

DESCRIPTION

TITLE OF THE INVENTION

DISPLAY CONTROL DEVICE, IMAGE DISPLAY SYSTEM AND
DISPLAY CONTROL METHOD

TECHNICAL FIELD

[0001]

The present disclosure relates to a display control device and method, and an image display system. Particularly, the present disclosure relates to a technique for adjusting a service life of an image display device provided with a display panel of a non-luminous type, such as a liquid crystal display panel.

BACKGROUND ART

[0002]

There are situations in which it is desired to have the service life of an image display device to expire simultaneously with the service life of another equipment. For example, it may be desired for the service life of an image display device used as a part of a television receiver to expire simultaneously with the service life of a power supply circuit, HDD or the like of the television receiver. Also, it may be desired for the service life of an image display device used for forming an instrument panel of an automobile to expire simultaneously with the service life of other components of the automobile. Similarly, it may be desired for the service life of an image display device used as a display of a train to expire simultaneously with the service life of other components of the train.

[0003]

Image display devices provided with a a non-luminous display panel, such as a liquid crystal panel, perform image display by converting electric power supplied from a power supply into light, and controlling the amount of light passed through the display panel. In many cases, the

service life of such an image display device is determined by the service life of the backlight.

The service life of the backlight depends on the aging deterioration due to light emission, and the deterioration depends on the amount of light emission. If the amount of light emission is reduced, the service life is extended, but the visibility of the displayed image is lowered due to the luminance reduction of the display screen.

[0004]

In Patent reference 1, it is proposed to reduce the amount of light emission of the backlight for the purpose of reducing the power consumption, and simultaneously compensate for the reduction in the amount of light emission, by correcting the gradation values of the image data, thereby restraining the luminance change in the displayed image.

PRIOR ART REFERENCES

PATENT REFERENCES

[0005]

[Patent Reference 1] Japanese Patent No. 5374802

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0006]

With the technique disclosed in Patent Reference 1, it may not be possible to continue the use of the backlight up to the target service life, because how fast the backlight deteriorates changes depending on the input images.

[0007]

An object of the present disclosure is to provide a display control device which enables the use of the backlight to be continued until the target service life is reached, and is also capable of restraining the degradation of the image quality.

MEANS FOR SOLVING THE PROBLEM

[0008]

A display control device according to the present disclosure is to control an image display device provided with a backlight and a display panel of a non-luminous type, including an image processing device and a life controller, wherein

said image processing device includes:

a brightness correction unit to correct a brightness of an input image and output a corrected image;

a corrected image luminance calculator to calculate an average luminance of the corrected image outputted from said brightness correction unit;

an input image luminance calculator to calculate an average luminance of said input image;

a dimming rate calculator to calculate a dimming rate of said backlight based on the average luminance of said corrected image and the average luminance of said input image;

a display history information generator to generate display history information based on the dimming rate calculated by said dimming rate calculator; and

a display history information storage to store the display history information generated by said display history information generator; wherein

said image processing device causes said backlight to emit light with said dimming rate, and causes said display panel to display said corrected image;

said display history information represents accumulated display time, from commencement of use of said image display device to a present time point, and an average value of the dimming rate during periods in which display was performed by said image display device, and

said service life controller controls a degree of the correction at said brightness correction unit based on the

display history information stored in said display history information storage, a service life at a time of commencement of use of said backlight, and a target service life of said backlight.

EFFECT OF THE INVENTION

[0009]

According to the present disclosure, it is possible to continue the use of the backlight until the target service life is reached, while restraining the degradation of the image quality of the displayed image.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

FIG. 1 is a block diagram showing an image display system according to a first embodiment.

FIG. 2 is a block diagram showing an example of a configuration of the brightness correction unit in FIG. 1.

FIG. 3 is a diagram showing an example of a gradation conversion curve used by the gradation converter in FIG. 2.

FIG. 4 is a block diagram showing another example of a configuration of the brightness correction unit in FIG. 1.

FIG. 5 is a block diagram showing another example of a configuration of the brightness correction unit in FIG. 1.

FIG. 6 is a diagram showing an example of a gradation conversion curve selected by the conversion curve selector in FIG. 5.

FIG. 7 is a block diagram showing another example of a configuration of the brightness correction unit in FIG. 1.

FIGs. 8(a) to 8(f) are diagrams showing processes of generating a gradation conversion curve at the conversion curve generator in FIG. 7.

FIG. 9 is a block diagram showing a computer for implementing all the functions of the display control device in FIG. 1, together with a backlight and a display panel.

FIG. 10 is a flowchart showing a procedure of processes

performed by the computer 9 in FIG. 9.

FIG. 11 is a block diagram showing an image display system according to a second embodiment.

FIG. 12 is a block diagram showing a computer implementing all the functions of the image processing device in FIG. 11, and a computer implementing all the functions of the service life controller in FIG. 11, together with a backlight and a display panel.

FIG. 13 is a flowchart showing a procedure of processes performed by the first computer in FIG. 12.

FIG. 14 is a flowchart showing a procedure of processes performed by the second computer in FIG. 12.

MODE FOR CARRYING OUT THE INVENTION

[0011]

FIRST EMBODIMENT

FIG. 1 shows an image display system according to a first embodiment. The image display system shown in FIG. 1 includes a display control device 2 and an image display device 6.

The display control device 2 includes an image processing device 3 and a service life controller 4.

The image processing device 3 includes an image input unit 11, a brightness correction unit 12, a corrected image luminance calculator 13, an input image luminance calculator 14, a dimming rate calculator 15, a display history information generator 17, and a display history information storage 18.

The service life controller 4 includes a service life predictor 41 and a correction degree adjuster 42.

[0012]

The image display device 6 includes a backlight 7 and a display panel 8.

The backlight 7 emits light by electric power supplied from a power supply, not shown.

The display panel 8 is formed, for example, of a liquid crystal panel, and spatially modulates the light from the backlight 7 to display an image. The display panel 8 has a plurality of pixels, and each pixel has an R (red) subpixel, a G (green) subpixel, and a B (blue) subpixel.

[0013]

The image input unit 11 receives an image signal of an analog format or a digital format, and outputs input image data Da of a digital format. The input image data Da is of a format suitable for processing in the image processing device 3. If the input image signal is of an analog format, the image input unit 11 may include an A/D (analog-to-digital) converter.

[0014]

The input image data Da may, for example, represent a color image. In such a case, the input image data Da may have, for each pixel, an R component value, a G component value, and a B component value. Alternatively, the input image data Da may have, for each pixel, a luminance component value and color difference component values.

[0015]

The brightness correction unit 12 corrects the input image data Da and outputs a corrected image data Db.

The correction at the brightness correction unit 12 is so made that the image (corrected image) Db represented by the corrected image data Db is brighter than the image (input image) Da represented by the input image data Da.

[0016]

The degree of the correction at the brightness correction unit 12 is changed under control by the service life controller 4, as will be described later. Control information for the control by the service life controller 4 is denoted by Ce.

[0017]

The display panel 8 performs display of an image based on the corrected image data Db outputted from the brightness correction unit 12. The display panel 8 displays an image by performing spatial modulation of the light from the backlight 7 based on the corrected image data Db. For the spatial modulation, the transmittance of the subpixels of each pixel in the display panel 8 is controlled according to the R component value, the G component value, and the B component value for the corresponding pixel included in the corrected image data Db.

