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MOTION SIGNAL PROCESSOR

This invention relates to motion signal processing systems.

5 A recently developed video signal processing system for use in digital televisions uses large memories usually and, in order to obtain a good quality of the displayed image, has frequent use of frame memories. The video
10 signal processing system utilizing such frame memories uses comb-filters so as to easily separate the luminance signals and the chrominance signals from the composite video signals. These comb-filters work well for still
15 images which do not contain image motion. However, it is a disadvantage of the above technique that, around motion areas, artifacts appear which greatly reduce the quality of the displayed image.

20 In order to avoid such degradation of the image near motion areas, it becomes necessary to switch from the frame combed signal to some kind of substitution signal that provides a better quality than the frame combed signal. There have been proposed two methods for
25 achieving the switching operation between the two signals, - one a hard switching technique and the other a soft switching technique.

The hard switching, as the result of motion detection, has only two states (1= motion area or 0= still
30 area) with no intermediate states. Therefore, when this hard switching is employed, a new degradation of the displayed image will be incurred. This degradation of the image is basically caused by the difference in resolution between the frame combed signal and the substitutional
35 signal of better quality. Another very noticeable

artifact appears when the substitution signal consists of a line combed signal. In this case, hanging dots appear along moving horizontal transitions.

5 This artifact becomes especially annoying when the image contains a lot of moving high frequency detail, and the system therefore rapidly switches between the two differently processed signals.

10 Therefore, for a digital video signal processor, it is desirable to have a soft switch which provides gradual transitions between moving and stationary portions of the picture. A general motion signal processing system for implementing this soft switching is as schematically shown
15 in Figure 1 of the accompanying diagrammatic drawings.

Figure 1 is an exemplary illustration of a 1-bit motion signal spreader. However, for full bit motion signal processing, the illustrated motion detector 100 and
20 control signal spreader 102 should respectively be replaced by a motion detector for producing full bit motion signals and a K value generator for generating K values of 0 to 1.

25 The general motion signal processing system includes essentially the motion detector 100 for detecting motion signals from the composite video signal input, and the control signal spreader 102 for processing the motion signals provided from the motion detector 100 so as to
30 generate a spread control signal of K and 1-K values. Furthermore, a spatial processor 106 spatially processes the composite video signal input by using line comb-filters and a temporal processor 110 temporally processes the composite video signal input by using frame
35 comb-filters. The respective outputs of the spatial

processor 106 and the temporal processor 110 are mixed with the control signal output of K value and 1-K value provided from the control signal spreader 102 by virtue of multipliers 112 and 114, respectively. In this case, the control signal is of $0 \leq K \leq 1$. The respective outputs of the multipliers 112 and 114 are mixed by means of an adder 116 to produce motion processed image signals. In the mean time, since the composite video signal input is delayed during processing by the motion detector 100 and the control signal spreader 102, delay circuits 104 and 108 delay the composite video signal input thereto by a predetermined time in order to match the delayed control signal of K and 1-K values with the outputs of the spatial processor 106 and the temporal processor 110.

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Figure 2 of the accompanying diagrammatic drawings is a block diagram showing examples of the structure of the motion detector 100 and the control signal spreader 102 according to the known prior art, in which a frame difference circuit 118 receives the composite video signal or luminance signal to detect the motion difference signal between frames. A spatial low pass filter 120 spatially lowpass-filters the frame difference signal provided from the frame difference circuit 118 so as to smooth the motion difference signal and restrict the color signal. An absolute value circuit 122 produces absolute values of the signal output from the spatial lowpass filter 120. The absolute values are compared with a predetermined threshold value by a comparator 124 which generates the 1-bit control signal according to the comparison. Thus, the 1-bit control signal is spread by a spreading processor 126 and the K values are then generated by K value generator 132. Herein, the K values have continuous values of $0 \leq K \leq 1$ in which, when a K value is 1, the motion

of the image is very significant, and when a K value is 0, the motion of the image is zero.

5 Since this prior art motion signal processor forcefully performs the spreading process centering around a detected motion signal, regarding the detected 1-bit motion signal as a motion signal ($K = 1$) in which motion is very considerable, the motion signal can not be spread adaptively. Accordingly, when a lot of moving
10 high-frequency detail is processed, the degradation of the displayed image can not be avoided successfully. Furthermore, when image signals contain impulse noises, the impulse noises may be misconceived as motion signals and thus spreading of the undesired image signals occurs.
15 In addition, since this structure detects only motion signals correlated to the time axis direction in accordance with only the frame difference signal, the motion signal has little spatial correlation. Therefore, it is difficult to process the motion signal spatially
20 adaptively according to the motion area.

