

PHASE MOTION DETECTION FOR YC SEPARATION

Field of the Invention

[0001] The present invention generally relates to video signal processing, and more particularly to a phase motion detection system for YC separation for image quality improvement.

Background of the Invention

[0002] In composite video television systems such as NTSC and PAL, luminance and chrominance information share a portion of the total signal bandwidth. While clean separation between luminance and chrominance is highly desired, current widely used video signal decoders can misinterpret the shared luminance and chrominance information, resulting in cross color and dot crawl. Both are highly disturbing artifacts. The term “cross color” refers to corruption of the chrominance spectrum caused by the misinterpretation of high-frequency luminance information as chrominance information. Cross color manifests itself in spectrum of bright colors changing from frame to frame. Conversely, the term “dot crawl” or “cross luminance” refers to corruption of the luminance spectrum by the misinterpretation of chrominance information as high-frequency luminance information. Dot crawl manifests itself in patterned high amplitude noise.

[0003] Both artifacts can be reduced by selectively filtering video signals during signal processing. The filtering process usually employs a 3D comb filter comprising at least one line comb filter and at least one frame comb filter. A line comb filter can reduce such artifacts but its effectiveness is limited to artifacts generated by vertical edges and it has a disadvantage of decreasing the vertical resolution. A frame comb filter, on the other hand, provides maximum picture resolution but can only be applied to stationary parts of a picture. To maximize the effectiveness of the comb filters, a highly precise motion detector that can differentiate between the moving and stationary pixels is required.

[0004] Conventional arts use a low pass inter-frame difference to generate a motion map to select line comb filters when motion is detected and frame comb filters when there

is no motion. Depending on the cut-off frequency of the low pass filter, the performance of the 3D comb filter varies. If the cut-off frequency is high, some motion due to cross luminance may be falsely detected and the 3D comb filter's effectiveness is reduced. If the cut-off frequency is low, motion with higher frequency content may not be detected and motion smearing results. The higher the overlapping of the chrominance with video bandwidth, the more ineffective the motion detection.

[0005] Some have improved the performance of motion detection by associating oblique correlation with likelihood of false motion. One disclosed motion detection device including an oblique correlation detection section, motion detection section and motion determination section decreases the sensitivity of motion detection in the presence of an oblique correlation. However, the implementation of the concept using decreased sensitivity in presence of oblique correlation is not sufficient because of the conflict of interests. On one hand, the decreased sensitivity may have impaired the detection of true motion for oblique objects. On the other hand, decreased sensitivity may not be sufficient to prevent false motion detection in mixed color/luminance edges since cross luminance are typically of large amplitudes.

[0006] Another example for motion detection uses a plurality of temporal pixels to determine the motion or still status of the video composite signal suitable for use in a 3D comb filter in video decoder. Yet another example for motion detection uses a motion detection circuitry with precise Y motion and C motion detection. The Y motion detection uses the frame difference of line-comb Y signal with chroma level and vertical edge consideration. The C motion detection uses the frame difference of line-comb C signal, together with the frame difference of composite signal and chroma vertical and horizontal correlation computed from the frame-comb Y signals of adjacent lines. Yet another example for motion detection uses a two-frame difference signal [and one-frame difference signal] [The bracketed part was deleted from 06-SIN-020] that has been filtered to remove chrominance information. The filtering is performed on at least one spatial axis according to the spatial correlation.

[0007] Generally, these methods do not consider motion contributed by chroma component because of interfering high frequency luminance at chroma band. However, there exists motion with purely color motion and a misdetection results in color smearing.

[0008] Still some use the two-frame difference to detect motion. Although this motion detection considers the contributions from both luminance and chroma, it does not represent the temporal difference between the frames being filtered and may not be sufficient for the PAL standard.

[0009] FIG 1 shows a typical prior art motion detector that is adapted for the PAL standard. The pixel difference $P_{n,n-2}$ between frame n and frame n-2, and the pixel difference $P_{n,n-4}$ between frame n and n-4 are computed by subtractors 701 and 702 respectively. Due to the inverted phase difference between frame n and n-2, a selection by a selector 707 of a vertical low pass filter 703, a horizontal low pass filter 704 and a vertical horizontal low pass filter 705 is performed by a correlator 706 to make the pixel values independent of cross colour. The final motion value is the maximum absolute pixel difference $P_{n,n-2}$ and absolute filtered pixel difference $P_{n,n-4}$.

[0010] Hence, there is a need to detect true luminance and chroma motions specific to motions between the frames used for temporal filtering or frame comb. The present invention is intended to capture specially the chroma-only motion and high frequency luminance motion.

Brief Description of the Drawings

[0011] Preferred embodiments according to the present invention will now be described with reference to the Figures, in which like reference numerals denote like elements.

[0012] FIG 1 shows a circuitry of a typical prior art motion detector that is adapted for the PAL standard.

[0013] FIG 2 shows an exemplary circuitry of the motion detection system for the PAL standard in accordance with one embodiment of the present invention.

[0014] FIG 3 shows an exemplary YC separation circuitry in accordance with one embodiment of the present invention.

Detailed Description of the Invention

[0015] The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention.

[0016] Throughout this application, where publications are referenced, the disclosures of these publications are hereby incorporated by reference to the maximum extent allowable by law, in their entireties, into this application in order to more fully describe the state of art to which this invention pertains.

[0017] In one embodiment of the present invention, there is provided a luminance motion detector for detecting low frequency luminance motion between a current frame and previous frame of a component video signal. The luminance motion detector comprises at least two vertical low pass filters (VLPF); wherein one of the at least two VLPF low pass filters at least three line signals of the current frame received from a signal input, and one of the at least two VLPF low pass filters at least three line signals of the previous frame received from the signal input; and wherein the two low pass filterings are done concurrently, a subtractor configured to receive outputs from the low pass filters; wherein the subtractor subtracts the low pass filtered line signals to generate line-comb signal differences, a horizontal low pass filter configured to receive outputs from the subtractor; wherein the horizontal low pass filter filters the line-comb signal differences to exclude possible interference of chroma residue, an absolute circuit configured to receive outputs from the horizontal low pass filter; wherein the absolute circuit extracts the magnitude of the low pass filtered line-comb signal differences to generate low frequency luminance difference, a coring circuit configured to receive outputs from the absolute circuit; wherein the coring circuit eliminates possible noise interference from the low frequency luminance difference, a multiplier configured to receive outputs from the coring circuit; wherein the multiplier multiplies the noise-free low frequency luminance difference, and a saturation circuit configured to receive outputs from the saturation circuit; wherein the saturation circuit clips the noise-free low frequency luminance difference to appropriate motion range to output the low frequency luminance motion for the current frame.

