Method and apparatus for evaluating color image signals

Verfahren und Apparat für Farbbildsignalbewertung

Méthode et appareil pour l'évaluation de signaux d'image en couleurs

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References cited:
• PROCEEDINGS OF THE INTERNATIONAL
CONFERENCE ON INDUSTRIAL
ELECTRONICS, CONTROL, AND
INSTRUMENTATION, CAMBRIDGE (US),
NOVEMBER 3-6, 1987; IEEE PRESS NEW
YORK (US) pages 703 - 708, XP10899 TOSHIO
ASANO ET AL. "Color quality inspection of
imaging device"

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BACKGROUND OF THE INVENTION

The present invention relates to a method for the quantitative evaluation of color image signals available from, for example, CCD color image sensors fabricated as a semiconductor IC. The invention also pertains to a color image signal evaluating apparatus utilizing the above-mentioned quantitative evaluation method.

In recent years there have been put to practical use CCD color image sensors which have mosaic color filters or stripe color filters coated on their front for creating color image signals. The CCD is produced using semiconductor IC techniques but it may sometimes be defective from various causes in its manufacturing process. Moreover, a positioning error or geometric misalignment is often induced when printing the color filter on the CCD in the fabrication of the color image sensor. Reproducing a color image signal derived from such an image sensor, the picture suffers various color reproduction errors owing to defects of the image sensor itself and geometric misalignment of the color filter. For instance, in the case where monochromatic light with no pattern, such as standard white light, is shed evenly all over the image receiving surface of the image sensor, (1) a slanted pattern of colored stripes appears in the reproduced picture, (2) a colored pattern of vertical or horizontal stripes appears in the reproduced picture, or (3) the reproduced picture is colored over a wide area.

In conventional testing of color image sensors, test personnel visually inspects the picture quality of a display image provided on a CRT display screen based on the color image signal from each image sensor and determines whether or not the above-mentioned color reproduction errors are each within a predetermined limit range. Hence, the traditional quality conformance inspection of color image sensors in the past was inefficient and many test personnel were needed for quality inspection of image sensors at the mass-production site, in particular. Besides, such evaluation of the picture quality is subjective and hence is inevitably subject to individual checkers’ judgment as to the aforesaid color reproduction errors—this poses a problem that image sensors having passed inspection scatter largely in their quality as to the color reproduction errors.

The document "Proceedings of the International Conference on Industrial Electronics, Control and Instrumentation", Nov. 3-6, 1987, IEEE Press New York (US), pages 703 to 708, discloses an automated color defect inspection system of color imaging devices. The system uses color image processing technology, but does not use the conventional primary color components R, G, B. In this known system, two kinds of chrominance signals (R-Y, B-Y) are introduced to analyze color images.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a method for quantitatively evaluating various color reproduction errors of a color image signal from a color image sensor and a color image signal evaluating apparatus employing the quantitative evaluating method.

This object is achieved with an apparatus and a method as claimed, in claims 1 and 6 respectively.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating an apparatus for evaluating basic chromaticity according to the first embodiment of the present invention;
Fig. 2 is a flowchart showing a process for detecting the basic chromaticity by the apparatus shown in Fig. 1;
Fig. 3 is a graph showing examples of variations of a maximum mean saturation with block sizes in the apparatus of Fig. 1;
Fig. 4 is a flowchart showing a process for detecting the basic chromaticity according to the second embodiment of the present invention;
Fig. 5 is a graph showing an example of the relationship between hue and a correcting value;
Fig. 6 is a block diagram illustrating an apparatus for evaluating a slanted pattern factor according to the third embodiment of the present invention;
Fig. 7 is flowchart showing a process for detecting the slanted pattern factor by the apparatus depicted in Fig. 6;
Fig. 8 is a graph showing an example of a saturation histogram;
Fig. 9 is a diagram showing a colored pattern written on a color matrix memory when the slanted pattern factor is large;
Fig. 10 is a diagram showing a colored pattern written on the color matrix memory when the slanted pattern factor is small;
Fig. 11 is a block diagram illustrating an apparatus for evaluating a border striped pattern factor according to the third embodiment of the present invention;
Fig. 12 is a flowchart showing a process for detecting the border striped pattern factor by the apparatus depicted
in Fig. 11;
Fig. 13 is a diagram for explaining the directions in which to integrate the contents of each color matrix memory and X and Y integrated counts obtained thereby;
Fig. 14 is a graph showing an example of a weighting function for the integrated counts;
Fig. 15 is a graph showing integrated saturation and for explaining a method of defining borders A and B of a striped pattern;
Fig. 16 is a diagram for explaining an operation for applying the integrated saturation to a low-pass filter;
Fig. 17 is a block diagram illustrating an apparatus for evaluating a center striped pattern factor according to the third embodiment of the present invention;
Fig. 18 is a flowchart showing a process for detecting the center striped pattern factor by the apparatus depicted in Fig. 17;
Fig. 19 is a graph showing an example of a weighting function for the integrated counts;
Fig. 20 is a graph showing an example of a weighting function for the integrated saturation;
Fig. 21 is a block diagram illustrating a general color reproduction error evaluating apparatus according to the third embodiment of the present invention; and
Fig. 22 is a block diagram illustrating another example of the general color reproduction error evaluating apparatus.

DETAILED EXPLANATION OF PREFERRED EMBODIMENT

[First Embodiment]

Fig. 1 illustrates in block form a color image signal evaluating apparatus for evaluating the basic chromaticity through utilization of a color image signal evaluating method according to the present invention. The basic chromaticity herein mentioned is a measure for evaluating a color reproduction error of an image which is formed on the display screen of a color CRT by red, green and blue monochromatic signals from an image sensor irradiated uniformly all over its image receiving surface with standard white light of no patterns, and which is wholly or partly colored very lightly in a certain color.

In Fig. 1 reference numeral 10 indicates a color image signal source obtained from the output of a color image sensor such as a color CCD. The color image signal source 10 may be composed of outputs 10R, 10G and 10B which are obtained by converting R, G and B signals from the color image sensor into digital form by means of A/D converters, or may be composed of memories 10R, 10G and 10B each having stored therein such digital signals for one frame.

This embodiment will be described in connection with the case where the color image signal source 10 is composed of the memories 10R, 10G and 10B. In this instance, a color image signal created by applying non-pattern standard white light evenly all over the image receiving surface of a color image sensor, for example, is separated into red, green and blue monochromatic signals (hereinafter referred to simply as R, G and B signals) and R, G and B image signal data obtained by A-D converting the monochromatic signals are stored in the three memories 10R, 10G and 10B, respectively.

The color image data R, G and B read out of the color image data source 10 are provided to an HLS transform part 20, wherein they are transformed to hue image data H, lightness image data L and saturation image data S.

The hue image data H is represented by angles from 0 to 360 degrees. For instance, angles from 0° to 30° and from 330° to 360° represent red; 30° to 90° represent yellow; 90° to 150° represent green; 150° to 210° represent cyan; 210° to 270° represent blue; and 270° to 330° represent magenta. The respective colors may sometimes be classified by numbers of 12 bits.

The lightness represents the brightness of the display image and the saturation represents the vividness of its color, and they are each expressed by a value ranging from 0 to 1.0. An algorithm for calculating from the levels of the R, G and B signals the hue H, the lightness L and the saturation S of a color composed by these signals, that is, an HLS transform algorithm, is well-known, hence no description will be given of the algorithm. The HLS transformation may be replaced with an HSV transformation or the like which is approximately equivalent thereto.

The hue image data H, the lightness image data L and the saturation image data S of one frame obtained in the HLS transform part 20 are stored in the hue, lightness and saturation image memories 30H, 30L and 30S, respectively.

For the evaluation of basic chromaticity according to the first aspect of the present invention, the hue image memory 30H and the lightness image memory 30L are unnecessary, because only the saturation image data S stored in the saturation image memory 30S is used.

As shown in the flowchart of Fig. 2, a calculation part 31 divides, in step S1, the saturation image data S in the saturation image memory 30S into blocks KB each composed of m × n pixels and, in step S2, the calculation part 31 reads out the saturation image data S for each block and calculates mean saturation in each block KB. In step S3 it is determined whether or not the saturation image data has been read out for all the blocks, and if not, the process returns to step S2. In this way, the process is performed over the entire area of the picture without overlapping of the blocks.
The number of pixels, \( m \times n \), of each block KB is initially about 10 \( \times \) 10, for example.

Thereafter, in step \( S_2 \) a maximum one of the mean saturation values in the frame is extracted and stored. In step \( S_2 \) it is determined whether or not the size of the block KB has exceed a predetermined value, and if not, the block size, \( m \times n \), is changed such that \( m = m + K_1 \) and \( n = n + K_2 \) in step \( S_2 \). Then, the process goes back to step \( S_1 \) and in steps \( S_2 \) and \( S_3 \) the mean saturation of each block is obtained again over the entire picture frame, after which a maximum mean saturation is extracted.

As described above, each time the size of the block KB is changed, the mean saturation of each block KB is obtained over the entire area of the picture and a maximum mean saturation value for the frame is extracted and stored in steps \( S_1 \) through \( S_3 \).

When it is determined in step \( S_2 \) that the block size becomes such that the frame of image can contain, for example, four blocks, the process proceeds to step \( S_4 \), in which the sum of all the maximum mean saturation values obtained until then is calculated, and the calculation part 31 outputs the sum as the basic chromaticity \( T_0 \).

Since the block size is gradually changed as mentioned above, a certain colored local pattern, for instance, provides a fixed maximum mean saturation value until the block size becomes about the same size of the colored pattern, and as the block size becomes larger than the size of the colored local pattern, the mean saturation of the block containing the colored local pattern gradually drops. On the other hand, the basic chromaticity over the entire picture provides substantially constant maximum mean saturation corresponding to its strength or intensity independently of the change in the block size. It can be determined, therefore, that the smaller the sum of the maximum mean saturation values, \( T_0 \), the less the basic chromaticity in terms of the size and intensity of the colored pattern.

Fig. 3 shows a graph in which the maximum mean saturation values of the block KB for respective block sizes are plotted based on measured data for various color image sensors A to F. The sum of the maximum mean saturation values, \( T_0 \), obtained in step \( S_2 \) represents the area surrounded by each of the curves A through F and the horizontal coordinate axis. There is a tendency that the color image sensors under test are good when they present characteristics close to a monotone decreasing function, that is, when the maximum mean saturation rapidly decreases with an increase in the block size \( m \) or \( n \) as indicated by the curves A, B, and C. Whereas, the color image sensors are no good when their characteristics are such as indicated by the curves D, E, and F.

As described above, according to the present invention, the saturation image data is divided into the blocks KB, the mean saturation is calculated for each block, the maximum mean saturation value for the frame is obtained for each block size, the maximum mean saturation values thus obtained are accumulated, and the accumulated value is provided as the basic chromaticity. The basic chromaticity is compared with a criterion of the quality of color image sensors, and they are determined to be good or no good, depending on whether the basic chromaticity is lower or higher than the criterion. Hence, the determination is made unequivocally. Accordingly, the quality inspection more reliable than the visual inspection can be achieved and the inspection can be effected automatically. This permits a larger number of devices in a shorter time, and hence achieves saving of labor.

