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(54) **CONVERSION OF VIDEO DATA FROM INTERLACED TO NON-INTERLACED FORMAT**

UMSETZUNG VON VIDEODATEN AUS EINEM VERSCHACHTELTEN IN EIN NICHTVERSCHACHTELTES FORMAT

CONVERSION DE DONNEES VIDEO, D'UN FORMAT ENTRELACE A UN FORMAT NON ENTRELACE

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Description

[0001] This invention relates to a method and apparatus for converting an interlaced video signal to the deinterlaced or progressive scan video signal, and in particular to a method and apparatus which provides appropriate control to the effectiveness of the conversion.

[0002] Broadcast television signals are usually provided in interlaced form. For example, the phase alternate line (PAL) system used in Europe is made up of video frames comprising two interlaced fields. Each field comprises alternate lines of the frame. Thus, when the signal is applied to a display the first field will be applied to the odd numbered lines of the display followed by the second field being applied to the even numbered lines of the display. The frame rate, the rate at which frames comprising two interlaced fields are applied to a display is usually 50 Hz.

[0003] Progressive scan displays interpolate within the fields of each frame and sometimes between adjacent fields to provide data for the missing lines in each field, thereby converting each field to a frame and doubling the effective frame rate of the display. One of the problems when interpolating the missing lines of video fields is that of accurate detection of edges or contours marking variations in the visible information. US patent no. 5,532,751 looks at the variation between pixels which are used to interpolate missing pixels to detect edges or contours. If the variation is below a threshold, the orientation of an edge is estimated and a new pixel is formed from the average of the pixels lying along the estimated orientation. If the estimate of edge orientation is unsuccessful then a new pixel is formed from the average of two vertically aligned pixels within a field. This technique can generate artefacts in pictures which have two or more pairs of pixels with high resemblance.

[0004] An improvement upon this method is disclosed in US patent no. 6,133,957. In this, the variation between pixels or a set of pixels is computed to reconstruct edges or borders. Two variations with the lowest values are used and a reconstructed pixel is generated as a weighted average of the pixels used in the chosen variations.

[0005] Still a further improvement is set out in British patent no. 2402288. The solution presented here preserves vertical frequencies present in a frame which is being deinterlaced when accurate information on the position of an edge or border is not available.

[0006] All the techniques described above fetch input data from one instant of time only and search for the best match in vertically adjacent lines of a video field. They are referred to here as border reconstructers (BR).

[0007] One of the fundamental ideas behind a BR is the estimation of the correlation between two sets of pixels belonging to two vertically adjacent lines in a field at an instant of time.

[0008] Figure 1 shows three representations of short sections of two adjacent lines in a video field. In the example given in figure 1, we see only the lines from the current field being used although one or more adjacent fields can also contribute to the interpolation used to the derivation of pixel data for the missing lines as can additional lines in the current field.

[0009] In figure 1, three different possible interpolations schemes are shown and correlations are evaluated for these. The middle scheme comprises correlation of the data in the pixels above and below the pixel to be reconstructed and correlation of data between pairs of pixels positioned immediately adjacent to this. A further possible interpolation is evaluated in the left-hand example of figure 1 by looking at the correlation between pixels on lines which pass diagonally sloping down to the right through the pixel being reconstructed. The same process with the opposite diagonals is shown in the right-hand example of figure 1.

[0010] The correlation between the data in the various pairs of pixels can be derived using the sum of absolute differences (SAD) or the mean square error, or other well-known statistical techniques. The sum of absolute differences and the mean square error are derived as follows:

$$MSE = \sum (Ytop[i] - Ybot[n-i])^2$$

[0011] In the above formulas, *Ytop* and *Ybot* represent the luminance of the pixels in the lines above and below the pixel to be reconstructed in a field, and *n* is the number of pixels in each row. The luminance of a pair of pixels is involved in each single difference.

[0012] The graph on the right-hand side of figure 1 shows an example of SAD based procedure using five pixels only for each row and three correlations of symmetrically located sets of pixels, each set made up of the three pixel pairs. In practice, more pixels are involved in the computation to ensure greater accuracy. Preferably, between 7 and 30 pixels pairs are used.

[0013] If we use the SAD approach to comparing the values of pairs of pixels, then figure 1 leads to 3 SAD values. SAD 0, SAD 1 and SAD 2 which are shown graphically at the right-hand side of figure 1. This can be considered the correlation curve for the various possible interpolations. In many techniques, the interpolation scheme which gives the smallest difference in SAD or the smallest means square error (MSE) does not always produce the best quality final image. This is because the content of the image in the neighbourhood of the pixel being reconstructed can affect the SAD or MSE. For example, if there are a few thin lines passing close to the pixel to be reconstructed there is a risk that in reconstruction, the lines result in pixelation or flickering in the final image. In US 6,133,957 and GB 2402288 this problem has been addressed by blending several relative minima in a correlation curve together and has also been approached by clamping the result using the values generated by the pixels directly above and below the one to be reconstructed. The problem with these approaches is

that even though blending and clamping reduce the effect of incorrect analysis of the correlation curve, they are affected by the incorrect starting point for the procedure.

[0014] EP-A2-0 785 683 discloses a method for converting an interlaced video signal to a progressive video signal according to the preamble of claim 1.

[0015] We have appreciated that by modifying the correlation curve with an adjustment curve selected in dependence on the form of the correlation curve increases the likelihood of selecting the correct minimum value from the correlation curve. The adjustment curve is selected or altered in dependence on a confidence measure derived from the correlation curve data.

[0016] Preferably, the local minima for various portions of the correlation data are detected and the selection of an adjustment curve to combine with the correlation curve to generate the most likely interpolation scheme to produce good results is made in dependence on the relative positions of minima in the correlation data.

[0017] Preferably the correlation data is divided into segments and local minima detected in each segment.

[0018] In accordance with one aspect of the invention there is provided a method for converting an interlaced video signal to a progressive scan video signal comprising the steps of:

for each pixel in each missing line of a video field in a video signal to be converted, providing correlation data for each of a set of possible interpolations between adjacent pixels to be used in reconstructing the missing pixel;
from the correlation data deriving a confidence measure from the correlation data;
determining from the confidence measure the interpolation scheme most likely to produce an accurate missing pixel; and
interpolating the missing pixel using he selected interpolation scheme
wherein the step of deriving a confidence measure comprises determining the number of maxima and minima in the correlation data and deriving the confidence measure in dependence on the result of the determination.

[0019] A preferred embodiment of the invention will now be described in detail by way of example with reference to the accompanying drawings in which:

Figure 1 shows schematically the type of SAD analysis which is made when interpolating missing pixels in converting interlaced video signals to progressive scan signals;
Figure 2 shows a block diagram of the processes which have to take place in an embodiment of the invention;
Figure 3 shows a number of different examples of correlation curves which might be obtained:
Figure 4 shows diagrammatically how a correlation curve is analysed;
Figure 5 shows examples of the curves which might be combined with the correlation curve;
Figure 6 is a graph which shows how the sensitivity of the curves of figure 5 to an additional factor;
Figure 7 shows an example of a resultant curve after combination with of one of the curves of figure 5;
Figure 8 shows a block diagram of an embodiment of the invention.
Figure 9 shows three different correlation curves and the topological data which is extracted from them;
Figure 10 shows how a correlation curve can be cleansed to remove small local maxima or minima;
Figure 11 is a flow diagram showing the procedure for detecting maxima and minima; and
Figure 12 is a flow diagram showing the procedure for deriving a confidence measure from the information about extremes extracted by the procedure of figure 11.

[0020] The diagram of figure 2 is now explained with reference to the 5 pixel interpolation schemes shown in figure 1. As mentioned above, in practice more pixels than 5 will be used and more interpolation schemes than the 3 shown in figure 1 will be used but we refer to these for ease of understanding.

