing up of each image into blocks of 16×16 points and calculates, for each block, a matrix of the transformation coefficients by the cosine transformation previously defined. The values of the coefficients of each block are supplied to the device 33 in turn, in the order specified by figure 2, and are applied on the one hand, and on the other, to the first input of the subtracter 31 so as to calculate the difference between each coefficient and the homologous coefficient of the homologous block in the preceding frame, the decoding means 30 supplying the value of this homologous coefficient to the second input of the subtracter 31. The difference values supplied by the output from the subtracter 31 are delayed by the device 33 and then applied to the second input of the multiplexer 22. The latter transmits them if the block represents a slightly animated or fixed scene. Otherwise, it transmits the coefficient values supplied by the device 33.

The multiplexer 22 is controlled by a logic signal supplied by the output from the control means 29. The input of the means 29 receives the difference calculated by the subtracter 31 and compares

it on the one hand with the threshold value $+ S$ and on the other hand with the threshold value $- S$ by means of the comparators 40 and 42. The threshold $+ S$ corresponds to the positive differences and the threshold $- S$ corresponds to the negative differences. When the absolute value of the difference between two homologous coefficients is higher than the threshold value, the comparator 40 or the comparator 42 supplies a logic signal to the circuit 41. The latter supplies a logic signal corresponding to an intra-image encoding throughout the time for encoding of one block if the difference is higher than the threshold for at least one of the first ten coefficients of a block. In order to generate the choice of the type of encoding it is necessary to consider the first ten coefficients of each block; that is why delay devices 33 and 32 are provided so as to delay the values supplied by the device 21 and by the subtracter 31, by a time corresponding to ten coefficients, i.e. corresponding to ten image points.

The delay devices 33 and 32 may each be constituted by a shift register possessing ten stages and controlled by a clock signal at the rate of analysis of the image points. The logic circuit 41 is a sequential circuit the construction of which is within the capabilities of the specialist. The construction of the cosine transformation device 21 is within the capabilities of the specialist since cosine transformation is a transformation the use of which is very conventional for the encoding of images.

The weighting device 23 applies the same weighting whatever the type of encoding in progress. This weighting consists of multiplying the value applied at its input by a coefficient equal to:

$\exp \frac{-(u^2 + v^2)}{15^2}$, u and v being respectively the line index and the column index of the coefficient the encoding of which is in progress, in the transformation matrix. When the indices u and v increase, the significance applied to the coefficient decreases. Coefficients having high indices, i.e. corresponding to high spatial frequencies, are therefore multiplied by values close to zero. The values of the indices u and v are determined by synchronisation and control means not shown, the construction of which is within the capabilities of the specialist.

The standardisation device 24 multiplies the values which are applied at its input, by a variable coefficient supplied by the flow regulation device 27. The quantification device 25 performs the transformation of the values applied at its input with a floating point into whole number values. The encoding device 26 encodes by two Huffman codes the value and the address of the coefficients or of the coefficient differences which are applied to its input. The encoding of the address is an encoding by ranges, the coefficients being processed in the order shown in figure 2. This encoding permits a great reduction in the quantity of information to be transmitted by taking advantage of the fact that a large number of coefficients of high rank have a zero value and that they are distributed in ranges of great length. The device 26 inserts into the series of encoded information a code word indicating the change in type of encoding, under the action of the logic signal supplied by the output from the means 29.

The flow regulation device 27 comprises a shift register used as buffer memory and control means monitoring the filling of this register and calculating a standardisation parameter value as a function of the extent of this filling, for example by means of a table stored in a read-only memory. The decoding means 30 permit reconstitution of a series of transformation coefficients encoded and then decoded and stored for a period corresponding to one frame. The decoding means 30 are connected to the output from the quantification device 25 in order to take out a series of values to be decoded.

This series of values is applied to the inverse standardisation device 50 which receives the value of the standardisation parameter supplied by the device 27. The device 50 multiplies the value to be decoded by the reciprocal of the standardisation parameter, for example by means of a table stored in a read-only memory. The device 50 supplies a series of values to the inverse weighting device 49. The latter multiplies each of the values by a weighting equal to $\exp \frac{u^2 + v^2}{15^2}$.

If the encoding in progress is an intra-image encoding, the multiplexer 47, commanded by the control means 29, transmits the series of values supplied by the inverse weighting device 49. If the block currently being encoded is undergoing inter-image encoding, the multiplexer 47 transmits a series of values supplied by the adder 48 which performs the reconstitution of the coefficient values by adding the value of the homologous coefficient of the homologous block in the preceding image to the difference value which is then supplied by the device 49.

The decoded coefficient values supplied by the output from the multiplexer 47 are stored in the memory 46 for a period equivalent to the processing of one frame less ten points. The value reconstituted by the memory 46 is used on the one hand in order to calculate a coefficient difference value by means of the subtracter 31, and in order simultaneously to decode this same coefficient difference value by means of the adder 48.