While in the above the process ends when the block size is reduced down to 1/4, the block size in this instance is not limited specifically thereto but may also be set to an arbitrary value. Moreover, the blocks are described not to overlap but the same results could be obtained, even if the blocks overlap.

It will easily be understood that the present invention is applicable not only to the test of semiconductor color image sensors but also as a method and apparatus for evaluating color image signals.

[Second Embodiment]

In the above-described first embodiment of the present invention only the saturation data is used to define the basic chromaticity for determining the presence or absence of the color reproduction error. The human color sensitivity differs with colors, and the reproducibility of colors scatters owing to different characteristics of color filters coated on the image sensors; namely, a specific color is emphasized or deemphasized according to the model of the color image sensor used.

In determining the presence or absence of color reproduction error based solely on the saturation value, there is the possibility of determining "color shading is present" even if the saturation value is large due to the presence of color reproduction error in a color to which the human eyes are not so much sensitive.

According to the second embodiment of the present invention, basic chromaticity free from the above defect is detected as a measure for evaluating color reproduction error. To this end, the hue image memory 30H in Fig. 1, though not used in First Embodiment, is employed and the hue image data read out of the hue image memory 30H is provided to the calculation part 31 as indicated by the broken line in Fig. 1.

According to the second embodiment of the present invention, when the mean saturation of each block KB in the saturation image memory 30S is obtained in step \( S_2 \) of the flowchart shown in Fig. 2, hue values at pixel positions corresponding to pixels forming the block KB are read out from the hue image memory 30H, color correction values are computed from the read-out hue values and are used to correct the saturation values of pixels forming the block.
KB, and the saturation values thus corrected are averaged to thereby compute the mean saturation of the block KB. Fig. 4 shows the flow of this process. In step $S_{22}$, the saturation values of $m \times n$ pixels forming each block KB are read out from the saturation image memory $30S$, and at the same time, hue values $H$ are read out of the hue image memory $30H$ at the corresponding pixel positions. In step $S_{22}$, color correction values $F$ are obtained from the hue values $H$.

The color correction value $F$ in step $S_{22}$ is given, for example, by

$$F = A_0 + \sum_{i=1}^{h} A_i \cos(i \cdot H + B_i) \quad ...(1)$$

where in $A_0$, $A_1$, and $B_i$ are coefficients. Fig. 5 shows the characteristic of the color correction value $F$ in the case where $h = 2$, $A_0 = 2.0$, $A_1 = 1.0$, $A_2 = 0.5$, $B_1 = 10$ and $B_2 = 300$. By suitably selecting the values of $h$, $A_0$, $A_1$, and $B_i$, the correction characteristic shown in Fig. 5 can be set to a desired characteristic.

In step $S_{22}$, the saturation value $S$ is multiplied by the color correction value $F$ to obtain a corrected saturation. In step $S_{24}$, the corrected saturation value is used to compute the mean saturation of each block KB.

After the mean saturation of each block KB having the block size $m \times n$ is calculated over the entire image frame as in steps $S_2$ and $S_4$ depicted in Fig. 2, a maximum mean saturation value is selected in step $S_6$, and in step $S_8$ such maximum mean saturation values obtained in steps $S_4$ through $S_8$ are added together. Instead of adding together all the maximum mean saturation values at one time in step $S_6$, they may also be added one by one in step $S_8$.

Upon request, the basic chromaticity $T_s$, which is the result of the addition, is compared with a reference value. The basic chromaticity above the reference value means no good and the basic chromaticity below the reference value means good.

As described above, according to the second embodiment of the present invention, in the case of obtaining the mean saturation, the saturation value at each pixel is corrected by a color correction value obtained from the hue value at the pixel position, by which it is possible to make the decision in conformity to the human color sensitivity or the characteristic of the color filter mounted on the front of the image sensor.

Since the color correction value $F$ can be set to a desired value for each color as shown in Fig. 5, by a suitable selection of the value $h$ shown in Eq. (1), the criterion can be set for each color in accordance with the color characteristics of the color signal from the device under test. Accordingly, a striped pattern of a color not so strong in terms of the human color sensitivity can be declared to be negligible even though its mean saturation value is large, and a striped pattern of a color pale but easily noticeable can be declared no good. This enables, for example, CCD manufacturers to classify color image sensors according to their own criteria.

Although in the above the color correction value is calculated for each pixel, it is also possible to adopt a method in which the hue image memory $30H$ is also divided into blocks KB as is the case with the saturation image memory $30S$ and the color correction value $F$ is obtained from the mean saturation of each block KB through use of Eq. (1).

Also it is possible to employ an arrangement in which curves for determining the color correction value $F$ are prestored in a memory and a curve having various characteristics is called, as required, for converting the hue value to the color correction value.

[Third Embodiment]

Fig. 6 illustrates in block form a color image signal evaluating apparatus for evaluating a slanted striped pattern according to the third embodiment of the present invention.

In Fig. 6 reference numeral 10 indicates a color image signal source which is the output of a color image sensor such as a color CCD, as in the case of Fig. 1. For instance, standard white light is irradiated over the entire area of the image receiving surface of the color image sensor. As a result of this, the red, green and blue signals $R$, $G$ and $B$ are provided from the color image signal source 10 separately of one another.

The respective monochromatic signals $R$, $G$ and $B$ thus output from the color image signal source 10 are transformed by the HLS transform part 20 to hue image data and saturation image data.

The hue image data $H$ and the saturation image data $S$ of one frame, thus obtained from the HLS transform part 20, are stored in the hue image memory $30H$ and the saturation image memory $30S$, respectively. That is, letting the number of all pixels forming one frame be represented by $N$, $N$ pieces of hue image data $H$ and $N$ pieces of saturation image data $S$ are loaded into the memories $30H$ and $30S$. Fig. 6 shows an arrangement in which the brightness image data $L$ is also obtained. The brightness image data $L$ is stored in the brightness image memory $30L$.

Only those of the saturation data stored in the memory $30S$ which are above a reference value are used for the evaluation of the color image signal. The reference saturation value may be the mean saturation value per pixel for the entire saturation data stored in the memory $30S$, a value obtained by multiplying the mean saturation value by a fixed coefficient, or a certain value equal to or greater than 0 predetermined regardless of the saturation data $S$. When
the reference value is 0, all the pieces of saturation data S are to be subjected to evaluation. Here, the calculation part 31 follows the flowchart of Fig. 7 to define the reference value of saturation by the mode of saturation and determines the slanted striped pattern factor based on correlation coefficients of pixel positions where saturation is higher than the reference value.

In step S1, the saturation image data is read out of the saturation image memory 30S to obtain a histogram, from which is obtained a mode value of saturation or the most frequent level in the histogram. Fig. 8 shows an example of the histogram of saturation image data. The histogram can be obtained by dividing the width of saturation 0 to 1.0 into, for example, 1,000 equal sections and by calculating the number of pixels in each saturation section. The center saturation value in each saturation section may be used as the saturation representing the section. In this example, a saturation value Sm is shown to present the highest frequency value (which will hereinafter referred to as a mode value).

In the next step S2 the mode saturation value Sm is multiplied by a predetermined ratio p to obtain the reference saturation value Sr. This example will be described with respect of the case where the predetermined ratio p is 0.5.

In step S3, pixels with saturation above the reference saturation value Sr are read out from the memory 30S. Further, the hue image data H is read out from the hue image memory 30H using each of the addresses of the pixels where the saturation is above the reference saturation Sr; the color represented by the hue image data H is decided by a color deciding part 32 and a "1" is written, at the corresponding address, in that one of color matrix memories 40R to 40M which corresponds to the color identified by the color deciding part 32. At addresses corresponding to the other pixel positions "0"s are held. Consequently, "1"s are stored in each of the color matrix memories 40R to 40M at pixel positions where the saturation value is larger than the reference value Sr = 0.5Sm. The colors corresponding to the color matrix memories 40R, 40G, 40B, 40Y, 40C and 40M are red for 40R, green for 40G, blue for 40B, yellow for 40Y, cyan for 40C and magenta for 40M.

Next, in step S4 a correlation coefficient r of the X and Y coordinates of pixel positions where the "1"s have been written in the color matrix memory is obtained for each color, that is, for each of the six colors in this example. The correlation coefficient r is given by the following equations:

\[
\begin{align*}
    r &= \frac{\sigma_{xy}}{\sigma_x \sigma_y} \\
    \sigma_x &= \sqrt{\frac{1}{n} \sum_{i=1}^{n} (x_i - \bar{x})^2} \\
    \sigma_y &= \sqrt{\frac{1}{n} \sum_{i=1}^{n} (y_i - \bar{y})^2} \\
    \sigma_{xy} &= \frac{1}{n} \sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})
\end{align*}
\]...

Here, \((x_i, y_i)\) is the pixel position where "1" is stored, \(n\) is the number of such pixel positions, and \(x\) and \(y\) are mean values of \(x_i\) and \(y_i\) (where \(i = 1, \ldots, n\)).

The absolute values of the correlation coefficients \(r\) for the six colors are obtained. The absolute values will hereinafter be represented by \(R\). The absolute value \(R\) is large when the pixel positions where "1"s are stored in each of the color matrix memories 40R through 40M are distributed so that they form a slanted pattern as shown in Fig. 9. On the other hand, when the pixel positions where "1"s have been stored are discrete as depicted in Fig. 10, the absolute value is small.

In step S5, the number of pixels, \(n\), where "1"s have been written in each of the color matrix memories 40R through 40M is divided by the total number, \(N\), of pixels of one frame to normalize the pixel number \(n\), obtaining its normalized
value $K = n/N$. This normalization is intended to permit evaluation of colors for image sensors with different numbers of pixels.

In step $S_2$, the values $R$ and $K$ are obtained for each color and a slanted striped pattern factor $I = R \times K$ for each color. In the next step $S_3$, a maximum one of the slanted striped pattern factors $I$ of the respective colors is detected and the maximum slanted striped pattern factor is provided as a representative slanted striped pattern factor $I_m$ of the color image signal. Alternatively, a mean value of the slanted striped pattern factors of all the colors may be used as the representative slanted striped pattern factor $I_m$. The calculation part $31$ outputs the representative slanted striped pattern factor $I_m$ thus defined. For example, when the representative slanted striped pattern factor $I_m$ is larger than a predetermined value, it can be determined that the image sensor under test is no good.

In its computation in step $S_3$, the slanted striped pattern factor $I = R \times K$, may also be weighted for each color. That is, colors can be classified into gay and quiet colors. Therefore, it is considered reasonable to employ different criteria for respective colors by multiplying the slanted striped pattern factors $I$ of gay colors by large weighting coefficients $W$. The weighting coefficient $W$ can be set, for example, to $1.0$ for red $R$ and magenta $M$, $0.75$ for green $G$ and yellow $Y$, and $0.5$ for cyan $C$ and blue $B$.

