

APPARATUS FOR ADAPTIVELY CONTROLLING

A RECURSIVE FILTER

This invention relates to circuitry for **2173066**
adaptively controlling recursive filters.

5 The invention will be described, by way of example, in the environment of a video signal processing system such as used in a television receiver, however, it is to be understood that it is not limited to such an application.

10 In video systems recursive filters may be used to reduce noise in the frequency band of the video signal. From frame-to-frame there is a relatively high degree of signal correlation. Thus, if a video signal from successive frames is summed, the correlated video signal will add linearly, but random noise accompanying the
15 signal will not. The summed signal is generally normalized to a desired amplitude range and the signal-to-noise ratio of the averaged signal is enhanced by the processing.

20 A typical video recursive filter includes a delay device coupled in a recirculating loop with circuitry for combining a fraction of delayed signal with a fraction of incoming signal. The combined signal is applied to the delay device which delays the combined signal by the time period necessary to insure that
25 constituent parts of each combined video signal samples are from corresponding pixels of successive video frames. The fractional parts of the incoming and delayed signals are obtained by scaling the two signals by factors K and $(1-K)$ respectively. Thus, if the amplitude of the
30 incoming signal is equal to the amplitude of the averaged signal from the delay device, the new combined signal will be normalized to equal the input signal. In a digital processing system, the normalization tends to minimize the sample bit size required of the delay device. If the
35 incoming signal consists of 8-bit samples, the sample size in the delay device can be held to e.g. 9 or 10 bits. This is an important design aspect in reducing the

manufacturing costs of recursive filters for consumer applications.

When the images represented by video signals change, recursively filtered video signals tend to be degraded. Phantom images are introduced in the reproduced images and picture sharpness along moving image edges is degraded. To counter these undesirable effects it is known to adaptively change the parameters of the recursive filter when motion occurs. The adaptive changes are performed independently for each picture element (pixel). Typically changes are made to the filter scale factors in response to the amplitude of the change in the video signal between successive frames. For larger interframe video signal changes a larger fraction of the incoming signal is applied in the averaging process and for smaller interframe video signal changes a larger fraction of the averaged delayed signal is applied in the averaging process.

After interframe image motion ceases a recursive filter system can be conditioned to more rapidly converge to the desired noise reduction level by applying a sequence of successively smaller scale factors. The timing of the sequence is determined separately for each pixel and is a function of the history of the interframe image motion for the respective pixels. An example of this type of system is described in U.S. Patent No. 4,240,106 entitled "Video Noise Reduction". The system in this patent develops sequences of scale factors for each pixel wherein successive scale factor values are equal to the reciprocals of the number of frames from the last frame in which motion was detected.

While the foregoing systems tend to enhance the performance of recursive filters in video signal processing systems they do not address an important element in the filtering process. This element is the amplitude of the noise in the signal being processed. If the noise level is low, less noise reduction is required and the filter may be adaptively conditioned to converge

at a faster rate than when a greater degree of noise reduction is required. Programming the system for less noise reduction when the signal noise level is low tends to condition the system to be more tolerant to interframe
5 image motion.

According to one aspect of the invention, there is provided scale factor generating circuitry for use with a video signal recursive filter including an input port, an output port from which a signal, delayed by
10 substantially one frame period with respect to signal applied to said input port, is available, and means for scaling and combining said delayed signal and said signal applied to said input port, wherein the degree of scaling of said signal applied to said input port and said
15 delayed signal is adaptively controlled by selective application of scale factors, said scale factor generating circuitry comprising: means coupled to said input port and said output port for producing difference samples of signal separated by one frame period;
20 detection means responsive to said difference samples for producing a signal corresponding to the difference sample having the smallest magnitude over a predetermined portion of a frame period; means responsive to the signal produced by said detection means for generating a
25 threshold value; comparator means responsive to said difference samples and said threshold value for producing at an output port thereof a motion signal whenever the magnitude of a difference sample is greater than the magnitude of the threshold value; and means responsive to
30 said motion signal for producing said scale factors.

