US 20030133019A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2003/0133019 A1**

HIGURASHI et al. (43) **Pub. Date: Jul. 17, 2003**

(54) **IMAGE PROCESSING APPARATUS FOR JOINING A PLURALITY OF IMAGES**

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(*) Notice: This is a publication of a continued prosecution application (CPA) filed under 37 CFR 1.53(d).

(21) Appl. No.: **08/964,180**

(22) Filed: **Nov. 4, 1997**

(30) **Foreign Application Priority Data**

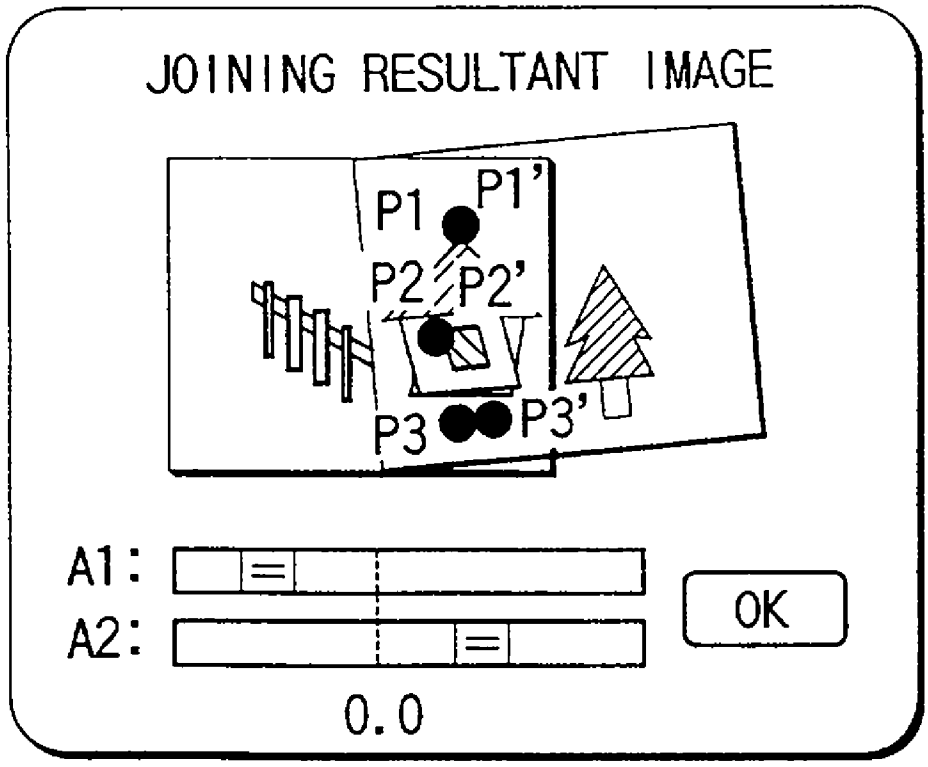
Nov. 8, 1996 (JP) 8-296750
Nov. 22, 1996 (JP) 8-312260

Publication Classification

(51) **Int. Cl.**[7] **H04N 5/235**
(52) **U.S. Cl.** **348/218.1**; 348/222.1; 348/362

(57) **ABSTRACT**

In an image processing apparatus of the present invention, which displays image data, such as images photographed by imaging apparatus such as a digital camera and photographing conditions as images before correction and images after correction, on an image display section, distortion and color tone of images obtained from an unused camera are corrected and joined to each other as viewing images before and after correction, so that the parameters used in the correction are stored in accordance with its apparatus, and the stored parameters are read out and used to correct in images obtained from previously used camera, and the joined image and image data are displayed on a monitor and output by a printer, or stored in a recording medium.



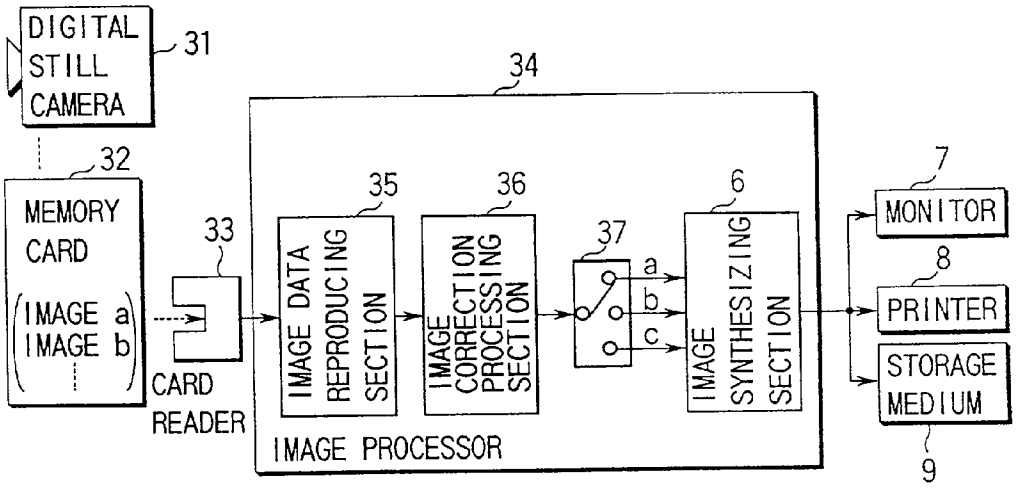

DIGITAL STILL CAMERA
31
34
32
MEMORY CARD
IMAGE a
IMAGE b
33
CARD READER
35
IMAGE DATA REPRODUCING SECTION
36
IMAGE CORRECTION PROCESSING SECTION
37
a
b
c
6
IMAGE SYNTHESIZING SECTION
IMAGE PROCESSOR
7
MONITOR
8
PRINTER
STORAGE MEDIUM
9

FIG. 1

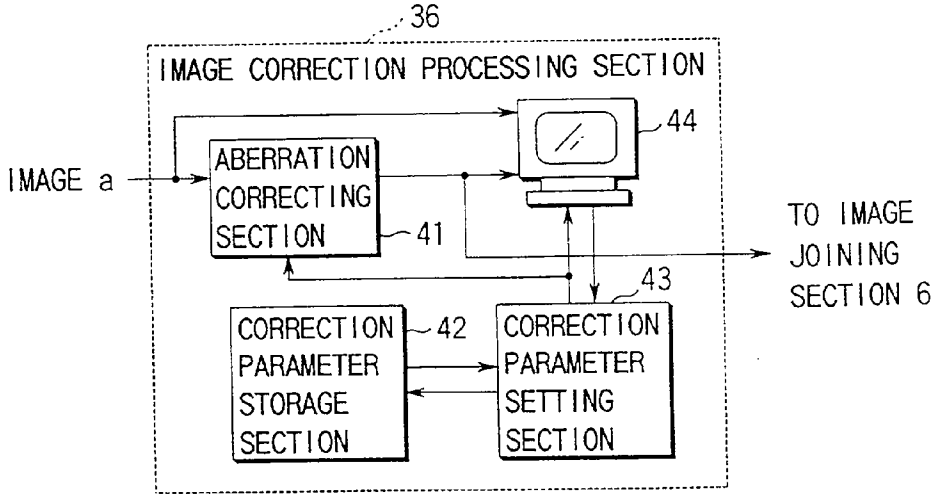

36
IMAGE CORRECTION PROCESSING SECTION
44
IMAGE a
ABERRATION CORRECTING SECTION
41
TO IMAGE JOINING SECTION 6
43
CORRECTION PARAMETER STORAGE SECTION
42
CORRECTION PARAMETER SETTING SECTION