Thus, a maximum or mean value of the values obtained by multiplying the slanted striped pattern factors $I$ of the respective colors by the weighting coefficients $W$ may be defined as the representative slanted striped pattern factor $I_m$, by which the detection sensitivity can be enhanced for the gay colors.

As described above, the color reproduction error which is contained in the color image signal and appears as a slanted striped pattern in the reproduced picture can be detected mechanically, not artificially. Accordingly, the color image signal from the color image sensor can be evaluated in a short time. This permits testing of a large number of color image sensors in a short time and hence saves labor. Moreover, since the evaluation does not scatter, the test can be made with high reliability.

While in the above the six colors, i.e., red, green, blue, yellow, cyan, and magenta, are used, it can easily be understood that the present invention is not limited specifically to the six colors but is applicable as well to the test employing three to 12 colors including red, green, and blue.

Next, a description will be given, with reference to Figs. 11 through 16, of a color image signal evaluating apparatus for evaluating vertical and lateral stripes in peripheral portions of the picture through utilization of the color image signal evaluating method still according to the third embodiment of the present invention. As shown in Fig. 11, the apparatus has an arrangement in which color saturation memories $50R$ to $50M$ corresponding to the respective colors are connected to the calculation part $31$ in the apparatus depicted in Fig. 6. Also in this embodiment, for instance, standard white light with no pattern is applied all over the image receiving surface of an image sensor not shown. As is the case with Fig. 6, the red, green and blue monochromatic signals $R, G$ and $B$ from the color image signal source 10, which is the output of the image sensor, are transformed by the HLS transform part 20 to hue image data $H$, lightness image data $L$, and saturation image data $S$, which are stored in the memories $30H, 30L$ and $30S$, respectively.

As in the case of Fig. 6, the saturation image data $S$ is read out of the saturation image memory $30S$ to obtain a histogram of saturation, from which is obtained a mode value $S_m$ of saturation or the most frequent level in the histogram. The mode saturation value $S_m$ is used to determine the reference saturation $S_r$ in the same manner as in the case of Fig. 6, and the positions or addresses of pixels where values of the saturation image data in the memory $30S$ are greater than the reference saturation values are provided to the color deciding part $31$. The color deciding part $31$ identifies the colors corresponding to those pieces of hue image data in the memory $30H$ which correspond to the above addresses and selects the color matrix memories $40R$ through $40M$ of the corresponding colors accordingly and writes therein a "1" at each of the corresponding addresses as in the case of Fig. 6. As a result of this, red image data based on the saturation image data having values greater than the reference saturation value $S_r$ are stored in the memory $40R$. Similar image data are stored in the memories $40G$ to $40M$ as well.

Moreover, the calculation part $31$ performs, as shown in Fig. 12, the following process using the data stored in the saturation image memory $30S$ and the color matrix memories $40R$ through $40M$.

Step $S_4$: Let the picture size be represented by numbers of pixels, $N_x$ and $N_y$, in the $x$- and $y$-axis directions, respectively. Accordingly, $N = N_x \times N_y$. According to the second embodiment of the present invention, $X$ and $Y$ registers $40x$ and $40y$ are provided in association with each of the color matrix memories $40R$ through $40M$, as exemplified in Fig. 13 in which the $X$ and $Y$ registers $40x$ and $40y$ are shown to be provided in association with the color matrix memory $40R$. The numbers of pixels each having stored therein a "1" in each column and each row of each color matrix memory are integrated, or counted in the $Y$ and $X$ directions, respectively, by the calculation part $31$ to obtain $N_x$ integrated values $Cx$ and $Ny$ integrated values $Cy$.

These integrated values $Cx$ and $Cy$ are stored in the $X$ and $Y$ registers $40x$ and $40y$. These integrated values will hereinafter be referred to as integrated counts. To equalize the evaluation of a striped pattern in the $X$ and $Y$ directions, the $N_x$ integrated counts $Cx$ are each multiplied by $N_x/N_y$, or the $Ny$ integrated counts $Cy$ are each multiplied by $N_x/N_y$. In the following description such a normalized integrated counts will be used as $Cx$ for the $X$ axis. The above processing is performed for each of the color matrix memories $40R$ through $40M$. 


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Step S2: According to this embodiment of the invention, the integrated counts Cx (normalized) and Cy loaded in the X and Y registers 40x and 40y provided in association with each color matrix memory are subjected to weighting shown in Fig. 14 so as to detect and evaluate stripes in the peripheral portion of the picture. In this instance, the integrated counts at those portions of each of the registers 40x and 40y which extend from either end thereof by a length, for example, 1/10 that of each register is weighted using a portion of a cosine function called an inverted Tucky 80% window, for example. By this weighting, detection sensitivity is provided in the peripheral portion of the picture.

Step S2: The calculation part 31 detects positions Xm and Ym of maximum ones of the integrated counts Cx and Cy for each color.

Step S3: According to the second embodiment of the invention, the saturation data corresponding to those pixel positions in each of the color matrix memories 40R to 40M at which the "1"s" have been stored are read out of the saturation image memory 30S and written into each of the corresponding color saturation memories 50R to 50M at the corresponding pixel positions. X and Y registers 50x and 50y are provided in association with each of the color saturation memories 50R to 50M, and saturation values in each memory are integrated in the X and Y directions to obtain Nx integrated values Sx and Ny integrated values Sy. These integrated values will hereinafter be referred to as integrated saturation values.

The integrated saturation values Sx and Sy are stored in the X and Y registers 50x and 50y. As is the case with the aforesaid integrated counts Cx, the integrated saturation values Sx are normalized by multiplication with Nx/Ny. In the following description the normalized integrated saturation values are used as Sx. The above processing is performed for each of the color saturation memories 50R through 50M.

Step S3: The integrated saturation values Sx and Sy corresponding to the positions Xm and Ym of the maximum integrated counts Cx and Cy in each of the color matrix memories 40R through 40M are obtained as Sxm and Sym, respectively.

Step S4: For each color the positions A and B where the integrated saturation values are, for example, 0.2 times the maximum values Sxm and Sym are detected on both sides of each of the positions Xm and Ym where the integrated saturation values are Sxm and Sym. Fig. 15 exemplifies this in respect of the integrated saturation Sx in the X register 50x provided in association with one of the color saturation memories.

Where the position where the saturation value is 0.2 times the maximum value cannot be found on either one of sides of the position Xm, that is, where the integrated saturation values Sx on that side are all greater than 0.2Sxm, the end of the X register 50x on that side is regarded as the position A or B. In a similar manner, the positions A and B are defined on both sides of Ym with respect to the integrated saturation values Sx in the Y register 50y. The process of step S3 is to define the positions of both ends A and B of the vertical or lateral stripe widthwise thereof.

It is preferable that prior to the detection of the positions A and B in step S3 the integrated saturation values Sx and Sy held in the X and Y registers 50x and 50y be applied to a low-pass filter with a length 3 (a 3-pixel length) to reduce noise. The low-pass filter with a length 3 in the case of the X register 50x, for instance, is a low-pass characteristic which is obtained by such processing as mentioned below.

That is to say, where the data loaded in the X register 50x of a certain color are arranged in the order Sx0, Sx1, Sx2, Sx3, ..., Sxn... (where i = 1, ..., Nx) as shown in Fig. 16, for example, three consecutive pieces of data Sx(i-1), Sxi and Sx(i+1) are respectively multiplied by weighting coefficients W1, W2 and W3 in multipliers 12, 13 and 14 and the multiplied outputs are added together by an adder 11. For example, when the weighting coefficients W1, W2 and W3 are 0.25, 0.5 and 0.25, the output Sxi of the adder 11 is given by the following equation:

\[
Sxi = 0.25Sx(i-1) + 0.5Sxi + 0.25Sx(i+1)
\]

The value Sxi is calculated for i = 1, ..., Nx. In this case, Sx0 = 0 and Sx(Nx+1) = 0. The calculated values are sequentially held in an auxiliary register 50a. When the value Sxi is obtained in the register 50a for all its, the register 50a is updated in accordance with the contents of the register 50a. An abrupt change in the value between the adjacent data Sx and Sx(i+1) is made gentle by this filtering. The data Sy in the Y register 50y is also subjected to similar processing.

Step S5: The distances Dx and Dy, between the two positions A and B detected in step S3 for integrated saturation values Sx and Sy of each color, as shown in Fig. 15 (only in connection with Sx), that is, the widths of the vertical and lateral stripes, are determined.

Step S6: The integrated saturation values Sx and Sy between the positions A and B are respectively summed up for each color. The sum values are represented by Vx and Vy. In this case, when Dx = 0, then Vx = 0, and when Dy = 0, then Vy = 0. These values mean integrated values of saturation S of sample pixels in the stripe defined by A and B in each of the saturation memories 50R through 50M. That is, these values mean the total strengths of saturation of the stripes.

Step S7: The integrated counts Cx and Cy between the two positions A and B are summed up for each color,
obtaining sum values Kx and Ky. In this case, when Dx = 0, then Kx = 0 and when Dy = 0, then Ky = 0. These values each mean the area of the stripe defined in width by A and B.

Step S10: Values \( \alpha_v \) and \( \alpha_h \), which are given by the following equations, are defined as vertical-stripe and lateral-stripe parameters, respectively.

\[
\begin{align*}
\alpha_v &= Vx + Dx + Nx \times Wx \\
\text{where: } &Wx = \begin{cases} 
0.5[1+\cos(2\pi \cdot 2Dx/Nx)]^J & \text{for } 0 < Dx \leq Nx/4 \\
0 & \text{for } Dx < Nx/4
\end{cases} \tag{7}
\end{align*}
\]

\[
\alpha_h = Vy + Dy + Ny \times Wy \\
\text{where: } &Wy = \begin{cases} 
0.5[1+\cos(2\pi \cdot 2Dy/Ny)]^J & \text{for } 0 < Dx \leq Ny/4 \\
0 & \text{for } Dy < Ny/4
\end{cases} \tag{8}
\]

In Eq. (7), \((Vx + Dx)\) represents mean integrated saturation per a column of pixels on the vertical stripe of the width Dx, and this is normalized in Eq. (7) through division by the X-direction size Nx of the display screen. The thus normalized value is weighted in Eq. (7) by a weighting function Wx which depends on Dx/Nx. The same is true of Eq. (8). Incidentally, J is a value of about 5, for example.

Step S11: Since stripes are negligible when their widths are smaller than a certain value and their colors are not vivid, the parameters of a stripe whose widths Dx and Dy are smaller than K (K = 10, for example) are further weighted by the following equations:

\[
\alpha'_v = \alpha_v \times [0.5[1+\cos(2\pi \cdot Dx/2K)]]^{L} \tag{9}
\]

\[
\alpha'_h = \alpha_h \times [0.5[1+\cos(2\pi \cdot Dy/2K)]]^{L} \tag{10}
\]

In the above, L is a value of 0.67 or so, for instance. By a suitable selection of the value L, the values \( \alpha'_v \) and \( \alpha'_h \) can be made to approach 0 at a desired speed as the width of the stripe becomes smaller than the value K.