According to another aspect, there is provided a scale factor generating circuit for a video signal recursive filter including means for delaying an incoming signal by substantially at least one frame period and
5 means for scaling and combining said incoming and delayed signals, which scaling means has a control input port for applying control signals corresponding to scale factors, said scale factor generating circuit comprising: means responsive to said incoming and delayed signals for
10 developing difference samples indicative of image motion between successive frames; means responsive to the difference samples for developing a signal sample representative of the minimum noise in an image portion of a frame period; means responsive to said signal sample
15 representative of the minimum noise for developing a threshold value; means responsive to said difference samples and said threshold value for producing a motion signal when the magnitude of the difference sample exceeds the magnitude of said threshold value; and
20 means responsive to said motion signal for generating said control signals.

The invention will now be described by way of example with reference to the accompanying drawings in which FIGURE 1 is a block diagram of an adaptive digital recursive filter employing scale factor generating circuitry embodying the present invention, which recursive filter is arranged to perform noise reduction and separation of the luminance component from composite video signal; and

FIGURE 2 is a block diagram of an illustrative minimum value detector for use in the FIGURE 1 system.

In the Figures, broad arrows interconnecting circuit elements represent multiconductor connections for parallel-bit samples. Narrow arrows interconnecting circuit elements represent single conductor connections for serial bit digital samples or analog signals.

FIGURE 1 is a motion/noise adaptive recursive filter for processing video signals. The circuitry circumscribed by the dashed line boxes 21 and 31 defines the more general system. The entire circuitry shown in FIGURE 1 is directed toward the more specific application, of separating the luminance component from composite video signal.

The circuitry circumscribed in the dashed box 21 is a recursive filter of the type generally described in U.S. Patent No. 4,485,403, and is adaptive by virtue of the capability to change the scale factor K_m of scaling circuit 16. Noise reduced video signal is available at the output connection, 27, of the video signal delay element 22. Alternatively noise reduced video signal may be taken from the input connection 19 of the video signal delay element 22.

Briefly, circuit 21 operates as follows. Video signal samples, V_x , to be processed are applied from input port 10 to a subtracter 12. Delayed samples V_{dy} from delay element 22 are coupled to a second input port of

subtractor 12 which develops the difference samples $(V_x - V_{DY})$. The difference samples are coupled via compensating delay element 14, to the input of scaling circuit 16. Scaling circuit 16 develops scaled difference sample values $K_m(V_x - V_{DY})$ which are coupled to an input port of adder 20. Delayed samples V_{DY} from delay element 22 are coupled via compensating delay element 18 to a second input port of adder 20 which develops the sample sums V_Y given by

$$\begin{aligned} V_Y &= V_{DY} + K_m(V_x - V_{DY}) \\ &= K_m V_x + (1 - K_m)V_{DY} \end{aligned} \quad (1)$$

The delay element 22 and the compensating delay elements 14 and 18 are designed so that the samples V_x and V_{DY} combined in subtractor 12 correspond to like pixels of succeeding frames. Compensating delay element 14 is required to afford circuitry 31 time to develop scale factors K_m , for scaling circuit 16 on a pixel-by-pixel basis, i.e. a sample-by-sample basis. Compensating delay element 18 is provided to accommodate the delay introduced by both the compensating delay element 14 and the scaling circuit 16.

The values of samples V_{DY} correspond to the samples V_Y delayed by one video frame period. Expanding equation (1) by substituting V_Y for V_{DY} with the appropriate time shift and simplifying it can be shown that the signal component, V_{SY} , of samples V_Y equal the signal component, V_{SX} , of the input samples V_x . The noise component V_{NY} of the samples V_Y is reduced by the factor $\sqrt{K_m/(2-K_m)}$. These results assume that the signal component V_{SX} is in component video form, i.e. either luminance or chrominance signal. However, if the signal component V_{SX} is a chrominance component or composite video including a chrominance component, provision must be made to invert the phase of the chrominance component before it is fed back from the delay element 22 to elements 12 and 20. Such chrominance component phase inversion is known in the art of video signal recursive filters.

