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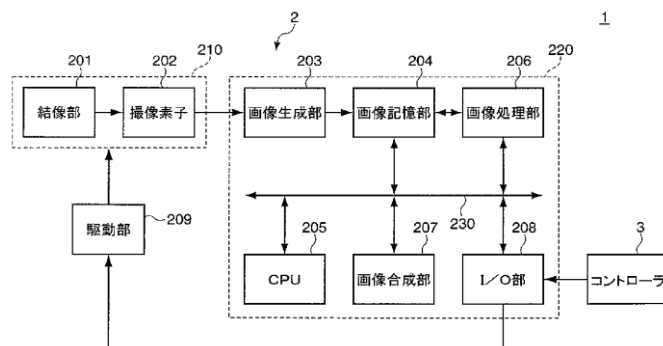
(54) [Title of the invention] Imaging apparatus

(57) [Abstract]

[Problem] To provide an imaging apparatus capable of correcting and effectively using inconvertible areas that are produced during conversion of a captured image with a prescribed distortion to a display image for display.

[Means of solving the problem] An imaging element 202 photoelectrically converts, pixel by pixel, an optical image that is formed on an imaging surface in which a plurality of pixels are two-dimensionally arranged to an electrical signal; an image forming unit 201 forms an optical image, having a different resolution in a central part than in a peripheral part of the captured image, on the imaging surface; an image generation unit 203 generates the captured image on the basis of the electrical signals output from the imaging element 202; an image processing unit 206 converts the captured image generated by the image generation unit 203 to a display image for display; and an image synthesis unit 207 uses a part of the display image, captured separately, to correct an inconvertible area in the display image that is produced when the captured image is converted to the display image.

[Representative Drawing] Figure 5



- 3: Controller
201: Image forming unit
202: Imaging element
203: Image generation unit
204: Image storage unit
206: Image processing unit
207: Image synthesis unit
208: I/O unit
209: Drive unit

[Claims]

[Claim 1]

An imaging apparatus, characterized in comprising:

an imaging element that photoelectrically converts an optical image, which is formed on an imaging surface in which a plurality of pixels are two-dimensionally arranged, to an electrical signal, pixel by pixel;

an imaging unit comprising an image forming unit that forms an optical image, having a different resolution in a central part from that in a peripheral part of an image that is captured, on the aforementioned imaging surface;

a captured image generation unit that generates a captured image on the basis of the electrical signals output from the aforementioned imaging element;

a display image creation unit that converts the captured image generated by the aforementioned captured image generation unit to a display image for display;

and a display image correction unit that uses a part of the aforementioned display image, captured separately, to correct an inconvertible area in the display image that is produced during conversion from the aforementioned captured image to the display image.

[Claim 2]

The imaging apparatus set forth in Claim 1, characterized in additionally comprising a drive unit that drives the aforementioned imaging unit in a predetermined direction, and in that the aforementioned display image correction unit uses a part of the aforementioned display image that is obtained by using the aforementioned drive unit to drive the aforementioned imaging unit in a predetermined direction to correct an inconvertible area in the display image that is produced during conversion from the aforementioned captured image to the display image.

[Claim 3]

An imaging apparatus, characterized in comprising:

an imaging element that photoelectrically converts an optical image, which is formed on an imaging surface in which a plurality of pixels are two-dimensionally arranged, to an electrical signal, pixel by pixel;

an imaging unit comprising an image forming unit that forms an optical image, having a different resolution in a central part from that in a peripheral part of an image that is captured, on the aforementioned imaging surface;

a captured image generation unit that generates a captured image on the basis of the electrical signals output from the aforementioned imaging element;

a display image creation unit that converts the captured image generated by the aforementioned captured image generation unit to a display image for display;

and an information synthesis unit that synthesizes predetermined information in an inconvertible area in the display image that is produced during conversion from the aforementioned captured image to the aforementioned display image.