Step S12: For the afore-mentioned maximum integrated count positions Xm and Ym in each of the color matrix memories 40R through 40M, standard deviations \( d_x \) and \( d_y \) are obtained concerning the positions Xj, Yk of all pixels having stored therein "1" within the stripe width defined as mentioned previously. The standard deviations are modified ones, which are given by the following equations:

\[
d_x = \sqrt{n_x} \times \sqrt{\sum_{j=1}^{n_x} (x_j - Xm)^2 \cdot S_j^2} \quad \ldots (11)
\]

\[
d_y = \sqrt{n_y} \times \sqrt{\sum_{k=1}^{n_y} (y_k - Ym)^2 \cdot S_k^2} \quad \ldots (12)
\]

In the above, \( S_j \) and \( S_k \) are saturation values of each sample pixel at the position Xj, Yk and \( n_x \) and \( n_y \) are the numbers of sample pixels having stored therein "1" within the stripe widths Dx and Dy.

Step S13: For each color the following equations are calculated:
The calculation part 31 outputs the peripheral striped pattern factor \( Pm \) thus calculated.

The color image signal can be evaluated based on the peripheral striped pattern factor \( Pm \) obtained as mentioned above. That is, when the value of the peripheral striped pattern factor \( Pm \) is large, it can be determined that a vertical or lateral striped pattern occurs near the border of the screen owing to the color reproduction error. Accordingly, the quality of image sensor can be checked depending on whether or not the peripheral striped pattern factor \( Pm \) is greater than a predetermined value.

As described above, according to this embodiment of the present invention, it is possible to qualitatively detect a striped pattern which occurs near the border of the display screen owing to the color reproduction error. In consequence, the quality inspection can be effected with higher reliability than in the case of visual inspection. In addition, the use of a computer for calculating the pattern factor permits automatic inspection, and hence achieves labor saving as well.

In the above embodiment the cosine function is used as the curve for providing the weighting function, but a polygonal line function may also be employed. It will be seen that the length of the low-pass filter is not limited specifically to "3".

Next, a description will be given, with reference to Figs. 17 through 20, of a color image signal evaluating apparatus for evaluating vertical and lateral stripes near the center of the display screen through utilization of the color image signal evaluating method still according to the third embodiment of the present invention. The apparatus of this embodiment is basically identical in construction with the apparatus of Fig. 11 except the provision of a histogram flattening part 33. Also in this evaluation method, an image sensor (not shown) is irradiated all over its image receiving surface with, for example, standard white light, and its output \( R \), \( G \) and \( B \) signals are used as the \( R \), \( G \), and \( B \) monochromatic signals which are derived from the signal source 10 in Fig. 17.

This embodiment is common to that of Fig 6-10 and that of Fig. 11 to 16 also in the process in which a "1" is written into each of the color matrix memories 40S to 40M at the pixel positions corresponding to those in the corresponding saturation memory at which the saturation value is greater than the reference saturation value.

According to the present embodiment of the invention, the saturation histogram obtained in the calculation part 31 is provided to the histogram flattening part 33, wherein it is flattened. What is intended to mean by "histogram flattening" is to make the mean number of pixels per unit saturation constant over the entire area of the display screen. The histogram flattening emphasizes the contrast among colors in terms of their vividness.

The saturation image data emphasized in the histogram flattening part 33 is written into each of the color saturation memories 50R through 50M as in the case of Fig. 11. Referring now to Fig. 18, the subsequent process by the calculation part 31 will be described.

Step S1: The integrated counts \( Cx \) and \( Cy \) obtained in the same manner as described previously in connection with fig. 11 are loaded into the registers 40x and 40y similar to those shown in Fig. 13. This embodiment is also common to third embodiment in that the integrated count is normalized through multiplication by the image size ratio \( Nx/Ny \) to thereby eliminate the influence of different image sizes in the \( X \) and \( Y \) directions.

Step S2: According to the third embodiment of the invention, in order to detect and evaluate a striped pattern in the center of the display screen, the integrated counts \( Cx \) and \( Cy \) loaded in the \( X \) and \( Y \) registers 40x and 40y each of the color matrix memories 40R to 40M (see Fig. 13) are subjected to weighting depicted in Fig. 19. In this instance, the integrated counts at those portions of each of the registers 40x and 40y which extend from either end and thereof by a length of, for example, 1/10 that of each register is weighted by a portion of a cosine function called a Turkey 80% window, for instance, this weighting provides detection sensitivity in the center of the display screen.

Step S3: The positions \( Xm \) and \( Ym \) of the maximum ones of the integrated counts \( Cx \) and \( Cy \) are detected for each of the color matrix memories 40R through 40M.

Step S4: The saturation values stored in each of the color saturation memories 50R through 50M after being subjected to the histogram flattening are integrated in the \( Y \) and \( X \) directions, and the integrated saturation values \( Sx \)
and Sy are stored in the registers 50x and 50y provided in association with each color saturation memory. As in the case of Fig. 12, the integrated saturation value Sx stored in the register 50x is multiplied by the ratio Nx/Ny, whereby it is normalized for eliminating the influence of the size of the screen.

Step S5: As in step S2 of the flowchart shown in Fig. 12, the integrated saturation values Sx and Sy corresponding to the positions Xm and Ym of the maximum ones of the integrated counts Cx and Cy in the registers 40x and 40y for each of the color matrix memories 40R through 40M are obtained as Sxm and Sm, respectively. In this instance, the integrated saturation value of each color in each direction is subjected to weighting shown Fig. 20. The curve for this weighting is a modified form of a cosine function which uses, as one cycle thereof, the lengths of each color saturation memory in the X and Y directions, i.e. the sizes Nx and Ny of the display screen in the X and Y directions.

The integrated saturation values Sx and Sy stored in the registers 50x and 50y of each color are provided to the low-pass filter having a length of, for example, 3 to reduce noise as described previously in connection with Fig. 16.

Step S6: As in step S6 of the flowchart shown in Fig. 12, the positions A and B where the integrated saturation values are, for example, 0.5 times the maximum ones Sxm and Sm are detected on both sides of the positions Xm and Ym where the integrated saturation values are Sxm and Sm (see Fig. 15). Where such a position is not found on either one of sides of the positions Xm and Ym, that is, where the integrated saturation values Sx and Sy are all greater than 0.5Sxm and 0.5Sy on that side, ends of the registers 50x and 50y on that side are regarded as the positions A or B.

Step S7: For each color the distance between the positions A and B, that is, the widths of the vertical and lateral stripes, Dx and Dy, are obtained.

Step S8: The integrated saturation values Sx and Sy between the positions A and B are respectively summed up for each color to obtain values Vx and Vy. In this case, when Dx = 0, then Vx = 0 and when Dy = 0, Vy = 0.

Step S9: Mean values SX and SY of the integrated saturation values Sx and Sy in the registers 50x and 50y are obtained for each color. Standard deviations of the integrated saturation data for the mean integrated saturated values are obtained by the following equations for integrated saturation data Sxh and Syi stored in the registers 50x and 50y within the ranges between (Nx/8) + 1 to 7Nx/8 and between (Ny/8) + 1 to 7Ny/8 except their both end portions, for example, 1/8 the entire lengths of the registers.

\[
e_{x} = \sqrt{\frac{\sum (Sx - \bar{S}x)}{n}} \quad (16)
\]

\[
e_{y} = \sqrt{\frac{\sum (Sy - \bar{Sy})}{n}} \quad (17)
\]

Step S10: Modified standard deviations qx and qy of the pixel positions relative to the maximum integrated count positions Xm and Ym corresponding to each of the color matrix memories 40R through 40M are obtained, by the following equations, for all pixels (the number of which is represented by n) having "1" within the central area of the color matrix memory except its marginal portions on all sides by a width equal to 1/16 its length. The numbers of sample pixels in this case are represented by Nx and Ny.

\[
x = \sqrt{\sum_{j=1}^{n} \frac{(Xj-Xm)^{2}}{Sj^{2}}} \quad \ldots (18)
\]

\[
y = \sqrt{\sum_{k=1}^{n} \frac{(Yk-Ym)^{2}}{Sk^{2}}} \quad \ldots (19)
\]

Step S11: The following equations are calculated:

\[
Qx = Vx \times e_{x} \times q_{x} \times n \quad (20)
\]
Step S12: The following equations are calculated:

\[ U_x = Q_x \times D_x^2 \times \left[ 0.5 \{ 1 + \cos(2\pi D_x/N_x) \} \right]^2 \]  
\[ U_y = Q_y \times D_y^2 \times \left[ 0.5 \{ 1 + \cos(2\pi D_y/N_y) \} \right]^2 \]  

Step S13: For example, if \( n < 2000 \), then the following center stripe parameters are calculated:

\[ \beta_x = U_x \times \left[ 0.5 \{ 1 + \cos(\pi/n) \} \right]^2 \]  
\[ \beta_y = U_y \times \left[ 0.5 \{ 1 + \cos(\pi/n) \} \right]^2 \]  

In the above, \( J \) can be set to 3.67, for example.

Step S14: Further, if the widths of the stripe, \( D_x, D_y \), are smaller than \( K \) (where \( K = 10 \), for example) as in step S11 of the flowchart shown in Fig. 12, then the center stripe parameters are weighted as follows:

\[ \beta_x' = \beta_x \times \left[ 0.5 \{ 1 + \cos(2\pi D_x/2K) \} \right]^L \]  
\[ \beta_y' = \beta_y \times \left[ 0.5 \{ 1 + \cos(2\pi D_y/2K) \} \right]^L \]  

In the above, \( L \) is 6.6, for instance.

Step S15: By the above-described processing a total of 12 pairs of data, \( \beta_x \) and \( \beta_y \), or \( \beta_x' \) and \( \beta_y' \), are obtained. A mean value \( Pa \) of these 12 pairs of data is used as the center stripe pattern factor, the calculation part 31 outputs the thus calculated center stripe pattern factor \( Pa \).

As described above, according to the third embodiment of the invention, the striped pattern factor can be obtained quantitatively. Accordingly, the quality of color image sensors can mechanically be checked and products of uniform characteristics can be obtained. Moreover, this method does not call for any manual operation, and hence is labor-saving and affords reduction of the manufacturing costs of image sensors.

In the above embodiment the low-pass filter with a length 3 is employed, but the length can be selected suitably.

Further, a portion of the cosine function is used as the weighting function, but a polygonal line function or similar one can be used.

As described above, the color image signal evaluating methods according to the third embodiment of the present invention individually evaluate color image signals based on different kinds of color reproduction errors. Accordingly, checking of color image sensors for all kinds of color reproduction errors is time-consuming and no comprehensive evaluation cannot be achieved.