FIG. 2

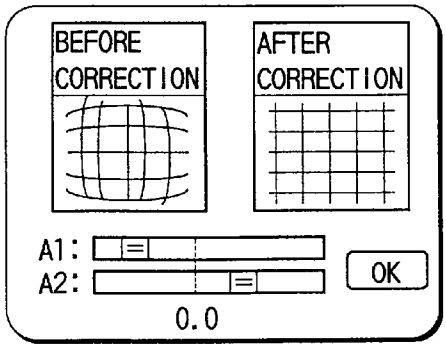


FIG. 3A

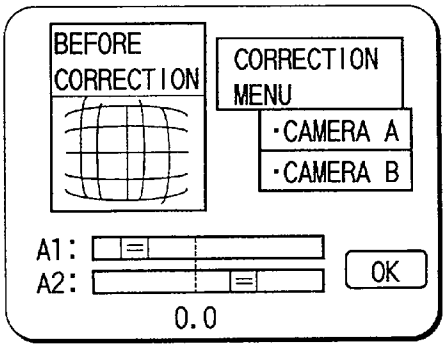


FIG. 3B

NAME OF MENU	A1	A2
CAMERA A	-0.030	+0.150
CAMERA B	-0.002	-0.010
⋮	⋮	⋮

FIG. 4

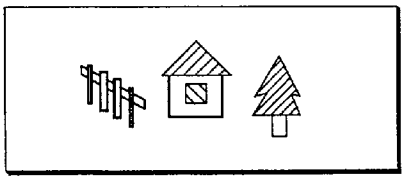


FIG. 5A

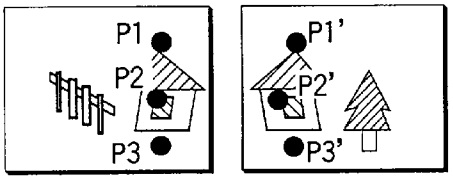


FIG. 5B

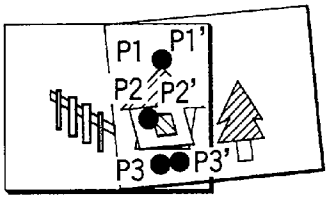


FIG. 5C

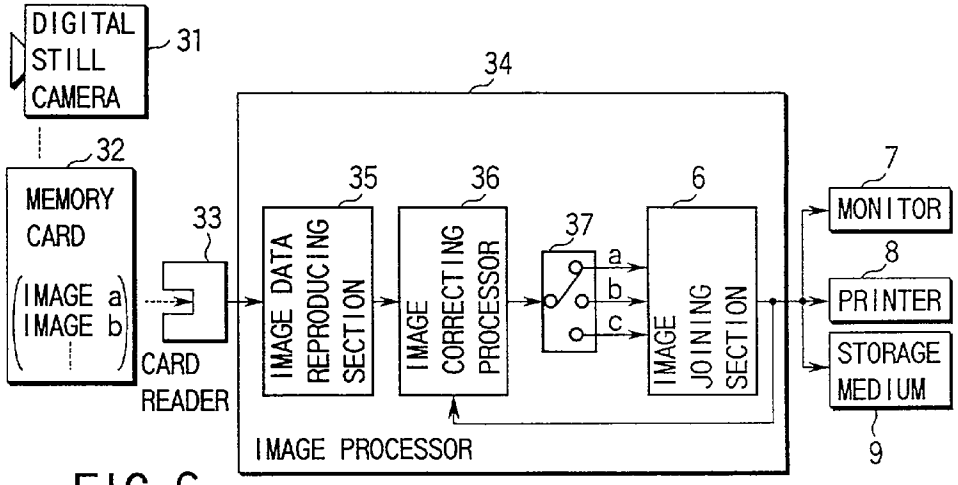


FIG. 6

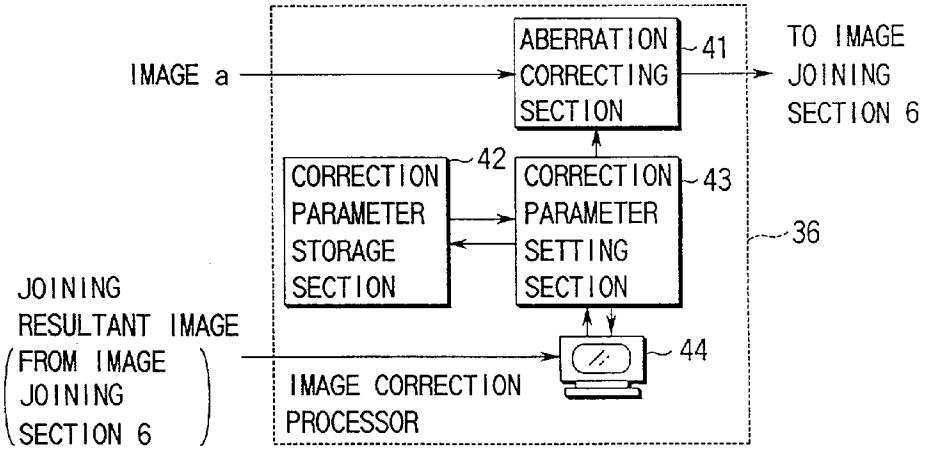


FIG. 7

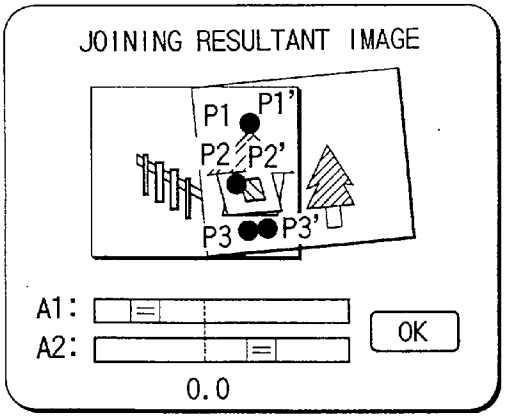


FIG. 8

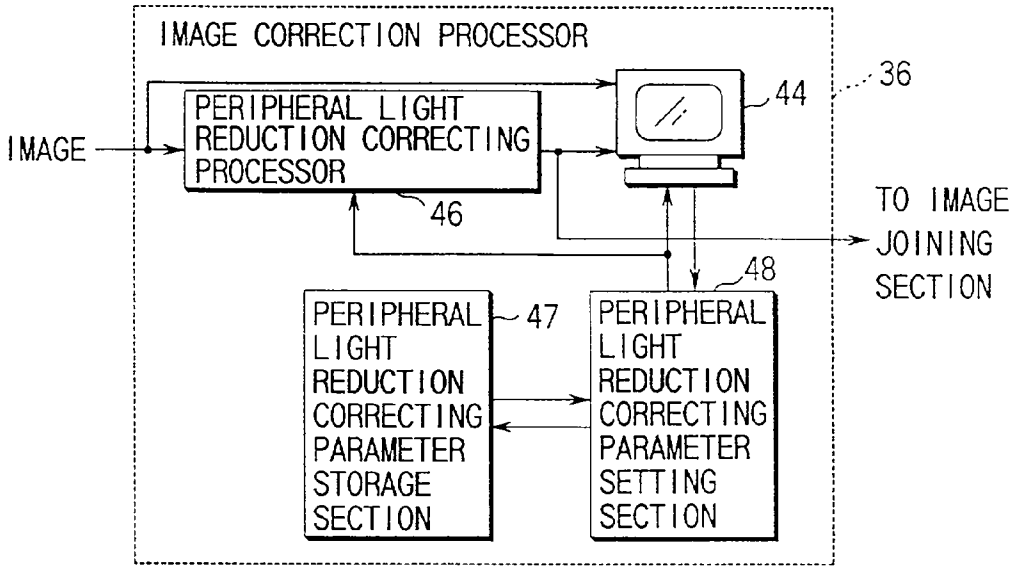


FIG. 9

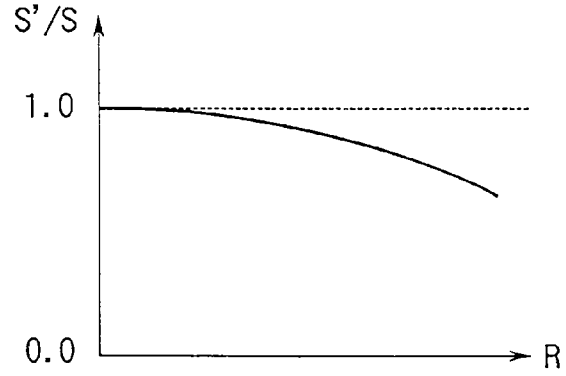


FIG. 10

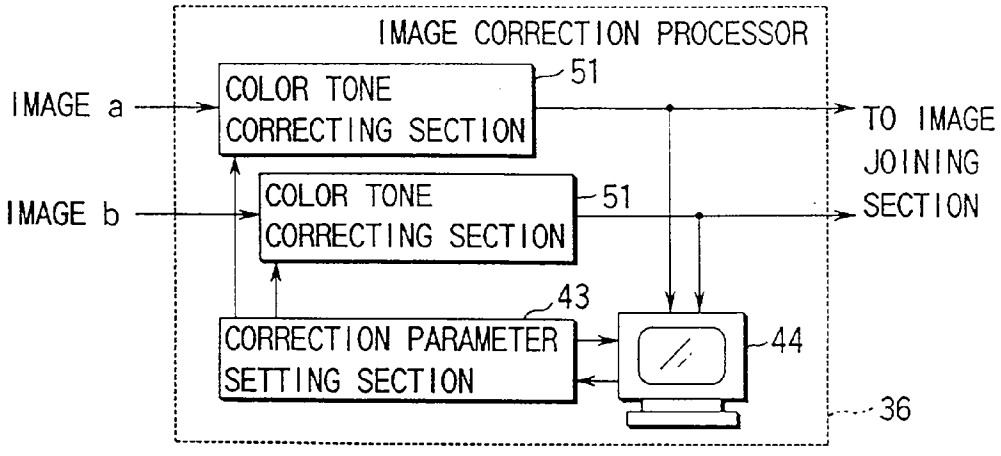


FIG. 11

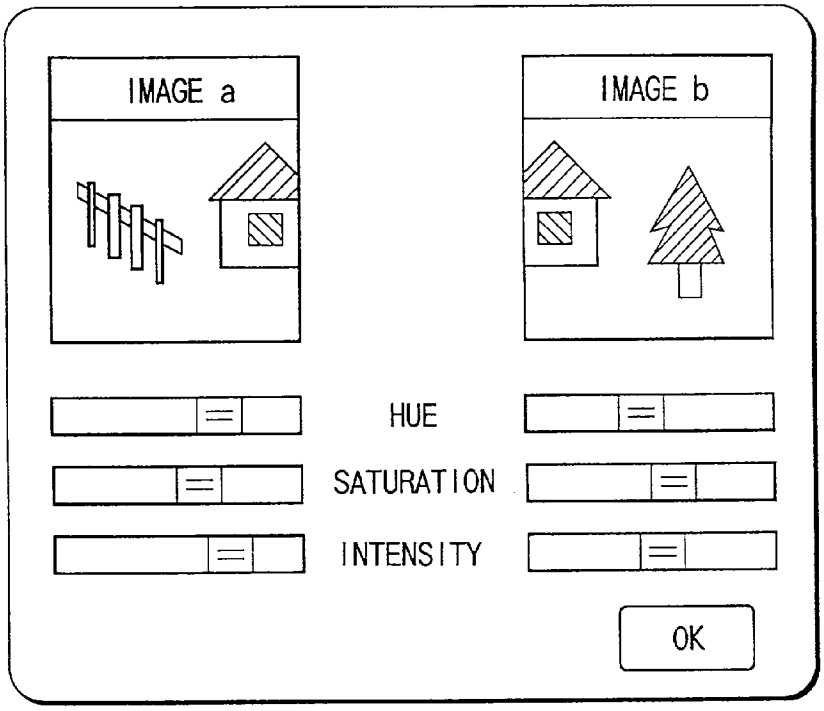


IMAGE a
IMAGE b
HUE
SATURATION
INTENSITY
OK

FIG. 12

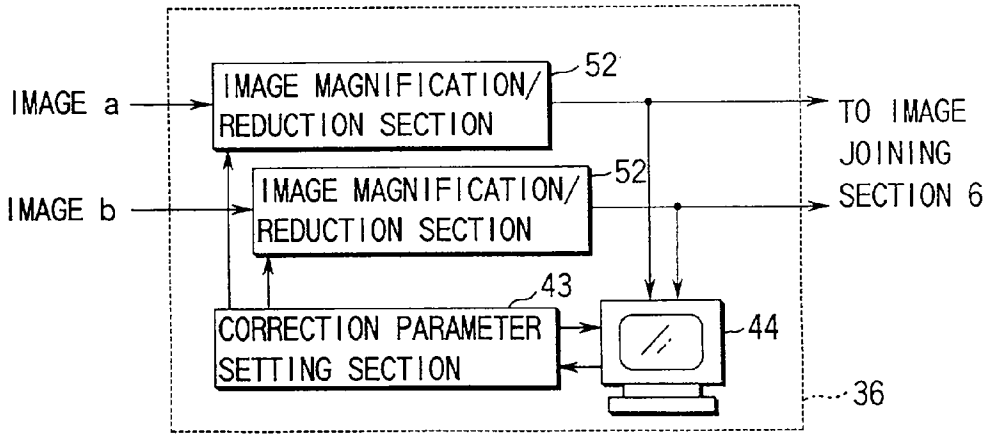


IMAGE a
IMAGE b
IMAGE MAGNIFICATION/ REDUCTION SECTION
52
IMAGE MAGNIFICATION/ REDUCTION SECTION
52
TO IMAGE JOINING SECTION 6
CORRECTION PARAMETER SETTING SECTION
43
44
36