[0021] In figure 2, unit 1 performs the derivation of correlation data for the correlation curve shown in figure 1. In this example 3 points are used. In practice, the number of points used will be proportional to the number of pixels used. In unit 2, an analysis of the information contained in the correlation curve is performed to produce a confidence evaluation for the curve in the form of confidence data. This comprises a measure as to the clarity of the information contained in the correlation data. Examples of the type of correlation curve which can be generated with the correlation data are shown in figure 3. The two left-hand side curves have clear maxima and a single minimum each. Thus, it is highly likely that the minimum value created by the SAD of figure 1 from the various sets of pairs of pixels is the correct minimum to use and therefore the correct set of pairs of pixels to use for the interpolation of the pixel of a missing line. The third curve of figure 3 has three minima and 3 maxima. Therefore the data for this graph gives no indication as to which of the minima detected is the most relevant.

[0022] The fourth example in figure 3 gives a curve with 2 distinct minima. Either of these could be the correct one to use in determining the interpolation scheme to use. However, they are physically separated by a number of pixels and therefore it is unclear which of them should be used.

[0023] In figure 2, the correlation data is generated in a logical sequence, for example in figure 1 starting with the left-hand interpolation scheme and moving to the right. Whatever the scheme adopted, a logical sequence is required so that there is an incremental change in the relative positions of the pixels being used by the interpo-

lation scheme. In graphical representation, this would mean, for example, when looking at the graph on the right-hand side of figure 1, the first SAD point plotted is that generated by the pixels selected in the left-hand side scheme of figure 1 i.e. the diagonal line joining the pixels slope downwards to the right through the pixel to be reconstructed. For the middle point, the lines joining the pairs of pixels are vertical and for point 2 the lines joining the pairs of pixels slope upwards to the right. A similar type of approach is taken whatever number of pixels or whatever interpolation scheme is used.

[0024] In the confidence evaluation stage of figure 2, the SAD measurements from figure 1 are received in turn from correlation analysis in unit 1. The data as it is received is compared with previous data to determine where local minima occur.

[0025] An example of this is shown in figure 4 for a curve which has 2 statistically significant minima MIN 1 and MIN 2. There is also a minimum min x which is ignored as it's size in proportion to the rest of the curve is insignificant. The confidence evaluation unit 2 determines a confidence measure representing whether the correlation data is likely to produce the correct result for the interpolation scheme to be used and then uses this to select an adjustment data which is combined with the data for each point on the correlation curve. The confidence measure is supplied to adjustment curve unit 3 which selects the adjustment data to use in dependence on the output of the confidence evaluation unit 2 and supplies the data for this curve to a combination unit 4 which combines it with a correlation data from the correlation curve unit 1. The resultant data is then sent to a resultant data analysis unit 5 which can select the appropriate minimum from the resultant data and from this determine which interpolation system (see figure 1) should be used in interpolating the missing pixel.

[0026] The selection of data represented by a curve which might be used by the adjustment curve analysis unit 3 of figure 2 is shown in figure 5. These are produced by the equation:

$$F(x) = b * |x|^a$$

[0027] In this formula *b* is a parameter which is adjusted in dependence on the confidence evaluation derived from the confidence evaluation unit 2 i.e. the confidence measure, a is either a constant in the preferred embodiment or can be related to the confidence measure as well. x relates to the position of the interpolation scheme to which the confidence evaluation relates in the logical sequence of interpolation schemes.

[0028] Figure 5 shows various different curves for different values of a with a value of b equal to 1. Although all of these could deliver good performance in specific cases, we have appreciated that the best overall curve in dealing with many situations is produced by a curve with a fixed value of a equals to 2. Because this exponential value is relatively low, the continuity of the first derivative *b* is more significant. Examples of this curve for various values of b are shown in figure 6. Thus it can be seen that as b increases, the steepness of the curve increases.

[0029] The zero value of the curve is in the centre of the graph of figure 6 and figure 5. This corresponds to the centre position of the logical incremental interpolation schemes. In figure 1 this would be a central interpolation scheme with the pairs of pixels being positioned vertically with respect to the pixel to be reconstructed.

[0030] The curve selected in dependence on the confidence measure b is then passed to the resultant curve generation unit for which combines the data from the curve with the data from the correlation curve unit 1 to produce data for a resultant curve. This is fed to a resultant curve analysis unit 5 which looks for any minima in the resultant curve. An example of a resultant curve and the components of which it is formed is shown in figure 7. As can be seen, a correlation curve with 2 minima which are physically separate after combination with an adjustment curve selected in accordance with a confidence measure derived from the correlation curve produces a resultant curve with one minimum much lower than the other. Thus, the position of this minimum is used to select the interpolation scheme to be used to generate the pixel. This process is performed in turn for each pixel to be interpolated on each line of each field of an input video sequence.

[0031] A more detailed block diagram of an example of a system embodying the invention is shown in figure 8. This comprises a field store 20 to which a field of a new video signal being converted from an interlaced video signal to a progressive scan video signal is stored. From this, each line of the field is read out in turn to line stores 22 and 24. Preferably, a first line is read to line store 22 and then passed to line store 24. At the same time, the next line which will be used with the first line for generating the missing lines of the field in the field store is read to line store 22. The system then analyses the lines to select the best interpolation schemes are used for each pixel in turn before passing the line stored in line store 22 to line store 24 and reading the next line of the field from the field store 20 to the line store 22.

[0032] Once 2 lines are stored in line stores 22 and 24 a correlation unit 26 produces, for each pixel in turn to be generated for the line position between the two lines in the line stores 22 and 24, a series of correlations in logical order for the different possible interpolation schemes to be used in generating that pixel. At the ends of the lines, not all the possible interpolations will be available. The correlation unit 26 calculates for example a sum of absolute differences or a least means squared analysis of the correlation between different pairs of pixels to be used in each of the interpolation schemes. The sums of absolute differences are provided in turn for each pixel to a confidence evaluation unit 28. When all the

values from the correlation unit 26 have been added to the confidence evaluation unit 28 a confidence value is generated. This is related to the positions and numbers of local minima for the correlation values produced by the correlation unit 26.

[0033] This confidence value is then provided to an adjustment curve selector 30 which uses it to modify a predetermined adjustment curve. In its most straightforward form the confidence value is used as a multiplier on the adjustment curve. More complex schemes can be used. Alternatively, the confidence value can be used to select between a plurality of predefined adjustment curves.

[0034] The data representing the adjustment curve is then provided from the adjustment curve selector 30 to a resultant data generation unit 32. Here the data from the adjustment curve is combined with the data from the correlation unit 26. For curves where the correlation data for a pixel which has 2 or more minima, the resultant data generation unit 32 should by combining correlation data with the adjustment curve data produce a set of adjusted correlation data which has a clear minimum value. This clear minimum value is then detected in a resultant data analysis unit 34. This provides data about the correlation value for a pixel which gives the minimum adjusted value. In dependence on this, an interpolation scheme selector 36 selects an interpolation scheme to be used to generate the pixel in question. The data for that interpolation is then provided either from the line stores 22 and 24 or from the field store 20 to an interpolator 38 which generates the value for the missing pixel. The system then proceeds to the next of the missing pixels to be generated until all missing pixels between the lines in the 2 line stores have been generated. The system then moves the pixel data from line store 22 to line store 24 and reads in the next available line from the field store 20. This continues until the missing lines for the whole field have been generated and the data is available for display.

[0035] Preferably the process takes place in real time so that it can be performed on a video signal being received by a television receiver which converts the signal to a non-interlaced form ready for display.

[0036] In an improvement on the arrangement of figure 8, two or more sets of the hardware of figure 8 could be provided operating in parallel in different lines of the field store 20 to improve processing speed.

[0037] In an alternative, the system of the figure 8 can be implemented in a dedicated processor. Two or more of these can be provided in parallel to improve the speed of processing. One possibility is to have a processor available for each of the missing lines of the field stored in the field store 20 to minimise processing time. This of course would make the unit more expensive.