[Claim 4]

The imaging apparatus set forth in Claim 3, characterized in that the aforementioned information synthesis unit synthesizes text information in an inconvertible area in the display image that is produced during conversion from the aforementioned captured image to the aforementioned display image.

[Claim 5]

The imaging apparatus set forth in Claim 3 or 4, characterized in that the aforementioned information synthesis unit synthesizes an enlarged image, obtained by enlarging a part of the aforementioned display image, in an inconvertible area in the display image that is produced during conversion from the aforementioned captured image to the aforementioned display image.

[Detailed description of the invention]

[0001]

[Technical field of the invention]

The present invention relates to an imaging apparatus for effectively utilizing inconvertible areas in a display image that are produced when a captured image is converted to a display image.

[0002]

[Prior art]

In the past, a method of improving resolution by a method of improving resolution by generating a captured image of an entire subject in which a plurality of partially captured images are synthesized in a digital camera, using an image sensor such as a CCD, has been proposed (see, for example, Patent Document 1).

[0003]

In recent years, a lens (referred to below as a foveated lens) has been proposed that mimics the fovea centralis, which is a feature of human vision (see, for example, Non-patent Document 1). Images captured using this foveated lens characteristically have high resolution in the central part and low resolution in the peripheral parts.

[0004]

[Patent Document 1]

Japanese Unexamined Patent Application Publication No. H11-196317

[Non-patent Document 1]

“Development of a new visual sensor having a fovea – Development of a wide-angle high-distortion lens,” Transactions of the Society of Instrument and Control Engineers, 1995, Vol. 31, No. 10, p. 1556-1563

[0005]

[Problem to be solved by the invention]

Meanwhile, when an image is captured using a foveated lens, distortion occurs due to the characteristics of the lens. It is therefore necessary to perform a geometric transformation from the captured image to create a display image from which distortion has been removed. Figure 16 shows the size of an optical image with respect to the imaging surface of an imaging element. Figure 16(a) shows the size of an optical image relative to the imaging surface when a circular optical image is in contact with the upper and lower sides of the imaging surface of the imaging element; Figure 16(b) shows the size of an optical image relative to the imaging surface when a circular optical image is in contact with the right and left side of the imaging surface of the imaging element; Figure 16(c) shows the size of an optical image relative to the imaging surface of the imaging element when a circular optical image is in contact with each vertex of the imaging surface. As shown in Figures 16(a) to 16(c), the imaging surface of the imaging element is a rectangle with an upper side and a lower side of equal length, and a right side and a left side of equal length, in which the upper and lower sides are longer than the right and left side; and an optical image formed on the imaging surface by the foveated lens has a circular shape with a center point at the intersection of two diagonal lines on the imaging surface.

[0006]

When the entire optical image fits on the imaging surface as shown in Figure 16(a), the area in which no image is formed is increased, so that the number of unused pixels increases and resolution declines. Meanwhile, when the entire imaging surface fits into the optical image, as shown in Figure 16(c), the resolution is high, but since the optical image greatly protrudes from the imaging surface, imaging an imaging target with a wide angle of view is difficult. Setting the position of an optical image and the position of the imaging surface as shown in Figure 16(b), so that the right and left sides of the imaging surface are in contact with the optical image, enables imaging with a wide angle of view, without impairing the resolution.

[0007]

However, when the captured image shown in Figure 16(b) is converted into a display image, areas that cannot be converted are produced above and below the display image. This is because the captured image develops barrel distortion due to the properties of the lens, and the barrel distortion, when converted to a display image, is converted with the image in the upper side part of the imaging surface curved downward and image in the lower side of the imaging surface curved upward.

[0008]

The present invention has been devised to solve the abovementioned problems, and thus with the object of providing an imaging apparatus capable of correcting and effectively using inconvertible areas in a display image that are produced during conversion of a captured image, having a predetermined degree of distortion, to a display image for display.