[0018] In another embodiment of the present invention, there is provided a method for detecting low frequency luminance motion between a current frame and previous frame of a component video signal. The method comprises the steps of low pass filtering at least three line signals of the current frame received from a signal input, low pass filtering at

least three line signals of the previous frame received from the signal, wherein the two low pass filterings are done concurrently, subtracting the low pass filtered line signals to generate line-comb signal differences, horizontal low pass filtering the line-comb signal differences to exclude possible interference of chroma residue, extracting the magnitude of the low pass filtered line-comb signal differences to generate low frequency luminance difference, eliminating possible noise interference from the low frequency luminance difference, multiplying the noise-free low frequency luminance difference, and clipping the noise-free low frequency luminance difference to appropriate motion range to output the low frequency luminance motion for the current frame.

[0019] In another embodiment of the present invention, there is provided a phase motion detector for detecting chroma motion of a current frame of a component video signal in the presence of luminance. The phase motion detector comprises a phase difference (PD) computing circuit for receiving from a signal input the current frame signal and a plurality of previous frame signals, and computing absolute phase difference values, an enhanced chroma motion values(CD) computing circuit configured to receive outputs from the PD computing circuit, said CD computing enhanced chroma motion values by incorporating motion contributed by the quadrature chroma modulation using the absolute phase difference values from at least 3 lines, a horizontal low pass filter configured to receive outputs from the CD computing circuit, said horizontal low pass filter smoothing the enhanced chroma motion values, a coring circuit configured to receive outputs from the horizontal low pass filter, said circuit coring the smoothed enhanced chroma motion values, a multiplier configured to receive outputs from the coring circuit, said multiplier multiplying the cored enhanced chroma motion values, and a saturation circuit configured to receive outputs from the multiplier, said saturation circuit clipping the multiplied enhanced chroma motion values to generate the chroma motion signal.

[0020] In another embodiment of the present invention, there is provided a method for detecting chroma motion of a current frame of a component video signal in the presence of luminance. The method comprises the steps of receiving from a signal input the current frame signal and a plurality of previous frame signals, computing absolute phase difference values between the current frame signal and the plurality of previous frame signals, computing enhanced chroma motion values using the absolute phase difference values from a plurality of lines, smoothing the enhanced chroma motion values,

coring the smoothed enhanced chroma motion values, multiplying the cored enhanced chroma motion values, and clipping the multiplied enhanced chroma motion values to generate the chroma motion signal.

[0021] In another embodiment of the present invention, there is provided a demodulated phase motion detector for detecting high frequency luminance motion of a current frame of a component video signal in the presence of chroma. The demodulated phase motion detector comprises a plurality of demodulation circuits for receiving the current frame signal and a plurality of previous frame signals, and demodulating and low pass filtering the YC signals from the frame signals to generate two sets of chroma signals, a plurality of computing circuits configured to receive outputs from the demodulation circuits, said plurality of computing circuits computing absolute phase differences PDU_m/PDV_m from the two sets of chroma signals, a maxd circuit configured to receive outputs from the computing circuits, said maxd circuit taking the maximum between the PDU and PDV and duplicating the values to generate intermediate high frequency luminance motion, a horizontal low pass filter configured to receive outputs from the maxd circuit, said horizontal low pass filter smoothing the intermediate high frequency luminance motion values, a coring circuit configured to receive outputs from the horizontal low pass filter, said coring circuit coring the intermediate high frequency luminance motion values, a multiplier configured to receive outputs from the coring circuit, said multiplier multiplying the intermediate high frequency luminance motion values, and a saturation circuit configured to receive outputs from the multiplier, said saturation circuit clipping the intermediate high frequency luminance motion values to generate the high frequency luminance motion signal.

[0022] In another embodiment of the present invention, there is provided a method for detecting high frequency luminance motion of a current frame of a component video signal in the presence of chroma. The method comprises the steps of receiving the current frame signal and a plurality of previous frame signals, demodulating and low pass filtering the YC signals from the frame signals to generate two sets of chroma signals, computing circuits computing absolute phase differences PDU_m/PDV_m from the two sets of chroma signals, taking the maximum between the PDU and PDV and duplicating the values to generate intermediate high frequency luminance motion, smoothing the intermediate high frequency luminance motion values, coring the intermediate high frequency luminance

motion values, multiplying the intermediate high frequency luminance motion values, and clipping the intermediate high frequency luminance motion values to generate the high frequency luminance motion signal.

[0023] In another embodiment of the present invention, there is provided a motion detection system for detecting motions in a current frame of a component video signal. The system comprises a luminance motion detector for detecting low frequency luminance motion between current frame and previous frame, a phase motion detector for detecting average difference chroma motion between the current frame and a plurality of previous frames, a demodulated phase motion detector for detecting average difference high frequency luminance motion between the current frame and a plurality of previous frames, a max circuit for taking the maximum among these three motion values, a saturation circuit for clipping the maximum motion value, and a 5H-max circuit for processing the maximum motion value in a 5-pixel horizontal window to generate the final motion value.

[0024] In another embodiment of the present invention, there is provided a method for detecting motions in a current frame of a component video signal. The method comprises the steps of detecting low frequency luminance motion between current frame and previous frame, detecting average difference chroma motion between the current frame and a plurality of previous frames, detecting average difference high frequency luminance motion between the current frame and a plurality of previous frames. taking the maximum among these three motion values, clipping the maximum motion value, and processing the maximum motion value in a 5-pixel horizontal window to generate the final motion value.

[0025] In another embodiment of the present invention, there is provided an YC separation circuitry for separating a current frame of component video signals into Y and C signals. The circuitry comprises an inter-line correlator for detecting the relative chroma correlation between current and next line and current and previous line of the current frame from a signal input, a line comb for removing the redundant chroma residue from the Y signal, a frame comb for subtracting a previous frame signal $Y_{m,n-1}$ from the current frame signal $Y_{m,n}$ using a subtractor to generate the frame comb output, a motion detector for detecting motions in a current frame of a component video signal, a mixer circuit configured to receive outputs from the line comb and frame comb, said mixer circuit extracting the final clean chroma signal using a weighted sum of line comb output, C_2D ,

and frame comb output, C_3D , and a subtractor configured to receive outputs from the motion detector, said subtractor extracting the final clean luminance signal.

[0026] In another embodiment of the present invention, there is provided a method for separating a current frame of component video signals into Y and C signals. The method comprises the steps of detecting the relative chroma correlation between current and next line and current and previous line of the current frame from a signal input, removing the redundant chroma residue from the Y signal, subtracting a previous frame signal $Y_{m,n-1}$ from the current frame signal $Y_{m,n}$ using a subtractor to generate the frame comb output, detecting motions in a current frame of a component video signal, extracting the final clean chroma signal using a weighted sum of line comb output, C_2D , and frame comb output, C_3D , and extracting the final clean luminance signal.