[0038] For certain pixels to be generated, the resultant data analysis unit 34 may generate data which remains unclear. In such a situation, some form of exception processing is provided. This could involve using a different adjustment curve to improve the quality of the resultant data output. Other schemes are possible.

[0039] One further area where significant improvement in the reliability of the correct pixels being interpolated in missing lines is the confidence with which analysed correlation data can produce to a significant result. This confidence is used in the example given above to generate a confidence measure which can be used to select adjustment data to combine with the correlation data to produce a set of resultant data from which the correlation scheme most likely to produce the correct result for the pixel to be interpolated is selected. Confidence measures can be used in other methods of selecting interpolation schemes.

[0040] We have devised a procedure for examining the correlation data to improve the reliability of the selection of interpolation schemes which can be used in combination with the adjustment data discussed above, or can be used in other methods. For example, if the confidence measure is above a predetermined value then it could be deemed to be sufficiently accurate for no adjustment to correlation data to be required and for the interpolation data to be required and for the interpolation scheme to be selected directly from the correlation data. If the confidence measure is below a predetermined value then it could be used in combination with the adjustment data discussed above or in some other scheme.

[0041] In order to produce a confidence measure from the correlation data, the first step is to extract the topology of points from the correlation data. This is shown with regard to the graphs of figure 9. The top example in figure 9 shows a reasonably smooth correlation curve with a maximum close to one end and a minimum approximately two-thirds of the way along the line. The significant points of this curve are selected in the central graph to give the resultant set of the data points on the right-hand side.

[0042] A more complex graph is shown from the central line of figure 9. This has two distinct minima at slightly different levels with a local maximum between them. A set of data points derived from this is shown on the right-hand side.

[0043] The bottom example is the most straightforward and starts from a maximum on the left-hand side decreasing reasonably smoothly to a minimum on the right-hand side. This can be shown with only two data points.

[0044] These data points generated now form an array of output data which comprises three elements namely:

value of the relative extremes (relative maximum or minimum) as an integer value;
position of the relative extremes (as an index in the correlation data); and, a flag indicating whether the extreme is a relative maximum or minimum.

[0045] An important additional step is shown in relation to figure 10. This comprises what we refer to as cleaning the data. This is necessary to prevent the subsequent procedure from analysing extremes which are not signif-

icant when reconstructing the general shape or topology of the correlation data. It eliminates those maxima and minima which are too close to each other. As can be seen in figure 10, the curve representing the correlation data has a local maximum close to the minimum value of the curve. Analysis of this by a cleaning procedure removes the local maximum leaving the two local minima and the local maximum represented by a single point in the topology.

[0046] The procedure for cleaning the correlation data is now described in relation to figure 11.

[0047] Initially at 40 a relative extreme is found (maximum or minimum). Then, at 42 a determination is made as to whether or not the extreme is the first point of correlation data or the last point, corresponding to the first and last interpolation schemes which could be used. If it is not, the procedure goes to step 44. If it is, then the procedure skips directly to the end and the position in the correlation curve and whether or not it is a maximum or minimum are stored in a data array. If the extreme is at some other point on the curve, then at 44, if the extreme found is a minimum and the previous extreme is a maximum, or if the extreme just found is a maximum and the previous is a minimum then the procedure passes to 46. This determines whether or not the extreme was on the left border of the correlation curve. If it was, then the amount and identity (maximum or minimum) of the new extreme are stored in a data array replacing the corresponding values of the previous extreme. If the previous extreme is not on the left border at 46 then the procedure passes to 50. If determination is made as to whether or not the present extreme is on the right-hand border, i.e. is the last extreme in the correlation curve. If it is, then the present extreme is discarded at 52. Otherwise nothing changes as at 54. If the result from 44 was that the extreme found was a minimum and the previous had not been a maximum or if the extreme found had been a maximum and the previous extreme had not been a minimum then the procedure passes to 56. A determination is made as to whether or not the extreme just found is a minimum and the previous extreme is a minimum, or if the extreme just found is a maximum and the previous is a maximum. If neither is the case then the procedure does nothing at 54. If it is the case, then the present extreme and the new extreme are averaged.

[0048] Once the correlation data has been checked and cleaned to eliminate any extremes which are too close together, the data is passed to a processor which performs the procedure set forth in figure 12. The purpose of this is to examine the values of the data within the topology array and in response to this to return a value which gives an indication of the confidence of the correlation data being able to be used to select the correct interpolation scheme for reconstruction of a pixel in a missing line. This confidence measure is generated for each pixel in turn in a missing line, and for each missing line.

[0049] The example of figure 12 uses three data values in determining the confidence measure to use. These are extreme count which is an integer value of the number of extremes but its maxima and minima found in the cleansed correlation data, extreme amount which is the magnitude of each maximum and minimum in the correlation data, and extreme ID which is a value representing the position of each maximum and minimum in the data. These values are selected from a cleansed correlation data array at 60.

[0050] At 62, a determination is made as to whether or not the extreme count value is 2 or 3 (with the first extreme being a maximum). If it is, then the curve is either a general diagonal line or a general V indicating that the minimum correlation value is relatively clear. Therefore at 64 the result is set to Sure-Val representing a high degree confidence in the correlation data. If the extreme count is not 2 or 3 then the procedure passes to 66. This determines whether the extreme count is 4 or 3 (for data where the first extreme is a minimum). If it is, then a default value Default-Val is set as a result at 68. This represents a lower degree of confidence in the ability of the correlation data to be used to select the correct interpolation scheme.

[0051] If the extreme count is not 4 or 3 then the procedure passes to 70 which determines whether or not the extreme count is 5. If it is, then if the first extreme is determined to be a maximum at 72 then the equation shown at 74 is performed on the correlation data corresponding to the maxima and minima to derive a confidence value. If the extreme count at 70 is determined not to be 5, then it is greater than 5, a result is set to be a value called Max-Val. This indicates that there are too many maxima and minima in the correlation data and that the minima closer to the centre, i.e. the position of the pixel to be reconstructed should be emphasised.

[0052] If at 72 the first extreme is not a maximum, then the result is set to be Default - Val as was done at 68 indicating that some emphasis should be given to the new one closer to the centre point but not so much as with max under par val.

[0053] Using the value Sure-Val, Default-Val and Max-Val, different values to be given to the parameter b used in the selection of adjustment data as shown in figure 6. So, Sure-Val could correspond to a value of b 0.05, default val to a value of b of 1 and max val to a value of b of 2. Thus curves with more maxima and minima will receive more adjustment than those with fewer maxima and minima. The values can also be used in other schemes for selecting interpolations to be used when reconstructing a missing pixel.

[0054] The procedures shown in figure 12 can be extended to look for cleansed correlation data with more maxima and minima and therefore have more values of the confidence measure to be provided. The procedure can be modified to take account of the relative size of the relative maxima or minima and their proximity in determining which one is most likely to be useful in indicating the correct interpolation scheme to use.

Claims

1. A method for converting an interlaced video signal to a progressive scan video signal comprising the steps of:

   for each pixel in each missing line of a video field in a video signal to be converted, providing correlation data for each of a set of possible interpolations between adjacent pixels to be used in reconstructing the missing pixel;
   deriving a confidence measure from the correlation data;
   determining from the confidence measure the interpolation scheme most likely to produce an accurate missing pixel; and
   interpolating the missing pixel using the selected interpolation scheme
   characterised in that
   the step of deriving a confidence measure comprises determining the number of maxima and minima in the correlation data and deriving the confidence measure in dependence on the number of maxima and minima so determined.

2. A method according to claim 1 in which the step of determining the confidence measure including the step of determining the relative positions of the pixels from which each correlation was made and using this in deriving the confidence measure.

3. A method according to claim 1 or 2 including the step of selecting adjustment data for the correlation data from the confidence measure and adjusting the correlation data with adjustment data.