Assuming that the input signal is a composite video signal, and that no provision is made for chrominance phase inversion, the samples V_{SY} will have a luminance component V_{LY} and a chrominance component V_{CY} . In the absence of interframe image motion, the luminance component V_{LY} will converge to a value which is equal to the input luminance component V_{LX} . The chrominance component V_{CY} in the absence of motion will tend to converge to the value given by

$$V_{CY} = V_{CX} K_m / (2 - K_m). \quad (2)$$

In an adaptive system the values of the scale factor K_m are determined on a pixel-by-pixel basis according to the history of interframe image motion for each pixel. If motion exists between the current frame and the preceding frame the scale factor, K_m , may be set to a value of one in order not to incur signal bandwidth reduction. When interframe image motion ceases the scale factor K_m is established at a value or a sequence of values less than one, which values are determined by the time desired for the system to converge to the steady state and the desired amount of noise reduction.

Additional elements 24 and 26 are coupled with recursive filter 21 in order to process composite video to produce a noise reduced luminance component with complete cancellation of the chrominance component. To accomplish complete cancellation of the chrominance component, the chrominance component V_{CY} at the output of adder 20 must be made to converge to a steady state value in the first frame of no motion. If this condition is met a portion of the input chrominance component can be subtracted from V_Y or V_{DY} to completely cancel the chrominance component therein. Causing the chrominance component to converge in the first frame of no motion may be achieved if three values for K_m are applied which correspond to "one" for motion, $1/(2 - K_m)$ the first frame after motion, and K_m for successive frame periods. With this sequence of scale factor values, the chrominance

component, V_{CY} converges to $K_m/(2-K_m)$ times the input chrominance component value in the first frame of no motion.

Noise reduced luminance with the chrominance component cancelled is available at the output port of adder 26. Samples from delay element 22 are coupled via compensating delay element 23 to one input port of adder 26. Scaled sample differences from scaling circuit 24 are coupled to a second input port of adder 26. Sample differences from subtracter 12 are applied to the input of scaling circuit 24.

Output samples, V_o , from adder 26 are expressed by the equation

$$V_o = K_o(V_x - V_{DY}) + V_{DY} \quad (3)$$

where K_o is the scale factor applied to scaling circuit 24. The values of the scale factor K_o are "one" during interframe image motion, one-half for the first frame after motion, and $K_m/2$ for succeeding frames. Rearranging equation (3) and solving for the luminance component V_{LO} and the chrominance V_{CO}

$$V_{LO} = K_o V_{LX} + (1-K_o) V_{LD} \quad (4)$$

$$V_{CO} = K_o V_{CX} + (1-K_o) V_{CDY} \quad (5)$$

From equations (4) and (5) for K_o equal to "one" i.e. during motion periods, V_{LO} and V_{CO} are equal to V_{LX} and V_{CX} respectively. Thus, alternate means must be provided to separate luminance and chrominance during motion intervals. An example of such alternate means may be a low-pass filter connected in parallel with the recursive filter, which is switched into the circuit when motion is detected.

The first frame of no motion the scale factor K_o is set to one-half. The samples V_{DY} correspond to the unaltered composite video of the previous frame. Since there is no motion the luminance component of signal V_{DY} is correlated with the luminance component of the incoming samples but the chrominance component is shifted 180 degrees in phase. Under these conditions and with the value of scale factor K_o equal to one-half the luminance and chrominance components from equations (4) and (5) are

$$V_{LO} = 1/2V_{LX} + (1-1/2)V_{LX} = V_{LX} \quad (6)$$

$$V_{CO} = 1/2V_{CX} + (1-1/2)(-V_{CX}) = 0 \quad (7)$$

which indicates that the chrominance component is completely cancelled during this frame. For this interval the system functions as a frame comb filter with a luminance output. Note that for this frame the chrominance V_{CY} is equal to $V_{CS}K_m/(2-K_m)$. These values will be the values V_{CDY} during the next frame period and succeeding frame periods in which there is no interframe image motion.