Preferred embodiments of the present invention aim to provide a motion signal processor for spreading motion signals by utilizing 1-bit control signals.

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Another aim is to provide a motion signal processor for facilitating not only hard switching but also soft switching by spreading the motion signals spatially.

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Another aim is to provide a motion signal processor which detects a maximum value of motion signals by means of a frame difference signal of an image window so as to produce 1-bit control signals according to the result of comparing the maximum value with a predetermined threshold
35 value.

Another aim is to provide a motion signal processor for spreading motion of the image signals, according to the presence of a 1-bit control signal obtained by comparing a frame difference signal of full bits with a predetermined threshold value.

Another aim is to provide a motion signal processor for detecting an area of the motion signals thereby to adaptively spread the motion.

Another aim is to provide a motion signal processor for spreading motion signals diagonally again which are spread horizontally and vertically, thereby to further smooth the motion signals.

Another aim is to provide a motion signal processor in which a step number of a control signal is optimally minimized so as to simplify the structure of the system.

Another aim is to provide a motion signal processor which utilizes 1-bit, not full bit, during a motion signal process, so that respective hardware may be embodied simply.

Another object is to provide means for spatially spreading a motion signal over a specific value by detecting the maximum value of an image window and a motion signal processor for reconstructing (or presuming) the motion adaptively by using the spread motion signal according to the spatial motion area of the motion signal.

According to the present invention, there is provided a motion signal processor for spreading video image signals of a motion area of an image and smoothing

a boundary region between said motion area and a still area of said image, wherein said processor comprises:

5 means for generating a frame difference signal from an input video signal;

spatial low pass filtering means for filtering said frame difference signal and producing a spatially low pass filtered signal;

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absolute value producing means coupled to said spatial low pass filtering means for producing an absolute value signal, said absolute value signal being an absolute value of said spatially low pass filtered signal;

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motion signal spreading means coupled to said absolute value producing means, said motion signal spreading means being operable to produce a spread motion signal, said spread motion signal being produced by spreading a degree of image motion present in pixels of said motion area amongst adjacent pixels of said image by processing said image with an image window and, at any given window position within said image, attributing a maximum motion value to a predetermined pixel within said image window, said maximum motion value being determined by a highest motion value of either: said predetermined pixel itself or, a function of other pixels within said image window; and

20 25 30 motion factor generating means for generating motion factors based upon said spread motion signal.

Preferably, said motion signal spreading means comprises:

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a maximum value processing means, coupled to the absolute value producing means, for processing input absolute value signals by means of said image window and attributing said maximum motion value to a centre pixel of said image window in accordance with motion values of said centre pixel and said other pixels within said window.

Said motion signal spreading means may further comprise:

a comparator, operably coupled to the maximum value processing means, for comparing the maximum motion value provided from the maximum value processing means with a predetermined reference level; and

an area detector coupled to the comparator, for constructing said spread motion signal from output signals of the comparator.

Preferably, said maximum value processing means comprises:

a maximum value selection means for comparing said absolute value signal with delayed absolute value signals, selecting as said maximum motion value a highest of said absolute value signal and absolute value delayed signals, and supplying said maximum motion value to said comparator.

Said maximum value processing means may comprise a plurality of sample delay means and line delay means and said maximum value selection means, said maximum value selection means having a plurality of inputs and a single output, wherein:

a first input thereof is connected directly to said absolute value producing means;

5 a second input thereof is connected to said absolute value producing means via a first sample delay means;

10 a third input thereof is connected to said absolute value producing means via said first sample delay means and a second sample delay means;

a fourth input thereof is connected to said absolute value producing means via a first line delay means;

15 a fifth input thereof is connected to said absolute value means via said first line delay means and a third sample delay means;

20 a sixth input thereof is connected to said absolute value producing means via said first line delay means, said third sample delay means and a fourth sample delay means;

25 a seventh input thereof is connected to said absolute value producing means via said first line delay means and a second line delay means;

30 an eighth input thereof is connected to said absolute value producing means via said first and second line delay means and a fifth sample delay means; and

35 a ninth input thereof is connected to said absolute value producing means via said first and second line delay means, said fifth sample delay means and a sixth sample delay means;

wherein said maximum value selection means is operably arranged to select from amongst the signals appearing on its first to ninth inputs and to output the signal having a highest motion value as said maximum
5 motion value.