4. A method according to claim 3 in which the step of determining the interpolation scheme does so in dependence on the adjustment data.

5. Apparatus for converting an interlaced video signal to a progressive scan video signal comprising:

   means for each pixel in each missing line of a video field in a video signal to be converted which provides correlation data for each set of possible interpolations between adjacent pixels to the pixel to be reconstructed;
   means for deriving a confidence measure from the correlation data;
   means for determining from the confidence measure the interpolation scheme most likely to produce an accurate missing pixel; and
   means for interpolating a missing pixel using the selected interpolation scheme;
   characterised in that
   the means for deriving a confidence measure comprises means for determining the number of maxima and minima in the correlation data and means for deriving the confidence measure in dependence thereon.

6. Apparatus according to claim 5 in which the means for deriving a confidence measure also includes means for determining the relative positions from the pixels from which each correlation was made and means for deriving the confidence measure therefrom.

7. Apparatus according to claim 5 or 6 including means for selecting adjustment data for the correlation data from the confidence measure and means for adjusting the correlation data with the adjustment data.

8. Apparatus according to claim 7 in which the means for determining the interpolation scheme does so in dependence on the adjusted correlation data.

Patentansprüche

1. Verfahren für die Konvertierung eines Videosignals mit Zeilensprung in ein Videosignal ohne Zeilensprung, folgende Schritte umfassend:

   für jedes Pixel in jeder fehlenden Zeile eines Videofelds in einem zu konvertierenden Videosignal, das Bereitstellen von Korrelationsdaten für jede aus einem Satz möglicher Interpolationen zwischen benachbarten Pixel, die bei der Rekonstruktion des fehlenden Pixels verwendet werden sollen;
   Ableiten eines Konfidenzmaßes aus den Korrelationsdaten;
   Bestimmen des Interpolationsschemas, das am wahrscheinlichsten ein genaues fehlendes Pixel produziert, aus dem Konfidenzmaß; und
   Interpolieren des fehlenden Pixels mithilfe des ausgewählten Interpolationsschemas, **dadurch gekennzeichnet, dass** der Schritt der Ableitung eines Konfidenzmaßes die Bestimmung der Anzahl der Maximal- und Minimalwerte in den Korrelationsdaten und die Ableitung des Konfidenzmaßes in Abhängigkeit von der Anzahl der so bestimmten Maximal- und Minimalwerte umfasst.

2. Verfahren nach Anspruch 1, in dem der Schritt der Bestimmung des Konfidenzmaßes den Schritt der Bestimmung der relativen Positionen der Pixel beinhaltet, aus denen die jeweilige Korrelation erstellt wurde, und deren Verwendung bei der Ableitung des Konfidenzmaßes.

3. Verfahren nach Anspruch 1 oder 2, das den Schritt der Auswahl von Anpassungsdaten für die Korrela-

tionsdaten aus dem Konfidenzmaß und der Anpassung der Korrelationsdaten mit den Anpassungsdaten beinhaltet.

4. Verfahren nach Anspruch 3, in dem der Schritt der Bestimmung des Interpolationsschemas in Abhängigkeit von den Anpassungsdaten erfolgt.

5. Vorrichtung für die Konvertierung eines Videosignals mit Zeilensprung in ein Videosignal ohne Zeilensprung, umfassend:

Mittel für jedes Pixel in jeder fehlenden Zeile eines Videofelds in einem zu konvertierenden Videosignal, das Korrelationsdaten für jede aus einem Satz möglicher Interpolationen zwischen benachbarten Pixel für die zu rekonstruierenden Pixel bereitstellt;
Mittel für die Ableitung eines Konfidenzmaßes aus den Korrelationsdaten;
Mittel für die Bestimmung des Interpolationsschemas, das am wahrscheinlichsten ein genaues fehlendes Pixel produziert, aus dem Konfidenzmaß; und
Mittel für die Interpolation eines fehlenden Pixels mithilfe des ausgewählten Interpolationsschemas;

dadurch gekennzeichnet, dass die Mittel für die Ableitung eines Konfidenzmaßes Mittel für die Bestimmung der Anzahl von Maximal- und Minimalwerten in den Korrelationsdaten und Mittel für die Ableitung des Konfidenzmaßes in Abhängigkeit davon umfassen.

6. Vorrichtung nach Anspruch 5, in dem die Mittel für die Ableitung eines Konfidenzmaßes auch Mittel für die Bestimmung der relativen Positionen der Pixel beinhalten, aus denen die jeweilige Korrelation erstellt wurde, und Mittel für die Ableitung des Konfidenzmaßes daraus.

7. Vorrichtung nach Anspruch 5 oder 6, welche die Mittel für die Auswahl von Anpassungsdaten für die Korrelationsdaten aus dem Konfidenzmaß und Mittel für die Anpassung der Korrelationsdaten mit den Anpassungsdaten beinhaltet.

8. Vorrichtung nach Anspruch 7, in der die Mittel für die Bestimmung des Interpolationsschemas dies in Abhängigkeit von den angepassten Korrelationsdaten tun.

Revendications

1. Procédé de conversion d'un signal vidéo entrelacé en un signal vidéo de balayage progressif comprenant les étapes de :

pour chaque pixel dans chaque ligne manquante d'un champ vidéo dans un signal vidéo à convertir, la fourniture de données de corrélation pour chaque interpolation d'un ensemble d'interpolations possibles entre des pixels adjacents devant être utilisés dans la reconstruction du pixel manquant ;
la dérivation d'une mesure de confiance à partir des données de corrélation ;
la détermination à partir de la mesure de confiance du schéma d'interpolation le plus probable pour produire un pixel manquant juste ; et
l'interpolation du pixel manquant en utilisant le schéma d'interpolation choisi, **caractérisé en ce que** l'étape de dérivation d'une mesure de confiance comprend la détermination du nombre de maximums et de minimums dans les données de corrélation et la dérivation de la mesure de confiance en fonction du nombre de maximums et de minimums ainsi déterminés.

2. Procédé selon la revendication 1, dans lequel l'étape de détermination de la mesure de confiance comprenant l'étape de détermination des positions relatives des pixels à partir desquelles la corrélation a été effectuée et de l'utilisation de ceci dans la dérivation la mesure de confiance.

3. Procédé selon la revendication 1, ou 2, comprenant l'étape de sélection de données d'ajustement pour les données de corrélation à partir de la mesure de confiance et l'ajustement des données de corrélation avec les données d'ajustement.

4. Procédé selon la revendication 3, dans lequel l'étape de détermination du schéma d'interpolation est faite en fonction des données d'ajustement.

5. Appareil pour convertir un signal vidéo entrelacé en un signal vidéo de balayage progressif comprenant :

des moyens pour chaque pixel dans chaque ligne manquante d'un champ vidéo dans un signal vidéo devant être converti, qui procurent des données de corrélation pour chaque ensemble d'interpolations possibles entre des pixels adjacents au pixel devant être reconstruit ;
des moyens pour dériver une mesure de confiance à partie des données de corrélation ;
des moyens pour déterminer, à partir de la mesure de confiance, le schéma d'interpolation le plus probable pour produire un pixel manquant juste ; et
des moyens pour faire une interpolation d'un pixel manquant en utilisant le schéma d'interpo-

lation choisi ; **caractérisé en ce que** les moyens pour dériver une mesure de confiance comprennent des moyens pour déterminer le nombre de maximums et de minimums dans les données de corrélation et des moyens pour dériver la mesure de confiance en dépendant.

6. Appareil selon la revendication 5, dans lequel les moyens pour dériver une mesure de confiance comprennent également des moyens pour déterminer les positions relatives des pixels à partir desquelles chaque corrélation a été faite et des moyens pour dériver la mesure de confiance de celles-ci.