[0009]

[Means of solving the problem]

The imaging apparatus of the present application comprises: an imaging element that photoelectrically converts an optical image, which is formed on an imaging surface in which a plurality of pixels are two-dimensionally arranged, to an electrical signal, pixel by pixel; an imaging unit that comprises an image forming unit that forms an optical image, having a different resolution in a central part from that in a peripheral part of an image that is captured, on the imaging surface; a captured image generation unit that generates a captured image on the basis of the electrical signals output from the imaging element; a display image creation unit that converts the captured image generated by the captured image generation unit to a display image for display; and a display image correction unit that uses part of the display image, captured separately, to correct an inconvertible area in the display image that is produced during conversion from the captured image to the display image.

[0010]

This configuration enables correction and display of inconvertible areas in display images that are images for display, and thus enables creation of high-resolution display images, since thereby optical images are formed on an imaging surface with high resolution in a central part of a captured image and lower resolution in peripheral parts than in the central part, a captured image is generated on the basis of the electrical signals output from the imaging element, the generated captured image is converted to a display image for display, and an inconvertible area in a display image that is produced during conversion from the captured image to the display image is corrected using a part of the display image that has been captured separately.

[0011]

The abovementioned imaging apparatus preferably also comprises a drive unit that drives the imaging unit in a predetermined direction, and the display image correction unit uses a part of the display image that is obtained by using the drive unit to drive the imaging unit in a predetermined direction to correct an inconvertible area in a display image that is produced during conversion from the captured image to the display image.

[0012]

This configuration enables correction and display of inconvertible areas in display images that are images for display, and thus enables creation of high-resolution display images, since thereby a part of the display image that is obtained by using the drive unit to drive the imaging unit in a predetermined direction is used to correct an inconvertible area in a display image that is produced during conversion from the captured image to the display image.

[0013]

In addition, the imaging apparatus of the present application comprises: an imaging element that photoelectrically converts an optical image, which is formed on an imaging surface in which a plurality of pixels are two-dimensionally arranged, to an electrical signal, pixel by pixel; an imaging unit that comprises an image forming unit that forms an optical image, having a different resolution in a central part from that in a peripheral part of an image that is captured, on the imaging surface; a captured image generation unit that generates a captured image on the basis of the electrical signals output from the imaging element; a display image creation unit that converts the captured image generated by the captured image generation unit to a display image for display; and an information synthesis unit that synthesizes predetermined information in an inconvertible area in a display image that is produced during conversion from the captured image to the display image.

[0014]

This configuration enables effective use of inconvertible areas, even when the inconvertible areas are included in display images that are images for display, since thereby optical images are formed on an imaging surface with high resolution in a central part of an image that has been captured, and lower resolution in peripheral parts than in the central part; a captured image is generated on the basis of the electrical signals output from the imaging element; the generated captured image is converted to a display image for display; and predetermined information is synthesized in an inconvertible area in a display image that is produced during conversion from the captured image to the display image.

[0015]

In the abovementioned imaging apparatus the information synthesis unit preferably synthesizes text information in an inconvertible area in a display image that is produced during conversion from the captured image to the display image.

[0016]

This configuration enables display of text information concerning a display image together with the display image, thereby enabling effective use of an inconvertible areas in a display image that is produced during conversion from the captured image to the display image, since text information is synthesized in the inconvertible area.

[0017]

In the abovementioned imaging apparatus the information synthesis unit preferably synthesizes an enlarged image, obtained by enlarging a part of the display image, in an inconvertible area in the display image that is produced during conversion from the captured image to the display image.

[0018]

This configuration enables display of an enlarged image of a part of a display image together with the display image, thus enabling effective use of an inconvertible area in the display image that is produced during conversion from the captured image to the display image, since an enlarged image of a part of the display image is synthesized in the inconvertible area.

[0019]

[Embodiments of the invention]

Embodiments of the present invention are described below on the basis of the drawings.

First embodiment:

Figure 1 is a block diagram of a surveillance system in the present embodiment.