Preferably, said comparator generates a 1-bit motion signal.

10 The area detector may comprise a plurality of sample delay means and line delay means and an adding circuit, said adding circuit having a plurality of inputs and an output, wherein:

15 a first input thereof is connected directly to said comparator;

a second input thereof is connected said comparator via a seventh sample delay means;

20 a third input thereof is connected to said comparator via said seventh sample delay means and an eighth sample delay means;

25 a fourth input thereof is connected to said comparator via a third line delay means;

a fifth input thereof is connected to said comparator via said third line delay means and a ninth sample delay
30 means;

a sixth input thereof is connected to said comparator via said third line delay means, said ninth sample delay means and a tenth sample delay means;

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a seventh input thereof is connected to said comparator via said third line delay means and a fourth line delay means;

5 an eighth input thereof is connected to said comparator via said third and fourth line delay means and an eleventh sample delay means; and

10 a ninth input thereof is connected to said comparator via said third and fourth line delay means, said eleventh sample delay means and a twelfth sample delay means;

15 wherein said adding circuit is operably connected to add together each of the signals appearing on its first to ninth inputs.

The adding circuit is preferably provided with a weighting factor so as to boost a level of the one bit motion signal input from the comparator.

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The invention includes a digital video signal processing system, provided with a motion signal processor according to the present invention. The invention also includes a television or video recorder/player provided with such a signal processing system.

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For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to Figures 3 to 15 of the accompanying diagrammatic drawings, in which:

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Figure 3 shows schematically an embodiment of a motion signal processor according to the present invention;

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Figure 4 shows a maximum value processing means of Figure 3 having a "3 x 3" image window;

5 Figure 5A and 5B show "3 x 3" image windows taken for explaining the embodiment of the invention;

Figure 6 shows an area detector of Figure 3 having a "3 x 3" image window;

10 Figure 7A shows an example of an image window obtained by the area detector of Figure 6;

Figure 7B shows a characteristic graph of the area detector in the event that a clipping process is
15 performed;

Figure 7C shows another exemplary characteristic graph of the area detector in the event that a clipping process is performed;

20 Figure 7D shows an exemplary diagram for explaining the spreading of an image signal in the case of a "3 x 3" rectangular image window;

25 Figure 7E shows an exemplary diagram for explaining the spreading of an image signal in the case of a "5 x 5" diamond image window;

Figure 7F shows a diagram illustrating an operational
30 characteristic of the area detector;

Figure 8 shows a diagram of the area detector connected to a spatial lowpass filter, for improving a smoothing characteristic;

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Figures 9A and 9B show the output characteristics of a K value generator of Figure 3;

Figure 10A shows another embodiment of a control
5 signal spreader according to the invention;

Figure 10B shows a soft switching processor utilizing a full bit motion signal of a maximum value processing means;
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Figure 11A shows a block diagram of a spatial spreader which can be replaced by the area detector of Figure 3 according to another embodiment of the invention;

Figures 11B and 11C show respectively one-dimensional output characteristics of the spatial spreader and the diagonal lowpass filter of Figure 11A;
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Figure 12 shows a detailed diagram of horizontal or vertical spreaders of Figure 11A;
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Figures 13A and 13B show detailed circuit diagrams of the basic block cells of Figure 12 and their processed values;
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Figures 14A and 14B show a detailed circuit diagram of the horizontal spreader of Figure 12 completed by utilizing basic block cells and intermediate values thereof; and
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Figure 15 shows the result of image signal spreading accomplished by the spatial spreader of Figure 11A.

In all of the figures, like reference numerals denote
35 like or corresponding parts.