[0018]

FIG. 2 shows an example of a configuration of the brightness correction unit 12.

The brightness correction unit 12 shown in FIG. 2 includes a gradation converter 201. The gradation converter 201 converts the gradation values of the input image data Da to brighten the image.

[0019]

If the input image data Da has the R component value, the G component value, and the B component value, the gradation values of the R component value, the G component value, and the B component value may be converted separately, or the R component value, the G component value, and the B component value may be converted to the luminance component value and the color difference component values, and the gradation values of the luminance may be converted, and then may be used for inverse conversion into the R component value, the G component value, and the B component value.

[0020]

For example, a gradation conversion curve TC shown in FIG. 3 is used for the gradation conversion. The gradation conversion curve TC shown in FIG. 3 has an upwardly convex shape, and is at the same position as or above a straight

line TN of "output=input", and the larger the difference from the straight line TN is, the larger the degree of image brightening, i.e., the degree of correction is.

[0021]

Incidentally, the gradation conversion curve shown in FIG. 3 is just an example, and does not limit the present embodiment. For example, although the gradation conversion curve TC shown in FIG. 3 is above the straight line TN of "output=input" throughout the entire range, except at the minimum value and the maximum value of the input gradation value, this does not impose a limitation to the present embodiment, and it is satisfactory if the curve is above the straight line TN of "output=input" for the major part of the range of the input gradation value. In short, it is satisfactory if the gradation conversion causes such correction that the average luminance of the corrected image Db is higher than the average luminance of the input image Da, for the majority of the input images Da.

[0022]

The gradation converter 201 may be of such a configuration that can change the form of the gradation conversion curve TC according to the control information Ce from the service life controller 4. Alternatively, the gradation converter 201 may be of such a configuration that stores a plurality of gradation conversion curves TC, and selects one of the plurality of the gradation conversion curves TC according to the control information Ce from the service life controller 4.

[0023]

FIG. 4 shows another example of a configuration of the brightness correction unit 12.

The brightness correction unit 12 shown in FIG. 14 includes a maximum component value calculator 202, an intra-frame maximum value calculator 203, a gain determination

unit 204, and a gain multiplier 205.

[0024]

The maximum component value calculator 202 calculates, for each pixel of the input image data Da, a maximum component value M which is a maximum value among the R component value Dar, the G component value Dag, and the B component value Dab.

[0025]

The intra-frame maximum value calculator 203 calculates an intra-frame maximum value Mmax which is a maximum value among the maximum component values M respectively calculated by the maximum component value calculator 202 for all the pixels within the frame.

[0026]

The gain determination unit 204 determines a gain coefficient Ka for each frame, based on the intra-frame maximum value Mmax calculated by the intra-frame maximum value calculator 203. The gain coefficient Ka is calculated, for example, according to the following equation (1).

$$K_a = (T_{\max} / M_{\max}) \times \beta \quad (1)$$

In the equation (1), Tmax is a maximum value (maximum gradation value) among the values which can be assumed by each component value. For example, if each component value is expressed by 8 bits, the maximum gradation value is 255.

β is an adjustment coefficient. As the adjustment coefficient β , 1 or a value close to 1 is used.

If the adjustment coefficient β is 1, and Tmax is 255, and Mmax is 128, then

$$K_a = (255 / 128) \times 1 \doteq 2$$

[0027]

The gain multiplier 205 corrects the input image data Da using the gain coefficient Ka determined by the gain determination unit 204, to generate the corrected image data

Db.

The gain coefficient K_a is determined for each frame, and the gain coefficient K_a determined for each frame is used for the multiplication of the gradation values of the input image D_a of the particular frame.

[0028]

Where the input image data D_a has an R component value, a G component value, and a B component value, the R component value, the G component value, and the B component value may be multiplied by the gain coefficient K_a , separately, or they may be converted into a luminance component value and color-difference component values, and the luminance component value may be multiplied by the gain coefficient K_a , after which it may then be used for inverse conversion into an R component value, a G component value, and a B component value.

[0029]

The gain determination unit 204 may be configured to change the adjustment coefficient β according to the control information C_e from the service life controller 4.

[0030]

FIG. 5 shows another example of a configuration of the brightness correction unit 12.

The brightness correction unit 12 shown in FIG. 5 includes a maximum component value calculator 202, an intra-frame average value calculator 206, a conversion curve selector 207, and a gradation converter 201c.

The maximum component value calculator 202 in FIG. 5 is similar to the maximum component value calculator 202 in FIG. 4.

[0031]

The intra-frame average value calculator 206 calculates an intra-frame average value M_{ave} which is an average value of the maximum component values M respectively calculated by

the maximum component value calculator 202 for all the pixels in the frame.

[0032]

The conversion curve selector 207 stores, in advance, a plurality of gradation conversion curves, and selects one of the stored gradation conversion curves based on the intra-frame average value M_{ave} calculated by the intra-frame average value calculator 206.

For example, the conversion curve selector 207 selects a gradation conversion curve causing a stronger degree of correction as the intra-frame average value M_{ave} is smaller.

[0033]

FIG. 6 shows examples of the gradation conversion curves stored in the conversion curve selector 207. In the illustrated case, two gradation curves TC1 and TC2 are stored.

Each of the two gradation conversion curves TC1 and TC2 has an upwardly convex shape. The gradation conversion curve TC1 is at the same position as or above the straight line TN of "output=input". The gradation conversion curve TC2 is at the same position or above the gradation conversion curve TC1. Accordingly, it can be said that the gradation conversion curve TC2 causes a stronger degree of correction than the gradation conversion curve TC1.

[0034]

For example, the conversion curve selector 207 selects the gradation conversion curve TC1 if the intra-frame average value M_{ave} is larger than a threshold value M_{th} , and selects the gradation conversion curve TC2 if the intra-frame average value M_{ave} is not larger than the threshold value M_{th} . The selected gradation conversion curve is denoted by TCs.

[0035]

The gradation converter 201c performs the conversion of

the gradation values of the input image data Da using the gradation conversion curve TCs selected by the conversion curve selector 207, to generate the corrected image data Db.

The selection of the gradation conversion curve is performed for each frame, and the gradation conversion curve selected for each frame is used for the gradation conversion of the input image data Da of the particular frame.

Like the gradation converter 201 in FIG. 2, the gradation conversion may be performed on each of the R component value, the G component value, and the B component value separately, or it may be performed on the luminance component value.

[0036]

The conversion curve selector 207 may be of such a configuration that can change the form of the gradation conversion curve which is selected based on the intra-frame average value Mave, according to the control information Ce from the service life controller 4.

[0037]

Alternatively, the conversion curve selector 207 may be of such a configuration that stores three or more gradation conversion curves, and selects one of the stored gradation conversion curves according to the intra-frame average value Mave and the control information Ce from the service life controller 4.

For example, it may be so arranged that a gradation conversion curve causing a larger degree of correction is selected in a case in which the control information Ce requires enlargement of the degree of correction, compared with a case in which the control information Ce does not require a change in the degree of correction, provided that the intra-frame average value Mave is unchanged. Inversely, it may be so arranged that a gradation conversion curve causing a smaller degree of correction is selected in a case

in which the control information C_e requires reduction of the degree of correction, compared with a case in which the control information C_e does not require a change in the degree of correction, provided that the intra-frame average value M_{ave} is unchanged.

[0038]

FIG. 7 shows another example of a configuration of the brightness correction unit 12.