[0020]

As shown in Figure 1, a surveillance camera 2 (corresponding to an imaging apparatus) that images a

predetermined surveillance target area is communicably connected to a controller 3 via a communication network 4 in a surveillance system 1. The controller 3 is, for example, a personal computer or a mobile phone, and includes an image display unit 31 that displays an image transmitted from the surveillance camera 2. If the controller 3 is a personal computer, the image display unit 31 comprises, for example, a CRT monitor or a liquid crystal monitor, and if the controller 3 is a mobile phone, the image display unit 31 comprises, for example, a liquid crystal monitor. The surveillance camera 2 and the controller 3 also each comprise a communication unit (not shown) for enabling mutual communication.

[0021]

In the surveillance system 1, when the surveillance target area is imaged by the surveillance camera 2, data from the image is transmitted from the surveillance camera 2 to the controller 3 via the communication network 4, and meanwhile, when a request is input from the controller 3 to the surveillance camera 2, the information indicated in the request (referred to below as requested information) is sent from the controller 3 to the surveillance camera 2 via the communication network 4, and the surveillance camera 2 operates on the basis of the requested information.

[0022]

The requests are, for example, requests for establishing a communication connection with the surveillance camera 2, requests for switching image data transmitted from the surveillance camera 2, and requests for operation of the surveillance camera 2.

[0023]

The image captured by the surveillance camera 2 can thus be visually recognized on the image display unit 31 of the controller 3, and the surveillance camera 2 can be operated remotely.

[0024]

The communication network 4 for communicably connecting the surveillance camera 2 and the controller 3 comprises a wireless local area network (LAN), using a transmission medium such as radio waves or infrared radiation, a LAN constructed in accordance with Ethernet (registered trademark) standards, or the like.

[0025]

Note that although the surveillance camera 2 and the controller 3 are connected via the communication network 4 in the present embodiment, the present invention is not specifically limited thereto, and the surveillance camera 2 may be connected directly to the controller 3, or the internet may be used as the communication network 4. Moreover, the surveillance camera 2 and the controller 3 in the present embodiment may be connected by wireless communication such as Bluetooth (registered trademark).

[0026]

Figure 2 is an external view of the surveillance camera 2 used in the surveillance system 1. As shown in Figure 2, a surveillance camera 2 comprises a camera 21, a frame 22 bent in a U-shape, a gear motor 23 for moving an optical axis L (i.e., a surveillance direction) of the camera 21 in the vertical direction (referred to below as the tilt direction) and a gear motor 24 for moving the optical axis L of the camera 21 in the left-right direction (referred to below as the pan direction).

[0027]

A tilt-direction rotating shaft 25 of the camera 21 protrudes from the side surfaces 22A and 22A' of the U-shaped frame 22, and is attached to the U-shaped frame 22 by passing through hole 22B drilled therein, and an output shaft of the gear motor 23 is attached to the tip of the rotating shaft 25 protruding from the side surface 22A. At the center of the lower surface of the U-shaped frame 22, a panning rotation shaft 26 protrudes downward, and an output shaft of the gear motor 24 is attached to the tip of the rotation shaft 26.

[0028]

The gear motor 24 is affixed to the frame 22, and is configured integrally with the frame 22 to be rotatable in the pan direction, and the gear motor 23 is affixed to the camera 21.

[0029]

In the abovementioned configuration, the U-shaped frame 22 rotates around the rotation shaft 26 when the gear motor 24 is driven to rotate, thereby moving the optical axis L of the camera 21 in the pan direction, and the camera 21 rotates around the rotation axis 25 when the gear motor 23 is driven to rotate, thereby moving the optical axis L of the camera 21 in the tilt direction.

[0030]

In the following explanation, the operation of the surveillance camera 2 in which the optical axis L of the camera 21 moves in the pan direction is referred to as a pan operation, and the operation of the surveillance camera 2 in which the optical axis L moves in the tilt direction is referred to as a tilt operation.