First of all, referring to Figure 3 which is a basic block diagram of a particular example of an embodiment of the invention, the operation and structure of the frame difference circuit 118, the spatial lowpass filter 120, the absolute value circuit 122 and the comparator 124 are generally similar to those of the prior art explained above with reference to Figure 2. In other words, the frame difference detector 118 detects the motion signal differences between the frames, which are applied to the spatial lowpass filter 120 for filtering low frequency components from this frame difference signal. The output of the spatial lowpass filter 120 consists of positive and negative components and this signal is changed to an absolute value (positive value) by the absolute value circuit 122. The maximum value processing means 128 which receives the absolute value selects the maximum value of the signals input from an "M x N" image window in order to spread spatially the motion centering on the selected maximum value, in which the smoothing effect is determined according to the selection of the shape of the image window. According to experiments with embodiments of the invention, rectangular and diamond image windows had a good smoothing effect even for very high-frequency detail. In particular, when the frame difference signal is placed around the boundary between the motion region and still region, embodiments of the invention have obtained outstanding effects.

The size and shape of the image window should be properly adjusted. This is because, if the size of the image window is unnecessarily big, the quality of the image can be degraded due to the excess spreading of the motion.

Since the output generated from the maximum value processing means 128 is itself a spatially spread signal, it can be used as a motion control signal for controlling the soft switching directly by means of a K value generator which has the characteristics as shown in Figures 9A and 9B. Such an arrangement is described hereinafter, with reference to Figure 10B.

Referring once again to Figure 3, the output of the maximum value processing means 128 is compared with a threshold value which is set in advance by the comparator 124. If the signal output from the maximum value processing means 128 is greater than the threshold value THR, then the value which is selected by the maximum value processing means 128 is recognized as a maximum value and thus the comparator 124 will produce a 1-bit motion signal. Such a motion signal means that the motion detected in relation to the temporal axis is a signal component of which the motion is greater than the threshold value THR, and this signal is the value which is spread spatially by means of the maximum value processing means 128. Therefore, it is possible for this motion signal to be used for hard switching.

The purpose of the area detector 130 which receives the above 1-bit motion signal is to reconstruct the image signal spatially rather than spread the motion. In this case, the image reconstruction is implemented by means of detecting a new motion area of the image window by using the motion which exceeds a specific value, in which the motion is spatially spread by the maximum value processing means 128 by means of selecting the maximum value of the image window, and reconstructing the motion spatially according to the motion of the image window.

In other words, the area detector 130 processes again the motion signal which is corrected in advance by the maximum value processing means 128 so as to presume the spatial correlation of the new motion signal and this newly presumed motion is applied to the K value generator 132 which generates the motion factor K value. In the meantime, by properly restricting the maximum value of the output from the area detector 130, it can be easily accomplished that the motion process is simplified and that, in case of a wide image window, the great difference between the centre of the motion region and the still region can be overcome. The K and 1-K values are applied to the multipliers 112, 114 (as shown in Figure 1) and thus mixed with the outputs from the spatial processor 106 and the temporal processor 110.

The theoretical basis of this process can be supported by the temporal correlation of the frame difference signal. In view of the one dimensional characteristic as shown in Figure 7F, the amount of motion can be presumed on the basis of the motions Δx and $\Delta x'$ in the direction of the x axis. Therefore, if these signals are spread into two dimensions, a new motion signal can be reconstructed which can be mapped into a gradual adaptive motion signal of 0 to 1, having the spatial correlation to the time axis or in accordance with the time axis, by re-processing the motion signal component which is over a specific value.

In Figure 4, the maximum value processing means 128 of Figure 3 is illustrated in detail. In the drawing, an exemplary circuit for the "3 x 3" rectangular image window is shown, in which the maximum value processing means 128 comprises a maximum value selection circuit 150 with a plurality of selection terminals and connected to a

plurality of sample delays 134, 136, 140, 142, 146, 148 and two line delays 138, 144. The maximum value processing means 128 receives the absolute value of the spatial lowpass-filtered frame difference signal which is processed in sequence by means of the frame difference circuit 118, the spatial lowpass filter 120 and the absolute value circuit 122. In this case, a first image line is arranged with a signal "a" applied to the maximum value selection circuit 150 without delay, a signal "b" which is delayed by the sample by a sample delay 134, and a signal "c" which is a further delayed signal of the signal "b", by way of the sample delay 136.

In the meantime, a second image line is arranged with a line-delayed signal "d", which is delayed by one line by means of the line delay 138, and is applied to the maximum value selection circuit 150; a signal "e" which is delayed by one sample by means of the sample delay 140; and a signal "f" which is a further delayed signal of the signal "e" by means of the sample delay 142.