Figure 7 gives a general diagram of an example of an embodiment of the decoding device according to the invention for decoding of the encoded values supplied by the encoding device described above. This decoding device comprises: a flow regulation device 52; a decoding device 53; an inverse standardisation device 54; an inverse weighting device 55; a multiplexer 56 having two inputs and one output; an inverse cosine transformation device 57; and an inter-image decoding device 62.

An input of the flow regulation device 52 is connected to an input terminal 51 receiving encoded values. The regulation device 52 possesses a first output connected to an input of the decoding device 53 and a second output connected to a control input of the inverse standardisation device 54. The decoding device 53 possesses an output connected to an input of the device 54. An output from the inverse standardisation device 54 is connected to an input of the inverse weighting device 55. The latter possesses an output connected to a first input of the multiplexer 56 and to a first input of the means 62. The means 62 possess an output connected to a second input of the multiplexer 56. The multiplexer 56 possesses an output

connected to a second input of the means 62 and to an input of the device 57. An output from the device 57 is connected to an output terminal 58 of the decoding device according to the invention.

The inter-image decoding means 62 comprise a memory 61 for storage of the coefficients of the block, in the preceding image, homologous to the block currently being decoded. The first input of the means 62 is connected to a first input of the adder 60. The second input of the means 62 is connected to a data input of the memory 61. An output from the latter is connected to a second input of the adder 60. An output from the adder 60 is connected to the output from the means 62.

The flow regulator 52 receives via the input terminal 51 a series of binary values having a constant rate but transmitting values of encoded coefficients at a variable rate. The decoding device 53 must reconstitute coefficients, or coefficient differences, at a constant rate corresponding to the analysis and reconstitution rate of a frame. The regulation device 52 therefore comprises a buffer memory constituted by an offset register in which are written at a constant rate the binary values received via the input terminal 51. These binary values are decoded at a variable rate by the decoding device 53 in accordance with the tables of the Huffman codes used for the encoding, by recalculating the addresses which are encoded by ranges. The filling of the buffer memory of the device 52 is strictly balanced with the filling of the buffer memory located in the flow regulation device 27 for the encoding.

The device 52 comprises control means which monitor this filling and determine the same standardisation parameter as in the encoding device. This standardisation parameter is applied to the inverse standardisation device 54 which performs the multiplication of each value applied to its input by the reciprocal value of the standardisation parameter. The device 54 may be identical to the device 50 and may be constituted by a read-only memory storing a table of values. The inverse weighting device 55 multiplies each of the values applied in turn to its input by a weighting equal to $\exp \frac{u^2 + v^2}{15^2}$.

The values of the indices u and v are determined by synchronisation and control means not shown, the construction of which is within the capabilities of the specialist.

The multiplexer 56 receives on its first input the values supplied directly by the output from the device 55 and it receives on its second input a value decoded by the means 62. The means 62 decode the coefficient difference values, by adding by means of the adder 60 the value of the homologous coefficient of the homologous block in the preceding image.

The decoding device 53 detects the binary words inserted into the series of the coded information in order to indicate the changes in type of coding and supplies a command signal to the multiplexer 56. The latter transmits the value supplied by the output from the device 55 when the coding is intra-image and transmits the value supplied by the output from the means 62 when the coding is inter-image. The output from the multiplexer 56 therefore supplies a decoded series of coefficient values to the inverse cosine transformation device 57. The latter reconstitutes a series of brightness values in the order in which they were analysed.

The invention is not confined to the examples of embodiments described above; many variants are available to the specialist, particularly for construction of the control means 29 detecting the degree of animation of each block, and for choosing the type of transformation.

The encoding and decoding of colour television images can be performed by processing in parallel three series of digital values corresponding to a brightness signal and two colour difference signals.

The invention can be applied in particular to the transmission or to the storage of television images with reduced flow.

CLAIMS

1. Adaptive process for encoding and decoding of a series of images by transformation, each image point being represented by a digital value, the encoding consisting of dividing each image into blocks of points and of applying a two-dimensional transformation to each block so as to obtain a matrix of values termed transformation coefficients of the block; and consisting, for each block of points, of:

- discriminating whether the block represents a very animated or slightly animated scene;

- transmitting the value of the transformation coefficients of the block in the first case, or the difference in value of these coefficients, with respect to the value of the homologous coefficients of the homologous block in the preceding image, in the second case;

- transmitting information indicating whether the block represents a slightly animated or very animated scene;

the decoding consisting of applying to the transmitted values corresponding to one block, an inverse transformation of the transformation applied for its encoding if this block represents a very animated scene;

and further consisting, if the block represents a slightly animated scene, of determining a value of the coefficients of this block, by adding the difference in value of each of its coefficients respectively to the value of the homologous coefficients of the homologous block in the preceding image, before applying the inverse transformation;

characterised in that the encoding further consists of applying a weighting to the values of the coefficients and of the coefficient differences, before transmitting them, with a larger weighting for the coefficients and the coefficient differences corresponding to the low spatial frequencies of the image, with respect to those corresponding to the high spatial frequencies,



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and in that the decoding further consists of applying a weighting reciprocal to that of the encoding to the values of the coefficients and of the differences before applying the inverse transformation to them.