[0027] In another embodiment of the present invention, there is provided an article of manufacture. The article comprises means for receiving component video signals for separation processing to Y and C component signals, means for outputting separated Y and C component signals, and a YC separation circuitry for separating the received component video signals into Y and C component signals, said YC separation circuitry comprising an inter-line correlator for detecting the relative chroma correlation between current and next line and current and previous line of the current frame from a signal input, a line comb for removing the redundant chroma residue from the Y signal, a frame comb for subtracting a previous frame signal $Y_{m,n-1}$ from the current frame signal $Y_{m,n}$ using a subtractor to generate the frame comb output, a motion detector for detecting motions in a current frame of a component video signal, a mixer circuit configured to receive outputs from the line comb and frame comb, said mixer circuit extracting the final clean chroma signal using a weighted sum of line comb output, C_2D , and frame comb output, C_3D , and a subtractor configured to receive outputs from the motion detector, said subtractor extracting the final clean luminance signal.

[0028] While embodiments of the present invention will be described in reference to the accompanying drawings, the specifics and details are provided for the sole purpose of illustrating selected embodiments of the present invention. It is to be appreciated that the present invention may be practiced without employing the specifics and details. Furthermore, certain variations of the specifics and details in the practice are permissible without deviation from the scope of the appended claims.

[0029] The present invention provides a comprehensive solution that detects all types of motions including high frequency luminance motion and chroma motion independent of the signal processing done prior to input. In order to detect all types of motions in composite signals, the present invention provides a motion detection system that comprises a luminance motion detector for detecting the low frequency luminance motion due to the low frequency luminance changes, a phase motion detector for detecting mainly the chroma motion due to the chroma changes, and a demodulated phase motion detector for detecting mainly the high frequency luminance motion due to the high frequency luminance changes. The functions and operations of each motion detector in the motion detection system will be described briefly first and a detailed description will be followed.

[0030] The luminance motion detector detects precise changes in the low frequency luminance component between frame n and frame $n-2$ used for the frame comb in the PAL standard. For detection of the low frequency luminance motions, the input signal is first vertically filtered to remove chroma residues, to present best-case line-comb Y signals for difference computation. Then, the difference signal is low-pass filtered to eliminate the possibility of chroma component corruption at high frequency, and the low pass filtered difference signals are used to generate the low frequency luminance motion.

[0031] The phase motion detector detects mainly chroma changes from temporally co-located pixels in YC signal. The changes are made independent of chrominance residue in luminance by considering the phase relationship of the YC signal. YC pixels from current frame n , and three previous frames $n-1$, $n-2$ and $n-3$ in the PAL standard are used to determine chroma motion and at least three lines are used. In one embodiment, the phase motion detector provides the differences of chroma motion between frame n and frame $n-2$ and chroma motion between frame $n-1$ and $n-3$. As chroma components U and V are orthogonally modulated in composite signal, chroma motion information for U and V is present only on alternate lines of absolute phase difference. Hence the combined chroma motion for each line takes the maximum between the current chroma phase difference and vertical interpolated chroma phase difference from the top and bottom lines to incorporate motion contributed by quadrature chroma modulation. Alternatively the median or max of the chroma phase difference from the three lines may be taken.

[0032] The demodulated motion detector detects mainly high frequency luminance changes from temporally co-located pixels in demodulated U and V signals. The YC signal is first demodulated and low pass filtered to eliminate aliasing effect, generating DU and DV component signal. Output pixels from demodulation circuits of current frame n, and three previous frames n-1, n-2 and n-3 in PAL standard are used to determine high frequency luminance motion. The changes are made independent of luminance residue in chroma by considering the phase relationship of the demodulated signal.

[0033] As each of the above detectors has its advantages and limitations, they can be combined constructively to give measures of motion between the frames to be filtered.

[0034] Now referring to FIG 2, there is provided an exemplary circuitry of the motion detection system for the PAL standard in accordance with one embodiment of the present invention. As shown in FIG 2, the motion detection system **100** comprises a luminance motion detector **101** that detects low frequency luminance motion between frame n and n-2, a phase motion detector **102** that detects average difference chroma motion between frames n, n-2, n-1 and n-3, and a demodulated phase motion detector **103** that detects average difference high frequency luminance motion between frames n, n-2, n-1 and n-3. The motion detection system **100** further comprises signal input and frame delay memories for providing signal inputs to the motion detectors. The motion detection system **100** also comprises components including a max circuit **501**, a saturation circuit **502**, and a 5H-max circuit **503** for deriving the final motion value, K_{motion} . A more detailed description of the motion detection apparatus will be provided hereinafter.

[0035] The luminance motion detector **101** comprises vertical low pass filters **201/202**, a subtractor **203** configured to receive outputs from the low pass filters, a horizontal low pass filter **204** configured to receive outputs from the subtractor, an absolute circuit **205** configured to receive outputs from the horizontal low pass filter, a coring circuit **206** configured to receive outputs from the absolute circuit, a multiplier **207** configured to receive outputs from the coring circuit, and a saturation circuit **208** configured to receive outputs from the saturation circuit. In order to detect low frequency luminance motion between frame n and frame n-2, the luminance motion detector **101** receives from the signal input YC_n the subsequent line signal $Y_{m+2,n}$, current line signal $Y_{m,n}$, and previous line signal $Y_{m-2,n}$ for the current frame via four luminance line delay memories (not shown). All three line signals are low pass filtered by the vertical low pass

filter **201** with coefficients $[1 \ 2 \ 1]/4$ to cancel out-of-phase chroma signal to generate line-comb signal YLC_n . Concurrently, the luminance motion detector **101** receives from the signal input YC_{n-2} the subsequent line signal $Y_{m+2,n-2}$, current line signal $Y_{m,n-2}$ and previous line signal $Y_{m-2,n-2}$, for the previous frame $n-2$ via two frame delay memories and four additional luminance line delay memories (not shown). The subscript n refers to a frame and m to a line of the video signals. Similarly, all three line signals of frame $n-2$ are low pass filtered by the vertical low pass filter **202** to cancel out-of-phase chroma signal to generate line-comb signal YLC_{n-2} . The line-comb signals YLC_n and YLC_{n-2} may alternatively be the output of line combs of a separation circuitry discussed in detail hereinafter.

[0036] These line-comb signals YLC_n and YLC_{n-2} are then subtracted by the subtractor **203** to generate line-comb signal differences. The horizontal low pass filter **204**, with low pass frequency characteristics not exceeding the lower end of the overlapping frequency band of chroma and luminance signal or band-stop frequency characteristics attenuating the chroma band, subsequently filters the line-comb signal differences to exclude possible interference of chroma residue. The magnitude of the low pass filtered line-comb signal differences is extracted by the absolute circuit **205** to generate low frequency luminance difference YLD that passes through the coring circuit **206** to eliminate possible noise interference. Finally, the noise-free low frequency luminance difference YLD is multiplied by the multiplier **207** via gain GI , and clipped by the saturation circuit **208** to appropriate motion range to output the low frequency luminance motion YLM .