Furthermore, in order to arrange a third image line, the line delay 144 delays the output of the line delay 138 by one line to provide a signal "g" to the maximum value selection circuit 150, the sample delay 146 delays the signal "g" by one sample to provide a signal "h" to the maximum value selection circuit 150, and the sample delay 148 delays the signal "h" by a further sample to apply the signal "i" to the maximum value selection circuit 150. The image signal obtained in the above described manner is as shown in Figure 5A.

The maximum value selection circuit 150 compares the motion signals which are obtained by the sample delays and the line delays to generate a maximum value of the motion

signals. In this case, the maximum value $M(e)$ which is selected by the maximum value selection circuit 150 is

$$M(e) = \text{MAX} (a, b, c, d, e, f, g, h, i) \dots\dots\dots(1)$$

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where $M(e)$ represents the motion of current position "e".

Referring to Figure 5B, there is shown an illustration of the "3 x 3" rectangular image window, in which respective pixels are replaced by specific substantial values. In this example, in accordance with the formula (1), the maximum value $M(e)$ of the image window is represented as follows;

$$M(e) = \text{MAX} (0, 1, 0, 7, 2, 3, 0, 6, 7) = 7 \dots\dots(2)$$

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In this embodiment, when the threshold value THR which is set to the comparator 124 is 4, the maximum value of the image window shown in Figure 5B will become 7 according to the formula (2). Therefore, the output of the comparator 124 generates the 1-bit motion signal of a value 1. As a result, the maximum value processing means 128 will recognize the current position "e" as of significant motion.

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In this case, the spatial spreading of the motion area is implemented by selecting the maximum value of the image window by using the maximum value processing means and thus reconstructing spatially, whereby the respective motions are correlated to one another.

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Referring to Figure 6, the detailed block diagram of the area detector of Figure 3, which is to presume the motion area by receiving the output of the comparator 124, includes a number of sample delay circuits 152-162, two

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line delay circuits 164, 166, and an adder 168. In this area detector, the operation of the sample delay circuits 152-162 and the line delay circuits 164, 166 is similar to that of the maximum value processing means of Figure 4, and the only difference, is that the maximum value selection circuit 150 with a selection switch as shown in Figure 4 is replaced by an area detector 168 embodied as an adder as illustrated in Figure 6.

Thus the motion signals which are applied to the area detector 168 are 1-bit signals having only the values of "1" or "0". Therefore, the image window which is presumed by means of the respective sample delay circuits 152-162 and line delay circuits 164, 166 is as illustrated in Figure 7A. The adder 168 counts only the number of respective samples a'-i' with the value "1". Thus, the characteristic formula of the area detector 130 can be represented as the following formula (3):

$$S(e) = A \times (\text{Number of Motion Samples}) \dots\dots\dots(3)$$

where $S(e)$ is the output of the adder 168 and A is the weight applied to the adder 168 to determine the slope of its characteristic curve.

The area detector 130 may be designed to have a characteristic different to the formula (3). That is to say, a characteristic as represented in formula (4) can be obtained by providing a constant B in addition to the formula (3).

$$S(e) = A \times (\text{Number of Motions Samples}) - B \dots\dots\dots(4)$$

The processing of the formula (4) is usually performed by the K value generator, but in this case it

may be performed by the area detector 130. Of course, in this case, the K value generator will be unnecessary (simply, it can be implemented by dividing the output of the area detector by a given maximum step value). The meaning of the respective characteristic curve, which is shifted toward the right hand side as illustrated in Figure 7C, is that a kind of spatial (or areal) threshold is established in order for the area detector 130 to spread the motion area only when the number of the motion signals over a predetermined value (B/A) are present at the image window.

The characteristic formula (3) represents a specific case of the formula (4) at which $B=0$. In this processing, the above result can be obtained when the motion is spread by an area detector not having the maximum value detection circuit. The area detector mentioned in relation to this case has a spreading feature different to the above ones.