In the second and all succeeding frame periods in which there is no motion the value of scale factor K_o is set to $K_m/2$. Substituting this value for K_o in equations (4) and (5) and solving

$$V_{LO} = (K_m/2)V_{LX} + (1-K_m/2)V_{LX} = V_{LX} \quad (8)$$

$$V_{CO} = (K_m/2)V_{CX} + (1-K_m/2)(-V_{CX}K_m/(2-K_m)) = 0 \quad (9)$$

indicating that for all non motion frames the chrominance component is cancelled.

For the above system the motion adaptive circuit 31 provides the scale factors to scaling circuits 16 and 24. However, each set of scale factors will contain only three values as indicated in Table I.

Table I

MOTION SIGNAL	DELAYED MOTION SIGNAL	K_o	K_m
0	0	$K_{mi}/2$	K_{mi}
0	1	1/2	
$1/(2-K_{mi})$			
1	0	1	1
1	1	1	1

The value K_{mi} is variable according to the noise content of the incoming signal. For instance, if the system determines that the signal contains a relatively low amplitude noise content the selected set of scale factors K_o and K_m may be derived from a value of K_{mi} equal to 1/4. Alternatively, if the signal contains more noise, the selected set of scale factors may be derived from a value of K_{mi} equal to e.g. 1/16 or 1/32.

The circuitry circumscribed by the dashed box 31 is illustrative circuitry according to the present invention for generating the appropriate sequences of scale factors K_m and K_o on a pixel-by-pixel basis. This circuitry is responsive to the sample differences from subtractor 12. Note that if the input signal V_x contains a chrominance component e.g. the input signal is composite video signal, the chrominance component of V_{Dy} will be 180 degrees out of phase with the chrominance component of input samples V_x , and they will add constructively in subtractor 12 even when there is no interframe image motion. The luminance components of input samples V_x and delayed samples V_{Dy} will cancel in subtractor 12 when there is no motion and will produce sample differences when image changes occur from frame-to-frame. These luminance sample differences are an indication of image motion. In order to detect motion from the sample differences if the input signal contains chrominance, the chrominance component must be removed from the sample differences before they are applied to the motion detector.

The chrominance component of the sample differences is eliminated by the low-pass filter 27 which has a pass-band designed to attenuate the frequency spectrum occupied by chrominance signals. The luminance component of the sample differences from low-pass filter 27 is applied to the absolute value circuit 28 which converts all of the luminance sample differences to a single polarity, e.g. positive. These samples are applied to a second low-pass filter 32 which smooths the output of the absolute value circuit.

Output samples from low-pass filter 32 are applied to one input of the comparator 30 which compares them to a reference value from adder 42. If the samples from low-pass filter 32 exceed the reference value, comparator 30 provides a motion signal for the respective pixel sample, on output connection 33. Note low-pass filter 32, by smoothing the sample differences from circuit 28, tends to preclude the comparator from

developing a jittering motion signal for successive samples. Note also that comparator 30 may alternatively be connected to compare the sample differences ahead of the absolute value circuit 28 as indicated by the phantom connection 29.

The motion - no motion signals from comparator 30 are applied to a motion memory 34 which delays them by one or more frame periods. The motion - no motion signals and delayed motion - no motion signals from comparator 30 and motion memory 34 are coupled as partial address codewords to ROM 38 which outputs the desired sequences of scale factors K_m for scaling circuit 16 and scale factor K_0 for scaling circuit 24, on a pixel-by-pixel basis, examples of which are illustrated in Table I.