Fig. 21 illustrates the comprehensive color image signal evaluation apparatus according to the third embodiment of the invention.

Reference numerals 110A, 110B, 110C and 110D indicate units for different kinds of color reproduction errors. These color reproduction error evaluating units are those shown in Figs. 1, 6, 11 and 17, respectively, and they output the basic chromaticity \( Ts \), the slanted stripe pattern factor \( Im \), the border stripe pattern factor \( Pm \) and the center stripe pattern factor \( Pa \).

These evaluated output data \( Ts, Im, Pm \) and \( Pa \) are provided to multipliers 111A through 111D, wherein they are multiplied by coefficients \( Ea, Eb, Ec \) and \( Ed \) prestored in a memory 112, and the multiplied outputs are applied to an adder 113.

The adder calculates the sum total \( \Omega \) of the multiplied outputs by

\[ \Omega = Ea \times Ts + Eb \times Im + Ec \times Pm + Ed \times Pa \]
The sum total Ω is provided to a deciding part 114, wherein it is compared with a reference value for deciding whether the device under test is good or no good. The result of decision is displayed on a display 115. The signal representing the decided result can also be used for automatically classifying, for example, color image sensors according to the decision.

The coefficients Ea, Eb, Ec and Ed prestored in the memory 112 can be experimentally obtained in advance. By combinations of these coefficients different kinds of color image sensors, for example, can be evaluated. The coefficients Ea, Eb, Ec and Ed can be set, for instance, as follows: Ea = 1.0, Eb = 0.1, Ec = 2.0 and Ed = -1.5.

The color reproduction error evaluating units are not limited specifically to the afore-mentioned units. Of course, other kinds of color reproduction error evaluating units may also be provided.

Although the color reproduction error evaluating units 110A through 110D in Fig. 21 are described to correspond to those depicted in Figs. 1, 6, 11 and 17, respectively, these units 110A through 110D are common in some constituent elements, as will be seen from Figs. 1, 6, 11 and 17.

Fig. 22 is a functional block diagram of a comprehensive color image signal evaluating apparatus constructed to share the same constituent elements.

The image signal source 10, the HLS transform part 20, the hue image memory 30H, the saturation image memory 30S, color matrix memories 40R to 40M, the histogram calculation part 31a, and the color saturation memories 50R to 50M are used in common to all or some of the different kinds of color reproduction error evaluation.

In the evaluation of the basic chromaticity according to first embodiment of the invention, the saturation data S is read out from the saturation image memory 30S for each predetermined block size and in a maximum mean saturation calculation part 34 the mean value of the saturation in each block is calculated, (step S3 in Fig. 2), a maximum one of the mean saturation values is found (step S4), and each time the block size is changed under control of a control part 100, the maximum mean saturation value is accumulated in an adding part 36 to obtain the basic chromaticity Ts, which is held in a basic chromaticity register 116A.

In the evaluation of the basic chromaticity Ts according to the second embodiment of the invention, prior to the calculation of the mean saturation value according to the first embodiment of the invention, the maximum mean saturation calculation part 34 reads out the hue image data H of the corresponding block in the hue image memory 30H, and then reads out the correction value F corresponding to the hue image data H from a correction value memory 35 having prestored therein such a correction value characteristic as shown in Fig. 5 and corrects the corresponding saturation by the correction value F (step S33 in Fig. 4), thereafter calculating the mean saturation.

In the evaluation of the slanted stripe pattern factor Im according to the invention, the correlation coefficient r of the pixel positions where "1" is stored in each of the color matrix memories 40R to 40M is calculated by a correlation coefficient calculation part 39 (step S4 in Fig. 7), the number of pixels, n, where "1" is stored is calculated by a pixel counter 41 (step S3), the slanted stripe pattern factor I for each color is calculated by a multiply and mean part 42 based on the correlation coefficient r and the number of pixels n (step S3), and in this embodiment the mean value of such slanted stripe pattern factors is output as the slanted stripe pattern factor Im and is held in a slanted pattern factor register 116B.

In the evaluation of the border stripe pattern factor Pm according to the invention, the stored contents of each of the color matrix memories 40R to 40M and each of the color saturation memories 40R to 50M are integrated by an integrated count calculation part 37 and an integrated saturation value calculation part 38 in the X and Y directions to obtain the integrated counts Cx and Cy and the integrated saturation values Sx and Sy, which are stored in each of the integrated count memories 40x and 40y and the integrated saturation memories 50x and 50y.

A border stripe pattern factor calculation part 44 determines the positions Xm and Ym of the maximum ones of the integrated counts Cx and Cy (step S3 in Fig. 12), defines the borders A and B of the striped pattern on both sides of the integrated saturation values Sx and Sym of the positions Xm and Ym (step S3), and calculates the integrated saturation summed values Vx and Vy (step S3) and the integrated count summed values Kx and Ky (step S3) within the areas defined by the borders A and B. Further, the calculation part 44 calculates the stripe parameters α and αb from the values Vx and Vy (step S10) and then calculates the standard deviations δx and δy of pixel positions having "1" near the border (step S12). The calculated results are held in a border stripe pattern factor register 116C. Incidentally, the sensitivity constant 0.2 for defining the borders A and B of the striped pattern in step S3 and the constant J for calculating the parameters α and αb by Eqs. (7) and (8) in step S10 are prestored in a parameter register 43.

In the evaluation of the center stripe pattern factor Pm according to the invention, the saturation is stored in each of the color saturation memories 50R through 50M after being emphasized in the histogram flattening part 33 (step S4 in Fig. 18). A center stripe pattern factor calculation part 45 defines the borders A and B of the striped pattern and calculates the integrated saturation summed values Vx and Vy in the area defined by the borders A and B as in the case of the evaluation of the border stripe pattern factor mentioned above. Further, the calculation part 45 calculates the deviations δx and δy of the integrated saturation values in the center (step S3) and then calculates the standard deviations δx and δy of pixel positions having "1" relative to the positions Xm and Ym in each matrix memory except its marginal portions (step S10). The calculation part 45 calculates the center stripe pattern parameters βx and βy from
the results of the above calculations and outputs the mean value of the parameters as the center stripe pattern factor \( Pa \), which is held in the center stripe pattern factor register 116D.

The data \( Ts, Im, Pm \) and \( Pa \) stored in the registers 116A to 116D are provided to the multipliers 111A to 111D, respectively, wherein they are multiplied by the coefficients \( Ea, Eb, Ec \) and \( Ed \) read out of the coefficient memory 112, and these multiplied results are added together by the adder 113. The added output \( \Omega \) is compared with a predetermined reference value in the deciding part 114. When the former is greater than the latter, it is decided that the color reproduction error contained in the color image signal is too large, i.e., that the image sensor under test is no good. When the added output is smaller than the reference value, the image sensor is decided to be good. The decision is displayed on the display 115.

While in Figs. 6, 11 and 17 the calculation part 31 and the color deciding part 32 are shown as different blocks, the calculation part 31 may be constructed to perform the function of the color deciding part 32 as well. That is, in the apparatus shown in Fig. 22 the data processing in and after the HLS transform part 20 can be executed by a computer, but a desired processing feature can also be constructed by dedicated hardware so as to speed up the data processing.

As described above, according to the third embodiment of the present invention, different kinds of color reproduction errors are detected in numerical form by the color reproduction error evaluating units 110A to 110D, the numerical values of the color reproduction errors thus detected are summed up after being multiplied by coefficients for normalization, and the color image signal is decided to be good or no good, depending on whether the sum \( \Omega \) is greater than a predetermined value. Hence, a comprehensive check of the color image signal can be made by the apparatus of this embodiment. For example, when employed for the test of color image sensors, the evaluating apparatus permits testing of various kinds of color reproduction errors at one time with high accuracy and in a short time.

Furthermore, many kinds of color image sensors can be tested with high accuracy when coefficients to be prestored in the memory 112 for each kind of image sensor are prepared.

**Claims**

1. A color image signal evaluating apparatus, comprising:

   a color image signal transform means (20) for transforming a color image signal (R, G, B) to saturation image data (S);
   a saturation image memory (30S) for storing at least one frame of said saturation image data; and
   basic chromaticity calculating means (31; 110A) adapted to perform the following calculation steps:

   (a) the saturation image data read out of said saturation image memory (30S) are divided into non-overlapping blocks of a predetermined size over the entire image area and averaged for each pixel block to obtain a respective mean saturation value for each pixel block,
   (b) the maximum one of said mean saturation values is determined,
   (c) steps (a) and (b) are performed for each of a predetermined number of pixel block sizes, and
   (d) the sum total of the respective maximum mean saturation values obtained for each pixel block size is calculated,

   wherein the value of said sum total is output as basic chromaticity.

2. The apparatus according to claim 1, wherein said color image transform means (20) is adapted to transform said color image signal to said saturation image data (S) and hue image data (H), a hue image memory (30H) being provided for storing at least one frame of said hue image data corresponding to said frame of saturation data (S), and

   wherein said basic chromaticity calculating means (31; 110A) is adapted to calculate said mean saturation values from corrected image data obtained by correcting said saturation image data in each pixel block based on the hue image data in said hue image memory (30H) corresponding to that pixel block.

3. The apparatus of claim 2, wherein said basic chromaticity calculating means (31; 110A) includes means for correcting said saturation image data of each pixel in each pixel block, read out of said saturation image memory (30S) based on said hue image data read out of the corresponding pixel position in said hue image memory (30H).