The brightness correction unit 12 shown in FIG. 7 includes a maximum component value calculator 202, a histogram generator 208, a conversion curve generator 209, and a gradation converter 201c.

The maximum component value calculator 202 in FIG. 7 is similar to the maximum component value calculator 202 in FIG. 4.

[0039]

The histogram generator 208 generates a histogram representing the number of occurrences of the maximum component values M having each gradation value, among the maximum component values M respectively calculated by the maximum component value calculator 202 for all the pixels within each frame, i.e., the frequency of the above-mentioned maximum component values M for each gradation value.

[0040]

FIG. 8(a) shows an example of a generated histogram $H(M)$. In FIG. 8(a), the gradation value M on the horizontal axis is a value within a range of values which can be assumed by the maximum component value M , and a value of, for example, from 0 to 255.

In FIG. 8(a), the frequency $H(M)$ corresponding to each gradation value M represents the number of pixels having the maximum component value M equal to the particular gradation value. The range of the values which can be assumed by the

frequency $H(M)$ is from 0 to the total number of pixels in a frame.

[0041]

The conversion curve generator 209 generates a gradation conversion curve based on the histogram $H(M)$ generated by the histogram generator 208. The generation of the gradation curve involves normalization of the histogram and generation of a cumulative histogram.

[0042]

For example, the conversion curve generator 209 normalizes the histogram shown in FIG. 8(a), as shown in FIG. 8(b), to generate a normalized histogram $P(r)$, as shown in FIG. 8(b). For example, the normalization is performed such that the maximum value of the gradation value on the horizontal axis and the maximum value of the frequency on the vertical axis are both converted to 1. The normalized gradation value is denoted by r , and the normalized frequency is denoted by $P(r)$.

[0043]

Next, the conversion curve generator 209 generates a normalized cumulative histogram $T(r)$ shown in FIG. 8(c) from the normalized histogram $P(r)$ shown in FIG. 8(b). The normalized cumulative histogram $T(r)$ mentioned here represents, for each normalized gradation value r , a value obtained by accumulating the normalized frequency $P(r)$ from 0 up to the particular gradation value r .

[0044]

Incidentally, it can be also said that the histogram $H(M)$ shown in FIG. 8(a) represents a distribution function of the maximum component value M ; the normalized histogram $P(r)$ shown in FIG. 8(b) represents a distribution function of the normalized maximum component value r ; and the normalized cumulative histogram $T(r)$ shown in FIG. 8(c) represents a cumulative density function of the normalized

maximum component value r .

[0045]

Next, the conversion curve generator 209 generates a normalized gradation conversion curve $T2(r)$ shown in FIG. 8(e), by superimposing the normalized cumulative histogram $T(r)$ in FIG. 8(c) with a correction curve $G(r)$ exemplified in FIG. 8(d). The superimposition is achieved by multiplying $T(r)$ by $G(r)$.

That is, for each value of r , $T2(r)$ is calculated according to the following equation (2).

$$T2(r) = T(r) \times G(r) \quad (2)$$

[0046]

The correction curve $G(r)$ in FIG. 8(d) is prepared separately, and serves to brighten the image. The horizontal axis and the vertical axis in FIG. 8(d) assume a value from 0 to 1. The correction curve $G(r)$ has an upwardly convex shape, and is at the same position as or above the straight line TNn of "output=input". The greater the difference from the straight line TNn is, the greater the degree of image brightening, i.e., the correction degree is.

[0047]

Incidentally, the correction curve shown in FIG. 8(d) is just an example, and does not limit the present embodiment. For example, although the correction curve $G(r)$ shown in FIG. 8(d) is above the straight line TNn of "output=input" throughout the entire range, except at the minimum value and the maximum value of the input value, this does not impose a limitation to the present embodiment, and it is satisfactory if the curve is above the straight line TNn of "output=input" for the major part of the range of the input value.

[0048]

Next, the conversion curve generator 209 generates the

gradation conversion curve TC shown in FIG. 8(f) by performing inverse normalization on the normalized gradation conversion curve T2(r) shown in FIG. 8(e). With regard to the gradation conversion curve TC shown in FIG. 8(f), the horizontal axis represents the input (pre-conversion) gradation value, and the vertical axis represents the output (post-conversion) gradation value.

The inverse normalization is performed such that 1 on the horizontal axis and 1 on the vertical axis in FIG. 8(e) are both converted to the maximum value of the gradation value, e.g., 255.

[0049]

The gradation converter 201c performs the gradation value conversion on the input image data Da, using the gradation conversion curve TC generated by the conversion curve generator 209, to generate the corrected image data Db.

The gradation conversion curve is generated for each frame, and the gradation conversion curve generated for each frame is used for the gradation conversion of the input image data Da of the particular frame. As in the gradation converter 201 in FIG. 2, or in the gradation converter 20c in FIG. 7, the gradation conversion may be performed on the R component value, the G component value, and the B component value, or on the luminance component value.

[0050]

The conversion curve generator 209 may be of such a configuration that can change the form of the correction curve G(r) according to the control information Ce from the service life controller 4. Alternatively, the conversion curve generator 209 may be of such a configuration that stores a plurality of correction curves G(r), and selects one of the correction curves G(r), according to the control information Ce from the service life controller 4.

[0051]

As the brightness correction unit 12, one having a configuration other than those shown in FIG. 2, FIG. 4, FIG. 5 and FIG. 7 may be used. In short, it is satisfactory if it can perform the correction such that the average luminance of the corrected image is higher than the average luminance of the input image, for the majority of the input images.

[0052]

The corrected image luminance calculator 13 calculates the average luminance L_b of the corrected image D_b . The average luminance L_b of the corrected image D_b is an average value of the luminance of all the pixels forming the corrected image D_b . For example, the average luminance L_b can be determined by determining the luminance for each of all the pixels forming the corrected image D_b , from the R component value, the G component value, and the B component value of the particular pixel, and averaging the luminance of all the pixels.

[0053]

The input image luminance calculator 14 calculates the average luminance L_a of the input image D_a . The average luminance L_a of the input image D_a is an average value of the luminance of all the pixels forming the input image D_a . For example, the average luminance L_a can be determined by determining the luminance for each of all the pixels forming the input image D_a , from the R component value, the G component value, and the B component value of the particular pixel, and averaging the luminance of all the pixels.

[0054]

The ratio of the average luminance L_b of the corrected image D_b to the average luminance L_a of the input image D_a can be said to represent the degree of brightness correction at the brightness correction unit 12.

[0055]

The dimming rate calculator 15 calculates a dimming rate E based on the average luminance La calculated by the input image luminance calculator 14 and the average luminance Lb calculated by the corrected image luminance calculator 13. The calculation of the dimming rate E is performed, for example, according to the following equation (3).

$$E = (La/Lb) \times \alpha \quad (3)$$

[0056]

In the equation (3), α denotes an adjustment parameter. For example, if the average luminance La of the input image Da is 100, and the average luminance Lb of the corrected image Db is 125, and the adjustment parameter α is set to be 1, then

$$E = (100/125) \times 1 = 0.8$$

[0057]

The calculated dimming rate E is supplied to the backlight 7. The backlight 7 adjusts the amount of light emission based on the supplied dimming rate E. That is, it emits light with the adjusted amount of light emission. For example, a value obtained by multiplying the standard amount of light emission by the dimming rate E is used as the adjusted amount of light emission. The standard amount of light emission is, for example, the maximum amount of light emission.