[0037] The phase motion detector **102** comprises a phase difference (PD) computing circuit **301**, an enhanced chroma motion values (CD) computing circuit **302** configured to receive outputs from the PD computing circuit, a horizontal low pass filter **303** configured to receive outputs from the CD computing circuit, a coring circuit **304** configured to receive outputs from the horizontal low pass filter, a multiplier **305** configured to receive outputs from the coring circuit, and a saturation circuit **306** configured to receive outputs from the multiplier. In order to detect mainly chroma motion in the presence of luminance, the phase motion detector **102** receives from the signal input the current frame signal $YC_{m,n}$, and a plurality of previous frame signals $YC_{m,n-1}$, $YC_{m,n-2}$, and $YC_{m,n-3}$ via three YC frame delay memories. Then, the received frame signals are used

to compute the absolute phase difference values PD via the PD computing circuit **301** according to the following equation (1):

[0038]

$$\text{absolute_phase_difference} : PD_m = |YC_n - YC_{n-1} + YC_{n-2} - YC_{n-3}|; \quad (1)$$

[0039] wherein PD_m denotes the absolute phase difference values; YC_n, YC_{n-1}, YC_{n-2} , and YC_{n-3} are sequential frame signals; where m is omitted from all YC components for simplicity

[0040] Then, the absolute phase difference values PD_m , PD_{m+1} , and PD_{m-1} from 3 lines are used to compute the enhanced chroma motion values CD via the CD computing circuit **302** according to the below equation (2):

[0041]

$$\text{chroma_motion} : CD_m = \text{Max}\left\{PD_m, \frac{PD_{m-1} + PD_{m+1}}{2}\right\}; \quad (2)$$

[0042] wherein CD_m denotes the enhanced chroma motion values; PD_{m-1}, PD_m , and PD_{m+1} are the absolute phase difference values for three consecutive lines $m-1, m$, and $m+1$. Then the enhanced chroma motion values may be smoothed by the horizontal low pass filter **303**, cored through the coring circuit **304**, scaled by gain $G2$ via the multiplier **305**, and clipped by saturation circuit **306** to generate the chroma motion signal, CM .

[0043] The demodulated phase motion detector **103** complements the above detectors by detecting mainly high frequency luminance motion in the presence of chroma. The demodulated phase motion detector **103** comprises demodulation circuits **401-404**, computing circuits **405/406** configured to receive outputs from the demodulation circuits, a maxd circuit **411** configured to receive outputs from the computing circuits, a horizontal low pass filter **412** configured to receive outputs from the maxd circuit, a coring circuit **413** configured to receive outputs from the horizontal low pass filter, a multiplier **414** configured to receive outputs from the coring circuit, and a saturation circuit **415** configured to receive outputs from the multiplier.

[0044] In order to detect average difference high frequency luminance motion between frames $n, n-2, n-1$ and $n-3$, the demodulated phase motion detector **103** receives the current frame signal, $YC_{m,n}$, and a plurality of previous frame signals $YC_{m,n-1}, YC_{m,n-2}$, and $YC_{m,n-3}$, via three YC frame delay memories. The YC signals from the frame signals are demodulated the via the demodulation circuits **401-404** to generate two set of signals $\{DU_{m,n}, DU_{m,n-1}, DU_{m,n-2}, DU_{m,n-3}\}$ and $\{DV_{m,n}, DV_{m,n-1}, DV_{m,n-2}, DV_{m,n-3}\}$. The demodulation

process can be relatively simple to extract the U or V components from the composite signals by multiplying an in-phase and out-of-phase sine wave and subsequently employing a low pass filter of chroma bandwidth to eliminate aliasing effect.

[0045] The demodulated signals are first combined to compute the absolute phase differences PDU_m/PDV_m in the computing circuits **405**, **406** according to below equations (3-4):

$$[0046] \quad PDU_m = |DU_{m,n} - DU_{m,n-1} + DU_{m,n-2} - DU_{m,n-3}|; \quad (3)$$

$$PDV_m = |DV_{m,n} - DV_{m,n-1} + DV_{m,n-2} - DV_{m,n-3}|; \quad (4)$$

[0047] wherein PDU_m/PDV_m denote the absolute phase differences in chroma components U and V for line m; $DU_{m,n}$, $DU_{m,n-1}$, $DU_{m,n-2}$, $DU_{m,n-3}$ denote demodulated chroma U signals from frame n, n-1, n-2 and n-3; and $DV_{m,n}$, $DV_{m,n-1}$, $DV_{m,n-2}$, $DV_{m,n-3}$ denote demodulated V signals from frame n, n-1, n-2 and n-3.

[0048] Then, the maxd circuit **411** takes the maximum between the PDU and PDV and duplicates the values to generate the intermediate high frequency luminance motion YHD with same samples as signal YC per line.

[0049] The intermediate high frequency luminance motion values may then be smoothed by the horizontal low pass filter **412**, cored through the coring circuit **413**, scaled by gain G2 via the multiplier **414**, and clipped by the saturation circuit **415** to generate the high frequency luminance motion signal, YHM .

[0050] For any given video signal, the luminance motion detector **101** generates the low frequency luminance motion YLM , the phase motion detector **102** generates the chroma motion signal CM , and the demodulated phase motion detector **103** outputs the high frequency luminance motion signal YHM . Then the max circuit **501** takes the maximum among these three motion values. The maximum motion value is clipped by the saturation circuit **502**, and further processed as the maximum in a 5-pixel horizontal window by the 5H-max circuit **503**, resulting in the final motion value, K_motion .

[0051] The motion detection system and various motion detectors of the present invention can be embedded in an YC separation circuitry of a front end composite decoder so as to reduce chroma residue in luminance component and luminance residue in chroma component. The inputs to the YC separation circuitry is the frequency demodulated video signal in CVBS domain while the outputs are component Y and C signals. The C signal may be subsequently demodulated to generate U and V signals.

[0052] Now referring to FIG 3, there is provided an exemplary YC separation circuitry in accordance with one embodiment of the present invention. The separation circuitry 600 comprises an inter-line correlator 606, a line comb 602, a frame comb 620, and a motion detector 100. The separation circuitry further comprises components including a subtractor 613, a mixer circuit 614, a subtractor 615, and a saturation circuit 616. The motion detector 100 has been described in detail above. A more detailed description of the separation circuitry 600 will be devoted to other components hereinafter.

[0053] The inter-line correlator 606 detects the relative chroma correlation between the current and next line and current and previous line, such that the line comb 602 does not filter across contrasting colour regions. The inter-line correlator 606 comprises a narrowband filter 607, gradient circuits 608, 609 configured to receive outputs from the narrowband filter, horizontal low pass filters 610, 611 configured to receive outputs from the gradient circuits, and a function circuit 612 configured to receive outputs from the horizontal low pass filters.

[0054] The narrowband filter 607 isolates the sub-band of the YC interleave frequency band from the YC signal from the signal input. The narrowband filter 607 has a smaller bandwidth centered at chroma subcarrier frequency of 4.43 MHz compared to a wideband filter 601 (to be described below) for purposes of less interference from luminance signal. The gradients of current and next line, $G_{x,m,m+2}$, and current and previous line, $G_{x,m,m-2}$, are computed in the gradient circuits 608, 609 using narrow band-passed YC signals according to below equations (5-6), wherein the narrow band-passed YC signal is represented by YC for simplicity.

$$G_{x,m,m+2} = \max\{|YC_{x+1,m+2} - YC_{x-1,m}|, |YC_{x-1,m+2} - YC_{x+1,m}|\}, \quad (5)$$

$$G_{x,m,m-2} = \max\{|YC_{x+1,m-2} - YC_{x-1,m}|, |YC_{x-1,m-2} - YC_{x+1,m}|\}, \quad (6)$$

[0056] wherein $G_{x,m,m+2}$ denotes the gradients of current and next line, and $G_{x,m,m-2}$ the gradients of current and previous line of a sample x; $YC_{x,m}$ refers to the composite signal of sample x and line m.