FIG. 13

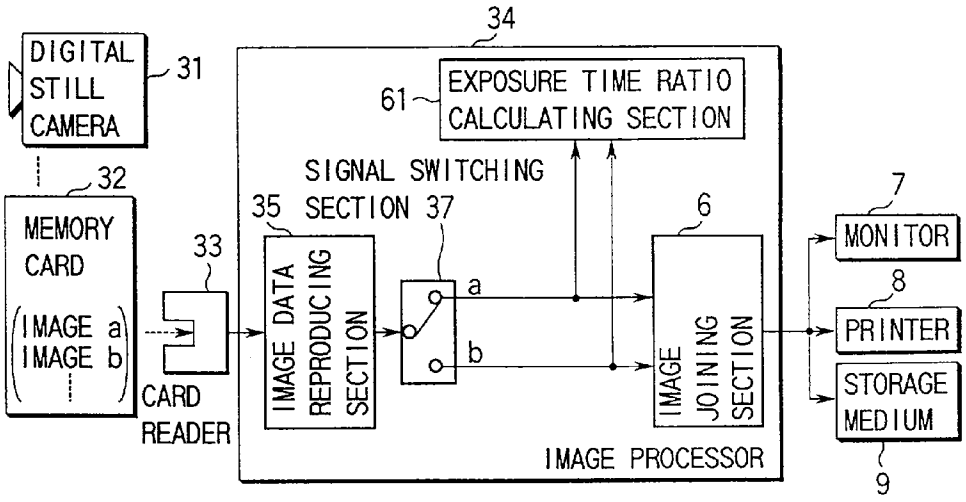


FIG. 14

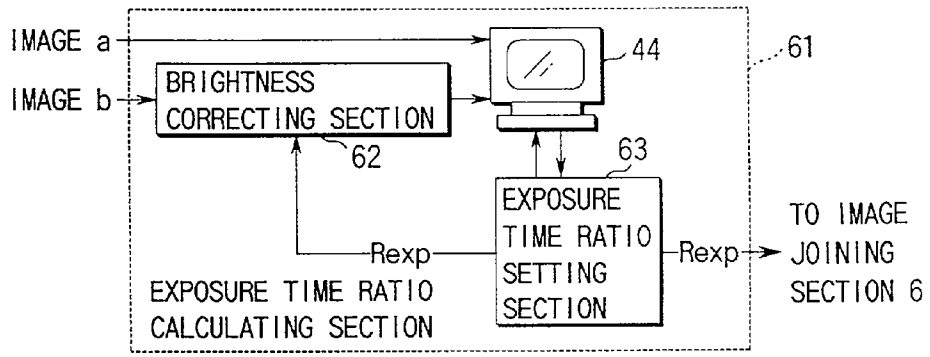


FIG. 15

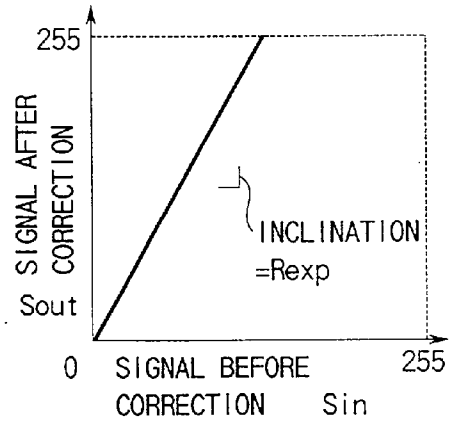


FIG. 16

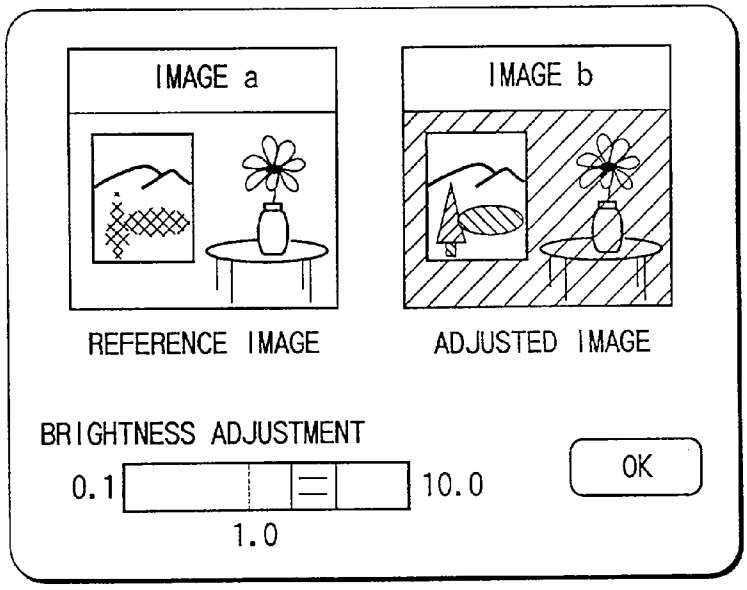


FIG. 17

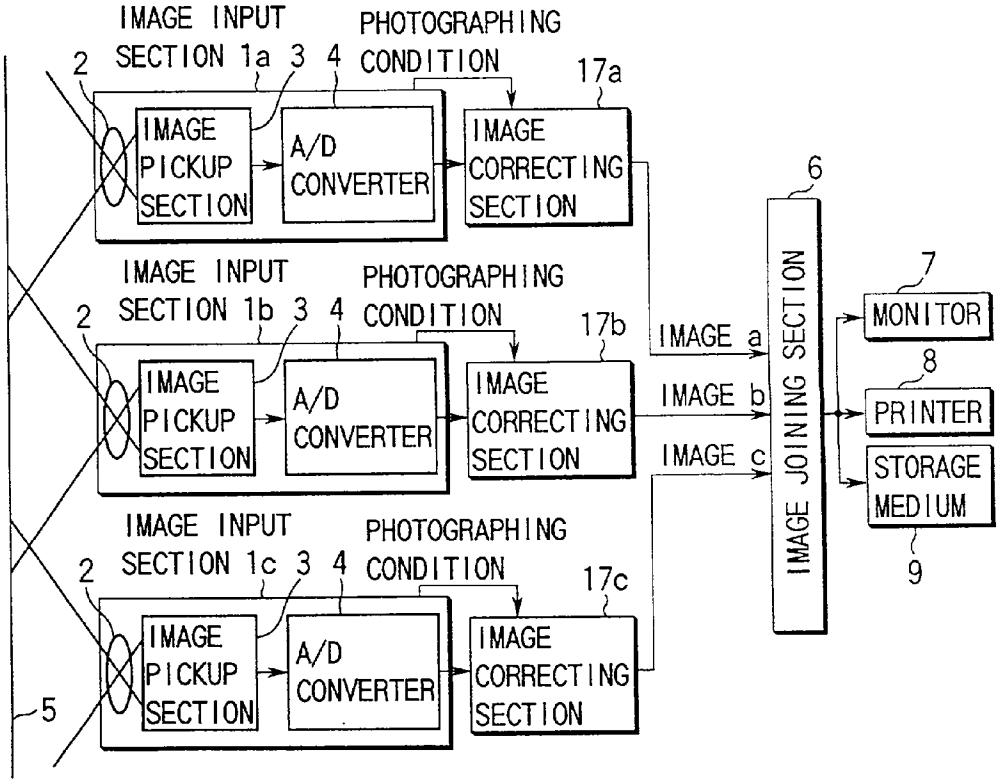


FIG. 18 PRIOR ART

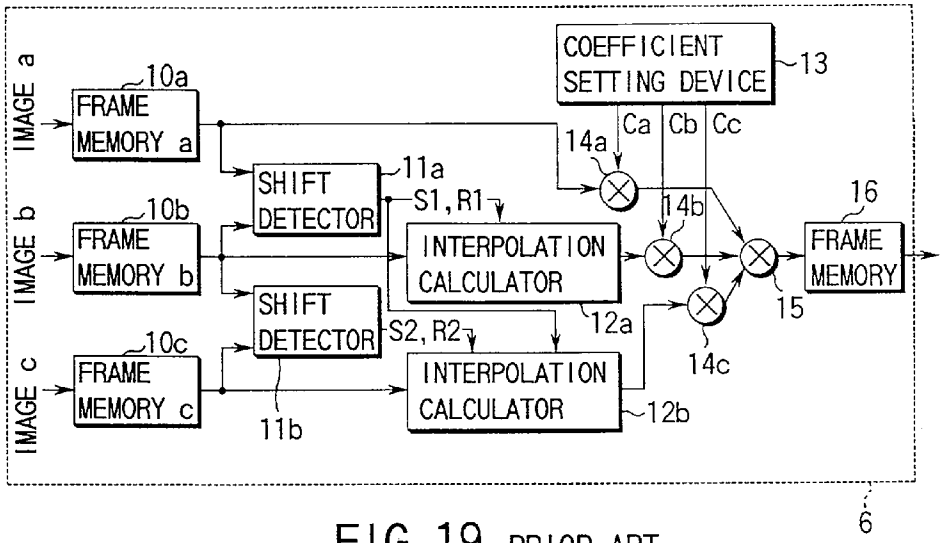


FIG. 19 PRIOR ART

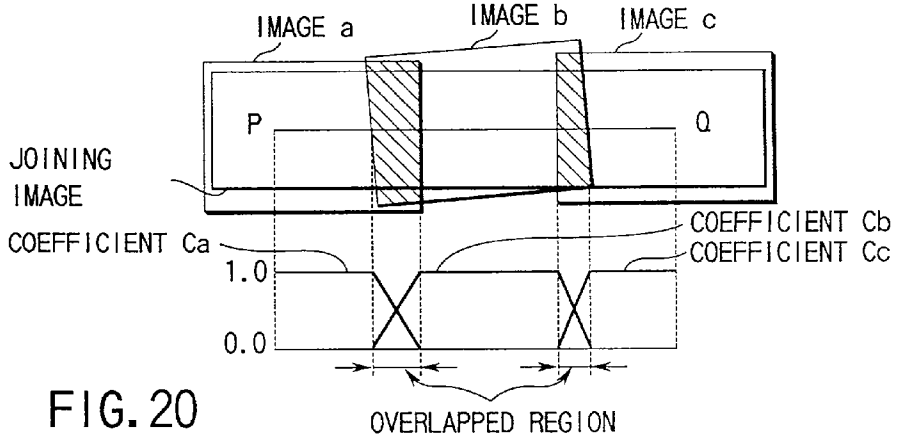


FIG. 20

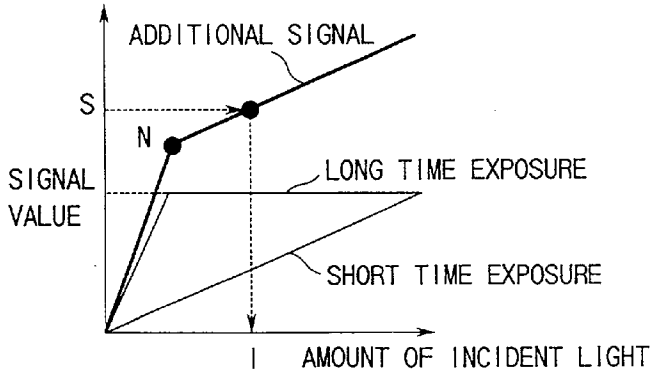


FIG. 21

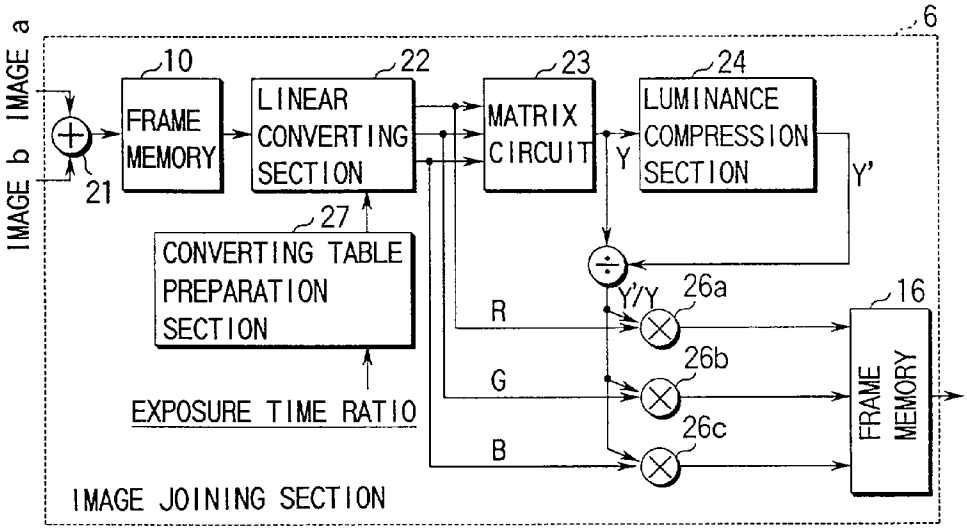


FIG. 22 PRIOR ART

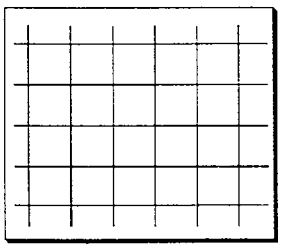


FIG. 23A

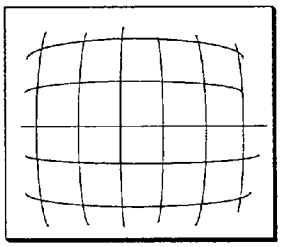


FIG. 23B

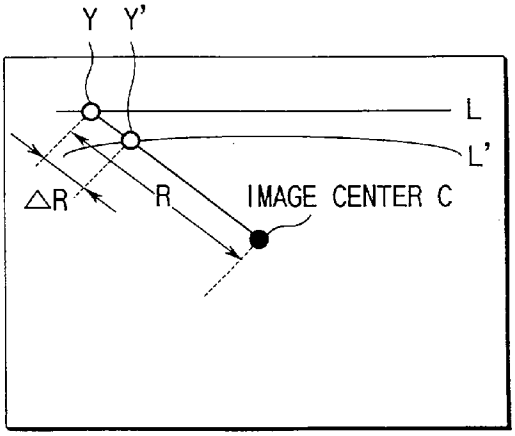


FIG. 23C

IMAGE PROCESSING APPARATUS FOR JOINING A PLURALITY OF IMAGES

BACKGROUND OF THE INVENTION

[0001] The present invention relates to an image processing apparatus for joining (restoring composition) a plurality of images taken to which one composition is divided with an overlap area where desired object exists or synthesizing a plurality of images taken with a different exposure, and more particularly to an image processing apparatus for extending a viewing angle of a joined image and its dynamic range of a synthesized image.

[0002] In recent years, personal computers (hereinafter called PC) got much more capability and their price is reducing in accordance with improvement of manufacture technique, so that they have been widely used in many companies, education, and home.

[0003] To input images to PC, an image is optically picked up from a film photographed by a conventional camera and is converted to an image signal to be input.

[0004] In addition to camera, imaging apparatus such as a video camera for taking the image are used in various situations. Particularly, in a digital still camera, a film, which is used in the general camera, doesn't have to be, used. Instead, the image is converted to a digital signal and recorded in storage medium, which is magnetically or optically recordable, so that the digital signal is input to the inputting device. Then, the image is reconstructed to be output to a display or a printer. As a result, developing process for films is unnecessary, and erasing and editing can be easily performed.

[0005] Moreover, demand for digital still cameras has been rapidly increased for the purpose of using the Internet communication in accordance with an increase Internet users, reduce the price of the digital still camera.

[0006] The digital still camera get a image of the object as an image signal by a solid state imaging device, such as CCD, using photoelectric conversion. However, since resolution and a dynamic range are low as compared with the ordinary film, the technique to make high resolution images and to extend a dynamic range of images have been strongly desired.

[0007] One of methods for obtaining high resolution image is increasing the number of pixels of the imaging device itself. However, it is generally known that the cost of the imaging device rapidly rises with the increase in the number of pixels.