4. The apparatus of claim 1, wherein said transform means (20) is adapted to transform said color image signal (R, G, B) to said saturation image data (S) and to hue image data (H), said apparatus further comprising:

   a hue image memory (30H) for storing at least one frame of said hue image data corresponding to said frame
of saturation data (S),
a plurality of color matrix memories (40R-40M) each corresponding to one of a corresponding plurality of predetermined colors and having storage positions corresponding to pixel positions of at least one frame,
a plurality of color saturation memories (50R-50M) each corresponding to one of said plurality of colors and having storage positions corresponding to pixel positions of at least one frame,
color identifying means (32) for identifying which of said plurality of colors said hue image data read out of said hue image memory (30H) belongs to,
color matrix memory write means for comparing said saturation image data read out of said saturation image memory (30S) with a reference saturation value and, when the former is greater than the latter, for writing a "1" into the corresponding pixel position of that one of said color matrix memories (40R-40M) that corresponds to the color identified by said color identifying means (32) based on the hue image data read out of said hue image memory (30H) at the corresponding pixel position,
slanted striped pattern factor calculating means (110B) for calculating, with respect to each of said color matrix memories (40R-40M), a correlation coefficient for X and Y coordinates of said pixel positions having said "1" written in the color matrix memory (40R-40M) and for outputting as a respective slanted striped pattern factor a value corresponding to said correlation coefficient,
color saturation image memory write means adapted to write said saturation image data read out of said saturation image memory (30S) and decided to be above said reference saturation value at the corresponding pixel positions into the color saturation memory (50R-50M) of the corresponding color,
integrated count calculating means (31) for integrating the stored contents of each of said color matrix memories (40R-40M) in the Y and X directions to obtain X and Y integrated counts and for weighting each of said X and Y integrated counts by a predetermined window function,
striped pattern width detecting means for integrating the contents of each of said color saturation memories (50R-50M) in the Y and X directions to obtain X and Y integrated saturation values, for comparing each of said X and Y integrated saturation values with a reference value and for detecting, in each of the X and Y directions, first and second pixel positions defining a respective range of pixel positions, over which the integrated saturation value exceeds the reference value, the distance between said first and second pixel positions defining the widths of vertical and lateral striped patterns, respectively, of the corresponding color,
border striped pattern factor calculating means (110C) for calculating for each of said plurality of colors and in each of the X and Y directions,
- the sum of saturation values at pixel positions of the respective color saturation memory (50R-50M) between said first and second pixel positions,
- a standard deviation of those pixel positions of the corresponding color matrix memory (40R-40M) having "1" written therein and being between positions corresponding to said first and second pixel positions,
- the sum of said X and Y weighted integrated counts, respectively, between pixel positions of the corresponding color matrix memory (40R-40M) corresponding to said first and second pixel positions, and
- the product of said sum of saturation values, said standard deviation and said sum of integrated counts, and

for outputting, as a border striped pattern factor, a value obtained on the basis of said products calculated for each color and each of the X and Y directions, and
center striped pattern factor calculating means (110D) for calculating for each of said plurality of colors and in each of the X and Y directions

- the sum of saturation values at pixel positions of a respective color saturation memory (50R-50M) between said first and second pixel positions,
- a standard deviation of those pixel positions of the corresponding color matrix memory (40R-40M) having "1" written therein and being between positions corresponding to said first and second pixel positions, and
- the product of said sum of saturation values and said standard deviation the product being divided by said standard deviation, and

wherein a value obtained on the basis of the results of the division calculated for each color and each of the X and Y directions is outputted as a center striped pattern factor.

5. The apparatus of claim 4, further comprising:

coefficient generating means (112) for generating predetermined coefficients (Ea, Eb, Ec, Ed) corresponding
to basic chromaticity, a slanted stripe pattern, a border stripe pattern and a center stripe pattern, respectively; multiplying means (111A-111D) for multiplying the outputs of said basic chromaticity calculating means (110A), said slanted stripe pattern factor calculating means (110B), said border stripe pattern factor calculating means (110C) and center stripe pattern factor calculating means (110D) by said coefficients (Ea, Eb, Ec, Ed) corresponding thereto, respectively; adding means (113) for adding together the products obtained from said multiplying means (111A-111D); and deciding means (114) for comparing the output of said adding means (113) with a reference value to decide the quality of said color image signal based in the result of comparison.

6. A color image signal evaluating method comprising the steps of

(a) transforming a color image signal (R, G, B) to saturation image data (S),
(b) storing said saturation image data (S) of at least one frame in a saturation image memory (30S),
(c) dividing said saturation image data into non-overlapping blocks of a predetermined size over the entire image area, and averaging said saturation image data read out of said saturation image memory for each pixel block to obtain a respective mean saturation value for each block,
(d) determining a maximum one of said mean saturation values,
(e) repeating steps (c) and (d) a predetermined number of times while changing the size of said pixel block, and
(f) calculating the sum total of the maximum mean saturation values obtained in step (d) and outputting, as basic chromaticity, the value of said sum total.

7. The method of claim 6, wherein

step (a) further comprises transforming said color image signal to hue image data (H),
step (b) further comprises storing said hue image data (H) of at least one frame in a hue image memory (30H), and
step (c) further comprises correcting said saturation image data (S) of each pixel block based in said hue image data (H) in said hue image memory corresponding to each pixel block and averaging the thus corrected saturation image data to obtain said mean saturation values.

8. The method of claim 7, wherein step (b) comprises correcting the saturation image data (S) of each pixel in said pixel block read out of said saturation image memory (30S) based on said hue image data (H) read out of the corresponding pixel position in said hue image memory (30H).

Patentansprüche

1. Farbbildsignalbewertungsvorrichtung mit:

1. einer Farbbildsignaltransformationseinrichtung (20) zum Transformieren eines Farbbildsignals (R, G, B) zu Sättigungs bilddaten (S),
einem Sättigungsbildspeicher (30S) zum Speichern mindestens eines Bildfeldes der Sättigungsbilddaten; und
einer die grundlegende Farbigkeit berechnenden Einrichtung (31; 110A), die geeignet ist, folgende Rechenschritte auszuführen:

(a) die aus dem Sättigungsbildspeicher (30S) gelesenen Sättigungsbilddaten werden in nichtüberlappen-de Blöcke einer vorherbestimmten Größe über die gesamte Abbildungsfläche unterteilt und für jeden Pi-xelleblock gemittelt, um einen entsprechenden mittleren Sättigungswert für jeden Pixelblock zu erhalten,
(b) unter den mittleren Sättigungswerten wird der maximale bestimmt,
(c) die Schritte (a) und (b) werden für jede einer vorherbestimmten Anzahl von Pixel-blockgrößen durchgeführt, und
(d) die Gesamtsumme der für jede Pixelblockgröße erhaltenen jeweiligen maximalen Sättigungswerte wird errechnet,

wobei der Wert der Gesamtsumme als grundlegende Farbigkeit ausgegeben wird.

2. Vorrichtung nach Anspruch 1, bei der die Farbbildsignaltransformationseinrichtung (20) geeignet ist, das Farbbildsignal in die Sättigungsbilddaten (S) und Farbtonbilddaten (H) zu transformieren, wobei ein Farbtonbildspeicher (30H)
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vorgesehen ist, der mindestens ein Bildfeld der Farbtonbilddateien entsprechend dem Bildfeld der Sättigungsdaten (S) speichert, und

bei der die die grundlegende Farbigkeit berechnende Einrichtung (31; 110A) geeignet ist, die mittleren Sättigungswerte aus korrigierten Bilddateien zu errechnen, die durch Korrektur der Sättigungsdaten in jedem Pixelblock auf der Grundlage der Farbtonbilddateien im Farbtonbildspeicher (30H) entsprechend diesem Pixelblock erhalten wurden.

3. Vorrichtung nach Anspruch 2, bei der die die grundlegende Farbigkeit berechnende Einrichtung (31; 110A) fähig ist, um die Sättigungsdateien für jedes Pixel in jedes Pixelblock, die aus dem Sättigungsdatenblock (30S) gelesen werden, anhand der Farbtonbilddateien zu korrigieren, die aus der entsprechenden Pixelposition in dem Farbtonbildspeicher (30H) gelesen werden.

4. Vorrichtung nach Anspruch 1, bei der die Transformationseinrichtung (20) geeignet ist, das Farbblendsignal (R, G, B) in die Sättigungsdateien (S) und in Farbtonbilddateien (H) zu transformieren und die Vorrichtung ferner folgendes aufweist:

- einen Farbtonbildspeicher (30H) zum Speichern mindestens eines Bildfeldes der Farbtonbilddateien entsprechend dem Bildfeld der Sättigungsdaten (S),
- eine Vielzahl von Farbmatrizespeichern (40R-40M), die jeweils einer entsprechenden Vielzahl vorherbestimmter Farben entsprechen und Speicherpositionen haben, die Pixelpositionen mindestens eines Bildfeldes entsprechen,
- eine Vielzahl von Sättigungsspeichern (50R-50M), die jeweils einer der Vielzahl von Farben entsprechen und Speicherpositionen haben, die Pixelpositionen mindestens eines Bildfeldes entsprechen,
- eine Farbidentifikationseinrichtung (32) zum Kennzeichnen zu welcher der Vielzahl von Farben die aus dem Farbtonbildspeicher (30H) gelesene Farbtonbilddatei gehört;
- eine Farbmatrizespeicherschreibeneinrichtung, die die aus dem Sättigungsdatenblock (30S) gelesenen Sättigungswerte in ein entsprechendes Pixelposition des einen der Farbmatrizespeicher (40R-40M) schreibt, die der Farbe entspricht, welche von der Farbidentifikationseinrichtung (32) anhand der aus dem Farbtonbildspeicher (30H) an der entsprechenden Pixelposition gelesenen Farbtonbilddatei identifiziert wurde;
- eine einen Schrägstreifenmusterfaktor berechnende Einrichtung (110B), die in bezug auf jeden der Farbmatrizespeicher (40R-40M) einen Korrelationskoeffizienten für X- und Y-Koordinaten der Pixelpositionen berechnet, an denen die *1* in den Farbmatrizespeicher (40R-40M) eingegeben ist, und die einen dem Korrelationskoeffizienten entsprechenden Wert als jeweiligen Schrägstreifenmusterfaktor ausgibt;
- eine Farbsättigungsbildspeicherschreibeneinrichtung, die geeignet ist, die aus dem Sättigungsdatenblock (30S) gelesenen Sättigungswerte, für die entschieden wurde, daß sie oberhalb des Sättigungswertes liegen, an den entsprechenden Pixelpositionen in den Farbsättigungsspeicher (50R-50M) der entsprechenden Farbe zu schreiben;
- eine integrierte Zählung berechnende Einrichtung (31), die den gespeicherten Inhalt jedes der Farbmatrizespeicher (40R-40M) in der Y- und X-Richtung integriert, um X- und Y-integrierte Zählwerte zu erhalten, und die jede der X- und Y-integrierten Zählwerte mittels einer vorherbestimmten Fensterfunktion gewichtet;
- eine Streifenmusterbreitenerfassungseinrichtung, die den Inhalt jedes der Farbsättigungsspeicher (50R-50M) in der Y- und X-Richtung integriert, um X- und Y-integrierte Sättigungswerte zu erhalten, die jeden der X- und Y-integrierten Sättigungswerte mit einem Bezugswert vergleicht, und die in jeder der X- und Y-Richtungen erste und zweite Pixelpositionen erfaßt, welche einen entsprechenden Bereich von Pixelpositionen bestimmen, über den der integrierte Sättigungswert den Bezugswert übersteigt, wobei die Entfernung zwischen den ersten und zweiten Pixelpositionen die Breite vertikaler und lateraler Streifenmuster jeweils der entsprechenden Farbe bestimmt;
- eine einen Randstreifenmusterfaktor berechnende Einrichtung (110C), die für jede der Vielzahl von Farben in jeder der X- und Y-Richtungen folgendes berechnet:

- die Summe der Sättigungswerte an Pixelpositionen des entsprechenden Farbsättigungsspeichers (50R-50M) zwischen den ersten und zweiten Pixelpositionen,
- eine Standardabweichung jener Pixelpositionen des entsprechenden Farbmatrizespeichers (40R-40M), in die *1* eingeschrieben ist und die zwischen Positionen sind, welche den ersten und zweiten Pixelpositionen entsprechen,
- die Summe der X- und Y-gewichteten integrierten Zählwerte jeweils zwischen Pixelpositionen des entsprechenden Farbmatrizespeichers (40R-40M) entsprechend den ersten und zweiten Pixelpositionen, und
- das Produkt der Summe von Sättigungswerten, die Standardabweichung und die Summe integrierter Zählungen, und
die als Randstreifenmusterfaktor einen Wert ausgibt, der auf der Basis der Produkte erhalten wurde, die für jede Farbe und jede der X- und Y-Richtungen berechnet wurden, und
eine einen Mittenstreifenmusterfaktor berechnende Einrichtung (110D), die für jede der Vielzahl von Farben und in jeder der X- und Y-Richtungen folgendes berechnet

- die Summe von Sättigungswerten an Pixelpositionen eines jeweiligen Farbsättigungsspeichers (50R-50M) zwischen den ersten und zweiten Pixelpositionen,
- eine Standardsabweichung jener Pixelpositionen des entsprechenden Farbmatrixspeichers (40R-40M), in die "1" eingeschrieben ist und die zwischen Positionen entsprechend den ersten und zweiten Pixelpositionen sind, und
- das Produkt der Summe von Sättigungswerten und der Standardabweichung, wobei das Produkt durch die Standardabweichung dividiert ist, und
bei der ein Wert, der auf der Basis der Ergebnisse der Division, die für jede Farbe und jede der X- und Y-Richtungen errechnet wurde, als ein Mittenstreifenmusterfaktor ausgegeben wird.