[0031]

The surveillance camera 2 employs a lens that mimics the fovea centralis, which is a feature of human vision (referred to below as a foveated lens) as an optical system for imaging a surveillance target area. Hence, the foveated lens used for the surveillance camera 2 will be described below.

[0032]

Figure 3(a) is a graph showing the distortion and angle of view characteristics of the foveated lens, in which the horizontal axis represents the distortion X expressed as a percentage and the vertical axis represents the angle of view θ expressed in degrees ($^{\circ}$). Figure 3(b) is a graph showing the angle of view and image height characteristics, in which the horizontal axis is the angle of view θ , and the vertical axis is the image height Y.

[0033]

As shown in Figure 3(a), the foveated lens has characteristics such that in an area with a small angle of view θ (the area up to approximately 5 degrees in Figure 3), the distortion X is a predetermined value X_i , and rapidly increases when the angle of view θ exceeds that area.

[0034]

The predetermined value X_i of the distortion X is a value at which an optical image of a subject transmitted through the central area of the foveated lens looks like a natural image seen by a human, without distortion, and for example $X_i = 3\%$ (in which case, $\theta_i = \text{approximately } 8^{\circ}$). Of course, even if the predetermined value X_i is set to a value of 3% or less, for example, approximately 1 or 2%, the image looks natural, similar to that seen by a human eye without distortion.

[0035]

Figure 3(a) shows the characteristics of a foveated lens having about -70% distortion at a half angle of view of approximately 50 degrees.

[0036]

Due to this characteristic, the height Y of the optical image formed by the foveated lens (referred to below as the image height) is such that in an area in which the angle of view θ is small (the area to the left of the dotted line shown in Figure 3(b)), the image height Y is approximately linear with respect to the angle of view θ , and the amount of change is large with respect to a unit change in the angle of view θ .

[0037]

Meanwhile, the image height Y is non-linear with respect to the angle of view θ in an area in which the angle of view θ is large (the area to the right of the dotted line shown in Figure 3(b)), the amount of change per unit change of the angle of view θ gradually decreases as the angle of view θ increases, and the image height Y is an approximately constant value. In other words, the resolution is high in areas in which the angle of view θ is small, and the resolution is low in areas in which the angle of view θ is large.

[0038]

As a result of appropriately setting the radius of curvature, etc. of the foveated lens, the foveated lens has a wider visual field than that obtained using an ordinary lens with a zoom magnification similar to that in the central area of the foveated lens with which a large image height Y is obtained (corresponding to the "area in which the angle of view θ is small") instead of the foveated lens, and projects a larger optical image of the subject in the central area of the foveated lens than that obtained using an ordinary lens with a field of view similar to that of the peripheral area of a foveated lens having this wide field of view (corresponding to the "area in which the angle of view θ is large") instead of the foveated lens.

[0039]

Note that although the foveated lens used in the present embodiment is a lens whereof the central area has the equivalent of a focal length f of 80 mm as converted for a 35 mm camera, and the peripheral area has the equivalent of a focal length f of 16 mm as converted for a 35 mm camera, the foveated lens is not limited thereto.

[0040]

The foveated lens has the function of enlarging the image in the central area of the visual field and compressing the image in the peripheral region, and is characterized in enabling obtainment of a natural image with a wide visual field at high resolution in the central area, and without noticeable distortion in the central area, or the like.

[0041]

Note that the abovementioned ordinary lens refers to a lens of which the relationship between the image height Y , the focal length f , and the angle of view θ is represented by $Y = f \cdot \tan \theta$.

[0042]

When imaging is performed using a foveated lens having the abovementioned characteristics as an image forming unit, the part of the captured image corresponding to the wide-angle region of the foveal lens shows a wide subject compressed, with the part corresponding to the telephoto region of the foveal lens showing a subject located in the central part enlarged as compared to a subject located in the peripheral portion, as shown in Figure 4.