Referring to Figure 7D, there is shown a motion spreading of a rectangular image window in the case that the constant A of the characteristic formula (3) is one (i.e., $A=1$). In relation to the image windows I, II, III of Figure 7D, the image window I represents the window of the image samples applied from the comparator 124 to the area detector 130 while the image window II represents the image sample signals which are not clipped. In addition, the image window III represents the result of a motion clipping process with a maximum step of seven. As can be understood from the drawing, it is to be noted that all of the pixels in the image window having the levels of eight and nine, are clipped to the maximum step value of seven. By means of limiting the maximum value of the area detector 130, the motion processing can be simplified and

in addition the motion difference between the central portions of the motion regions and the still region can be reduced, in case of a wide image window. Furthermore, Figure 7E represents the motion spreading in case of a "5 x 5" diamond image window. Likewise, the image window III illustrates an image window II, of which image samples are clipped to the maximum step value of seven. In order to obtain the best effect, it should be noted that the size of image window constructed by the area detector 130 must be larger than that of the image window constructed by the maximum value processing means 128.

Referring to Figure 8, which shows another embodiment of the invention, there is shown a block diagram of a circuit which replaces the area detector 130 of Figure 3 in association with a spatial lowpass filter 172, when the slope A of the area detector 130 is set to a relatively great value. In the drawing, a motion spreader 170 is provided with the 1-bit motion signal from the comparator 124 and imposes the weight A on this signal so as to boost up the level of motion signal. In other words, if the weight A is 10 (for example), then the level difference between the respective levels will become 10 which may causes rough motion spreading. Accordingly, in order to process the motion smoothly, the spatial lowpass filter 172 is used for lowpass-filtering. This circuit is more effective when the levels of the respective motion signals of the image window have discrete values.

In Figure 10A, which shows another embodiment of the invention, there is illustrated an arrangement in which the maximum value processing means 128 is arranged at the output terminal of the comparator 124. The advantage of this circuit is that since the maximum value processing means 128 should process only the 1-bit motion signal from

the comparator 124, the hardware of the maximum value processing means 128 can be manufactured with facility.

Referring to Figure 10B, which shows a soft switching
5 circuit operates by selecting a full-bit maximum value, this circuit generates motion signals from 0 to 1 in accordance with the characteristic of the K value generator as shown in Figs. 9A and 9B. In this case, the characteristic of Figure 9B illustrates a process for
10 reducing the output value when the input value is too big, in order to correct the motion signal which is spread excessively in case of a wide image window.

According to another embodiment of the invention, the
15 area detector 130 of Figure 3 can be replaced by a motion spreading circuit which is illustrated in Figure 11A. That is to say, a horizontal spreader 174 spreads the motion signal output from the comparator 124 horizontally and a vertical spreader 176 spreads this signal
20 vertically. If it is assumed that the vertical spreader 176 and the horizontal spreader 174 are matched with each other in their delay time, the maximum value processing means 178 detects the maximum value from the signal outputs of the spreaders and applies the maximum value to
25 a diagonal lowpass filter 180. The diagonal lowpass filter 180 spreads diagonally the motion signals which are already spread both in vertical and in horizontal direction, so as to spread the motion signals spatially close to the shape of a circle overall. In Figure 11B,
30 one-dimensional characteristic of the motion signals processed in such a manner is illustrated. In this case, if the maximum step value is N, the motion signals are smoothed by N-1 in the direction of the spreading process. From the characteristic curve, it is shown that the

discontinuous boundary area of the input signals is smoothed in the output signals.

Referring to Figure 11C, an image window relating to the diagonal lowpass filter is shown, in which the characteristic of the diagonal filter is illustrated in relation to horizontal and vertical sample points, in case that the maximum value is 4. The characteristic formula of the diagonal lowpass filter is represented as the following formula (5).

$$M(n) = \text{MAX} [(1+p+j+r)/4, n] \dots\dots\dots(5)$$

The formula (5) means that a value which is obtained by dividing by four the sum of the sample values in the diagonal direction, centering on the current sample point "n", is compared with the value of the current point value "n" so as to select the maximum value thereof.

The block diagram shown in Figure 12 is a detailed circuit diagram of the horizontal spreader 174 or/and the vertical spreader 176, in which there are included a number of basic block cells 182-188 and delay circuits 190-196 and an adder 198. In addition, the respective basic block cells 182-188 include, as illustrated in Figure 13A, sample delay circuits 200, 202 and maximum value circuits 204, 206. In this case, the intermediate values of the respective elements 200-206 are as shown in Figure 13B. Namely, the respective basic block cells process the 1-bit motion signals "o" which are applied to the respective basic block cells in order to obtain motion signals "s" which are spread by one sample toward both the right and left hand sides, and which are delayed by one sample.