[0058]

It can be said that the adjustment of the amount of light emission by the backlight 7 is performed so as to generally cancel the effects of the brightness correction by the brightness correction unit 12.

If the adjustment parameter α is 1, the average luminance of the image displayed on the image display device 6 is equal between a case in which the brightness correction

by the brightness correction unit 12 and the adjustment of the amount of light emission by the backlight 7 are not performed, and a case in which the brightness correction by the brightness correction unit 12 and the adjustment of the amount of light emission by the backlight 7 are performed.

[0059]

If the adjustment parameter α is smaller than 1, the average luminance of the image displayed on the image display device 6 is lowered. The adjustment parameter α is made to be smaller than 1 when it is desired to prolong the service life of the backlight at the expense of the average luminance.

[0060]

As has been described, both of the process of determining the dimming rate E based on the average luminance L_a of the input image D_a and the average luminance L_b of the corrected image D_b , and the process of changing the adjustment parameter α constitute adjustment of the degree of correction at the dimming rate calculator 15.

The process of reducing the parameter α to be less than 1 at the dimming rate calculator 15, in addition to the correction of enlarging the degree of correction at the brightness correction unit 12 can be said to be an adjustment for further enlargement of the degree of correction, i.e., an additional adjustment, at the dimming rate calculator 15.

[0061]

As has been described, by reducing the amount of light emission of the backlight 7, the service life of the backlight 7 can be extended. Also, the visibility of the displayed image can be maintained, because the brightness correction unit 12 generates the corrected image data D_b representing the corrected image D_b which is brighter than the input image D_a , and the modulation at the display panel

8 is performed using the corrected image data Db.

[0062]

The image input unit 11, the brightness correction unit 12, the corrected image luminance calculator 13, the input image luminance calculator 14, and the dimming rate calculator 15 operate every frame period.

[0063]

The display history information generator 17 generates display history information. The "generation" mentioned here includes initial generation at the time of starting the image processing device 3, and subsequent generation, i.e. updating. The generation of the display history information is performed, for example, every constant period TLa. In that case, the above-mentioned initial generation may be performed immediately after the starting, or upon elapse of the constant period TLa from the starting. The display history information represents accumulated display time from the commencement of use of the image display device 6 up to the present time point, and an average value of the dimming rate. The average value of the dimming rate is an average value of the dimming rate, up to the present time point, during the periods in which display is performed.

[0064]

The display history information generator 17 stores the generated display history information in the display history information storage 18. If the display history information is already stored, the information is rewritten.

[0065]

The accumulated display time and the average value of the dimming rate are calculated in the following manner.

For example, let us assume that, at a certain time point, the accumulated display time is D_NOW, and the average value of the dimming rate, i.e., the average dimming rate, is E_NOW, and the display history information

representing such values is stored in the display history information storage 18. Let us also assume that, thereafter, display is performed for a period D_ADD , and the average dimming rate during the period D_ADD is E_ADD . In that case, updated accumulated display time D_NOW' is calculated according to the following equation (4), and an updated average dimming rate E_NOW' is calculated according to the following equation (5).

$$D_NOW' = D_NOW + D_ADD \quad (4)$$

$$E_NOW' = (D_NOW \times E_NOW + D_ADD \times E_ADD) / (D_NOW + D_ADD) \quad (5)$$

[0066]

The period D_ADD may be one frame period, or may be a longer period.

If the display history information is generated every constant period TLa , the period D_ADD is equal to the period TLa .

If the period D_ADD is one frame period, the display history information generator 17 performs the calculation of the equation (5) every frame period.

If the period D_ADD is longer than one frame period, the display history information generator 17 measures the length of the period D_ADD . Also, the display history information generator 17 stores the dimming rate for each frame period during the period D_ADD , and determines the average value of the stored dimming rate for each frame over the period D_ADD .

[0067]

D_NOW' and E_NOW' thus calculated are used for rewriting the display history information storage 18. By the rewriting, D_NOW' and E_NOW' become new D_NOW and E_NOW .

[0068]

The display history information storage 18 is formed of a non-volatile memory which can hold the data even when it is not connected to a power supply.

Writing or rewriting of information in the display history information storage 18 may be performed each time the information is generated by the display history information generator 17, or every constant period TLb, or when a predetermined event has happened, for example, when the power of the image display system is turned off. If it is performed every constant period TLb, the initial writing after the starting of the image processing device 3 may be performed immediately after the starting, or upon elapse of the constant period TLb from the starting.

[0069]

If the information generated by the display history information generator 17 is not written promptly in the display history information storage 18, the information is temporarily held within the display history information generator 17.

[0070]

The service life controller 4 performs service life control based on the display history information stored in the display history information storage 18, as well as a target service life TRGT, and a service life L_ORG at the time of the commencement of use of the backlight 7, internally stored in advance.

The service life control is performed, for example, by adjusting the degree of correction at the brightness correction unit 12. For the control over the brightness correction unit 12, the control information Ce is supplied. When the brightness correction unit 12 performs the adjustment of the degree of correction, the dimming rate calculator 15 also performs the adjustment of the degree of correction. The service life control may include the additional adjustment of the degree of correction at the dimming rate calculator 5. Control information for control over the dimming rate calculator 5 is denoted by Cf.

[0071]

The service life means a period up to the time point when the light emission intensity falls to a certain value. The certain value is, for example, half the light emission intensity at the time of commencement of use.

As the service life L_ORG at the time of commencement of use, a service life $L_ORG(100)$ for a case in which use of the backlight is continued with the dimming rate of 100% is assumed to be stored. As the target service life $TRGT$, a target service life $TRGT(E)$ for a case in which use of the backlight is continued while adjusting the dimming rate E is assumed to be stored.

[0072]

The service life control is performed, for example, every constant period TLc . In such a case, the initial service life control after the starting of the service life controller 4 may be performed immediately after the starting, or upon elapse of the constant period TLc from the starting.

[0073]

The service life predictor 41 calculates a remaining service life L_RST of the backlight, based on the display history information stored in the display history information storage 18, and the service life $L_ORG(100)$ at the time of commencement of use, stored in advance in the service life predictor 41.

[0074]

For example, as the remaining service life L_RST , a remaining service life $L_RST(100)$ for a case in which the light emission is continued with the dimming rate of 100% is calculated according to the following equation (6).

$$L_RST(100) = L_ORG(100) - D_NOW \times E_NOW \quad (6)$$

In the equation (6),

$L_ORG(100)$ is a service life at the time of

commencement of use for a case in which the light emission is continued with the dimming rate of 100%,

D_NOW is the accumulated display time up to the present time point, and

E_NOW is the average dimming rate up to the present time point.

[0075]

A remaining service life L_RST(Eave) for a case in which the light emission by the backlight 7 is continued with a dimming rate equal to the average dimming rate Eave up to the present time point is calculated according to the following equation (7).

$$L_RST(Eave)=L_RST(100)/E_NOW \quad (7)$$

In this way, the service life of the backlight 7 can be predicted.

[0076]

The correction degree adjuster 42 calculates a target dimming rate E_RST based on the remaining service life L_RST(100), and the target service life TRGT(E) stored in advance in the correction degree adjuster 42, and controls the brightness correction unit 12 based on the calculated target dimming rate.

The target dimming rate E_RST is calculated, for example, in the following manner.