[0008] The applicant of the present application proposed the technique of joining the images taken by a plurality of imaging device as described in Japanese Patent Application KOKAI Publication No. 6-141246, and the technique of divisionally photographing the object by the movement of the camera so as to join a plurality of images obtained by one image pickup element.

[0009] However, in general when the photographed image is subjected to influence of distortion due to the optical system, the image is distorted. If the images are joined by the technique of Japanese Patent Application KOKAI Publication No. 6-141246, the composition of the overlapped parts differs between the images, and there occurs a problem object is seen double in the join image. Also, due to the displacement of the points, serving as a reference for joining, the image is detected as if it were rotated though the image is not actually rotated. As a result, there occurs a problem in which the images are not joined well.

[0010] To solve the above problems, the applicant of the present application proposed an image processing apparatus for compensating for influence of distortion comprising image correcting means for a geometrical correction as described in U.S. Pat. No. 08/541,644 (filing data: Oct. 10, 1995).

[0011] The structure of the image processing apparatus is shown in **FIG. 18**.

[0012] In the figure, each of image input sections **1***a* to **1***c* of the image processing apparatus comprises an optical system **2**, an image pickup section **3** such as CCD, and an A/D converter **4**. These image input sections are arranged to Capture different portions (positions) of an object **5** to have the overlapping area.

[0013] An output signal of each image pickup section **3** is digitized by the A/D converter **4** so as to be input to each of image correcting sections **17***a* to **17***c*. Each of the image correcting sections **17***a* to **17***c* reads photographing conditions such as a focus position when a image is taken and a characteristic parameter of the optical system so as to correct the distortion of the images taken by the image input sections **1***a* to **1***c*.

[0014] Next, in an image joining section **6**, the images (serving as input signals), which are corrected by the image correcting sections **17***a* to **17***c*, are joined to be a wide-angle image as shown in **FIG. 20**. Then, the joined image is output to a motor **9**, a printer **8** or a storage medium **9**.

[0015] The image joining section **6** is realized by the structure as shown in **FIG. 19**.

[0016] In this structure, the images a, b, and c are temporarily stored in a frame memory **10** respectively. Then, an amount of parallel movement **S1** and an amount of rotations **R1** between the adjacent images (e.g., images a and b) are obtained by a shift detector **11***a*. Similarly, an amount of parallel movement **S2** and an amount of rotations **R2** between the images b and c are obtained by a shift detector **11***b*.