[0057] The gradients are subsequently filtered by the horizontal low pass filters 610, 611 respectively for continuity to obtain $G_{m,m+2,lp}$ and $G_{m,m-2,lp}$. The lower the gradient, the higher the correlation, meaning a higher possibility that the pixels from the two lines belong to the same colour region. Thus the line-comb output from two lines

having a lower gradient should have a higher contribution towards the final comb value. K_2D is defined as the weight for the line comb filter between the current and previous line in the function circuit **612** according to the below equation (7):

$$[0058] \quad K_2D = \frac{G_{m,m+2,lp}}{G_{m,m+2,lp} + G_{m,m-2,lp}} \quad (7)$$

[0059] wherein $G_{m,m+2,lp}$ denotes the low passed gradients of current and next line, and $G_{m,m-2,lp}$ the gradients of current and previous line.

[0060] The line comb **602** removes the redundant chroma residue from the Y signal. The line comb **602** comprises a wideband filter **601**, subtractors **603**, **604** configured to receive outputs from the wideband filter, and a mixer **605** configured to receive outputs from the subtractors. The line comb **602** receives from the signal input a 3 line input, next line $YC_{m+2,n,wbp}$, current line $YC_{m,n,wbp}$ and previous line $YC_{m-2,n,wbp}$. The wideband filter **601** with frequency response modeling the chroma band in YC signal filters out the low and high frequency signal and retains only the frequency band with interleave Y and C signal. The inter-line differences are computed by the subtractors **603**, **604** and subsequently mixed by the mixer **605** corresponding to K_2D signal from the inter-line correlator **606**.

[0061] The output of the line comb filter is a weighted sum of inter-line pixel differences and the weights are determined by K_2D . The output can be expressed according to the below equation (8):

$$[0062] \quad C_2D = K_2D \times (YC_m - YC_{m-2}) + (1 - K_2D) \times (YC_m - YC_{m+2}); \quad (8)$$

[0063] wherein YC_m, YC_{m-2}, YC_{m+2} are the composite signals of line m, n-2 and m+2 respectively.

[0064] The frame comb **620** subtracts the previous frame signal $Y_{m,n-1}$ from the current frame signal $Y_{m,n}$ using the subtractor **613** to generate the frame comb output C_3D .

[0065] The final clean chroma signal, C_{out} , is extracted via the mixer circuit **614** using a weighted sum of line comb output, C_2D , and frame comb output, C_3D . The weights are determined by motion value, K_motion from the motion detector **100**. The final clean luminance signal, Y_{out} , is generated by subtracting the chroma signal from input

YC signal, YC_{in} , with the subtractor 615 and clipping the output to defined pixel range with the saturation circuit 616 according to the below equations (9-10):

$$C_{out} = (K_{motion} \times C_{2D} + (1 - K_{motion}) \times C_{3D});$$

$$Y_{out} = YC_{in} - C_{out}$$

wherein K_{motion} is the motion value, C_{2D} is line comb output; C_{3D} is the frame comb output; YC_{in} is the input composite signal; C_{out} is the output chroma signal Y_{out} is the output luminance signal.

Many embodiments of the present invention are very useful for component video with cross colour and cross luminance noise. More specifically, such embodiments of the present invention include high frequency luminance motion detection and chroma motion detection between specific frames to be temporally filtered. The embodiments are able to precisely detect motion independent of the interference noise from other video components using phase relationship such that residual cross component can be removed by a simple line and frame comb architecture to provide clean output signals. In addition, it has good coverage of different frequencies and component motion for increased robustness of motion detection.

The embodiments operate such that the inputs are not temporally filtered in the presence of motion and temporally filtered in the absence of motion, generating clean Y and C signals with reduction of cross colour and dot crawl and ensuring minimally modified signals in the absence of such artifacts.

The motion detectors and YC separation circuitries of the embodiments can be applied to end consumer products like chip, television, display sets, video CD player, DVD players or recorders and set-top-boxes with composite sources or sources that have composite conversion in at least one stage of processing prior to input.

While the present invention has been described with reference to particular embodiments, it will be understood that the embodiments are illustrative and that the scopes of the appended claims are not so limited. Alternative embodiments of the present invention have been set forth by implication and will be apparent to those having ordinary skill in the art to which the present invention pertains. Such alternate embodiments are considered to be encompassed within the scope of one or more of the appended claims. Accordingly, the scope of the present invention is described by the appended claims and is supported by the foregoing description.

CLAIMS

What is claimed is:

1. A luminance motion detector for detecting low frequency luminance motion between a current frame and previous frame of a component video signal, comprising:
 - at least two vertical low pass filters (VLPF); wherein one of the at least two VLPF is configured to low pass filter at least three line signals of the current frame received from a signal input, and the other of the at least two VLPF is configured to low pass filter at least three line signals of the previous frame received from the signal input; and wherein the detector is configured for concurrent operation of the two low pass filterings;
 - a subtractor configured to receive outputs from the low pass filters; wherein the subtractor is further configured to subtract the low pass filtered line signals to generate line-comb signal differences;
 - a horizontal low pass filter configured to receive outputs from the subtractor; wherein the horizontal low pass filter is further configured to filter the line-comb signal differences to exclude possible interference of chroma residue;
 - an absolute circuit configured to receive outputs from the horizontal low pass filter; wherein the absolute circuit is further configured to extract the magnitude of the low pass filtered line-comb signal differences to generate low frequency luminance difference;
 - a coring circuit configured to receive outputs from the absolute circuit; wherein the coring circuit is further configured to eliminate possible noise interference from the low frequency luminance difference;
 - a multiplier configured to receive outputs from the coring circuit; wherein the multiplier is further configured to eliminate the noise-free low frequency luminance difference; and
 - a saturation circuit configured to receive outputs from the saturation circuit; wherein the saturation circuit is further configured to clip the noise-free low frequency luminance difference to appropriate motion range to output the low frequency luminance motion for the current frame.