[0077]

First, a target value TRGT_RST(E) of the remaining service life is calculated according to the following equation (8).

$$TRGT_RST(E)=TRGT(E)-D_NOW \quad (8)$$

In the equation (8), TRGT(E) is the target service life at the time of commencement of use for a case in which the use is continued while adjusting the dimming rate E.

The target value TRGT_RST(E) of the remaining service life calculated according to the equation (8) is a target

value of the service life for the future for a case in which the use is continued while adjusting the dimming rate E.

[0078]

The target dimming rate E_RST for the future is calculated according to the following equation (9).

$$E_RST = L_RST(100) / TRGT_RST(E) \quad (9)$$

[0079]

In the above-described example, the service life $L_ORG(100)$ for a case in which the light emission is continued with the dimming rate of 100% is stored as the service life L_ORG at the time of commencement of use, and used for the process of calculating the target dimming rate E_RST . However, this is not essential. For example, a service life for a case in which the light emission is continued with a dimming rate other than 100% may be stored. In short, it is satisfactory if a service life for a case in which the light emission is continued with a constant dimming rate is stored. For example, a service life $L_ORG(\gamma)$ at the time of commencement of use, for a case in which the light emission is continued with a constant dimming rate $\gamma\%$ may be stored, and $L_ORG(\gamma) \times 100 / \gamma$ may be used in place of $L_ORG(100)$ in the equation (6).

[0080]

The correction degree adjuster 42 controls the degree of brightness correction at the brightness correction unit 12 based on the target dimming rate E_RST calculated in the manner described above. In the control of the degree of correction, the degree of brightness correction is adjusted, if required.

[0081]

The control over the brightness correction unit 12 is performed in the following manner.

If the dimming rate is to be made smaller, the degree of brightness correction is made larger. This is because,

if the degree of brightness correction is made larger, the corrected image Db becomes brighter, with the result that the dimming rate E calculated by the dimming rate calculator 15 becomes smaller.

[0082]

If the dimming rate is to be made larger, the degree of brightness correction is made smaller. This is because, if the degree of brightness correction is made smaller, the corrected image Db becomes darker (its brightness becomes nearer to the brightness of the input image Da), with the result that the dimming rate E calculated by the dimming rate calculator 15 becomes larger.

[0083]

In a case in which the brightness correction unit 12 is the one shown in FIG. 2, the control over the brightness correction unit 12 is performed in the following manner.

For enlarging the degree of brightness correction, a gradation conversion curve TC causing a larger degree of correction (larger degree of image brightening) is made to be used in the gradation conversion at the gradation converter 201. This may be achieved by changing the form of the gradation conversion curve TC stored in the gradation converter 201, in such a manner as to enlarge the degree of correction. If a plurality of gradation conversion curves TC are stored in the gradation converter 201, a gradation conversion curve TC causing a larger degree of correction may be made to be selected.

[0084]

Inversely, for reducing the degree of brightness correction, a gradation conversion curve TC causing a smaller degree of correction (smaller degree of image brightening) is made to be used in the gradation conversion at the gradation converter 201. This may be achieved by changing the form of the gradation conversion curve TC

stored in the gradation converter 201, in such a manner as to reduce the degree of correction. If a plurality of gradation conversion curves TC are stored in the gradation converter 201, a gradation conversion curve TC causing a smaller degree of correction may be made to be selected.

[0085]

If the brightness correction unit 12 is the one shown in FIG. 4, the control over the brightness correction unit 12 is performed in the following manner.

For enlarging the degree of brightness correction, the adjustment coefficient β used in the gain determination unit 204 is made larger.

Inversely, for reducing the degree of brightness correction, the adjustment coefficient β used in the gain determination unit 204 is made smaller.

[0086]

If the brightness correction unit 12 is the one shown in FIG. 5, the control over the brightness correction unit 12 is performed in the following manner.

For enlarging the degree of brightness correction, a gradation conversion curve causing a larger degree of correction is made to be used in the gradation conversion at the gradation converter 201c.

For this purpose, for example, the threshold value Mth used in the conversion curve selector 207 may be made smaller, so as to increase the likelihood that a gradation conversion curve causing a larger degree of correction is selected.

Alternatively, the conversion curve selector 207 may be configured to change the form of the gradation conversion curve selected based on the intra-frame average value Mave, according to the control information Ce from the service life controller 4, in such a manner as to enlarge the degree of correction.

[0087]

Also, where three or more gradation conversion curves are stored in the conversion curve selector 207, it may be so arranged that a gradation conversion curve causing a larger degree of correction is selected. For example, compared with a case in which the control information Ce does not require a change in the degree of correction, a gradation conversion curve causing a larger degree of correction may be made to be selected.

[0088]

Inversely, for reducing the degree of brightness correction, a gradation conversion curve causing a smaller degree of correction is made to be used in the gradation conversion at the gradation converter 201c.

For this purpose, for example, the threshold value Mth may be made larger, so as to increase the likelihood that a gradation conversion curve causing a smaller degree of correction is selected.

Alternatively, the conversion curve selector 207 may be configured to change the form of the gradation conversion curve selected based on the intra-frame average value Mave, according to the control information Ce from the service life controller 4, in such a manner as to reduce the degree of correction.

[0089]

Also, where three or more gradation conversion curves are stored in the conversion curve selector 207, it may be so arranged that a gradation conversion curve causing a smaller degree of correction is selected. For example, compared with a case in which the control information Ce does not require a change in the degree of correction, a gradation conversion curve causing a smaller degree of correction may be made to be selected.

[0090]

If the brightness correction unit 12 is the one shown in FIG. 7, the control over the brightness correction unit 12 is performed in the following manner.

For enlarging the degree of brightness correction, a correction curve $G(r)$ causing a larger degree of correction (larger degree of image brightening) is made to be used in the conversion curve generator 209.

For this purpose, the conversion curve generator 209 may change the form of the correction curve $G(r)$ in such a manner as to enlarge the degree of correction.

Also, if a plurality of correction curves $G(r)$ are stored in the conversion curve generator 209, it may be so arranged that a correction curve causing a larger degree of correction is selected.

[0091]

Inversely, for reducing the degree of brightness correction, a correction curve $G(r)$ causing a smaller degree of correction (smaller degree of image brightening) is made to be used in the conversion curve generator 209.

For this purpose, the conversion curve generator 209 may change the form of the correction curve $G(r)$ in such a manner as to reduce the degree of correction.

Also, if a plurality of correction curves $G(r)$ are stored in the conversion curve generator 209, it may be so arranged that a correction curve causing a smaller degree of correction is selected.

[0092]

When the degree of brightness correction at the brightness correction unit 12 is changed, the brightness of the corrected image D_b is changed, with the result that the dimming rate calculated by the dimming rate calculator 15 is changed.

[0093]

The correction degree adjuster 42 may be configured to

control the dimming rate calculator 15 as well as the brightness correction unit 12. For example, it may be configured to adjust the adjustment parameter α used at the dimming rate calculator 15. For example, it may be so arranged that the adjustment parameter α is set to a smaller value when it is desired to lengthen the time up to the expiration of the service life (the time until the light emission intensity falls to a certain value).

[0094]

The process of reducing the adjustment parameter α at the dimming rate calculator 15, in addition to the process of enlarging the degree of correction at the brightness correction unit 12 may be said to be an additional process for further enlargement of the degree of correction at the dimming rate calculator 15.