[0017] These amounts of parallel movement **S1**, **S2**, and amounts of rotations **R1** and **R2** are input to interpolation calculators **12***a* and **12***b*, together with the images read from frame memories **10***b*, **10***c*. Thereby, the images whose positional relationship are corrected can be obtained.

[0018] A coefficient setting device **13** sets coefficients Ca, Cb, and Cc of the respective images of **FIG. 20** such that the adjacent images are smoothly joined to each other. The pixel value of each image is multiplied by each of coefficients Ca, Cb, Cc by a multiplier **14**. Then, the overlapping portion is added by an adder **15**.

[0019] **FIG. 20** is a view showing the processing of the overlapping portion of the images to be joined.

[0020] The image b rotates anticlockwise against the image a. The rotation of the image b and the amount of overlapping (or amount of parallel movement) are calculated by the shift detector **11**. Also, as shown in **FIG. 20**, the pixel

value of each image is multiplied by each of coefficients Ca, Cb, Cc so as to smoothly connect the images a and b, which are overlapped with each other. In this way, the image joining section **6** outputs the image in which the plurality of images are joined with high resolution or a wide viewing angle are provided.

[**0021**] Regarding to extend dynamic range of the imaging device, the applicant of the present application proposed the following technique in Japanese Patent Application KOKAI Publication No. 63-232591.

[**0022**] Specifically, a plurality of images photographed with different exposure is synthesized so as to generate an image having a dynamic range, which is almost equal to the film.

[**0023**] The above technique can be realized by structuring the image joining section **6** as shown in **FIG. 22**.

[**0024**] **FIG. 22** conceptually explains an example in which two images are synthesized. Even in a case of joining three or more images, the images are synthesized by the same process.

[**0025**] Two images a and b are added to each other at an adder **21** to be stored in the frame memory **10**. A linear converting section **22** reads out data of the frame memory **10**. The linear converting section **22** calculates values corresponding to R, G, B values of incident light based on a look-up table so as to be input to a matrix circuit **23**. The R, G, B values obtained at this time exceed the dynamic range of an input device such as a digital still camera.

[**0026**] The converting table is determined from an exposure ratio, Rexp, of two images by a converting table preparation section. In the matrix circuit **23**, a luminance signal value Y is obtained from R, G, B values. A luminance compression section **24** outputs a luminance value Y' which is compressed to adjust to the output device. Then, a ratio of compressed signal to original one Y'/Y is obtained by a divider **25**. The ratio Y'/Y is multiplied by outputs R, G, B of the linear converting section **22** by a multiplier **25** so as to be stored in the frame memory **16** as a joining image result.

[**0027**] Generally, the signal value to be output from the imaging device is saturated for a certain amount of incident light in the case of longer time exposure as shown in **FIG. 21**.

[**0028**] The value of an additional signal in which the signal of the longer exposure and that of the shorter exposure are added is changed with respect to the amount of incident light as shown by a bent line showing as an additional signal in **FIG. 21**. Then, a converting table preparation section **27** determines a table in which an amount of incident light I is estimated from an additional signal value S.

[**0029**] Generally, since the image value is expressed by 256 steps of 0 to 255, luminance Y of each pixel is compressed, for example by the following equation (1):

$$Y'=b\cdot y^{a} \tag{1}$$

[**0030**] where a is a coefficient for determining a shape of compression and b is a coefficient for determining a gain of the entire image.

[**0031**] If two different exposure images are synthesized to each other by the above-mentioned method, there can be obtained an image having the dynamic range almost equal to the film and can be seen well from a dark part to a bright part.

[**0032**] However, in the conventional technique described in U.S. Pat. No. 08/541,644, photographing conditions, which are necessary for correcting distortion, and the parameter of the optical system have to be set in advance. Due to this, it is difficult to get the image having high resolution image or a wide viewing angle image and a panorama image by simply using an arbitrary photographing device which the user has.

[**0033**] The following will explain about the distortion with reference to **FIGS. 23A, 23B**, and **23**C.

[**0034**] More specifically, the distortion is generally a geometrical deformation, which is caused in accordance with the distance from the center of a lens. If the lattice object is photographed through the optical system without distortion, the image, which is shown in **FIG. 23**A, can be obtained. However, if the optical system suffered from distortion, the structure, which should be photographed by straight lines, are curved as shown in **FIG. 23B**. Thus, if the optical system has distortion, a straight line L is curved and captured as a curved line L' (**FIG. 23C**). As a result, a point Y on the straight line L is moved to a point Y' on the curved line L'. In this case, an amount of distortion ΔR at one point on the image can be expressed by a polynomial expression (2):

$$\Delta R=A1\cdot R^{3}+A2\cdot R^{5}+ \tag{2}$$

[**0035**] where R is a distance between a center of the image and the point Y.

[**0036**] To get the image whose distortion is corrected, point Y' may be moved by only an amount of distortion ΔR on the straight line connecting the center C of the image to point Y'. However coefficients A1, A2, . . . differ depending on the focal position of the optical system, it is difficult for the general user to know coefficients A1, A2, . . . correctly.

[**0037**] Also, coefficients A1, A2, . . . differ depending on the apparatus to be used. Due to this, when the different apparatus is used, the correction coefficient must be adjusted again.

[**0038**] Moreover, if images are taken by different zooming ratio, the size between adjacent images differs. Due to this, the images cannot be correctly joined to each other though the images are overlapped with each other. Also, for the object close to the user in such a case of an indoor place, the size is changed even if a photographer moves a few steps.

[**0039**] Moreover, there is a case in which a white balance is automatically adjusted. For example, the color tone differs depending on a case in which the object is photographed in a direction toward or away from the sun.

[**0040**] Due to this, when the images are joined by the above-mentioned technique, color is smoothly changed but the entire image seems unnatural one. Moreover, in the technique of the wide dynamic range, the table for estimating the amount of incident light from the additional signal must be prepared as explained in the prior art. However, as shown in **FIG. 21, a** point N where the inclination of the additional signal is changed varies depending on the exposure ratio Rexp. For this reason, the user must know the

exposure ratio Rexp of the plurality of images to be synthesized in advance. However, in many cases, the digital still cameras on the market have the structure in which the exposure can be adjusted but the user cannot know the ratio exactly.

BRIEF SUMMARY OF THE INVENTION

[0041] An object of the present invention is to provide an image processing apparatus which can correct images and be joined by a simple operation based on images themselves without knowing coefficients such as distortion of a camera, and an image processing apparatus which can effectively synthesize an image of a wide dynamic range image from only images.

[0042] To achieved the above object, there is provided an image processing apparatus comprising:

[0043] image input means for dividing one composition to have an overlap area where the same object as each other exists at a joining position to be input as a plurality of image parts;

[0044] correction parameter setting means for setting a correction parameter necessary to correct at least distortion of the plurality of image parts generated in each overlap area or a difference between the image parts;

[0045] image correcting means for correcting at least one image part of the plurality of image parts in accordance with the set correction parameter to eliminate at least distortion of the plurality of image parts generated in each overlap area or the difference between the image parts;

[0046] image joining means for sequentially joining the plurality of image parts corrected by the image correction means in the overlap area to restore the one composition; and

[0047] image display means for displaying the plurality of image parts input by the image input means, or at least one image part of the image parts corrected by the image correction means, or the restored image.

[0048] According to the above-structured image processing device, since the image corrected by image correction means can be displayed on the display means to be confirmed, the image can be effectively corrected without knowing the necessary correction parameter, and an image correctly jointed by image joining means can be obtained.

[0049] Also, according to the present invention, there is provided

[0050] an image processing device comprising:

[0051] image input means for inputting one composition as a plurality of images photographed at a different exposure;

[0052] correction parameter setting means for setting a correction parameter necessary to correct brightness of at least one image of the plurality of images having a different exposure;

[0053] brightness correction means for correcting brightness of at least one image of the plurality of images in accordance with the set correction parameter;

[0054] image display means for displaying at least one image of the images corrected by the brightness correction means; and

[0055] joining means for estimating an amount of incident light obtained when the one input image is input based on the plurality of input images and the set correction parameter to convert the plurality of images whose brightness is corrected by the brightness correction means to be placed in a displaying range of the image display means, thereby joining the plurality of images.

[0056] According to the above-structured image processing device, the images corrected by the image correction means are displayed on the image display means to set a correction parameter, the images whose brightness is corrected by the image joining means to be placed in the displaying range of the image display means based on the correction parameter.

[0057] The image processing device comprises correction parameter storing means for storing the correction parameters used in correcting the image in connection with names of corrected images or photographing devices and discrimination names of photographing methods. The correction parameter storing means selects a predetermined correction parameter from the correction parameters stored in the correction parameter storing means to be set.