2. The luminance motion detector of claim 1, wherein the three line signals are a subsequent line signal $Y_{m+2,n}$, a current line signal $Y_{m,n}$, and a previous line signal $Y_{m-2,n}$, wherein m denotes the numbering of line signal and n denotes the numbering of frame signal.
3. The luminance motion detector of claim 1, wherein the at least two VLPFs are configured to cancel out-of-phase chroma signal from the line signals to generate a line-comb signal.
4. The luminance motion detector of claim 1, wherein the horizontal low pass filter is configured to have low pass frequency characteristics not exceeding the lower end of the overlapping frequency band of chroma and luminance signal or band-stop frequency characteristics covering the chroma band.
5. A method for detecting low frequency luminance motion between a current frame and previous frame of a component video signal, comprising the steps of:
 - low pass filtering at least three line signals of the current frame received from a signal input;
 - low pass filtering at least three line signals of the previous frame received from the signal; wherein the two low pass filterings are done concurrently;
 - subtracting the low pass filtered line signals to generate line-comb signal differences;
 - horizontal low pass filtering the line-comb signal differences to exclude possible interference of chroma residue;
 - extracting the magnitude of the low pass filtered line-comb signal differences to generate low frequency luminance difference;
 - eliminating possible noise interference from the low frequency luminance difference;
 - multiplying the noise-free low frequency luminance difference; and
 - clipping the noise-free low frequency luminance difference to appropriate motion range to output the low frequency luminance motion for the current frame.

6. The method of claim 5, wherein the three line signals are a subsequent line signal $Y_{m+2,n}$, a current line signal $Y_{m,n}$, and a previous line signal $Y_{m-2,n}$, wherein m denotes the numbering of line signal and n denotes the numbering of frame signal.
7. The method of claim 5, wherein the first two low pass filterings cancel out-of-phase chroma signal from the line signals to generate a line-comb signal.
8. The method of claim 5, wherein the horizontal low pass filtering has low pass is configured to have frequency characteristics not exceeding the lower end of the overlapping frequency band of chroma and luminance signal or band-stop frequency characteristics covering the chroma band.
9. A phase motion detector for detecting chroma motion of a current frame of a component video signal in the presence of luminance, comprising:
 - a phase difference (PD) computing circuit configured for receiving from a signal input the current frame signal and a plurality of previous frame signals, and computing absolute phase difference values;
 - an enhanced chroma motion values (CD) computing circuit configured to receive outputs from the PD computing circuit, said CD computing enhanced chroma motion values by incorporating motion contributed by the quadrature chroma modulation using the absolute phase difference values from at least 3 lines;
 - a horizontal low pass filter configured to receive outputs from the CD computing circuit, said horizontal low pass filter smoothing the enhanced chroma motion values;
 - a coring circuit configured to receive outputs from the horizontal low pass filter, said coring circuit coring the smoothed enhanced chroma motion values;
 - a multiplier configured to receive outputs from the coring circuit, said multiplier multiplying the cored enhanced chroma motion values; and
 - a saturation circuit configured to receive outputs from the multiplier, said saturation circuit clipping the multiplied enhanced chroma motion values to generate the chroma motion signal.

10. The phase motion detector of claim 9, wherein when the plurality of previous frame signals are three previous frame signals, the computing absolute phase difference values is performed according to the following equation:

$$\text{absolute_phase_difference} : PD_m = |YC_n - YC_{n-1} + YC_{n-2} - YC_{n-3}|;$$

wherein PD_m denotes the absolute phase difference values; YC_n, YC_{n-1}, YC_{n-2} , and YC_{n-3} are sequential frame signals; where m is omitted from all YC components for simplicity.

11. The phase motion detector of claim 10, wherein computing the enhanced chroma motion values is performed according to the below equation:

$$\text{chroma_motion} : CD_m = \text{Max}\left\{PD_m, \frac{PD_{m-1} + PD_{m+1}}{2}\right\};$$

wherein CD_m denotes the enhanced chroma motion values; PD_{m-1}, PD_m , and PD_{m+1} are the absolute phase difference values for three consecutive lines $m-1, m$, and $m+1$.

12. A method for detecting chroma motion of a current frame of a component video signal in the presence of luminance, comprising the steps of:

receiving from a signal input the current frame signal and a plurality of previous frame signals;

computing absolute phase difference values between the current frame signal and the plurality of previous frame signals;

computing enhanced chroma motion values using the absolute phase difference values from plurality of lines;

smoothing the enhanced chroma motion values;

coring the smoothed enhanced chroma motion values;

multiplying the cored enhanced chroma motion values; and

clipping the multiplied enhanced chroma motion values to generate the chroma motion signal.

13. The method of claim 12, wherein when the plurality of previous frame signals are three previous frame signals, the computing absolute phase difference values is performed according to the following equation:

absolute_phase_difference : $PD_m = |YC_n - YC_{n-1} + YC_{n-2} - YC_{n-3}|$;

wherein PD_m denotes the absolute phase difference values; YC_n, YC_{n-1}, YC_{n-2} , and YC_{n-3} are sequential frame signals; where m is omitted from all YC components for simplicity.

14. The method of claim 13, wherein computing the enhanced chroma motion values is performed according to the below equation:

$$chroma_motion : CD_m = Max\left\{PD_m, \frac{PD_{m-1} + PD_{m+1}}{2}\right\};$$

wherein CD_m denotes the enhanced chroma motion values; PD_{m-1}, PD_m , and PD_{m+1} are the absolute phase difference values for three consecutive lines $m-1, m$, and $m+1$.

15. A demodulated phase motion detector for detecting high frequency luminance motion of a current frame of a component video signal in the presence of chroma, comprising:

a plurality of demodulation circuits configured for receiving the current frame signal and a plurality of previous frame signals, and demodulating and low pass filtering the YC signals from the frame signals to generate two sets of chroma signals;

a plurality of computing circuits configured to receive outputs from the demodulation circuits, said plurality of computing circuits computing absolute phase differences PDU_m/PDV_m from the two sets of chroma signals;

a maxd circuit configured to receive outputs from the computing circuits, said maxd circuit taking the maximum between the PDU and PDV and duplicating the values to generate intermediate high frequency luminance motion;

a horizontal low pass filter configured to receive outputs from the maxd circuit, said horizontal low pass filter smoothing the intermediate high frequency luminance motion values;

a coring circuit configured to receive outputs from the horizontal low pass filter, said coring circuit coring the intermediate high frequency luminance motion values;

a multiplier configured to receive outputs from the coring circuit, said multiplier multiplying the intermediate high frequency luminance motion values; and

a saturation circuit configured to receive outputs from the multiplier, said saturation circuit clipping the intermediate high frequency luminance motion values to generate the high frequency luminance motion signal.

16. The demodulated phase motion detector of claim 15, wherein when the plurality of previous frame signals are three frame signals, there are four demodulated circuits so that each demodulated circuit performs demodulation on one frame signal.

17. The demodulated phase motion detector of claim 15, wherein the absolute phase differences PDU_m/PDV_m are computed according to below equations:

$$PDU_m = |DU_{m,n} - DU_{m,n-1} + DU_{m,n-2} - DU_{m,n-3}|;$$

$$PDV_m = |DV_{m,n} - DV_{m,n-1} + DV_{m,n-2} - DV_{m,n-3}|;$$

wherein PDU_m/PDV_m denote the absolute phase differences in chroma components U and V for line m; $DU_{m,n}, DU_{m,n-1}, DU_{m,n-2}, DU_{m,n-3}$ denote demodulated chroma U signals from frame n, n-1, n-2 and n-3; and $DV_{m,n}, DV_{m,n-1}, DV_{m,n-2}, DV_{m,n-3}$ denote demodulated V signals from frame n, n-1, n-2 and n-3.