When the adjustment parameter α is reduced, the image displayed on the image display device 6 becomes darker. Accordingly, the process of reducing the adjustment parameter α is performed only when the priority is placed on the use until the target service life is reached, sacrificing the brightness of the displayed image.

[0095]

In the manner described above, it is possible to make adjustment so as to use the backlight 7 up to the target service life.

[0096]

Part or the entirety of the display control device 2 in FIG. 1 can be configured of processing circuitry.

For example, the functions of the various parts of the display control device 2 may be implemented by separate processing circuits, or the functions of a plurality of parts may be implemented all by a single processing circuit.

The processing circuitry may be formed of hardware or software, i.e., a programmed computer.

Part of the functions of the various parts of the display control device 2 may be implemented by hardware and the remaining part may be implemented by software.

[0097]

FIG. 9 shows a computer 9 implementing all the functions of the display control device 2, together with the backlight 7 and the display panel 8.

In the illustrated example, the computer 9 includes a processor 91 and a memory 92.

The memory 92 stores programs for implementing the functions of the various parts of the display control device 2. The memory 92 is used also for storing information stored in the various parts of the display control device 2 in FIG. 1. For example, the memory 92 is used also as the display history information storage 18.

[0098]

For example, the processor 91 comprises a CPU (Central Processing Unit), a GPU (Graphics Processing Unit), a microprocessor, a microcontroller, or a DSP (Digital Signal Processor), or the like.

[0099]

For example, the memory 92 comprises a semiconductor memory such as a RAM (Random Access Memory), a ROM (Read Only Memory), a flash memory, an EPROM (Erasable Programmable Read Only Memory), or an EEPROM (Electrically Erasable Programmable Read Only Memory), or a magnetic disc, an optical disc, or a magneto-optical disc, or the like.

[0100]

The processor 91 and the memory 92 may be integrated into an LSI (Large Scale Integration).

[0101]

The processor 91 implements the functions of the display control device 2 by executing the programs stored in the memory 92. The functions of the display control device

2 include the control over the amount of light emission by the backlight 7, and the control over the display at the display panel 8 (supply of signals to the display panel 8).

[0102]

The programs may be provided via a network, or may be provided being recorded in a recording medium, such as a non-transient recording medium. That is, the programs may be provided as a program product.

Although the computer in FIG. 9 consists of a single processor, it may comprise two or more processors.

[0103]

A procedure of processes performed by the processor 91, in a case in which the display control device 2 in FIG. 1 is formed of the computer in FIG. 9 will now be described with reference to FIG. 10. The processes in FIG. 10 are started each time one frame of the input image data Da is inputted.

[0104]

In step ST1, the processor 91 corrects the input image data Da to generate the corrected image data Db. This process is similar to the process performed by the brightness correction unit 12 in FIG. 1.

[0105]

In step ST2, the processor 91 calculates the average luminance Lb of the corrected image Db represented by the corrected image data Db generated in step ST1. This process is similar to the process performed by the corrected image luminance calculator 13 in FIG. 1.

[0106]

In step ST3, the processor 91 calculates the average luminance La of the input image Da represented by the input image data Da. This process is similar to the process performed by the input image luminance calculator 14 in FIG. 1.

The process in step ST3 may be performed in parallel

with the processes in steps ST1 and ST2.

[0107]

In step ST4, the processor 91 calculates the dimming rate E based on the average luminance La calculated in step ST3, and the average luminance Lb calculated in step ST2. This process is similar to the process performed by the dimming rate calculator 15 in FIG. 1.

[0108]

In step ST5, the processor 91 judges whether the display history information is to be generated. For example, judgment is made as to whether it is at a timing at which the display history information should be generated.

If the result in step ST5 is NO, the processor 91 returns to steps ST1 and ST3; whereas if the result is YES, the processor 91 proceeds to step ST6.

[0109]

In step ST6, the processor 91 generates the display history information based on the dimming rate E calculated in step ST4.

The processes in steps ST5 and ST6 are similar to the process performed by the display history information generator 17 in FIG. 1 for generating the display history information.

[0110]

In step ST7, the processor 91 judges whether the display history information generated in step ST6 is to be stored. For example, judgement is made as to whether it is a timing at which the display history information should be stored.

If the result in step ST7 is NO, the processor 91 returns to steps ST1 and ST3; whereas if the result is YES, the processor 91 proceeds to step ST8.

[0111]

In step ST8, the processor 91 writes the display

history information generated in step ST6 in the memory 92.

The processes in steps ST7 and ST8 are similar to the process performed by the display history information generator 17 in FIG. 1 for storing the display history information in the display history information memory 18.

[0112]

In step ST9, the processor 91 judges whether the service life control is to be performed. For example, judgement is made as to whether it is at a timing at which the service life control should be performed.

If the result in step ST9 is NO, the processor 91 returns to steps ST1 and ST3; whereas if the result is YES, the processor 91 proceeds to step ST10.

[0113]

In step ST10, the processor 91 calculates the remaining service life of the backlight based on the display history information stored in the memory 92, and the service life L_ORG at the time of commencement of use.

The processes in steps ST9 and ST10 are similar to the process performed by the service life predictor 41 in FIG. 1.

[0114]

In step ST11, the processor 91 calculates the target dimming rate E_RST based on the remaining service life L_RST(100) calculated in step ST10, and the target service life TRGT(E) stored in the memory 92, and adjusts the degree of correction based on the calculated target dimming rate. In the adjustment of the degree of correction, for example, the degree of correction in the brightness correction in step ST1 is adjusted. In the adjustment of the degree of correction, the adjustment parameter α used in step ST4 may also be adjusted.

The process in step ST11 is similar to the process performed by the correction degree adjuster 42 in FIG. 1,

and the process performed by the brightness correction unit 12 for adjusting the degree of correction based on the output of the correction degree adjuster 42. The process in step ST11 may include the process performed by the dimming rate calculator 15 for adjusting the degree of correction based on the output of the correction degree adjuster 42.

[0115]

In the examples of configurations described with reference to FIG. 1 to FIG. 10, the service life controller 4 performs the service life control every constant period TLc.

Alternatively, the service life controller 4 may be configured to perform the service life control when a predetermined event has happened, for example, when the power supply to the image display system is turned on.

[0116]

Also, the configuration may be such that the service life controller 4 performs the service life control each time the display history information in the display history information storage 18 is rewritten. In such a case, the configuration may be such that the fact that the information has been rewritten is notified from the display history information generator 17 to the service life predictor 41, and the service life predictor 41 performs the calculation of the remaining service life L_RST responsive to the notification. Control information for this notification is denoted by Cw. Also, similar control information may be supplied to the correction degree adjuster 42.

[0117]

Furthermore, the adjustment of the degree of correction at the correction degree adjuster 42 may be performed at a timing independent of the calculation of the target dimming rate E_RST at the service life predictor 41.

For example, if the calculation of the target dimming

rate E_RST is performed every constant period TLc, the adjustment of the degree of correction may be performed every constant period TLd which is different from the period TLc. The period TLd may be longer than the period TLc. If the adjustment of the degree of correction is performed every constant period TLd, the initial adjustment of the degree of correction after the starting of the image processing device 3 and the service life controller 4 may be performed immediately after the starting, or upon elapse of the constant period TLd after the starting.

Also, the adjustment of the degree of correction may be performed when a predetermined event has happened, e.g., when power supply to the image display system is turned on.