An assumption is made that every image frame will contain a portion of an image in which there is no motion. For this portion of the image, the amplitude of the sample differences from the output of subtracter 12 and consequently the output of low-pass filter 32 will correspond to the amplitude of the noise in the signal. It is further assumed that sample differences consisting of noise only, will have a lower amplitude than noise plus motion samples. Thus, if all the sample differences over the active image portion of each field (or frame) are measured to detect the smallest sample difference, this value will be representative of the noise in the respective field or frame.

Element 36 coupled to low-pass filter 32 detects the smallest sample difference in each field or frame. These differences are smoothed in low-pass filter 40 which is a digital filter clocked at the field or frame rate. The output of low-pass filter 40 is applied as one input to adder 42 and provides the base line for the reference values coupled to comparator 30. Onto this baseline is added a motion threshold value V_{TH} supplied by source 44 to provide an additional degree of noise immunity to the motion detector for instantaneous noise signals. The

motion reference value coupled to comparator 30 is therefore noise dependent.

In an alternative embodiment, adder 42 and source 44 may be replaced with e.g. a ROM having an address input port coupled to lowpass filter 40 and an output port coupled to comparator 30. This ROM will be programmed with appropriate reference values to correspond to the noise related signal applied as address codewords to its address input.

The noise related signal from low-pass filter 40 is also coupled to the input port of logic circuitry 46. Logic circuitry 46 develops codewords related to ranges of amplitudes of the noise related signals. A priority encoder such as the CD4532 integrated circuit manufactured by the Solid State Division of RCA Corporation is an example of the type of logic which may be implemented in logic circuit 46. The CD4532 develops a 3-bit output code effectively dividing an 8-bit input signal into eight ranges. For application to circuitry 31 of FIGURE 1, it is not necessary to divide the noise related signal into as many as eight ranges. The number of ranges will nominally be determined by designer preference but it is anticipated that three or four ranges will be sufficient. To adapt a circuit such as the CD4532 to partition an 8-bit input signal into e.g., 4 ranges represented by two bit codewords, pairs of the input bit lines may be ORed together with their output connection coupled respectively to the least significant input bit positions of the encoder.

The noise range related codewords produced by logic circuitry 46 are concatenated with the motion-no motion signals from comparator 30 and motion memory 34, and then coupled to the address input port of ROM 38.

ROM 38 may be partitioned into pages, with the address bits provided by logic circuitry 36 enabling the particular page, and the address bits provided from motion memory 34 and comparator 30 selecting the particular scale factors from the respective page. The pages are addressed

at a field or frame rate since information is provided to logic circuit 46 at a field or frame rate.

Each of the pages of ROM 38 will be programmed with a set or sets of scale factors appropriate for its
5 respective range of noise amplitude.

Additional circuitry, for controlling selection of the scale factors on a pixel basis and related to the magnitude of image motion derived from the instantaneous amplitude of the difference samples from subtractor 12,
10 may be coupled between low pass filter 27 and the address input of ROM 38. This additional circuitry may also comprise a priority encoder to generate additional address codewords bit for ROM 38. These additional address bits would be ORed with the address bits of logic circuitry 46
15 and effect (for limited motion) selection of the ROM 38 pages on a pixel basis. The larger the magnitude of image motion the larger the value of the scale factor K_m that is selected.

FIGURE 2 shows illustrative circuitry of a minimum
20 value detector 36' which may be substituted for element 36 of FIGURE 1. The function of the circuit is to detect the lowest valued sample difference occurring in the active image portion of a video signal. Circuit 36' examines a major portion of each field, i.e. the portion starting
25 with horizontal line 32 and ending with line 256, and only the active portion of these lines is examined.

The operation proceeds as follows. A parallel-bit latch 66 is preset to all ones by a digital one shot 68 at the beginning of the 32nd horizontal line.
30 The value in the latch 66 is coupled as a reference value to one input of comparator 65. Difference sample from low-pass filter 32 are coupled to a second input of comparator 65 and to the data input of latch 66. If the difference sample value is less than the reference value,
35 comparator 65 develops a control signal, to condition latch 66 to store the applied difference sample. The value of the difference sample stored in latch 66 becomes the new reference value for comparator 65. However,

if the applied difference sample from 32 is greater than the reference value, the current reference value is retained in latch 66. In effect, each successive sample is compared against an earlier lowest valued sample and if
5 the current sample is lower in value than all earlier samples the current sample becomes the new reference.