7. Appareil selon la revendication 5 ou 6, comprenant des moyens pour la sélection de données d'ajustement pour les données de corrélation à partir de la mesure de confiance et des moyens pour ajuster les données de corrélation avec les données d'ajustement.

8. Appareil selon la revendication 7, dans lequel les moyens pour déterminer le schéma d'interpolation le font en fonction des données de corrélation ajustées.

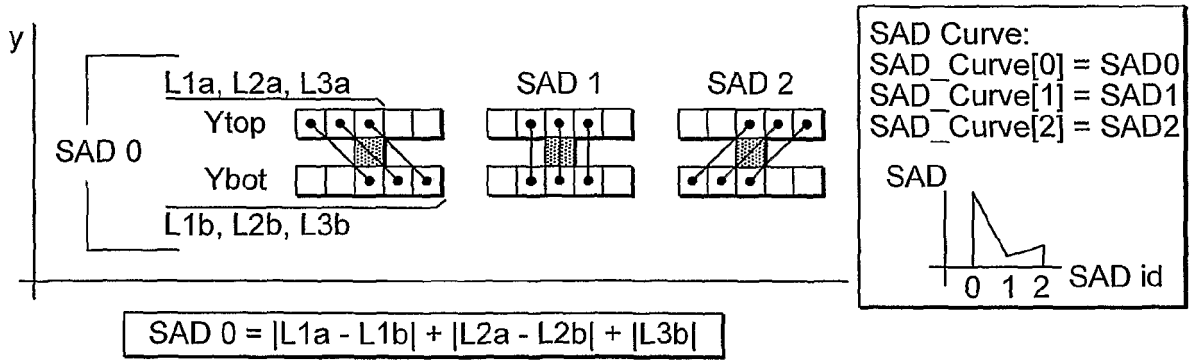

FIG. 1

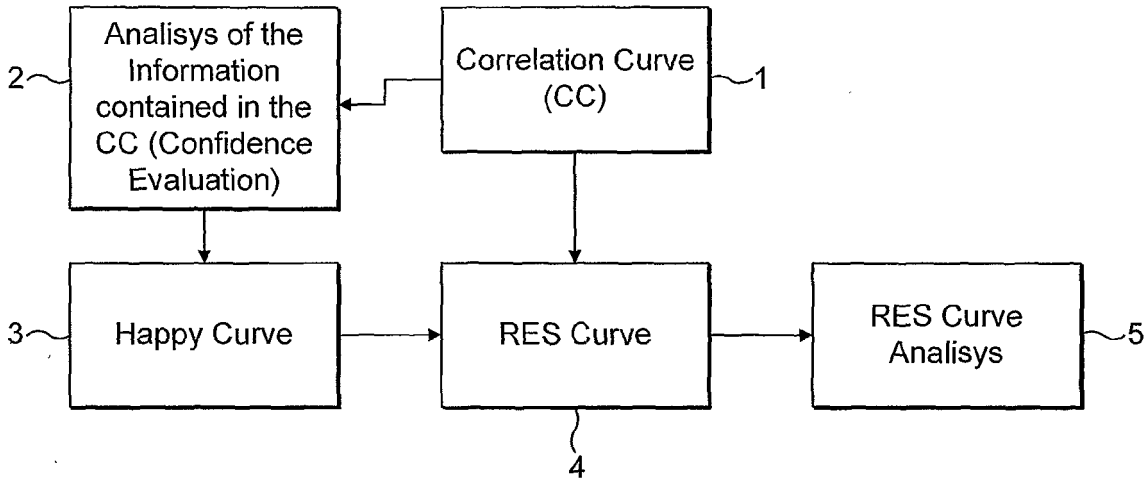

FIG. 2