Referring to Figure 14A, this is a complete diagram of an example of the spreader of Figure 12, in which there are three basic block cells 182, 184, 188 and each basic block cell is shown in more detail - as in Figure 13A.

5 Therefore, in this case that the maximum step value $N = 4$, the intermediate values processed from the respective basic block cells 182-188 are applied to the adder 198 and added to each other, thereby to obtain the final motion signal which is spread. The respective intermediate

10 values are as shown in Figure 14B. Namely, the resultant motion signal "h" with respect to the input motion signal "a" is of a motion signal which is spread with three samples delayed toward both the right and left hand sides. The above example is limited to the horizontal spreader

15 but, in the same manner, the vertical spreading may be implemented. Namely, if the sample delay circuits are substituted by line delay circuits, the vertical spreader can be constructed, in which the maximum value circuit, for a 1-bit input signal, can be embodied by means of an

20 OR gate.

Figure 15 illustrates, through image windows, an example of the intermediate values of motion signals which are processed by the spatial spreader of Figure 11A. That

25 is to say, the image window I represents the motion signal inputs; the image window II represents the motion signals which are spread horizontally by the horizontal spreader 174; the image window III represents the motion signals which are spread vertically by the vertical spreader 176;

30 and the image window IV represents the mixture of the spread signals of the image windows I and II by the maximum value processing means 178. Furthermore, the image window V represents the resultant motion signals of the mixed signals shown in the image window IV, which are

35 spread diagonally by means of the diagonal lowpass filter

180, whereby finally the motion signals are spread in all directions.

5 The adder 198 shown in Figure 14A has a feature that clips the maximum step value in order to avoid error during the signal processing. For instance, when the sum of the values applied to the adder 198 has a value greater than the maximum value, the output is limited to the maximum value.

10 In such a processing as described above, since the motion image is processed by means of the value which is spatially spread by the maximum value processing means, the threshold value of the comparator must be of a relatively great value.

15 Accordingly, as described above, in order to reconstruct motion adaptively according to a region of a 1-bit motion signal which is spread spatially, the embodiments of invention add the motion signal detected by the area detector to the motion value of or over a specific value in the time axis, which is spatially spread by the maximum value processing means. In addition, since the maximum value of the output can be limited by clipping the area detected value or the size of the image window, the smoothing effect of the motion signal at the boundary area of the motion and through a wide motion region may be implemented.

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30 Therefore, a great advantage may be that since an impulse noise which may be mis-recognized as a motion signal is processed to have a motion lower than that of a conventional spreading process, the apparatus as illustrated may have a good resistance to noise.
35 Furthermore, the hardware may be very simplified and, in

practice, can be constructed by the combination of logic elements because the motion signals are processed in 1-bit signals. Another particular feature is that the motion signals are reconstructed to be fit for the human's eye system by virtue of the spatial correlation. In case of the embodiment described in relation to Figure 11A, it is characterized in that the original motions in the time axis are spread spatially in all directions close to the shape of a circle.

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The illustrated embodiments of the invention provide circuits for smoothing image signals distributed around a boundary region of a motion image and a still image by spreading the transition which may occur between the above two regions, in which the circuit re-constructs the temporally processed motion signal into a spatially processed motion signal.

Although specific embodiments of the invention have been illustrated and described above, it is not intended that the invention be limited solely to the above disclosed embodiments. In addition, one skilled in the art may easily recognize that particular modifications or subconstructions may be used without departing from the scope of the invention. For instance, in the disclosed embodiments, although maximum values of motion are detected to process, minimum or intermediate values can also be used for similar processing. Furthermore, the size and shape of the image window can be adjusted to have a best condition according to the characteristics of the image to process, and the motion signal processing for the time axis can be implemented in the same manner as described above.