5. Vorrichtung nach Anspruch 4, ferner mit:
einer Koeffizienten erzeugenden Einrichtung (112), die vorherbestimmte Koeffizienten (EA, EB, EC, ED) erzeugt, welche der grundlegende Farbigkeit, einem Schrägstreifenmuster, einem Randstreifenmuster bzw. einem Mittenstreifenmuster entsprechen;
einer Multipliziereinrichtung (111A-111D), welche die Ausgaben der die grundlegende Farbigkeit berechnenden Einrichtung (110A), der den Schrägstreifenmusterfaktor berechnenden Einrichtung (110B), der den Randstreifenmusterfaktor berechnenden Einrichtung (110C) und der den Mittenstreifenmusterfaktor berechnenden Einrichtung (110D) mit den diesen entsprechenden Koeffizienten (EA, EB, EC, ED) multipliziert;
einer Addiereinrichtung (113), welche die von den Multipliziereinrichtungen (111A-111D) erhaltenen Produkte addiert; und
-einer Entscheidungseinrichtung (114), welche die Ausgabe der Addiereinrichtung (113) mit einem Bezugswert vergleicht, um über die Qualität des Farbbildsignals im Ergebnis des Vergleichs basierend zu entscheiden.

6. Farbbildsignalbewertungsverfahren mit folgenden Schritten:
(a) Transformieren eines Farbbildsignals (R, G, B) in Sättigungsbilddaten (S),
(b) Speichern der Sättigungsbilddaten (S) mindestens eines Bildfeldes in einem Sättigungsbildspeicher (30S),
(c) Dividieren der Sättigungsbilddaten in nichtüberlappende Blöcke einer vorherbestimmten Größe über die gesamte Abbildungfläche und Mitteln der aus dem Sättigungsbildspeicher gelesenen Sättigungsbilddaten für jeden Pixelblock, um einen jeweiligen mittleren Sättigungswert für jeden Block zu erhalten,
(d) Bestimmen eines maximalen der mittleren Sättigungswerte,
(e) Wiederholen der Schritte (c) und (d), um eine vorherbestimmte Anzahl von Malen, während eines Änderns der Größe des Pixelblocks, und
(f) Berechnen der Gesamtsumme der im Schritt (d) erhaltenen maximalen mittleren Sättigungswerte und Ausgeben des Wertes der Gesamtsumme als grundlegende Farbigkeit.

7. Verfahren nach Anspruch 6, bei dem
der Schritt (a) ferner das Transformieren des Farbbildsignals in Farbtonbilddaten (H) aufweist;
der Schritt (b) ferner das Speichern der Farbtonbilddaten (H) mindestens eines Bildfeldes in einem Farbtonbildspeicher (30H) aufweist, und
der Schritt (c) ferner das Korrigieren der Sättigungsbilddaten (S) jedes Pixelblocks anhand der Farbtonbilddaten (H) in dem Farbtonbildspeicher entsprechend jedem Pixelblock und das Mitteln der so korrigierten Sättigungsbilddaten umfaßt, um die mittleren Sättigungswerte zu erhalten.

8. Verfahren nach Anspruch 7, bei dem der Schritt (b) das Korrigieren der aus dem Sättigungsbildspeicher (30S) gelesenen Sättigungsbilddaten (S) jedes Pixels im Pixelblock anhand der Farbtonbilddaten (H) aufweist, die aus der entsprechenden Pixelposition in dem Farbtonbildspeicher (30H) gelesen wurden.
Recommandations

1. Dispositif d'évaluation de signal d'image en couleurs, comprenant :

- des moyens de transformation de signal d'image en couleurs (R, V, B) en données d'image de saturation (S) ;
- une mémoire d'image de saturation (30S) pour mémoriser au moins une trame désdites données d'image de saturation ; et
- des moyens de calcul de chromaticité de base (31 ; 110A), adaptés pour effectuer les étapes de calcul suivantes :

   (a) les données d'image de saturation lues depuis ladite mémoire d'image de saturation (30S) sont divisées
       en blocs non chevauchés d'une taille prédéterminée sur la totalité de la surface de l'image et on en réalise
       une moyenne pour chaque bloc de pixels afin d'obtenir une valeur de saturation moyenne respective pour
       chaque bloc de pixels,
   (b) la valeur maximale desdites valeurs de saturation moyennes est déterminée,
   (c) les étapes (a) et (b) sont effectuées pour chacune d'un nombre prédéterminé de tailles de bloc de
       pixels, et
   (d) la somme totale des valeurs de saturation moyennes maximales respectives obtenues pour chaque
       taille de bloc de pixels est calculée,

   dans lequel la valeur de ladite somme totale est délivrée en sortie à titre de chromaticité de base.

2. Dispositif selon la recommandation 1, dans lequel lesdits moyens de transformation d'image en couleurs (20) sont
   adaptés pour transformer ledit signal d'image en couleurs en lesdites données d'image de saturation (S) et en
   données d'image de teinte (H), une mémoire d'image de teinte (30H) étant présente pour mémoriser au moins
   une trame désdites données d'image de teinte correspondant à ladite trame de données de saturation (S), et
   dans lequel lesdits moyens de calcul de chromaticité de base (31 ; 110A) sont adaptés pour calculer lesdites
   valeurs de saturation moyennes à partir de données d'image corrigées obtenues en corrigeant lesdites données
   d'image de saturation dans chaque bloc de pixels en fonction des données d'image de teinte dans ladite mémoire
   d'image de teinte (30H) correspondant à ce bloc de pixels.

3. Dispositif selon la recommandation 2, dans lequel lesdits moyens de calcul de chromaticité de base (31 ; 110A) com-
   prennent des moyens pour corriger lesdites données d'image de saturation de chaque pixel dans chaque bloc de
   pixels, lues à partir de ladite mémoire d'image de saturation (30S) en fonction desdites données d'image de teinte
   lues concernant la position de pixel correspondante dans ladite mémoire d'image de teinte (30H).

4. Dispositif selon la recommandation 1, dans lequel lesdits moyens de transformation (20) sont adaptés pour transformer
   ledit signal d'image en couleurs (R, V, B) en lesdites données d'image de saturation (S) et en données d'image
   de teinte (H), ledit dispositif comprenant de plus :

   une mémoire d'image de teinte (30H) pour mémoriser au moins une trame désdites données d'image de teinte
   correspondant à ladite trame de données de saturation (S),
   une pluralité de mémoires de matrice de couleur (40R à 40M) correspondant chacune à l'une d'une pluralité
   correspondante de couleurs prédéterminées et ayant des positions de mémorisation correspondant à des
   positions de pixel d'au moins une trame,
   une pluralité de mémoires de saturation de couleur (50R à 50M) correspondant chacune à l'une de ladite
   pluralité de couleurs et ayant des positions de mémorisation correspondant à des positions de pixel d'au moins
   une trame,
   des moyens d'identification de couleur (32) pour identifier à laquelle de ladite pluralité de couleurs appartien-
   nent lesdites données d'image de teinte lues à partir de ladite mémoire d'image de teinte (30H),
   des moyens d'écriture de mémoire de matrice de couleur pour comparer lesdites données d'image de satu-
   ration lues à partir de ladite mémoire d'image de saturation (30) à une valeur de saturation de référence, et,
   lorsque les premières sont supérieures à la dernière, pour écrire un "1" dans la position de pixel correspondante
   de celle désdites mémoires de matrice de couleur (40R à 40M) qui correspond à la couleur identifiée par
   lesdits moyens d'identification de couleur (32) en fonction des données d'image de teinte lues à partir de ladite
   mémoire d'image de teinte (30H) dans la position de pixel correspondante,
   des moyens de calcul de facteur de motif en bandes incliné (110B) pour calculer, en fonction de chacune
des dites mémoires de matrice de couleur (40R à 40M), un coefficient de corrélation pour les coordonnées X et Y des dites positions de pixel ayant ledit "1° écrit dans la mémoire de matrice de couleur (40R à 40M) et pour délivrer en sortie à titre de facteur de motif en bandes incliné respectif une valeur correspondant audit coefficient de corrélation.

des moyens d’écriture de mémoire d’image de saturation de couleur adaptés pour écrire les dites données d’image de saturation dues à partir de ladite mémoire d’image de saturation (30S), et dont il a été décidé qu’elles étaient supérieures à ladite valeur de saturation de référence dans les positions de pixel correspondantes dans la mémoire de saturation de couleur (50R à 50M) de la couleur correspondante,
des moyens de calcul de décompte intégrés (31) pour intégrer les contenus mémorisés de chacune des dites mémoires de matrice de couleur (40R à 40M) dans les directions X et Y afin d’obtenir des décomptes intégrés X et Y et pour pondérer chacun des dites décomptes intégrés X et Y à l’aide d’une fonction de fenêtre prédéterminée,
des moyens de détection de largeur de motif en bandes pour intégrer les contenus de chacune des dites mémoires de saturation de couleur (50R à 50M) dans les directions X et Y afin d’obtenir des valeurs de saturation intégrées X et Y, pour comparer chacune des dites valeurs de saturation intégrées X et Y à une valeur de référence et pour déteindre, dans chacune des directions X et Y, des première et deuxième positions de pixel définissant une plage respective de positions de pixel, sur lesquelles la valeur de saturation intégrée dépasse la valeur de référence, la distance entre lesdites premières et deuxième positions de pixel définissant les larges de motifs en bandes vertical et latéral, respectivement, de la couleur correspondante,
des moyens de calcul de facteur de motif en bandes de bordure (110C) pour calculer, pour chacune de ladite pluralité de couleurs et dans chacune des directions X et Y :