Comparator 65 is coupled to the control input terminal of latch 66 by gate 64. Gate 64 having an input coupled to e.g. a horizontal blanking signal derived from
10 the video signal is enabled to couple comparator 65 to latch 66 only during the active image portions of each horizontal line. thus, samples occurring during the horizontal, back porch and color burst intervals are not included for minimum value detection.

15 At line 256 the value currently stored in latch 66 is loaded into latch 67 responsive to a control signal from one shot 69. This value is stored in latch 67 for the next field or frame period for use in determining the baseline of the reference value of comparator 30 and the K
20 scale factors.

The digital one shot 68 which is responsive to horizontal and vertical blanking pulses outputs a pulse at the beginning of the line 32 to set latch 66 to the maximum binary value commensurate with the number of
25 sample bits stored in the latch to reinitialize the minimum value detector each field or frame of video information.

The digital one shot 69, which is also responsive to horizontal and vertical blanking pulses
30 generates an output clock signal to latch 67 at line 256 of the field interval (or line 512 of the frame interval) to load the value from latch 66 into latch 67. Digital one shot 69 and digital one shot 68 may consist of binary counters arranged to count 256 and 32 horizontal blanking
35 pulses respectively.



CLAIMS:

1. Scale factor generating circuitry for use with a video signal recursive filter including an input port, an output port from which a signal, delayed by
5 substantially one frame period with respect to signal applied to said input port, is available, and means for scaling and combining said delayed signal and said signal applied to said input port, wherein the degree of scaling of said signal applied to said input port and said
10 delayed signal is adaptively controlled by selective application of scale factors, said scale factor generating circuitry comprising:

means coupled to said input port and said output port for producing difference samples of signal
15 separated by one frame period;

detection means responsive to said difference samples for producing a signal corresponding to the difference sample having the smallest magnitude over a predetermined portion of a frame period;

20 means responsive to the signal produced by said detection means for generating a threshold value;

comparator means responsive to said difference samples and said threshold value for producing at an output port thereof a motion signal whenever the
25 magnitude of a difference sample is greater than the magnitude of the threshold value; and

means responsive to said motion signal for producing said scale factors.

30 2. The scale factor generating circuitry set forth in Claim 1, wherein the means responsive to said motion signal comprises:

memory means, having an address input port coupled to said comparator means output port, which is
35 programmed to output predetermined scale factors corresponding to motion signals applied as address codes to said address input port.



3. The scale factor generating circuitry set forth in Claim 2, wherein the means responsive to said motion signal further includes:

means responsive to signal produced by said
5 detection means for generating codewords corresponding to predetermined magnitude ranges of the difference sample having the smallest magnitude; and

means for concatenating the codewords
corresponding to predetermined magnitude ranges with said
10 motion signal to form composite address codes and
applying said composite address codes to said memory means.

4. The scale factor generating circuitry set
15 forth in Claim 3, wherein said memory means is coupled to said comparator means by means including a delay means for delaying said motion signal by at least one frame period.

20 5. A scale factor generating circuit for a video signal recursive filter including means for delaying an incoming signal by substantially at least one frame period and means for scaling and combining said incoming and delayed signals, which scaling means has a
25 control input port for applying control signals corresponding to scale factors, said scale factor generating circuit comprising:

means responsive to said incoming and delayed
signals for developing difference samples indicative of
30 image motion between successive frames;

means responsive to the difference samples for
developing a signal sample representative of the minimum
noise in an image portion of a frame period;



means responsive to said signal sample representative of the minimum noise for developing a threshold value;

means responsive to said difference samples and
5 said threshold value for producing a motion signal when the magnitude of the difference sample exceeds the magnitude of said threshold value; and

means responsive to said motion signal for generating said control signals.