[0058] Moreover, the image processing device stores the parameter value once used in the correction in the correction parameter storing means, and the necessary value is selected from the correction parameter storing means. As a result, there is no need of newly correcting the parameter every image from the beginning.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0059] **FIG. 1** is a view showing a schematic structure of an image processing device according to a first embodiment of the present invention;

[0060] **FIG. 2** is a view showing a specific structure of an image correction processing section of **FIG. 1**:

[0061] **FIG. 3A** is a view showing a view showing instruction of processing to an image displayed on an image display section, and a correcting state of the image;

[0062] **FIG. 3B** is a view showing instruction of processing to the image displayed on the image display section, and a correction menu;

[0063] **FIG. 4** is a view showing an example of a type of a file stored in a correction parameter storing section;

[0064] FIG. SA is a view showing composition of an image to be photographed;

[0065] **FIG. 5B** is a view showing an example of the image photographed by an optical system having distortion;

[0066] **FIG. 5C** is a view showing composition when joining the images photographed by the optical system having distortion;

[0067] **FIG. 6** is a showing a schematic structure of an image processing device according to a second embodiment of the present invention;

[0068] **FIG. 7** is a view showing the structure of the image correction processing section of **FIG. 6**;

[0069] **FIG. 8** is a view showing an example of a synchronizing result displayed on an image display section of the image correction processing section;

[0070] **FIG. 9** is a view showing the structure of an image correction processing section in an image processing device according to a third embodiment of the present invention;

[0071] **FIG. 10** is a view showing a relationship between a distance from the center of the image and a signal value in order to explain peripheral reduction light;

[0072] **FIG. 11** is a view showing the structure of an image correction processing section in an image processing device according to a fourth embodiment of the present invention;

[0073] **FIG. 12** is a view showing an example of display to correct color display on the image display section of the image correction processing section;

[0074] **FIG. 13** is a view showing the structure of an image correction processing section having an image expansion/reduction section and a correction parameter setting section;

[0075] **FIG. 14** is a view showing a schematic structure of an image processing device according to a fifth embodiment of the present invention;

[0076] **FIG. 15** is a view showing the structure of an exposure time ratio calculating section;

[0077] **FIG. 16** is a view showing the relationship between an input image signal before correction and the signal after correction in a brightness correcting section;

[0078] **FIG. 17** is a view showing a display example on the display section of brightness correction;

[0079] **FIG. 18** is a view showing an example of the structure of a conventional image processing device;

[0080] **FIG. 19** is a view showing an example of the structure of an image joining section of **FIG. 18**;

[0081] **FIG. 20** is a view showing an overlapping state of images at a wide angle image joining time to connect the images;

[0082] **FIG. 21** is a view showing a characteristic of a signal obtained by adding a signal at long time exposure to a signal at short time exposure;

[0083] **FIG. 22** is a view showing one example of the structure of the image joining section of **FIG. 18**;

[0084] **FIG. 23A** is a view showing an image having no curve;

[0085] **FIG. 23B** is a view showing an image having distortion; and

[0086] **FIG. 23C** is a view showing a characteristic of the distortion.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0087] Embodiments of the present invention will now be specifically described with reference to the accompanying drawings.

[0088] **FIG. 1** shows a schematic structure of an image processing apparatus according to a first embodiment of the present invention. This embodiment shows an apparatus for easily correcting distortion as viewing the display or so to synthesize the corrected images, thereby obtaining an image of high resolution and a wide angle image.

[0089] The image processing apparatus of this embodiment comprises a memory card **32**, a card reader **33**, an image processing section **34**, a monitor **7**, a printer **8** for a print output, and a storage device **9** such as an optical disk storing images, or a memory card.

[0090] The memory card **32** records image data taken by a digital still camera **31** and a photographing condition data when the image was taken. The card reader **33** reads out image data from the memory card **32**. The image processing section **34** reproduces images from those image data, and provides correcting process such as distortion and a white balance to images to be joined. The monitor **7** displays the joined image and original image data.

[0091] The image processing section **34** comprises an image data reproducing section **35**, an image correction processing section **36**, a signal switching section **37**, and an image joining section **6**.

[0092] The image data reproducing section **35** provides a processing such as a decompression to image data read by the card reader **33**, and reproduces the images and photographing condition data. The image correction processing section **36** provides correcting process such as distortion and a color tone to the images. The signal switching section **37** executes an image switching for joining the images.

[0093] Using the apparatus of the above-mentioned structure, a user takes an image to be divided such that parts of an object image are overlapped with each other. In other words, one composition is divided to a plurality of image pieces to be taken such that the same object are captured at the end portion.

[0094] Processing such as compression, addition of header data is provided to these photographed images (image a, image b, . . .) in the digital still camera **31**. Thereafter, these images are recorded to the memory card **32** as image data.

[0095] The memory card **32** is inserted to the card reader **33**, and recorded image data is read out from the memory card **32** to be fetched to the image processing section **34**. Fetched image data is input to the image data reproducing section **35**, and processing such as decompression is provided thereto so that image data is reproduced. Then, the image correction processing section **36** provides a correcting process, and corrected image data is input to the image joining section **6**. The image joining section **6** has the structure as shown in **FIG. 19**. The image joining section **6** provides the same processing as described in U.S. Pat. No. 08/045,038 to join the images. The joined image is output to the monitor **7**, the printer **8**, or the storage medium **9**.

[0096] **FIG. 2** explains the specific structure of the image correction processing section **36**.

[0097] The image correction processing section **36** comprises an image display section **44**, a distortion correction processing section **41**, a correction parameter storage section **42**, and a correction parameter setting section **43**.

[0098] The image display section **44** displays an original image and a corrected image. The distortion correction processing section **41** provides a distortion to the input image. The correction parameter storage section **42** stores the parameter, which is used in the correcting process due to the distortion correction processing section **41**. The correction parameter setting section **43** adjusts the correction parameter to be set by the user's operation. Or, the correction parameter setting section **43** selects the correction parameter read out from the correction parameter storage section **42** to be set.

[0099] The image correction processing section **36** differently works depending on the case. There are two cases, one case is that a distortion correction is provided to images taken by a certain camera in which distortion correction is never provided to its images, which is used for the first time. The other case is that the correction is provided to images taken with a camera in which distortion correction has been already provided to its images and correction history has been left.

[0100] First, the following will explain the case in which the distortion correction has not been provided to the images taken by a camera.

[0101] The distortion correction processing section **41** inputs an image (e.g., image a) having distortion as shown in **FIG. 23B**. Then, the distortion correction processing section **41** outputs the image corrected based on equation (2) to the image display section **44** by use of an initial value, set in advance, of coefficients A1, A2, . . . in equation (2). The image display section **44** simultaneously displays the corrected image and an original image a.

[0102] Then, when a desired coefficient is set by the user's operation, the correction parameter setting section **43**, which comprises a mechanism for adjusting coefficients A1, A2, . . . , feeds back new coefficients A1, A2, to the distortion correction processing section **41** to renew the coefficients immediately.

[0103] The distortion correction processing section **41** outputs the image corrected by the new coefficient set, and the image display section **44** changes the displayed image to an image newly corrected.

[0104] The user operates the correction parameter setting section **43** as viewing at least one of two images. Thereby, coefficients A1, A2, . . . , which are used for appropriately correcting the image, are determined. At this time, to make the user operates easily, the correction parameter setting section **43** is preferably structured such that an imaginary adjusting knob displayed on the display section **44** is operated by a mouse, and a keyboard as shown in **FIG. 3A**. If the coefficients (A1, A2 in **FIGS. 3A, 3B**) are changed by the operation of the knob, the "image after correction" on the screen is recorrected in accordance with the new coefficient value, so that the image is renewed. If two or more images are needed to be displayed on the display screen, an arbitrary number of images can be, of course, displayed.

[0105] When the user judges that the correction is sufficient, he/she presses an "OK" key (clicks in the case of the mouse) to determine the coefficients A1, A2, ... Thus, the determined coefficients are stored in the correction parameter storage section **42** together with names identifying cameras, which are arbitrarily added by the user. For example, they may be stored to the correction parameter storage section **42** as a file as shown in **FIG. 4**.

[0106] Arbitrary images can be used for adjustment of the coefficients. However, the image which includes abject with straight lines such as a building, a book shelf, a window frame, and graph paper, can be easily adjusted.

[0107] Next, the following will explain for the case of correcting images by the camera in which its images has been already corrected in the past and the coefficients A1, A2, . . . by that time are stored in the parameter storage section **42** as a file.

[0108] In this case, since the correction parameters are stored with names of photographing equipments, those data is read when the image processing device is started, and displayed on the image display section **44** in a menu form as shown in **FIG. 3B**. If the user selects the name of the device to be used from the menu screen, the corresponding coefficients A1, A2, . . . are read out to the distortion correction processing section **41** from the correction parameter storage section **42** through the correction parameter setting section **43**. Thereby, the image to which the distortion correction processing is provided is output from the distortion correction processing section **41**.

[0109] As explained above, according to this embodiment, it is unnecessary to know distortion data of the optical system of photographing devices in advance. In other words, the user can determine the correction coefficients as viewing only the image itself. As a result, even in the case of the camera which is used for the first time, there is no need of knowing the characteristic of the optical system in advance.

[0110] Also, in the case of using the camera in which the photographed images were corrected in the past, the correction coefficients of distortion are recorded as data. As a result, the correction processing can be executed by only selecting data from the menu. Therefore, it is possible to avoid the complication of the operation in which the parameter must be set every time to correct the entire images used in the image synchronization.

[0111] In this embodiment, there was used the digital still camera in which the images are stored in the memory card. However, the present invention is not limited to the digital still camera. The image processing may be executed even by a device in which data is directly input to the image reproducing section. Moreover, the above embodiment explained the case in which the plurality of images was photographed by one input device. However, the images can be photographed by the structure using a plurality of input devices simultaneously. Furthermore, though this embodiment explained that the correction parameter setting section **43** was the imaginary adjusting knob on the image display section **44**, another switch of a rotation type or a slide type may be used.

[0112] Moreover, this embodiment explained the structure in which the image was corrected as comparing the original image with the processing result. However, in the case of the image of the object which includes straight line structure such as a building, a book shelf, a window frame, etc., only the image after the correction processing is displayed on the image display section **44**, and the lines are adjusted to be straight. Thereby, the coefficients A1, A2 can be determined.

[0113] The following will explain the image processing device of a second embodiment.

[0114] This embodiment, which is a modification of the first embodiment, will be explained with reference to FIGS. **5** to **8**. In these figures, the same reference numerals are added to the same structural portions as **FIGS. 1 and 2**, and the explanation is omitted.

[0115] **FIG. 6** is a view showing the structure of this embodiment. The second embodiment is different from the first embodiment in the point that the joined image output from the image joining section **6** is input to the image correction processing section **36**. **FIG. 7** shows the structure of the image correction processing section **36**. **FIG. 8** shows one example of the image displayed on the image display section **44** of the image correction processing section **36**.

[0116] According to this structure, image data (image a) to which decompression is provided by the image data reproducing section **35** is input to the distortion correction processing section **41** so that data, which is corrected by correction parameter values A1, A2, . . . set in advance, is output to the image joining section **6**. Similarly, the images, which are adjacent to the corrected image, are corrected by the distortion correction processing section to be output. The output images are joined by the image joining section **6**, so that the joined image is generated. Then, the resultant image is input to the image correction processing section **36**, and displayed by the image display section **44**.