[0043]

Consequently, the surveillance camera 2 can capture a wide area while capturing the central portion of the imaging area in high resolution.

[0044]

Next to be described is a surveillance camera in the first embodiment of the present invention. Figure 5 is a block diagram showing the configuration of the surveillance system 1 in the first embodiment.

[0045]

As shown in Figure 5, the surveillance system 1 in the first embodiment comprises a surveillance camera 2 and a controller 3. The surveillance camera 2 in the first embodiment comprises an image forming unit 201, an imaging element 202, an image generation unit 203 (corresponding to the captured image generation unit), an image storage unit 204, a central processing unit (CPU) 205, an image processing unit 206 (corresponding to the display image creation unit), an image synthesis unit 207 (corresponding to a display image correcting unit), an input/output (I/O) unit 208, and a drive unit 209. An imaging unit 210 comprises the image forming unit 201 and the imaging element 202, and a control unit 220 comprises the image generation unit 203, the image storage unit 204, the CPU 205, the image processing unit 206, the image synthesis unit 207, and the I/O unit 208.

[0046]

The image forming unit 201 forms an optical image, in which a central part has a different resolution from a peripheral part of a captured image, on an imaging surface of the imaging element 202, and corresponds to, for example, the abovementioned foveated lens.

[0047]

The imaging element 202 is a CCD color area sensor in which a plurality of photoelectric conversion elements such as photodiodes are two-dimensionally arrayed in a matrix, and (R), green (G), and blue (B) color filters are arranged in a ratio of 1:2:1 on a light receiving surface of each photoelectric conversion element. The imaging element 202 converts the optical image of the subject formed by the image forming unit 201 into analog electrical signals (i.e., image signals) of red (R), green (G), and blue (B) color components, which are output as R, G, and B color image signals. Note that the imaging element 202 may be a monochrome imaging element.

[0048]

The imaging element 202 controls imaging operations, such as starting and ending an exposure operation of the imaging element 202 and reading the signals output by the pixels of the imaging element 202 (for horizontal synchronization, vertical synchronization, and transfer), through use of a timing generator (not shown) or the like.

[0049]

The image generation unit 203 generates a captured image on the basis of an electrical signal output from the imaging element 202. First, the image generation unit 203 performs predetermined analog signal processing of an analog image signal output from the imaging element 202. Specifically, the image generation unit 203 reduces noise in the image signal through use of a correlated double sampling (CDS) circuit, and adjusts the level of the image signal through use of an auto gain control (AGC) circuit. The image generation unit 203 then converts the output analog R, G, B image signals into digital image signals (referred to below as digital signals) that comprise a plurality of bits. The image generation unit 203 performs, on the A/D-converted R, G, and B digital signals, black level correction for correcting the black level to a reference black level; white balance for converting the digital signal levels of red (R), green (G), and blue (B) color components on the basis of the appropriate white

standard for the light source; and gamma correction of the red (R), green (G), and blue (B) color digital signals for gamma characteristic correction. Since the above-described foveated lens is used as the image forming unit, the captured image generated by the image generation unit 203 is an image having a predetermined degree of distortion, as shown in Figure 4.

[0050]

In the following description, signals processed by the image generation unit 203 are considered to be captured image data, pixel data of each pixel constituting the captured image data to be image pixel data, and images related to the captured image data to be captured images. In the present embodiment, the captured image data for each color includes pixel data for each of the 1280×1024 pixels.

[0051]

The image storage unit 204 is a memory that temporarily stores captured image data output from the image generation unit 203, and is used as a work area for the CPU 205 to perform processing, to be described below, of the image data. The image storage unit 204 also stores at least one frame before the captured image data.