18. A method for detecting high frequency luminance motion of a current frame of a component video signal in the presence of chroma, comprising the steps of:

receiving the current frame signal and a plurality of previous frame signals;

demodulating and low pass filtering the YC signals from the frame signals to generate two sets of chroma signals;

computing circuits computing absolute phase differences PDU_m/PDV_m from the two sets of chroma signals;

taking the maximum between the PDU and PDV and duplicating the values to generate intermediate high frequency luminance motion;

smoothing the intermediate high frequency luminance motion values;

coring the intermediate high frequency luminance motion values;

multiplying the intermediate high frequency luminance motion values; and

clipping the intermediate high frequency luminance motion values to generate the high frequency luminance motion signal.

19. The method of claim 18, wherein when the plurality of previous frame signals are three frame signals, there are four demodulated circuits so that each demodulated circuit performs demodulation on one frame signal.

20. The method of claim 18, wherein the absolute phase differences PDU_m/PDV_m are computed according to below equations:

$$PDU_m = |DU_{m,n} - DU_{m,n-1} + DU_{m,n-2} - DU_{m,n-3}|;$$

$$PDV_m = |DV_{m,n} - DV_{m,n-1} + DV_{m,n-2} - DV_{m,n-3}|;$$

wherein PDU_m/PDV_m denote the absolute phase differences in chroma components U and V for line m; $DU_{m,n}, DU_{m,n-1}, DU_{m,n-2}, DU_{m,n-3}$ denote demodulated chroma U signals from frame n, n-1, n-2 and n-3; and $DV_{m,n}, DV_{m,n-1}, DV_{m,n-2}, DV_{m,n-3}$ denote demodulated V signals from frame n, n-1, n-2 and n-3.

21. A motion detection system for detecting motions in a current frame of a component video signal, comprising:

a luminance motion detector configured for detecting low frequency luminance motion between current frame and previous frame;

a phase motion detector configured for detecting average difference chroma motion between the current frame and a plurality of previous frames;

a demodulated phase motion detector configured for detecting average difference high frequency luminance motion between the current frame and a plurality of previous frames;

a max circuit configured for taking the maximum among these three motion values;

a saturation circuit configured for clipping the maximum motion value; and

a 5H-max circuit configured for processing the maximum motion value in a 5-pixel horizontal window to generate the final motion value.

22. The motion detection system of claim 21, wherein the luminance motion detector comprises:

at least two vertical low pass filters (VLPF); wherein one of the at least two VLPF is configured to low pass filter at least three line signals of the current frame received from a signal input, and the other of the at least two VLPF is configured to low pass filter at least

three line signals of the previous frame received from the signal input; and wherein the detector is configured to concurrent operation of the two low pass filterings;

a subtractor configured to receive outputs from the low pass filters; wherein the subtractor is further configured to subtract the low pass filtered line signals to generate line-comb signal differences;

a horizontal low pass filter configured to receive outputs from the subtractor; wherein the horizontal low pass filter is further configured to filter the line-comb signal differences to exclude possible interference of chroma residue;

an absolute circuit configured to receive outputs from the horizontal low pass filter; wherein the absolute circuit is further configured to extract the magnitude of the low pass filtered line-comb signal differences to generate low frequency luminance difference;

a coring circuit configured to receive outputs from the absolute circuit; wherein the coring circuit is further configured to eliminate possible noise interference from the low frequency luminance difference;

a multiplier configured to receive outputs from the coring circuit; wherein the multiplier is configured to multiply the noise-free low frequency luminance difference; and

a saturation circuit configured to receive outputs from the saturation circuit; wherein the saturation circuit is further configured to clip the noise-free low frequency luminance difference to appropriate motion range to output the low frequency luminance motion for the current frame.

23. The motion detection system of claim 21, wherein the phase motion detector comprises:

a phase difference (PD) computing circuit configured for receiving from a signal input the current frame signal and a plurality of previous frame signals, and computing absolute phase difference values;

an enhanced chroma motion values (CD) computing circuit configured to receive outputs from the PD computing circuit, said CD computing enhanced chroma motion values by incorporating motion contributed by the quadrature chroma modulation using the absolute phase difference values from at least 3 lines;

a horizontal low pass filter configured to receive outputs from the CD computing circuit, said horizontal low pass filter smoothing the enhanced chroma motion values;

a coring circuit configured to receive outputs from the horizontal low pass filter, said coring circuit coring the smoothed enhanced chroma motion values;

a multiplier configured to receive outputs from the coring circuit, said multiplier further configured for multiplying the cored enhanced chroma motion values; and

a saturation circuit configured to receive outputs from the multiplier, said saturation circuit further configured for clipping the multiplied enhanced chroma motion values to generate the chroma motion signal.

24. The motion detection system of claim 21, wherein the demodulated phase motion detector comprises:

a plurality of demodulation circuits configured for receiving the current frame signal and a plurality of previous frame signals, and demodulating and low pass filtering the YC signals from the frame signals to generate two sets of chroma signals;

a plurality of computing circuits configured to receive outputs from the demodulation circuits, said plurality of computing circuits further configured for computing absolute phase differences PDU_m/PDV_m from the two sets of chroma signals;

a maxd circuit configured to receive outputs from the computing circuits, said maxd circuit further configured for taking the maximum between the PDU and PDV and duplicating the values to generate intermediate high frequency luminance motion;

a horizontal low pass filter configured to receive outputs from the maxd circuit, said horizontal low pass filter further configured for smoothing the intermediate high frequency luminance motion values;

a coring circuit configured to receive outputs from the horizontal low pass filter, said coring circuit further configured for coring the intermediate high frequency luminance motion values;

a multiplier configured to receive outputs from the coring circuit, said multiplier further configured for multiplying the intermediate high frequency luminance motion values; and

a saturation circuit configured to receive outputs from the multiplier, said saturation circuit further configured for clipping the intermediate high frequency luminance motion values to generate the high frequency luminance motion signal.

25. A method for detecting motions in a current frame of a component video signal, said method comprising the following steps of:

- detecting low frequency luminance motion between current frame and previous frame;

- detecting average difference chroma motion between the current frame and a plurality of previous frames;

- detecting average difference high frequency luminance motion between the current frame and a plurality of previous frames;

- taking the maximum among these three motion values;

- clipping the maximum motion value; and

- processing the maximum motion value in a 5-pixel horizontal window to generate the final motion value.