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CLAIMS:

1. A motion signal processor for spreading video image signals of a motion area of an image and smoothing a boundary region between said motion area and a still area of said image, wherein said processor comprises:

means for generating a frame difference signal from an input video signal;

spatial low pass filtering means for filtering said frame difference signal and producing a spatially low pass filtered signal;

absolute value producing means coupled to said spatial low pass filtering means for producing an absolute value signal, said absolute value signal being an absolute value of said spatially low pass filtered signal;

motion signal spreading means coupled to said absolute value producing means, said motion signal spreading means being operable to produce a spread motion signal, said spread motion signal being produced by spreading a degree of image motion present in pixels of said motion area amongst adjacent pixels of said image by processing said image with an image window and, at any given window position within said image, attributing a maximum motion value to a predetermined pixel within said image window, said maximum motion value being determined by a highest motion value of either: said predetermined pixel itself or, a function of other pixels within said image window; and

motion factor generating means for generating motion factors based upon said spread motion signal.



2. A processor according to claim 1, wherein said motion signal spreading means comprises:

5 a maximum value processing means, coupled to the absolute value producing means, for processing input absolute value signals by means of said image window and attributing said maximum motion value to a centre pixel of said image window in accordance with motion values of said centre pixel and said other pixels within said window.

10 3. A processor according to claim 2, wherein said motion signal spreading means further comprises:

15 a comparator, operably coupled to the maximum value processing means, for comparing the maximum motion value provided from the maximum value processing means with a predetermined reference level; and

20 an area detector coupled to the comparator, for constructing said spread motion signal from output signals of the comparator.

4. A processor as claimed in claim 2 or 3, wherein said maximum value processing means comprises:

25 a maximum value selection means for comparing said absolute value signal with delayed absolute value signals, selecting as said maximum motion value a highest of said absolute value signal and absolute value delayed signals, 30 and supplying said maximum motion value to said comparator.

5. A processor according to claim 4, wherein said maximum value processing means comprises a plurality of 35 sample delay means and line delay means and said maximum



value selection means, said maximum value selection means having a plurality of inputs and a single output, wherein:

5 a first input thereof is connected directly to said absolute value producing means;

a second input thereof is connected to said absolute value producing means via a first sample delay means;

10 a third input thereof is connected to said absolute value producing means via said first sample delay means and a second sample delay means;

15 a fourth input thereof is connected to said absolute value producing means via a first line delay means;

a fifth input thereof is connected to said absolute value means via said first line delay means and a third sample delay means;

20 a sixth input thereof is connected to said absolute value producing means via said first line delay means, said third sample delay means and a fourth sample delay means;

25 a seventh input thereof is connected to said absolute value producing means via said first line delay means and a second line delay means;

30 an eighth input thereof is connected to said absolute value producing means via said first and second line delay means and a fifth sample delay means; and

35 a ninth input thereof is connected to said absolute value producing means via said first and second line delay



means, said fifth sample delay means and a sixth sample delay means;

wherein said maximum value selection means is
5 operably arranged to select from amongst the signals appearing on its first to ninth inputs and to output the signal having a highest motion value as said maximum motion value.

10 6. A processor as claimed in claim 3, 4 or 5, wherein said comparator generates a 1-bit motion signal.

7. A processor according to any of claims 3 to 6, wherein said area detector comprises a plurality of sample
15 delay means and line delay means and an adding circuit, said adding circuit having a plurality of inputs and an output, wherein;

a first input thereof is connected directly to said
20 comparator;

a second input thereof is connected said comparator via a seventh sample delay means;

25 a third input thereof is connected to said comparator via said seventh sample delay means and an eighth sample delay means;

a fourth input thereof is connected to said
30 comparator via a third line delay means;

a fifth input thereof is connected to said comparator via said third line delay means and a ninth sample delay means;

35



a sixth input thereof is connected to said comparator via said third line delay means, said ninth sample delay means and a tenth sample delay means;

5 a seventh input thereof is connected to said comparator via said third line delay means and a fourth line delay means;

10 an eighth input thereof is connected to said comparator via said third and fourth line delay means and an eleventh sample delay means; and

15 a ninth input thereof is connected to said comparator via said third and fourth line delay means, said eleventh sample delay means and a twelfth sample delay means;

wherein said adding circuit is operably connected to add together each of the signals appearing on its first to ninth inputs.

20 8. A processor as claimed in claim 7, wherein the adding circuit is provided with a weighting factor so as to boost a level of the one bit motion signal input from the comparator.

25 9. A motion signal processor substantially as hereinbefore described with reference to any of Figures 3 to 15 of the accompanying drawings.

30 10. A digital video signal processing system, provided with a motion signal processor according to any of the proceeding claims.

35 11. A television or video recorder/player provided with a signal processing system according to claim 10.