[0052]

The CPU 205 is for organically controlling the driving of the abovementioned camera 21 with, for example, a microcomputer having a built-in storage unit that comprises a ROM for storing a control program and a RAM for temporarily storing data, and each member inside the camera body described above, as well as comprehensively controlling the imaging operations of the surveillance camera 2. The CPU 205, the image storage unit 204, the image processing unit 206, the image synthesis unit 207, and the I/O unit 208 are mutually connected via a bus 230, and the image storage unit 204, the image processing unit 206, the image synthesis unit 207, and the I/O unit 208 operate on the basis of instructions from the CPU 205.

[0053]

The image processing unit 206 corrects distortion in the captured image by converting the captured image stored in the image storage unit 204 to a display image for display. Since, as indicated above, the captured image is distorted overall, if a configuration were adopted such that the captured image data is sent to the controller 3 as it is, distorted images would be displayed in the image display unit 31 of the controller 3, so that good visual recognizability of images (i.e. natural appearance when viewed with the naked eye) would be unobtainable. For this reason, it is necessary to correct the distortion in the captured image, and the image processing unit 206 prepares a display image, captured by a normal lens, for display by geometrically transforming the captured image. The image processing unit 206 stores the converted display image in the image storage unit 204. In the present embodiment, signals processed by the image processing unit 203 [sic] are considered to be display image data, and images related to display image data are considered to be display images.

[0054]

A method of converting an image captured by a foveated lens to an image captured by a normal lens is described below.

[0055]

First, the coordinates (u, v) of a point in a captured image corresponding to the coordinates (i, j; $0 \leq i \leq K$, $0 \leq j \leq L$) of a given pixel (referred to below as the pixel of interest) are calculated, taking the number of pixels of the captured image to be $M \times N$ pixels and the number of pixels of the display image to be $K \times L$ pixels. The following equations (1) to (3) represent the distance d (dx: x component, dy: y component) of coordinates (i, j) of a target pixel of the display image from the center coordinates (cvx, cvy) of the display image. The center coordinates (cvx, cvy) of the display image are the center of the display image, i.e. $cvx = K/2$ and $cvy = L/2$.

$$(1) \ dx = (K/2 - i)$$

$$(2) \ dy = (L/2 - j)$$

$$(3) \ d = (dx^2 + dy^2)^{1/2}$$

[0056]

The incident angle θ at the target pixel (i, j) is represented by equations (4) below, on the basis of equations (4) and (5).

$$(4) \ \tan \theta = d/f_l$$

$$(5) \ \tan (\theta/2) = (K/2)/f_l$$

$$(6) \theta = \text{atan}(d \cdot \tan(\theta_v/2)/(K/2))$$

[0057]

In the above equations (4) to (6), f_l represents the focal length from the foveate lens to the image sensor, and θ_v represents the horizontal angle of view.

[0058]

Since the image height h of the captured image is represented by $h = f(\theta)$, the coordinates (u, v) of the corresponding point in the captured image are represented by equations (7) and (8) below, using the center coordinates (cwx, cwy) of the captured image. The center coordinates (cwx, cwy) of the display image are at the center of the display image, that is, $cwx = M/2$ and $cwy = N/2$.

$$(7) u = cwx + h \times (dx / d)$$

$$(8) v = cwy + h \times (dy / d)$$

[0059]

If u and v are within the captured image ($0 \leq u \leq M$ and $0 \leq v \leq L$), the pixel value of the target pixel (i, j) of the display image is calculated. The pixel value of the coordinates (u, v) in the corresponding captured image are substituted for the pixel value of the target pixel (i, j) . If u and v are not expressible by integers (i.e., have decimals), an integer conversion process is performed to round off the decimal places. When this integer conversion process is performed, it is possible that some pixels in the captured image will have no corresponding pixels in the display image. That is, there may be parts with discontinuities in the integers of the position data, as a result of integer conversion processing. When in such a case there is no pixel in the display image corresponding to a pixel in the captured image, an interpolation process is performed to generate a pixel value for the pixel in the display image. In this interpolation processing the pixel value of one of the pixels vertically adjacent, for example, to the pixel that has no pixel value is used as it is. Alternatively, a linear function indicating the relationship between the position and the luminance, for example, is obtained in interpolation processing by using the image data of a pixel vertically adjacent to a pixel having no pixel value, and linear interpolation is performed to compute the pixel value of the pixel having no pixel value by integer conversion processing. If u and v are outside the captured image, it is determined that the area cannot be converted (referred to below as a missing area), and the pixel value is not calculated.