[0118]

As has been described, according to the first embodiment, it is possible to make the adjustment such that the backlight 7 can be used up to the target service life, while maintaining the visibility of the displayed image, or minimizing the reduction in the visibility of the displayed image.

[0119]

SECOND EMBODIMENT

FIG. 11 shows an image display system according to a second embodiment. The image display system shown in FIG. 11 includes a display control device 2b and an image display device 6.

The display control device 2b includes an image processing device 3b and a service life controller 4b.

The image processing device 3b and the service life controller 4b respectively have the same internal configurations as and similar functions to the image processing device 3 and the service life controller 4 in the first embodiment, but differ from the image processing device 3 and the service life controller 4 in the first

embodiment in that the service life controller 4b is provided to be separable from the image processing device 3b.

The image processing device 3b and the image display device 6 in combination form an image display apparatus 1b according to the present embodiment.

[0120]

For example, the image processing device 3b and the service life controller 4b are provided with connectors 301, 401, respectively, and the connectors 301, 401 can be interconnected by a cable 501, and in the state (non-connected state) in which the connection by the cable 501 is not made, the service life controller 4b are separated from the image processing device 3b.

[0121]

Because of the separability, the use in the following manner is possible.

For example, the service life controller 4b is normally separated from the image processing device 3b, and the service life controller 4b is connected to the image processing device 3b only when required. In the connected state, the service life controller 4b performs the service life control.

The service life control may be performed promptly when the service life controller 4b is connected to the image processing device 3b, i.e., when the connection is detected. Thereafter, the service life control may be performed every constant period TLc as long as the connected state is maintained.

[0122]

In the service life control, the service life controller 4b reads the information stored in the display history information storage 18, calculates the degree of correction that is required, and adjusts the degree of

correction based on the result of the calculation.

[0123]

As in the first embodiment, the adjustment of the degree of correction at the correction degree adjuster 42 in the service life controller 4b may be performed at a timing independent of the calculation of the target dimming rate E_RST at the service life predictor 41. For example, if the calculation of the target dimming rate E_RST at the service life predictor 41 is performed every constant period TLc, the adjustment of the degree of correction at the correction degree adjuster 42 may be performed every period TLd which is different from the period TLc. The period TLd may be longer than the period TLc.

[0124]

In the example of FIG. 11, the connector 301 and the connector 401 are connected by the cable 501. But as the connector 301 and the connector 401, connectors which can be connected directly, without a cable, may be used.

[0125]

Also, instead of providing the connectors 301, 401, the configuration may be such that interfaces capable of wireless mutual communication are provided, and data can be transmitted and received between the image processing device 3b and the service life controller 4b by the wireless mutual communication. In this case, it can be said that, in a state in which the communication is not performed, the service life controller 4b is in a state of being separated from the image processing device 3b, whereas in a state in which the communication is performed, the service life controller 4b is in a state of being connected to the image processing device 3b.

[0126]

Each of the image processing device 3b and the service life controller 4b of the display control device 2b in FIG.

11 may be configured, in part or in its entirety, of processing circuitry.

For example, the functions of the various parts of each of the image processing device 3b and the service life controller 4b may be implemented by separate processing circuits, or the functions of a plurality of parts may be implemented all by a single processing circuit.

The processing circuitry may be formed of hardware or software, i.e., a programmed computer.

Part of the functions of the various parts of each of the image processing device 3b and the service life controller 4b may be implemented by hardware, and the rest may be implemented by software.

[0127]

FIG. 12 shows a first computer 9b for implementing all the functions of the image processing device 3b, and a second computer 9c for implementing all the functions of the service life controller 4b, together with the backlight 7 and the display panel 8.

[0128]

The computer 9b includes a processor 91b and a memory 92b. The memory 92b stores programs for implementing the functions of various parts of the image processing device 3b.

The computer 9c includes a processor 91c and a memory 92c. The memory 92c stores programs for implementing the functions of various parts of the service life controller 4b.

The memory 92b is used also for storing information stored in various parts of the image processing device 3b in FIG. 11. For example, the memory 92b is used also as the display history information storage 18 in FIG. 11.

The memory 92c is used also for storing information stored in various parts of the service life controller 4b in

FIG. 11.

[0129]

For example, each of the processors 91b and 91c is formed of a CPU (Central Processing Unit), a GPU (Graphics Processing Unit), a microprocessor, a microcontroller or a DSP (Digital Signal Processor), or the like.

[0130]

For example, each of the memory 92b and the memory 92c is formed of a semiconductor memory, such as a RAM (Random Access Memory), a ROM (Read Only Memory), a flash memory, an EPROM (Erasable Programmable Read Only Memory), or an EEPROM (Electrically Erasable Programmable Read Only Memory), or a magnetic disc, an optical disc, or a magneto-optical disc, or the like.

[0131]

The processor 91b and the memory 92b may be integrated into an LSI. Similarly, the processor 91c and memory 92c may be integrated into an LSI.

[0132]

The processor 91b implements the functions of the image processing device 3b by executing the programs stored in the memory 92b. The functions of the image processing device 3b include the control over the amount of light emission at the backlight 7, and the control over the display at the display panel 8 (supply of signals to the display panel 8).

[0133]

The processor 91c implements the functions of the service life controller 4b by executing the programs stored in the memory 92c. The functions of the service life controller 4b include the calculation of the degree of correction.

[0134]

The programs may be provided via a network, or may be provided being recorded in a recording medium, such as a

non-transient recording medium. That is, the programs may be provided as a program product.

Although each of the computers 9b and 9c consists of a single processor, it may comprise two or more processors.

[0135]

The computer 9b and the computer 9c are interconnected by means of input-output interfaces 93b, 93c and a cable 94, in such a manner they can be separated from each other.

[0136]

A procedure of processes performed by the processor 91b in a case in which the above-described image processing device 3b is formed of the computer 9b in FIG. 12 will now be described with reference to FIG. 13. The processes in FIG. 13 can be performed even when the computer 9c is not connected to the computer 9b, and are started each time one frame of the input image data Da is inputted.

[0137]

The processes in steps ST1 to ST8 in FIG. 13 are respectively similar to those in steps ST1 to ST8 in FIG. 10. However, the processes performed are similar to those performed by the image processing device 3b in FIG. 11, rather than the processes performed by the image processing device 3 in FIG. 1.

[0138]

A procedure of processes performed by the processors 91b and 91c in a case in which the above-described image processing device 3b and service life controller 4b are formed of the computers 9b and 9c in FIG. 12 will now be described with reference to FIG. 14. The processes in FIG. 14 are performed in a state in which the computer 9c is connected to the computer 9b as shown in FIG. 12. The processes in FIG. 14 may be started promptly when the computer 9c is connected to the computer 9b, i.e., such connection is detected. After that, the processes may be

started every constant period TLc as long as the connected state is maintained.

[0139]

The processes in steps ST10 and ST11 in FIG. 14 are respectively identical to those in steps ST10 and ST11 in FIG. 10. However, the processes performed are similar to those performed by the service life controller 4b in FIG. 11 rather than those performed by the service life controller 4 in FIG. 1.

[0140]

In the example shown in FIG. 12, the input-output interface 93b and the input-output interface 93c are connected by the cable 94. Alternatively, as the input-output interfaces 93b and 93c, those provided with connectors which can be connected directly, without a cable, may be used.