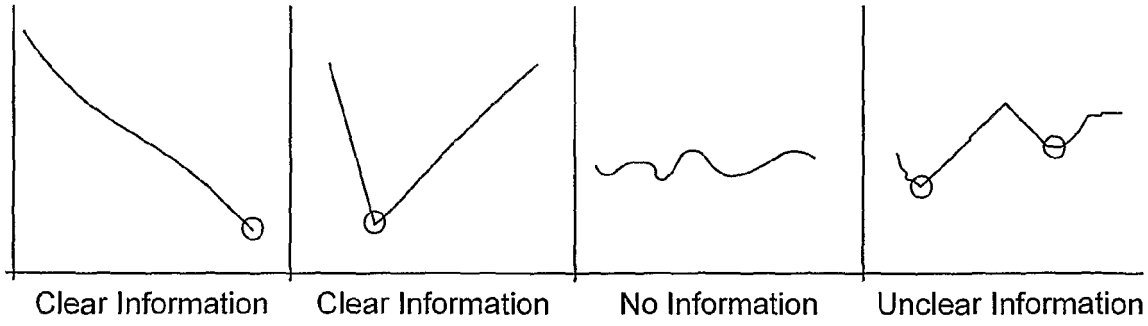

FIG. 3

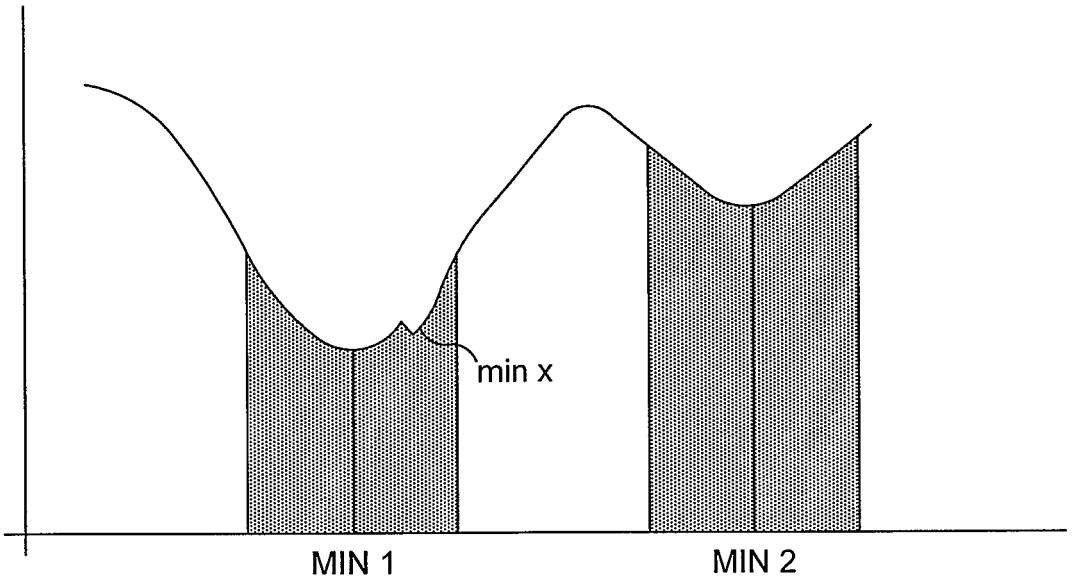
min x
MIN 1
MIN 2

FIG. 4

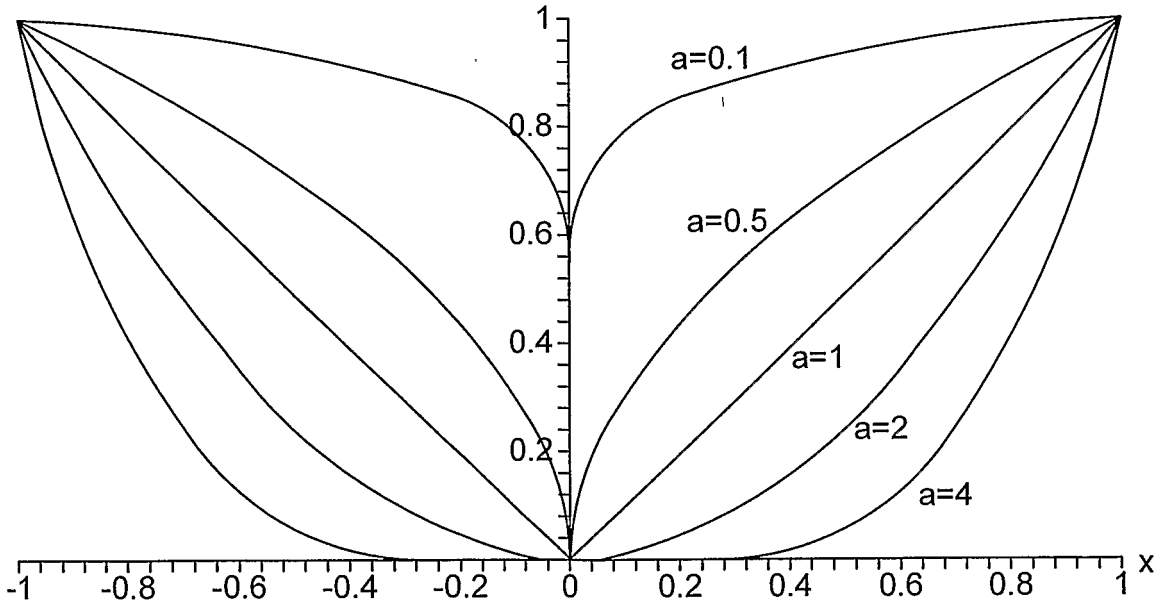
1
0.8
0.6
0.4
0.2
a=0.1
a=0.5
a=1
a=2
a=4
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
x

FIG. 5

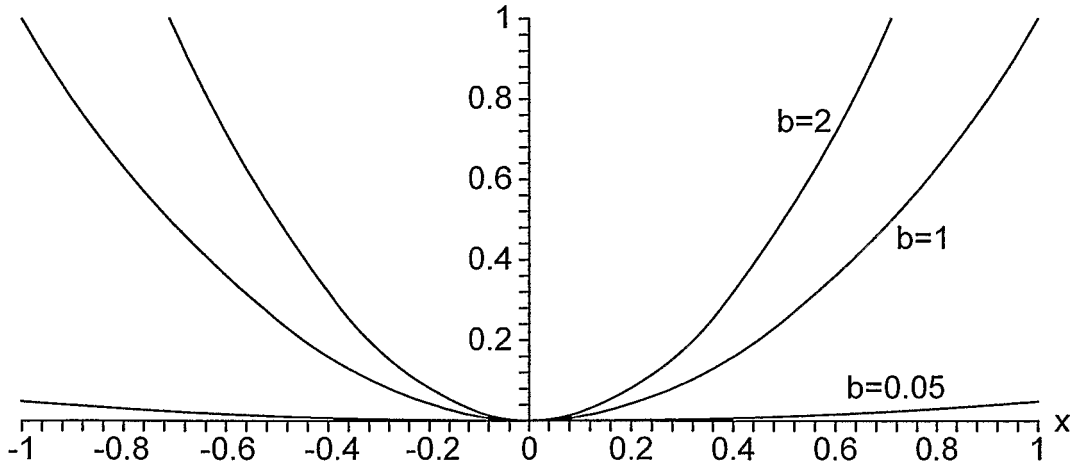
1
0.8
0.6
0.4
0.2
b=2
b=1
b=0.05
x
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

FIG. 6

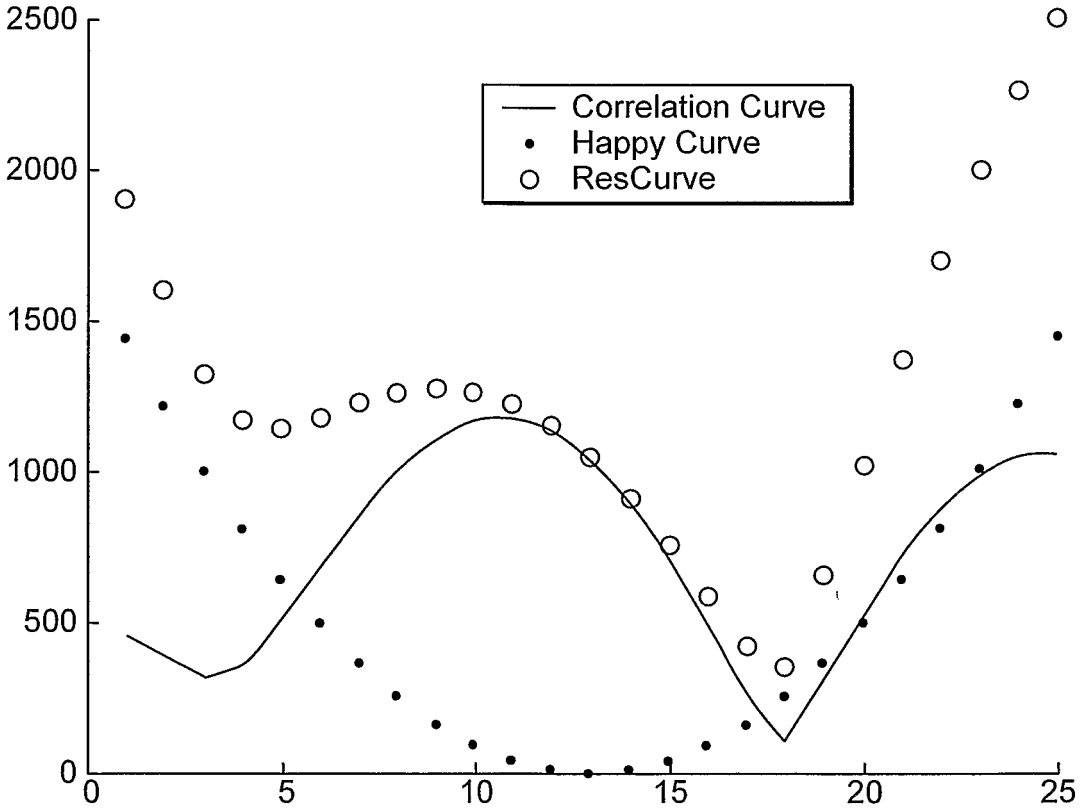
2500
2000
1500
1000
500
0
0
5
10
15
20
25
Correlation Curve
Happy Curve
ResCurve