10

6. The scale factor generating circuit set forth in Claim 5 wherein the means for generating said control signals comprises:

delay means coupled to said means for producing
15 said motion signal for delaying the motion-signal by at least one frame period;

means responsive to said motion signal and delayed motion signal for generating predetermined control signals in accordance with the history of image motion
20 indicated by said motion-signal and said delayed motion signal.

7. The scale factor generating circuit set forth in Claim 6 wherein the means for generating control
25 signals further comprises:

means responsive to said signal sample representative of the minimum noise, for producing a sample value corresponding to a particular one of a predetermined number of amplitude ranges encompassing said
30 signal sample; and

means responsive to said sample value corresponding to said one of the number of ranges for selecting a predetermined set of said predetermined control signals from which said means responsive to said
35 motion and delayed motion signals select said control signals.



8. Scale factor generating circuitry for a video signal recursive filter comprising:

5 a video signal input port; delay means having an input port and having an output port at which a video signal delayed by substantially at least one video frame period is available;

10 a subtractor circuit having an output port, a first input port coupled to the output port of said delay means and a second input port coupled to said video signal input port, a scaling circuit having an input port coupled to the output port of the subtractor circuit and an output port, and an adder having a first input port coupled to the output port of the scaling circuit, an output port coupled to the input port of said delay means, and a second input port coupled to the output port of the delay means, said scaling circuit having a control signal input port for applying control signals corresponding to respective scale factors;

20 means coupled to said subtractor circuit and responsive to difference signals produced thereby for determining the minimum difference signal over a period substantially equal to at least one half of a frame period;

25 means responsive to said minimum difference signal for producing a threshold value having a magnitude which is a predetermined quantity greater than said minimum difference signal; and

30 means responsive to said threshold value and said difference signal for producing said control signals.



1 9. The scale factor generating-circuitry set forth in Claim 8 wherein said means for producing said control signals comprises:

5 a comparator coupled to said subtractor and said threshold value producing means for generating a motion signal when the magnitude of said difference signals exceed the magnitude of said threshold value;

 means responsive to said minimum difference signal for producing a range signal corresponding to one
10 of a predetermined number of amplitude ranges; and

 control signal producing means responsive to said range signal to select one set of a predetermined number of sets of control signals and responsive to said motion signal to select control signals from the related
15 set of control signals.

 10. Scale factor generating circuitry for use with a recursive filter including an input port, an output port from which signals delayed by substantially a preset period with respect to signal applied to said input port
20 are available, and means for scaling and combining said delayed signals and signal applied to said input port and wherein the degree of scaling of said signals and delayed signals is adaptively controlled by selective application of scale factors, said scale factor generating circuitry
25 comprising:

 means having inputs suitable for coupling to said input port and said output port for producing difference samples of signal separated by said preset period;

30 detection means responsive to said difference samples for producing a signal corresponding to the difference sample having the smallest magnitude over a predetermined portion of the said preset period;



1 Claim 10 Contd.

means responsive to the signal produced by said
detection means for generating threshold values;

5 comparator means responsive to said difference
samples and said threshold values for producing at an
output port thereof an indicative signal whenever the
magnitude of a difference sample is greater than the
magnitude of the threshold value; and

10 means responsive to said indicative signal for
producing said scale factors.

11. A circuit according to claim 10 in
combination with a recursive filter including an input
port, an output port from which signals delayed by
15 substantially a preset period with respect to signal
applied to said input port are available, and means for
scaling and combining said delayed signals and signal
applied to said input port and wherein the degree of
scaling of said signals and delayed signals is adaptively
20 controlled by selective application of scale factors

25

12. A scale factor generating circuit
substantially as hereinbefore described with reference to
Figure 1 optionally as modified by Figure 2.

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13. A combination of a recursive filter and
a scale factor generating circuit substantially as
hereinbefore described with reference to Figure 1 optionally
as modified by Figure 2.

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