- la somme de valeurs de saturation dans des positions de pixel de la mémoire de saturation de couleur respective (50R à 50M) entre lesdites premières et deuxième positions de pixel,
- un écart standard des positions de pixel de la mémoire de matrice de couleur correspondante (40R à 40M) ayant un "1° écrit dans celles-ci, et se trouvant entre des positions correspondant auxdites premières et deuxième positions de pixel,
- la somme desdits décomptes intégrés pondérés X et Y, respectivement, entre des positions de pixel de la mémoire de matrice de couleur correspondante (40R à 40M) correspondant auxdites premières et deuxième positions de pixel, et
- le produit de ladite somme de valeurs de saturation, dudit écart standard et de ladite somme de décomptes intégrés, et

pour délivrer en sortie, à titre de facteur de motif en bandes de bordure, une valeur obtenue en fonction desdits produits calculés pour chaque couleur et chacune des directions X et Y, et
des moyens de calcul de facteur de motif en bandes central (110D) pour calculer, pour chacune de ladite pluralité de couleurs et dans chacune des directions X et Y :

- la somme de valeurs de saturation dans des positions de pixel d’une mémoire de saturation de couleur respective (50R à 50M) entre lesdites premières et deuxième positions de pixel,
- un écart standard des positions de pixel de la mémoire de matrice de couleur correspondante (40R à 40M) ayant un "1° écrit dans celles-ci, et se trouvant entre des positions correspondant auxdites premières et deuxième positions de pixel, et
- le produit de ladite somme de valeurs de saturation et dudit écart standard, le produit étant divisé par ledit écart standard, et

dans lequel une valeur obtenue en fonction des résultats de la division calculée pour chaque couleur et chacune des directions X et Y est délivrée en sortie à titre de facteur de motif en bandes central.

5. Dispositif selon la revendication 4, comprenant de plus :

des moyens de génération de coefficient (112) pour générer des coefficients prédéterminés (Ea, Eb, Ec, Ed) correspondant à une chromaticité de base, à un motif en bandes incliné, à un motif en bandes de bordure et à un motif en bandes central, respectivement ;
des moyens de multiplication (111A à 111D) pour multiplier les sorties desdits moyens de calcul de chromaticité de base (110A), desdits moyens de calcul de facteur de motif en bandes incliné (110B), desdits moyens de calcul de facteur de motif en bandes de bordure (110C) et desdits moyens de calcul de facteur de motif en bandes central (110D) par lesdits coefficients (Ea, Eb, Ec, Ed) correspondant à ceux-ci, respectivement ;
des moyens d'addition (113) pour ajouter les uns autres les produits obtenus à partir desdits moyens de multiplication (111A à 111D) ; et

des moyens de décision (114) pour comparer la sortie desdits moyens d'addition (113) à une valeur de référence afin de décider de la qualité dudit signal d'image en couleurs en fonction du résultat de comparaison.

6. Procédé d'évaluation de signal d'image en couleurs comprenant les étapes suivantes :

(a) la transformation d'un signal d'image en couleurs (R, V, B) dans des données d'image de saturation (S),
(b) la mémorisation desdites données d'image de saturation (S) d'au moins une trame dans une mémoire d'image de saturation (30S),
(c) la division desdites données d'image de saturation en blocs non chevauchés d'une taille prédéterminée sur la totalité de la surface de l'image, et la réalisation d'une moyenne desdites données d'image de saturation lues depuis ladite mémoire d'image de saturation pour chaque bloc de pixels afin d'obtenir une valeur de saturation moyenne respective pour chaque bloc,
(d) la détermination d'une valeur maximale desdites valeurs de saturation moyennes,
(e) la répétition des étapes (c) et (d) un nombre prédéterminé de fois en changeant la taille dudit bloc de pixels, et
(f) le calcul de la somme totale des valeurs de saturation moyennes maximales obtenues dans l'étape (d) et la délivrance en sortie, à titre de chromaticité de base, de la valeur de ladite somme totale.

7. Procédé selon la revendication 6, dans lequel :

l'étape (a) comprend de plus la transformation dudit signal d'image en couleurs en données d'image de teinte (H),
l'étape (b) comprend de plus la mémorisation desdites données d'image de teinte (H) d'au moins une trame dans une mémoire d'image de teinte (30H), et
l'étape (c) comprend de plus la correction desdites données d'image de saturation (S) de chaque bloc de pixels en fonction desdites données d'image de teinte (H) dans ladite mémoire d'image de teinte correspondant à chaque bloc de pixels et la réalisation de la moyenne des données d'image de saturation ainsi corrigées afin d'obtenir lesdites valeurs de saturation moyennes.

8. Procédé selon la revendication 7, dans lequel l'étape (b) comprend la correction des données d'image de saturation (S) de chaque pixel dans dudit bloc de pixels lues à partir de ladite mémoire d'image de saturation (30S) en fonction desdites données d'image de teinte (H) lues à partir de la position de pixel correspondante dans ladite mémoire d'image de teinte (30H).
FIG. 2

START

Divide saturation image into blocks of m x n pixels

S1

Pick up block KB & compute mean saturation

S2

Step S2 has been repeated for all blocks in a frame of image?

S3

Y

Find & store max mean saturation

S4

N

Block size is larger than predetermined size?

S5

Y

Ts = Σ(max means)

S7

END

m ← m + k1

n ← n + k2

S6
**FIG. 4**

1. READ SATURATION OF EACH PIXEL IN BLOCK KB & CORRESPONDING HUE
2. CALCULATE COLOR CORRECTION VALUE
3. CORRECT SATURATION S AT EACH PIXEL IN BLOCK KB BY COLOR CORRECTION VALUE
4. CALCULATE MEAN OF CORRECTED SATURATION

**FIG. 5**

![Graph showing color correction value over hue angle (0° to 360°)]

- Color correction value is plotted along the Y-axis, from 0° to 360°.
- The graph shows a peak labeled 'F' at a certain hue angle.
FIG. 7

START

S1

PRODUCE HISTOGRAM OF SATURATION VALUES & DETERMINE MODE SATURATION Sm

S2

CALCULATE REF SATURATION Sr = pSm

S3

EXTRACT PIXEL WITH SATURATION GREATER THAN Sr, DECIDE COLOR OF HUE DATA AT THE CORRESPONDING PIXEL, & WRITE "1" IN THE CORRESPONDING PIXEL POSITION IN MATRIX MEM OF THE DECIDED COLOR

S4

CALCULATE CORRELATION COEFF. r OF COORDINATES X,Y FOR PIXEL POSITIONS HAVING "1s" IN EACH COLOR MATRIX MEM, & OBTAIN ABSOLUTE VALUE OF THE CORR. COEFF.

S5

COUNT NUMBER n OF PIXELS HAVING "1" IN EACH COLOR MATRIX MEM, & NORMALIZE IT WITH TOTAL PIXEL NUMBER N IN A FRAME TO DEFINE K = n/N

S6

CALCULATE SLANTED PATTERN FACTOR DEFINED AS I = R x K

S7

OUTPUT, AS REPRESENTATIVE PATTERN FACTOR Im, MAX ONE OF SLANTED PATTERN FACTORS I OF RESPECTIVE COLORS

END
FIG. 8

FREQUENCY (NUMBER OF PIXELS)

SATURATION

FIG. 9

COLOR MATRIX

40R

FIG. 10

COLOR MATRIX

40R
FIG. 12

START

1. Obtain integrated counts $C_x, C_y$ for each color matrix mem $C_x \leftarrow C_x \cdot N_x/N_y$

2. Apply inverted Tukey 80% window to $C_x, C_y$

3. Determine positions $X_m, Y_m$ where $C_x, C_y$ are max

4. Calculate integrated saturation values $S_x, S_y$
   $S_x \leftarrow S_x \cdot N_x/N_y$

5. Obtain integrated saturation values $S_{xm}, S_{ym}$ at $X_m, Y_m$

6. Determine positions $A, B$ where integrated saturation values are $0.2S_{xm}, 0.2S_{ym}$ on both sides of $X_m, Y_m$

7. Determine stripe widths $D_x, D_y$ between $A&B$

8. $V_x = \sum_{i \in AB} S_{xi}$, $V_y = \sum_{j \in AB} S_{yj}$

9. $K_x = \sum_{i \in AB} C_{xi}$, $K_y = \sum_{j \in AB} C_{yj}$

10. Calculate vertical stripe parameter $\alpha_v$ & horizontal stripe parameter $\alpha_h$

11. Calculate weighted stripe parameters $\alpha_v'$ & $\alpha_h'$

12. Calculate standard deviations $d_x, d_y$ of pixel positions near the border
   
   $Q_x = \alpha_x \cdot d_x \cdot K_x$, $Q_y = \alpha_y \cdot d_y \cdot K_y$

13. Obtain max value $Q_m$ among $Q_x, Q_y$

14. $Z = \sum (K_x + K_y)$

15. Calculate peripheral stripe pattern factor $P_m$

END
FIG. 18

START

1. Obtain integrated counts: $C_x, C_y \leftarrow C_x \cdot N_x/N_y$

2. Apply Tukey 80% window to $C_x, C_y$

3. Determine positions $X_m, Y_m$ where $C_x, C_y$ are max

4. Subject saturation data to histogram flattening & obtain integrated saturation values: $S_x, S_y \leftarrow S_x \cdot N_x/N_y$

5. Obtain integrated saturation values $S_{xm}, S_{ym}$ at $X_m, Y_m$

6. Determine positions $A, B$ where integrated saturation values are 0.5$S_{xm}$, 0.5$S_{ym}$ on both sides of $X_m, Y_m$

7. Determine stripe widths $D_x, D_y$ between $A$ & $B$

8. Calculate averages: $V_x = \sum_{i \in AB} S_{xi}$, $V_y = \sum_{i \in AB} S_{yi}$

9. Calculate deviations $e_x, e_y$ of integrated saturation values near the center

10. Obtain standard deviations $g_x, g_y$ with respect to $X_m, Y_m$ for pixel positions having "1" near the center

11. $Q_x = V_x \times e_x + g_x + n$, $Q_y = V_y \times e_y + g_y + n$

12. $U_x = Q_x + D_x^2 \{ 0.5 \{ 1 + \cos (2\pi \cdot D_x / N_x) \} \}^2$

13. $U_y = Q_y + D_y^2 \{ 0.5 \{ 1 + \cos (2\pi \cdot D_y / N_y) \} \}^2$

14. Calculate center stripe parameters $B_x, B_y$

15. Calculate weighted center stripe parameters $B'_x, B'_y$

16. Calculate mean $P_a$ of center stripe parameter & output as center stripe pattern factor

END
FIG. 19

WEIGHTING FUNCTION FOR INTEGRATED COUNT

FIG. 20

WEIGHTING FUNCTION FOR INTEGRATED SATURATION