26. The method of claim 25, wherein the detecting low frequency luminance motion comprises the following steps of:

- low pass filtering at least three line signals of the current frame received from a signal input;

- low pass filtering at least three line signals of the previous frame received from the signal; wherein the two low pass filterings are done concurrently;

- subtracting the low pass filtered line signals to generate line-comb signal differences;

- horizontal low pass filtering the line-comb signal differences to exclude possible interference of chroma residue;

- extracting the magnitude of the low pass filtered line-comb signal differences to generate low frequency luminance difference;

- eliminating possible noise interference from the low frequency luminance difference;

- multiplying the noise-free low frequency luminance difference; and
- clipping the noise-free low frequency luminance difference to appropriate motion range to output the low frequency luminance motion for the current frame.

27. The method of claim 25, wherein the detecting average difference chroma motion comprises the following steps of:

- receiving from a signal input the current frame signal and a plurality of previous frame signals;
- computing absolute phase difference values between the current frame signal and the plurality of previous frame signals;
- computing enhanced chroma motion values using the absolute phase difference values;
- smoothing the enhanced chroma motion values;
- coring the smoothed enhanced chroma motion values;
- multiplying the cored enhanced chroma motion values; and
- clipping the multiplied enhanced chroma motion values to generate the chroma motion signal.

28. The method of claim 25, wherein the detecting average difference high frequency luminance motion comprises the following steps of:

- receiving the current frame signal and a plurality of previous frame signals;
- demodulating and low pass filtering the YC signals from the frame signals to generate two sets of chroma signals;
- computing circuits computing absolute phase differences PDU_m/PDV_m from the two sets of chroma signals;
- taking the maximum between the PDU and PDV and duplicating the values to generate intermediate high frequency luminance motion;
- smoothing the intermediate high frequency luminance motion values;
- coring the intermediate high frequency luminance motion values;
- multiplying the intermediate high frequency luminance motion values; and
- clipping the intermediate high frequency luminance motion values to generate the high frequency luminance motion signal.

29. An YC separation circuitry for separating a current frame of a component video signals into Y and C signals, comprising:

an inter-line correlator configured for detecting the relative chroma correlation between current and next line and current and previous line of the current frame from a signal input;

a line comb configured for removing the redundant chroma residue from the Y signal;

a frame comb configured for subtracting a previous frame signal $Y_{m,n-1}$ from the current frame signal $Y_{m,n}$ using a subtractor to generate the frame comb output;

a motion detector configured for detecting motions in a current frame of a component video signal;

a mixer circuit configured to receive outputs from the line comb and frame comb, said mixer circuit further configured extracting the final clean chroma signal using a weighted sum of line comb output, C_2D , and frame comb output, C_3D ; and

a subtractor configured to receive outputs from the motion detector, said subtractor further configured for extracting the final clean luminance signal.

30. The YC separation circuitry of claim 29, wherein the inter-line correlator comprises:

a narrowband filter configured for isolating the sub-band of the YC interleave frequency band from the YC signal from the signal input

gradient circuits configured to receive outputs from the narrowband filter, said gradient circuits further configured for computing the gradients of current and next line and current and previous line using narrow band-passed YC signals;

horizontal low pass filters configured to receive outputs from the gradient circuits, said horizontal low pass filters further configured for smoothing the gradients; and

a function circuit configured to receive outputs from the horizontal low pass filters, said function circuit further configured to output the weight for the line comb filter between the current and previous line.

31. The YC separation circuitry of claim 30, wherein the gradients are computed according to below equations:

$$G_{x,m,m+2} = \max\{|YC_{x+1,m+2} - YC_{x-1,m}|, |YC_{x-1,m+2} - YC_{x+1,m}|\},$$

$$G_{x,m,m-2} = \max\{|YC_{x+1,m-2} - YC_{x-1,m}|, |YC_{x-1,m-2} - YC_{x+1,m}|\},$$

wherein $G_{x,m,m+2}$ denotes the gradients of current and next line, and $G_{x,m,m-2}$ the gradients of current and previous line of a sample x; $YC_{x,m}$ refers to the composite signal of sample x and line m.

32. The YC separation circuitry of claim 31, wherein the weight for the line comb filter between the current and previous line is generated according to the below equation:

$$K_2D = \frac{G_{m,m+2,lp}}{G_{m,m+2,lp} + G_{m,m-2,lp}};$$

wherein K_2D is defined as the weight for the line comb filter between the current and previous line; $G_{m,m+2,lp}$ denotes the low passed gradients of current and next line, and $G_{m,m-2,lp}$ the gradients of current and previous line.

33. The YC separation circuitry of claim 29, wherein the line comb comprises:

a wideband filter configured for filtering out the low and high frequency signal and retaining only the frequency band with interleave Y and C signal;

a plurality of subtractors configured to receive outputs from the wideband filter, said plurality of subtractors further configured for computing the inter-line differences; and

a mixer configured to receive outputs from the subtractors, said mixer further configured for mixing the inter-line differences in corresponding to output signal from the inter-line correlator;

thereby outputting a weighted sum of inter-line pixel differences and the weights are determined.

34. The YC separation circuitry of claim 29, wherein the motion detector comprises:

a luminance motion detector configured for detecting low frequency luminance motion between current frame and previous frame;

a phase motion detector configured for detecting average difference chroma motion between the current frame and a plurality of previous frames; and

a demodulated phase motion detector configured for detecting average difference high frequency luminance motion between the current frame and a plurality of previous frames.

35. A method for separating a current frame of a component video signals into Y and C signals, said method comprising the steps of:

detecting the relative chroma correlation between current and next line and current and previous line of the current frame from a signal input;

removing the redundant chroma residue from the Y signal;

subtracting a previous frame signal $Y_{m,n-1}$ from the current frame signal $Y_{m,n}$ using a subtractor to generate the frame comb output;

detecting motions in a current frame of a component video signal;

extracting the final clean chroma signal using a weighted sum of line comb output, C_2D , and frame comb output, C_3D ; and

extracting the final clean luminance signal.

36. An article of manufacture, comprising:

a receiver;

an output component;

a YC separation circuitry; wherein the receiver is coupled to the YC separation circuitry and configured to provide component video signals; wherein the YC separation circuitry is configured to separate the component video signals into Y and C component signals, said YC separation circuitry comprising:

an inter-line correlator configured for detecting the relative chroma correlation between current and next line and current and previous line of the current frame from a signal input;

a line comb configured for removing the redundant chroma residue from the Y signal;

a frame comb configured for subtracting a previous frame signal $Y_{m,n-1}$ from the current frame signal $Y_{m,n}$ using a subtractor to generate the frame comb output;

a motion detector configured for detecting motions in a current frame of a component video signal;

a mixer circuit configured to receive outputs from the line comb and frame comb, said mixer circuit extracting the final clean chroma signal using a weighted sum of line comb output, C_2D , and frame comb output, C_3D ; and

a subtractor configured to receive outputs from the motion detector, said subtractor extracting the final clean luminance signal and;

wherein the output component is coupled to the YC separation circuitry and configured to receive the separated Y and C component signals.

37. The article of manufacture of claim 36, wherein the article is selected from the group consisting of chip, television, display sets, video CD player, DVD players or recorders and set-top-boxes with composite sources or sources that have composite conversion in at least one stage of processing prior to input.