FIG. 7

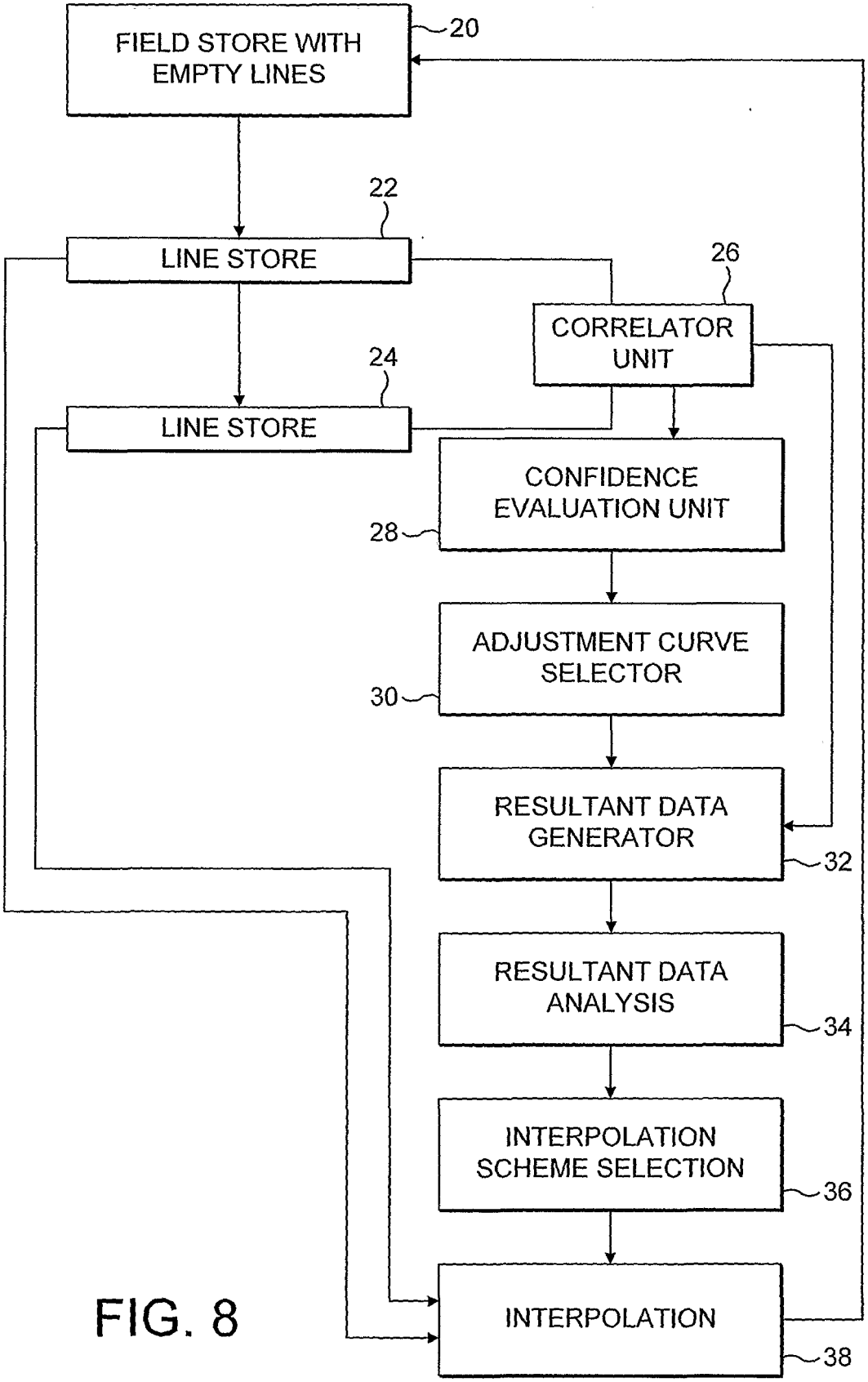
FIELD STORE WITH EMPTY LINES
20
22
LINE STORE
26
CORRELATOR UNIT
24
LINE STORE
CONFIDENCE EVALUATION UNIT
28
ADJUSTMENT CURVE SELECTOR
30
RESULTANT DATA GENERATOR
32
RESULTANT DATA ANALYSIS
34
INTERPOLATION SCHEME SELECTION
36
INTERPOLATION
38