[0117] Next, the following will explain an example of the actual processing by the user's operation with reference to **FIGS. 5A, 5B**, and **5**C.

[0118] **FIG. 5A** is an object to be photographed. When composition of the object is divided and input through the optical system having distortion to have an overlap area where the same object as each other exists at a joining position as a plurality of image parts.

[0119] For example, a plurality of pairs of characteristic points (P1 and P1', P2 and P2', and P3 and P3' in **FIG. 3B**) are set on the image. This setting can be automatically executed by the image joining section **6** under control of a predetermined program. Or, this setting can be designated by the user's operation. Two points are selected from the pair of characteristic points. The following will explain the case in which P1 and P2 are selected.

[0120] At this time, it is assumed that an amount of parallel movement and an amount of rotation are obtained on the basis of P1 and P2 and the images are joined by the image joining section **6** as the distortion correction coefficients A1, A2, . . . are maintained incorrectly as they are. As a result, as shown in **FIG. 5**C, P1 and P1' are correctly conformed to each other. Also, P2 and P2' are correctly conformed to each other. However, P3 and P3' are not conformed to each other. Then, the other points of its surroundings are not conformed to each other.

[0121] At this time, the joined result is displayed on the image display section **44**, and the user adjusts the coefficients A1, A2, . . . such that points other than reference points P1 and P2 are conformed to each other as viewing the display by the image processing device shown in **FIG. 6**. The adjusted coefficients A1, A2, . . . are immediately input to the distortion correction processing section **41**. Then, the newly corrected images are joined to each other by the image joining section **6**, and displayed on the image display section **44** again.

[0122] At this time, if the coefficients A1, A2, . . . are correctly set, not only P1 and P1', P2 and P2' but also P3 and P3' are conformed to each other, simultaneously. By this method, the image whose distortion is seemingly unclear such as a landscape image, and a figure image can be easily corrected.

[0123] In the above embodiment, the user adjusted the coefficients A1, A2, . . . as viewing the images displayed on the image display section **44**. However, a shift between P3 and P3' is automatically detected, and the coefficients A1, A2, . . . may be automatically corrected such that the detected shift becomes 0 or minimum.

[0124] Next, **FIG. 9** shows the structure of the image correction processing section of the image processing device of a third embodiment.

[0125] In these figures, the same reference numerals are added to the same structural portions as the first and second embodiments, and the explanation is omitted.

[0126] Generally, due to influence of peripheral reduction light in the optical system such as a camera, the brightness of the images is reduced as the image advances to the periphery. As a result, when the images with the peripheral reduction light are joined to each other, the image becomes dark at the overlapping area, and an unnatural joining image is generated.

[0127] The peripheral reduction light is a phenomenon in which the brightness of the image becomes darker as a distance R from the center of the image is increased as shown in **FIG. 10**. A ratio of signal value S' to an ideal signal value with the peripheral reduction light can be approximately obtained by the following polynomial expression (3):

$$S'/S=B0+B1\cdot R+B2\cdot R^2+ \quad (3)$$

[0128] In this case, the image correction processing section **36** comprises the image display section **44**, a peripheral reduction light correction processing section **46**, a peripheral reduction light correction parameter storage section **47**, and a peripheral reduction light correction parameter setting selection section **48**.

[0129] In the peripheral reduction light correction parameter setting selection section **48**, an imaginary knob for displaying coefficients B0, B1, B2, . . . is moved to set such that brightness of the image center and that of the surroundings are the same.

[0130] If the coefficients B0, B1, B2, . . . are set by the above-mentioned structure, the image can be easily corrected based on the image itself even if the user does not know various parameters of the optical system of a camera. As a result, the images joined by the image joining section **6** does not become dark even at the overlapping portion, and a natural image can be obtained as an entire screen.

[0131] Same as the case of distortion, the marginal is the phenomenon peculiar to its optical system of the imaging apparatus. As explained in the first embodiment, the correcting coefficient values are once stored in accordance with names of photographing devices. Then, the images can be corrected by selecting the name from the menu at the second time and the following.

[0132] Moreover, this embodiment explained that the images were corrected as comparing the original image with the process result. However, since the brightness of the entire image may be uniformed, only the image after correction is displayed on the image display section **44**, and the coefficients B0, B1, B2, 1 may be set and selected.

[0133] Next, the following will explain the structure for correcting a color tone by the image processing apparatus of a fourth embodiment of the present invention with reference to **FIGS. 11 and 12**.

[0134] The image processing correction processing section **36** in **FIG. 11** comprises the image display section **44**, a color tone correcting section **51**, and the correction parameter setting section **43**.

[0135] The color tone correcting section **51** converts the original image to hue (H), saturation (S), and intensity (I), respectively by HIS transformation. The correction parameter setting section **43** adjusts the correction parameter for transformation to H, S, I so as to correct the color tone.

[0136] The color correction section **51** corrects the input image based on hue H, saturation S, and intensity I to be output to the image display section **44**. The user operates the knob for adjusting hue H, saturation S, and intensity I on the screen shown in **FIG. 12** as comparing the images displayed on the image display section **44**, in order that both images have the same color tone.

[0137] By the above-structured image correction processing device **36**, not only the color tone of the overlapping area where the adjacent images are joined but also the color tone of the overall of the image can become natural. This embodiment explained that the original image was converted to hue (HI), saturation (S), and intensity (I), respectively. However, similar to the adjustment of white balance, signal levels of R, G, B can be adjusted.

[0138] Moreover, as shown in **FIG. 13**, an image magnification/reduction section **52** and the correction parameter setting selection section **43** are provided to the image correction processing section **36**. Thereby, there can be obtained a well joined image in accordance with the difference in a zoom ratio, and the change of the object size due to the change of the photographer's position.

[0139] Next, the following will explain the structure to extend the dynamic range of the input image by the image processing apparatus of a fifth embodiment of the present invention with reference to FIGS. **14** to **17**.

[0140] The image processing apparatus of this embodiment calculates exposure ratio Rexp from the taken image, and synthesizes images with the calculated exposure time ratio. In these figures, the same reference numerals are added to the same structural portions as the first embodiment, and the explanation is omitted.

[0141] The image processing apparatus of this embodiment has the structure in which an exposure time ratio calculating section **61** is provided to the image processing section **34**.

[0142] In the image processing section **34**, reproduced images a and b are input to the exposure time ratio calculating section **61** through the signal switching section **37**. As a result, an exposure time ratio Rexp is input to the image joining section **6**. In the image joining section **6**, the images a and b are synthesized with the calculated exposure time ratio Rexp, and the output image exceeds the dynamic range of the input device. Since the structure of the image joining section **6** uses the structure same as **FIG. 22**, the explanation is omitted.

[0143] **FIG. 15** explains the structure of the exposure time ratio calculating section **61**.

[0144] The exposure time ratio calculating section **61** comprises the image display section **44**, an exposure time ratio setting section **63** for adjusting the exposure time ratio Rexp by the user, and a brightness correcting section **62** for correcting brightness of the input image based on the exposure time ratio Rexp set by the exposure time ratio setting section **63**.

[0145] **FIG. 16** is a view showing the processing by the brightness correcting section **62**. The signal Sout, which is obtained by correcting the image signal Sin, can be expressed by the following equation (4):

$$Sout=Rexp\cdot Sin \tag{4}$$

[0146] At this time, if Rexp>1.0, the image becomes brighten. If Rexp<1.0, the image becomes darker.

[0147] **FIG. 17** shows a display example on the display section.

[0148] In the image a, which is used as a reference image, the indoor portion where a table, a flower, etc are presented is captured at a suitable exposure. Then, the portion out of the window where woods and mountains can be seen is captured at an over-exposure. In the image b, which is used as an adjusting image, the portion out of the window is formed at the suitable exposure, and the indoor portion is formed at the under-exposure.

[0149] The image a is displayed as a reference image, and the knob displayed on the screen is adjusted to correct brightness of the image b. The user designates the end of adjustment with an "OK" key when the brightness of the entire image b reaches the same as the reference image (image a). The exposure time ratio Rexp set in this way is output to the image joining section **6**, and the processing of the wide dynamic range is executed.

[0150] According to this embodiment, since the user can obtain exposure time ratio Rexp as confirming the image, a desired device can be used in the input device for inputting the image. Also, since it is unnecessary to record exposure time when taking images, the processing of the wide dynamic range can be easily executed.

[0151] Moreover, this embodiment explained the example in which the exposure time ratio between two images was used as a correction parameter. However, the present invention is not limited to the above example. The exposure time ratio among three or more images can be used as a correction parameter. The embodiment explained that one image was used as a reference image and the brightness of only the other image was corrected. However, brightness of both images can be corrected to generate an image having intermediate brightness. At this time, the exposure time ratio can be shown as in **FIG. 16**.

[0152] Moreover, as a method for photographing a plurality of brighter and darker images having a different

exposure, the diaphragm of the camera can be changed, and the amount of incident light may be controlled by transmittance of the reduction light filter. In other words, as the correction parameter, which is necessary for the processing of the wide dynamic range, the parameter, which shows the exposure ratio among the plurality of images, may be used. For example, the exposure time ratio shown in the above embodiment, a diaphragm ratio, a transmittance ratio of the reduction light filter can be used as a correction parameter.

[0153] In the above-explained embodiments, the images are taken by the digital still camera. However, the same processing as in the embodiments can be executed even in the image, which is obtained by digitizing the film photographed by the conventional camera, or the image, which is input from the image photographed by the video camera or the digital video camera through an image input board. The monitor **7**, which outputs the joined image, can be used as the image display device **44** of each embodiment.

[0154] Moreover, the above-explained embodiments can be combined with each other. Particularly, the correction parameter storage section **42** can be combined with the structure described in the first to third embodiments. In this case, the correction parameter storage section **42** can store the parameter if the user knows the characteristic of the optical system. Also, the correction parameter storage section **42** can be combined with the structure described in the fourth and fifth embodiments. In this case, the correction parameter storage section **42** can store the parameter to be used as a default value when the user executes the adjustment.