[0141]

Also, instead of providing the input-output interfaces 93b and 93c, configuration may be such that interfaces which are capable of wireless mutual communication are provided, and transmission and reception of data between the computers 9b and the computer 9c can be made by the wireless mutual communication. In such a case, it can be said that, in a state in which the communication is not made, the computer 9c is in a state of being separated from the computer 9b; whereas, in a state in which the communication is made, the computer 9c is in a state of being connected to the computer 9b.

[0142]

Even according to the second embodiment, effects similar to those of the first embodiment can be obtained.

Also, because the service life controller 4b is separable from the image processing device 3b, the service life controller 4b can be kept separated, when it is not

required. Accordingly, the convenience in use of the image display apparatus 1b including the image processing device 3b, or the image display system including the image display apparatus 1b is improved. For example, in cases in which the image display system or the image display apparatus 1b is of a portable-type, its size or weight can be reduced by separating the service life controller 4b, so that the portability is improved.

[0143]

Also, with the configuration of the second embodiment, the service life controller 4b need not be dedicated to the image display apparatus 1b. For example, it may be so arranged that a single service life controller 4b is provided for a plurality of image display apparatuses 1b having the same specification, and the service life controller 4b is connected to the plurality of image display apparatuses in turn, and service life control on the respective image processing devices 3b may be performed in turn. It is also possible to provide a plurality of image display apparatuses 1b having the same specification, and a plurality of service life controllers 4b having the same specification, and an arbitrary one of the service life controllers 4b is connected to an arbitrary one of the image display apparatuses 1b and used to perform the service life control.

[0144]

Even when the image processing device 3b and the service life controller 4b are respectively formed of the computers 9b and 9c, similar effects can be obtained because the computer 9c can be separated from the computer 9b.

[0145]

Various modifications can be made to the embodiments described above. For example, the various modifications described in connection with the first embodiment can also

be applied to the second embodiment.

So far, description has been made on the display control device and the image display system. However, it is also possible to implement a display control method using the display control device. Also, it is possible to have a computer to perform the processes in the display control device or the display control method by means of programs.

REFERENCE SIGNS

[0146]

1b: image display apparatus; 2: display control device; 3,3b: image processing device; 4,4b: service life controller; 6: image display device; 7: backlight; 8: display panel; 9,9b,9c: computer; 11: image input unit; 12: brightness correction unit; 13: corrected image luminance calculator; 14: input image luminance calculator; 15: dimming rate calculator; 17: display history information generator; 18: display history information storage; 41: service life predictor; 42: correction degree adjuster; 91,91b,91c: processor; 92,92b,92c: memory; 93b,93c: input-output interface; 94: cable; 201,201c: gradation converter; 202: maximum component value calculator; 203: intra-frame maximum value calculator; 204: gain determination unit; 205: gain multiplier; 206: intra-frame average value calculator; 207: conversion curve selector; 208: histogram generator; 209: conversion curve generator; 301: connector; 401: connector; 501: cable.

CLAIMS

[Claim 1]

A display control device to control an image display device provided with a backlight and a display panel of a non-luminous type, including an image processing device and a life controller, wherein

said image processing device includes:

a brightness correction unit to correct a brightness of an input image and output a corrected image;

a corrected image luminance calculator to calculate an average luminance of the corrected image outputted from said brightness correction unit;

an input image luminance calculator to calculate an average luminance of said input image;

a dimming rate calculator to calculate a dimming rate of said backlight based on the average luminance of said corrected image and the average luminance of said input image;

a display history information generator to generate display history information based on the dimming rate calculated by said dimming rate calculator; and

a display history information storage to store the display history information generated by said display history information generator; wherein

said image processing device causes said backlight to emit light with said dimming rate, and causes said display panel to display said corrected image;

said display history information represents accumulated display time, from commencement of use of said image display device to a present time point, and an average value of the dimming rate during periods in which display was performed by said image display device, and

said service life controller controls a degree of the correction at said brightness correction unit based on the

display history information stored in said display history information storage, a service life at a time of commencement of use of said backlight, and a target service life of said backlight.

[Claim 2]

The display control device as set forth in claim 1, wherein

said service life controller includes:

a service life predictor to predict a remaining service life of said backlight based on said display history information stored in said display history information storage, and the service life at the time of commencement of use of said backlight; and

a correction degree adjuster to control the degree of the correction at said brightness correction unit, based on the remaining service life predicted by said service life predictor and said target service life.

[Claim 3]

The display control device as set forth in claim 1 or 2, wherein

said service life controller also controls a degree of correction at said dimming rate calculator based on the display history information stored in said display history information storage, the service life at the time of commencement of use of said backlight, and the target service life of said backlight.

[Claim 4]

The display control device as set forth in any of claims 1 to 3, wherein said brightness correction unit includes a gradation converter to convert gradation values of said input image.

[Claim 5]

The display control device as set forth in claim 4, wherein

said input image has an R component value, a G component value, and a B component value for each pixel,

said brightness correction unit also includes:

a maximum component value calculator to calculate a maximum value among the R component value, the G component value, and the B component value for each pixel of said input image;

an intra-frame average value calculator to calculate an average value of the maximum values calculated by said maximum component value calculator, for each frame; and

a conversion curve selector to select a gradation conversion curve based on the intra-frame average value calculated by said intra-frame average value calculator; wherein

said gradation converter converts the values of said input image using the gradation conversion curve selected by said conversion curve selector.

[Claim 6]

The display control device as set forth in claim 4, wherein

said input image has an R component value, a G component value, and a B component value for each pixel;

said brightness correction unit also includes:

a maximum component value calculator to calculate a maximum value among the R component value, the G component value, and the B component value for each pixel of said input image;

a histogram generator to generate a histogram of the maximum values calculated by said maximum component value calculator, for each frame; and

a conversion curve generator to generate a gradation conversion curve based on the histogram generated by said histogram generator; wherein

said gradation converter converts the values of said

input image using the gradation conversion curve generated by said conversion curve generator.

[Claim 7]

The display control device as set forth in any of claims 1 to 3, wherein

said input image has an R component value, a G component value, and a B component value for each pixel; wherein

said brightness correction unit includes:

a maximum component value calculator to calculate a maximum value among the R component value, the G component value, and the B component value for each pixel of said input image;

an intra-frame maximum value calculator to calculate a maximum value among the maximum values, calculated by said maximum component value calculator, within each frame; and

a gain multiplier to determine a gain based on the maximum value calculated for the particular frame by said intra-frame maximum calculator, and multiply gradation values of said input image by the determined gain.

[Claim 8]

The display control device as set forth in any of claims 1 to 7, wherein

said service life controller is configured to be separable from said image processing device.

[Claim 9]

An image display system including the display control device as set forth in any of claims 1 to 8, and said image display device.

[Claim 10]

A display control method for an image display device provided with a backlight and a display panel of a non-luminous type, comprising:

correcting a brightness of an input image to output a

corrected image;

calculating an average luminance of said corrected image and an average luminance of said input image;

calculating a dimming rate of said backlight based on the average luminance of said corrected image and the average luminance of said input image;

generating display history information based on said dimming rate;

storing said display history information in a display history information storage; and

causing said backlight to emit light with said dimming rate and causing said corrected image to be displayed by said display panel; wherein

said display history information represents accumulated display time from commencement of use of said image display device, up to a present time point, and an average value of the dimming rate during periods in which display is performed by said image display device, and

a correction degree in the brightness correction is controlled based on the display history information stored in said display history information storage, a service life at a time of commencement of use of said backlight, and a target service life of said backlight.