FIG. 8

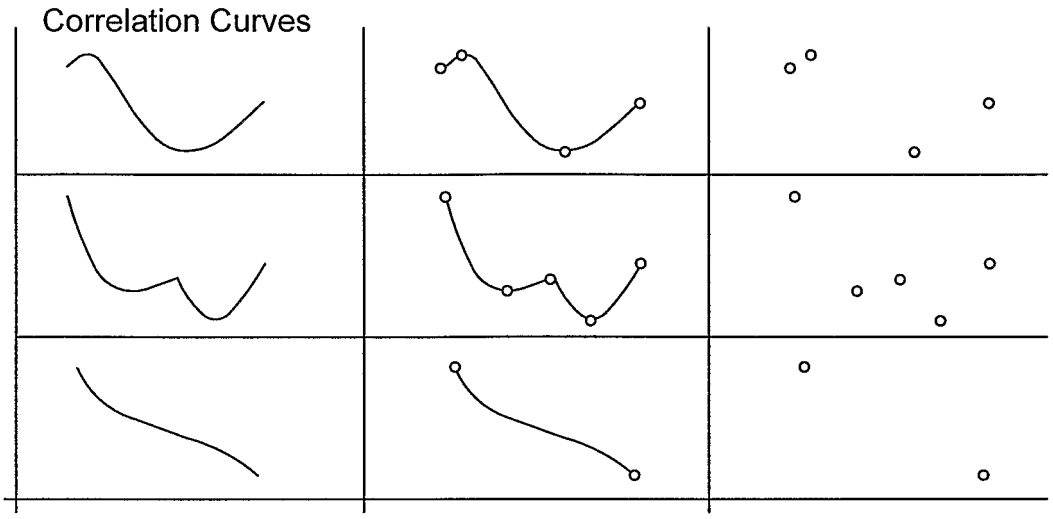

FIG. 9

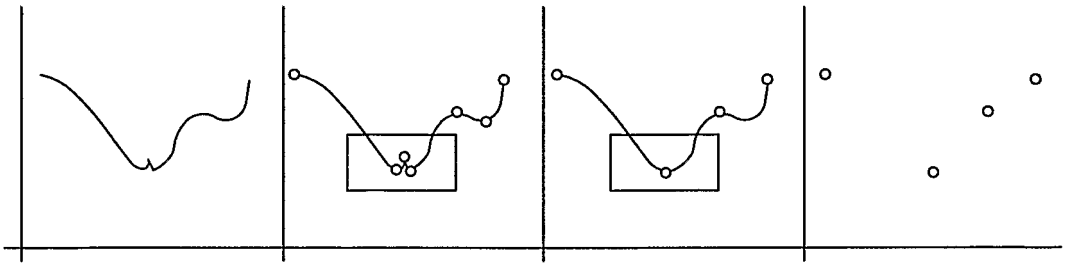

FIG. 10

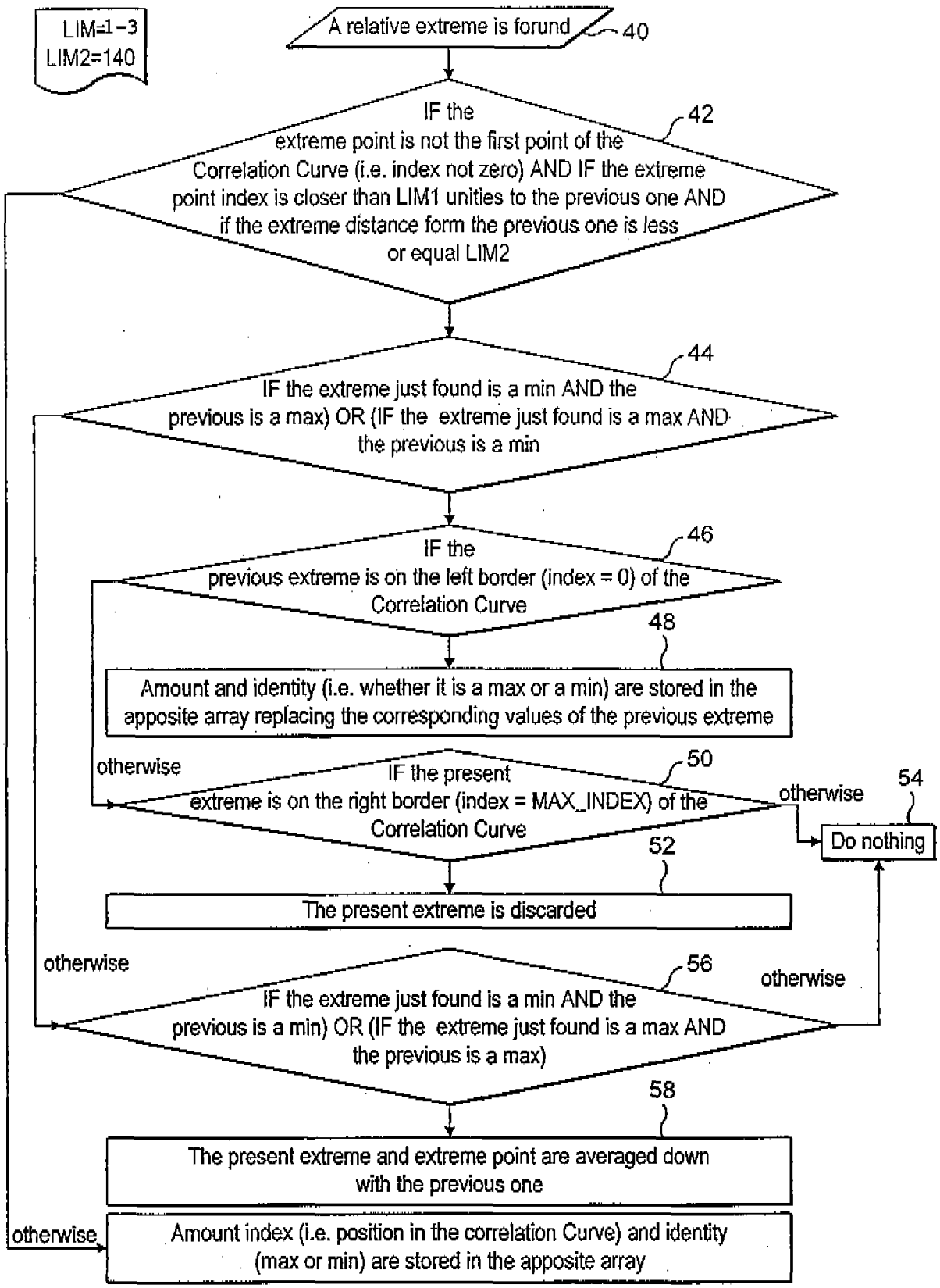
LIM=1-3
LIM2=140
A relative extreme is forund
40
IF the extreme point is not the first point of the Correlation Curve (i.e. index not zero) AND IF the extreme point index is closer than LIM1 unities to the previous one AND if the extreme distance form the previous one is less or equal LIM2
42
IF the extreme just found is a min AND the previous is a max) OR (IF the extreme just found is a max AND the previous is a min
44
IF the previous extreme is on the left border (index = 0) of the Correlation Curve
46
Amount and identity (i.e. whether it is a max or a min) are stored in the apposite array replacing the corresponding values of the previous extreme
48
otherwise
IF the present extreme is on the right border (index = MAX_INDEX) of the Correlation Curve
50
otherwise
54
Do nothing
The present extreme is discarded
52
otherwise
IF the extreme just found is a min AND the previous is a min) OR (IF the extreme just found is a max AND the previous is a max)
56
otherwise
The present extreme and extreme point are averaged down with the previous one
58
otherwise
Amount index (i.e. position in the correlation Curve) and identity (max or min) are stored in the apposite array

FIG. 11

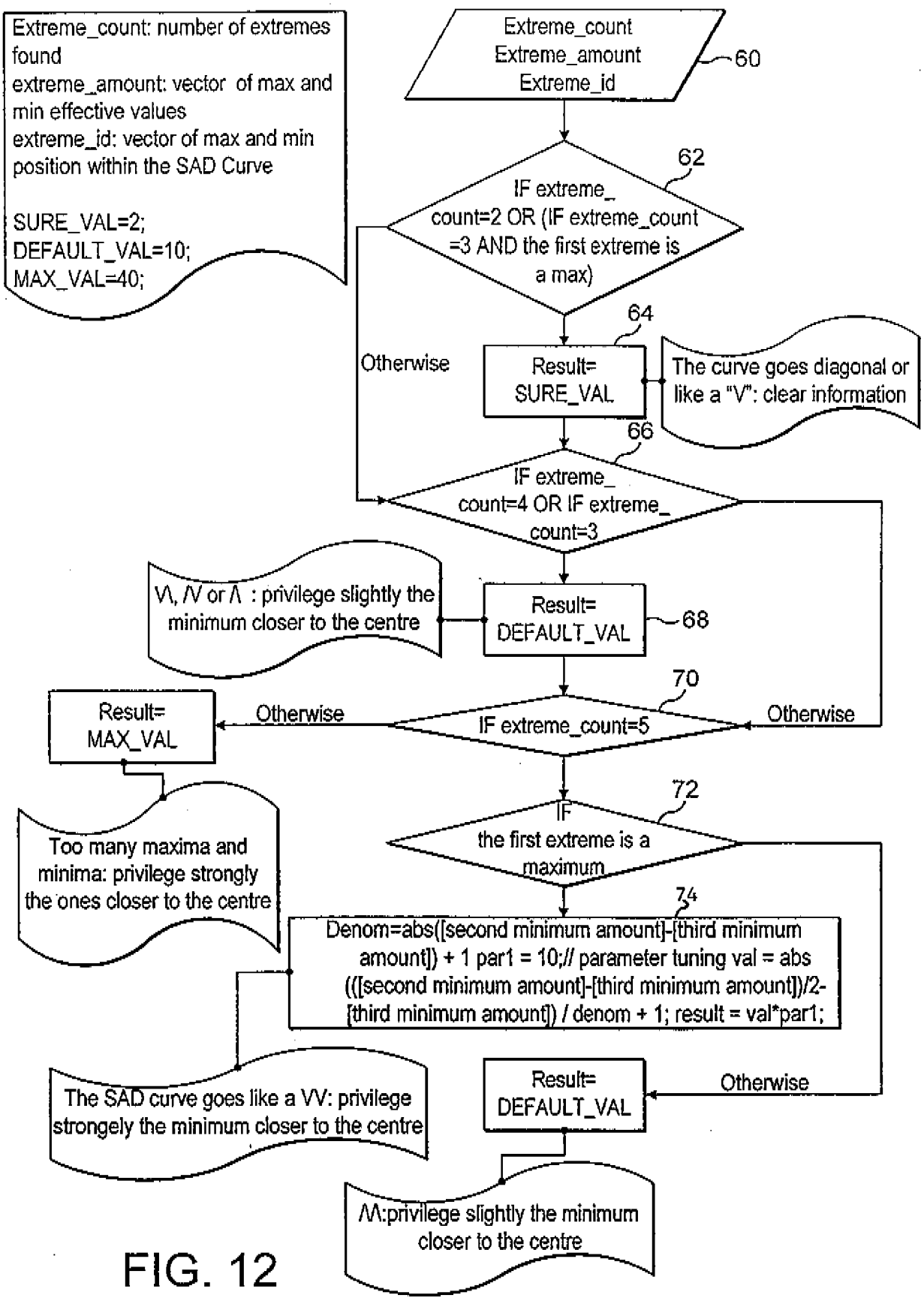
Extreme_count: number of extremes found
extreme_amount: vector of max and min effective values
extreme_id: vector of max and min position within the SAD Curve
SURE_VAL=2;
DEFAULT_VAL=10;
MAX_VAL=40;
Extreme_count
Extreme_amount
Extreme_id
60
62
IF extreme_ count=2 OR (IF extreme_count =3 AND the first extreme is a max)
Otherwise
64
Result= SURE_VAL
The curve goes diagonal or like a "V": clear information
66
IF extreme_ count=4 OR IF extreme_ count=3
\/\, /\/ or /\ : privilege slightly the minimum closer to the centre
Result= DEFAULT_VAL
68
70
Result= MAX_VAL
Otherwise
IF extreme_count=5
Otherwise
Too many maxima and minima: privilege strongly the ones closer to the centre
72
IF the first extreme is a maximum
74
Denom=abs([second minimum amount]-[third minimum amount]) + 1 par1 = 10;// parameter tuning val = abs (([second minimum amount]-[third minimum amount])/2-[third minimum amount]) / denom + 1; result = val*par1;
The SAD curve goes like a VV: privilege strongely the minimum closer to the centre
Result= DEFAULT_VAL
Otherwise
/\/\:privilege slightly the minimum closer to the centre

FIG. 12

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5532751 A **[0003]**
- US 6133957 A **[0004] [0013]**
- GB 2402288 A **[0005] [0013]**
- EP 0785683 A2 **[0014]**