[0155] According to the present invention, there can be provided the image processing apparatus, which can correct only from the image photographed by a various imaging apparatus which the user has or the photographing device of a reasonable price, thereby obtaining the joined images with wide viewing angle and the image of the wide dynamic range. In this case, there is no need of knowing the characteristics of the distortion and peripheral reduction light optical system in advance. Moreover, there is no need of using the photographing device of a high price, which can control and record the photographing conditions such as exposure time, white balance, etc.

1. An image processing apparatus comprising:

image input means for getting a plurality of image parts dividing one composition such that the image parts have overlapping areas, each having the same image of an object in the overlapping area as in the overlapping area of the next image part;

correction parameter setting means for setting a correction parameters necessary to correct at least distortion of said plurality of image parts generated in each overlap area or a difference between the image parts;

image correcting means for correcting at least one image part of said plurality of image parts in accordance with said set correction parameter to eliminate at least distortion of said plurality of image parts generated in each overlap area or the difference between the image parts;

image joining means for sequentially joining the plurality of image parts corrected by said image correction means in said overlap area to restore said one composition; and

image display means for display at least said plurality of image parts input by said image input means or said image parts corrected by said image correction means.

2. An image processing apparatus comprising:

image input means for inputting one composition as a plurality of images taken with a different exposure;

correction parameter setting means for setting correction parameters necessary to correct brightness of at least one image of said plurality of images having a different exposure;

brightness correcting means for correcting brightness of at least one image of said plurality of images in accordance with said set correction parameters;

image display means for displaying at least one image of the images corrected by said brightness correction means; and

image synthesizing means for estimating an amount of incident light obtained when said one input image is input based on said plurality of input images and said set correction parameters to convert said plurality of images whose brightness is corrected by said brightness correction means to be placed in a displaying range of said image display means, thereby joining said plurality of images.

3. The image processing apparatus according to claim 1 or **2**, wherein said image correction means corrects the image by changing the correction parameter in accordance with differences in brightness between a plurality of images displayed by said image display means.

4. The image processing apparatus according to claim 1 or **2**, wherein said image correction means corrects the image by changing the correction parameter in accordance with the distortion of one image displayed by said image display means or in accordance with differences in distortion between a plurality of images displayed by said image display means.

5. The image processing apparatus according to claim 1 or **2**, wherein said image correcting means corrects the image by changing the correction parameter in accordance with differences in image magnification between a plurality of images displayed by said image display means.

6. The image processing apparatus according to claim 1 or **2**, wherein said image correcting means corrects the image by changing the correction parameter in accordance with differences in color data between a plurality of images displayed by said image display means.

7. The image processing apparatus according to claim 6, wherein said color data is at least one of hue, saturation, and intensity.

8. The image processing apparatus according to claim 6, wherein said color data is at least one of R, G and B values for adjusting a white balance.

9. The image processing apparatus according to claim 1 or **2**, wherein said image correction means corrects the image by changing the correction parameter in accordance with peripheral reduction light of one image display by said image display means or in accordance with differences in

peripheral reduction light between a plurality of images displayed by said image display means.

10. The image processing apparatus according to claim 3, wherein said image correction means corrects the image by changing an exposure ratio between a plurality of images, which is used as said correction parameter, in accordance with difference in brightness between said plurality of images displayed by said image display means.

11. The image processing apparatus according to claim 4, wherein further comprising correction parameter storing means for storing one or a plurality sets of said correction parameters used in correcting said image in connection with the name of the imaging apparatus used to take the image, and said correction parameter setting means selects a desired set of correction parameters from the correction parameters stored in said correction parameter storing means.

12. The image processing apparatus according to claim 9, wherein further comprising correction parameter storing means for storing one or a plurality sets of said correction parameters used in correcting said image in connection with the name of the imaging apparatus used to take the image, and said correction parameter setting means selects a desired set of correction parameters from the correction parameters stored in said correction parameter storing means.

13. An image processing method comprising:

an image input step of getting a plurality of image parts dividing one composition such that the image parts have overlapping areas, each having the same image of an object in the overlapping area as in the overlapping area of the next image part;

a correction parameter setting step of setting correction parameters necessary to for correct at least images distortion or image difference occurring in the overlapping areas of each image part;

an image correcting step of correcting at least one of said plurality of image parts in accordance with said correction parameters, thereby to correct distortion of images or image difference occurring in at least the overlapping areas of each image part;

a composition restoring step of restoring said composition by sequentially combining said plurality of image parts corrected, one to another, with overlapping the same at overlapping areas; and

an image displaying step of display at least said plurality of image parts input or said plurality of image parts corrected.

14. An image processing method comprising:

an image input step of inputting a plurality of images obtained by taking one composition at different exposures;

a correction parameter setting step of setting a correction parameters indispensable for correcting the brightness of at least one of said plurality of images taken with different exposures;

an image correcting step of correcting the brightness of said at least one image in accordance with the correction parameter set;

an image displaying step of displaying at least one of images corrected in the image correcting step; and

an image synthesizing step of combining said plurality of images corrected in brightness in the image correcting step, into one image to be displayed within a range of the imaging display step, by inferring an amount of incident light obtained when said composition is input in the image input step, from said plurality of images which have been input and said correction parameter which has been set.

15. The image processing method according to claim 13 or **14**, which further comprises a correction parameter storing step of storing one or a plurality sets of the correction parameters used in correcting the image, in connection with the name of the photographing apparatus and the name of the photographing method used to photograph the image, and in which said correction parameter setting step is to select and set a desired set of correction parameters from correction parameters stored in said correction parameter storing step.

16. The image processing method according to claim 13 or **14**, which further comprises a correction parameter storing step of storing one or a plurality sets of the correction parameters used in correcting the image, in connection with the name of the photographing apparatus and the name of the photographing method used to photograph the image, and in which said correction parameter setting step is to select and set a desired set of correction parameters from correction parameters stored in said correction parameter storing step.

17. The image processing method according to claim 13 or **14**, wherein said image correcting step is to change the correction parameter in accordance with differences in image magnification between a plurality of images displayed in said image displaying step.

18. The image processing method according to claim 13 or **14**, wherein said image correcting step is to correct the image by changing the correction parameter in accordance with differences in color data between a plurality of images displayed by said image display means.

19. The image processing method according to claim 13 or **14**, wherein said image correcting step is to is to correct the image by changing the correction parameters in accordance with peripheral reduction light of one image displayed in said image displaying step or in accordance with differences in peripheral reduction light between a plurality of images displayed in said image displaying step.

20. The image processing method according to claim 13 or **14**, wherein said image correcting step is to correct the image by changing an exposure ratio between a plurality of images, which is used as said correction parameter, in accordance with differences in brightness between said plurality of images displayed in said image displaying step.

21. A recording medium recording computer programs for restoring an image by combining a plurality of image parts divided from one composition, each image parts having the same image of an object in an overlapping area, said recording medium recording:

an image inputting program for inputting said plurality of image parts;

a correction parameter setting program for setting correction parameters indispensable for correcting images distortion or image difference occurring in at least the overlapping areas of each image part;

an image correcting program for correcting at least one of said plurality of image parts in accordance with said correction parameters, thereby to correct distortion of

images or image difference occurring in at least the overlapping areas of each image part;

a composition restoring program for restoring said composition by sequentially combining said plurality of image parts corrected, one to another, with overlapping the same at overlapping areas; and

an image displaying program for displaying said plurality of image parts input, or at least one of said plurality of image parts corrected.

22. A recording medium recording computer programs for correcting a plurality of images obtained by taking one composition with different exposures, to provide an image having a desired brightness, said recording medium comprising:

an image inputting program for inputting one composition in the form of a plurality of images photographed at different exposures;

a correction parameter setting program for setting a correction parameters indispensable for correcting the brightness of at least one of said plurality taken with images photographed at different exposures;

an image correcting program for correcting the brightness of said at least one image in accordance with the correction parameter set;

an image displaying program for displaying at least one of images corrected in accordance with the image correcting program; and

an image synthesizing program for combining said plurality of images corrected in brightness in accordance with said image correcting program, into one image to be displayed within a range of accordance with said imaging display program, by inferring an amount of incident light obtained when said composition is input in accordance with said image inputting program, from said plurality of images which have been input and said correction parameter which has been set.

23. The recording medium according to claim 21 or **22**, which further comprises a correction parameter storing program for storing the correction parameter used in correcting the image, in connection with the name of the photographing apparatus and the name of the photographing method used to photograph the image, and in which said correction parameter setting program is designed to select and set a desired correction parameter from correction parameters stored in accordance with said correction parameter storing program.

24. The recording medium according to claim 21 or **22**, which further comprises a correction parameter storing program for storing the correction parameter used in correcting the image, in connection with the name of the photographing apparatus and the name of the photographing method used to photograph the image, and in which said correction parameter setting program is designed to select and set a desired correction parameter from correction parameters stored in accordance with said correction parameter storing program.

25. The recording medium according to claim 21 or **22**, wherein said image correcting program is designed to correct the image by changing the correction parameter in accordance with differences in image magnification between a plurality of images displayed in accordance with said image displaying program.

26. The recording medium according to claim 21 or **22**, wherein said image correcting program is designed to correct the image by changing the correction parameter in accordance with differences in color data between a plurality of images displayed in accordance with said image display program.

27. The recording medium according to claim 21 or **22**, wherein said image correcting program is designed to correct the image by changing the correction parameter in accordance with peripheral reduction light of one image displayed by using said image displaying program, or in accordance with differences in peripheral reduction light between a plurality of images displayed in said image displaying step.

28. The recording medium according to claim 21 or **22**, wherein said image correcting program is designed to correct the image by changing an exposure ratio between a plurality of images, which is used as said correction parameter, in accordance with differences in brightness between said plurality of images displayed by using said image displaying program.

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