2. Process as claimed in claim 1, characterised in that, in order to discriminate whether the block represents a very animated or slightly animated scene, it consists of: calculating the difference between each transformation coefficient of this block and the homologous coefficient of the homologous block in the preceding image; comparing the absolute value of this difference with a threshold; then concluding that the block represents a very animated, or slightly animated, scene depending on the result of this comparison for the coefficients corresponding to the low spatial frequencies.

3. Process as claimed in claim 1, characterised in that, in order to regulate the flow of the data supplied by the encoding, it further consists of multiplying by a variable parameter, termed standardisation parameter, the values of the coefficients or of the coefficient differences, after having weighted them and before transmitting them;

and in that the decoding further consists of multiplying by a variable parameter termed inverse standardisation parameter, depending on the quantity of data transmitted, the values of the coefficients or of the coefficient differences which have been transmitted.

4. Encoding device for implementation of the process as claimed in claim 1, comprising:

- a transformation device (21) receiving a series of digital values representative of the points of an image and reconstituting a series of transformation coefficients corresponding to a series of blocks of points;

- first means (30) for supplying a series of transformation coefficients corresponding to the block homologous to the block currently being encoded, in the preceding image;

- second means (29 and 31) coupled to the transformation device (21) so as to discriminate between the blocks representing a very animated scene and the blocks representing a slightly animated scene;



- a subtracter (31) coupled to the transformation device and to the first means (30) for calculating a series of differences between the transformation coefficients of each block and the homologous transformation coefficients of the homologous block in the preceding image;

- a multiplexer (22) for selection of the series of the coefficients supplied by the transformation device (21) or the series of the differences supplied by the subtracter (31), controlled by the second means (29, 31);

characterised in that it further comprises a weighting device (23) having an input coupled to the output from the multiplexer (22), in order to reduce the values of the series selected by the multiplexer (22) when they correspond to coefficients or to coefficient differences of high rank in the lines and the columns of the matrix of the transformation coefficients of a block, and then to transmit them to an output terminal (28) of the encoding device.

5. Device as claimed in claim 4, for implementation of the process as claimed in claim 2, characterised in that the second means (29 and 31) comprise:

- the above-mentioned subtracter (31),
- two comparators (40, 42) connected to an output of the subtracter (31) and having respectively two threshold values of opposite sign;

- a logic circuit (41) connected to an output of each of the comparators (40, 42) and supplying a signal indicating for each block whether it represents a very animated or slightly animated scene, depending on the signals supplied by the two comparators (40, 42) for the coefficients of this block.

6. Device as claimed in claim 4, for implementation of the process as claimed in claim 3, characterised in that it further comprises, in series at the output from the weighting device (23):

- a standardisation device (24) for increasing or reducing the values of the coefficients and of the coefficient differences, by multiplying them by the value of a standardisation parameter;



- a quantification device (25) for removing the decimal part of the values of coefficients or of coefficient differences;

- an encoding device (26) for encoding by Huffman codes the values and the addresses of the coefficients and of the coefficient differences before transmitting them, and for generation of a code word indicating whether a block represents a very animated or slightly animated scene;

- a transmission flow regulation device (27), supplying the value of the standardisation parameter to the standardisation device (24).

7. Decoding device for implementation of the process as claimed in claim 1, comprising:

- first means (52 to 55) for receiving a code word and encoded data encoding the values representative of the points of a block of points of an image, and for reconstituting a series of values constituted by transformation coefficients or differences of transformation coefficients of the brightness values, depending on the value of the code word, and for reconstituting a control signal which is a function of the value of the code word;

- second means (62) for determining a value for each coefficient of a block by adding a value of a coefficient difference supplied by the first means (53) to the value of the corresponding coefficient in the homologous block of the preceding image;

- a multiplexer (56), commanded by the signal generated by the first means (53), so as to transmit to an output terminal (58) of the decoding device either the values reconstituted by the first means (53), or the values determined by the second means (62);

- a device (57) for transformation reciprocal to that applied for the encoding, coupled to the output from the multiplexer (56), for reconstituting a series of digital values representative of the image points;

characterised in that the first means (52 to 55) comprise an inverse weighting device (55) for applying to the values of the transformation coefficients and of the transformation coefficient differences, a weighting reciprocal to that applied during the encoding.



8. Decoding device as claimed in claim 6, characterised in that the first means (52 to 55) comprise in series:

- a flow regulation device (52) for receiving encoded data with a constant binary flow, and for determining the value of a standardisation parameter;

- a decoding device (53) for decoding of the encoded data received by the regulation device and supplying at a constant rate a series of transformation coefficients or coefficient differences, and for decoding a code word indicating whether the block corresponding to these data represents a very animated or slightly animated scene and for generating a corresponding logic signal;

- a standardisation device (54) coupled to an output from the decoding device (53), for multiplying by the value of the standardisation parameter the transformation coefficients and coefficient differences supplied by the decoding device (53).