[0060]

Each pixel value of the display image is calculated in this way, the captured image is converted into a display image, and the display image converted from the captured image for display is stored in the image storage unit 204.

[0061]

The image synthesis unit 207 uses a part of a display image, obtained by using the drive unit 209 to drive the imaging unit in a predetermined direction, to correct an inconvertible area (i.e., a missing area) in the display image that is produced when a captured image is converted to a display image by the image processing unit 206. That is, the image synthesis unit 207 combines an inconvertible missing area of the display image that is produced when the captured image is converted to a display image, with a first display image, obtained by using the drive unit 209, discussed below, to drive the imaging unit 210 vertically, and a second display image, obtained by again using the drive unit 209 to drive the imaging unit 210 vertically.

[0062]

The I/O unit 208 controls input and output of data between the controller 3 and the drive unit 209, sends image data to the controller 3, receives request information from the controller 3, etc.

[0063]

The drive unit 209 comprises gear motors 23 and 24, and drives the optical axis L of the surveillance camera 21 in the pan direction and the tilt direction in accordance with commands from the CPU 205.

[0064]

Next to be described is the operation of the surveillance camera 2 in the first embodiment. Figure 6 is a flowchart showing the operation of the surveillance camera 2 in the first embodiment.

[0065]

In step S1, the CPU 205 instructs the drive unit 209 to reset. The CPU 205 instructs the drive unit 209 to return the imaging unit 210 position to the initial position.

[0066]

In step S2, the CPU 205 outputs a display image to the controller 3. That is, the CPU 205 reads the display image stored in the image storage unit 203 [sic] and outputs the display image to the controller 3 via the I/O unit 208. The image display unit 31 of the controller 3 displays the input display image. When the surveillance camera 2 is activated, i.e. when the surveillance target area is first imaged, the processing in step S2 is skipped, and the processing in step S3 and subsequent steps is performed.

[0067]

In step S3, the CPU 205 determines whether or not the drive amounts (PTZ amounts) p, t, and z output from the controller 3 for pan operation, tilt operation, and zoom operation have been detected. When the respective drive amounts p, t, and z respectively for pan operation, tilt operation, and zoom operation are detected therein (YES in step S3), processing proceeds to step S4, and when the drive amounts p, t, and z respectively for pan operation, tilt operation, and zoom operation are not detected, processing returns to step S2, and processing is performed from step S2 onward. Instructions as to the respective drive amounts for pan operation, tilt operation, and zoom operation are given by an input unit included in the controller 3.

[0068]

In step S4, the CPU 205 instructs the drive unit 209 as to the drive amount in the pan direction and the drive amount in the tilt direction. The instruction as to drive amount in the pan direction given by the CPU 205 is the drive amount p output from the controller 3, and the drive amount in the tilt direction instruction given by the CPU 205 is the amount $t - \alpha$ obtained by subtracting the vertical angle of view α of a missing area from the drive amount t output from the controller 3.

[0069]

At this point, a method of calculating the vertical angle of view α of a missing area will be described. Figure 7 is a diagram illustrating a method of calculating the vertical angle of view α of a missing area.

[0070]

As shown in Figure 7, the following equation (9) holds when the number of pixels in the vertical direction of the display image is L (pixels), the angle of view in the vertical direction of the display image is θH , the focal length is fl, the number of pixels in the vertical direction of the missing area is n (pixels), and the angle of view of the missing area in the vertical direction is α . (9) $\tan \theta H = L/fl$

[0071]

Equation (9) can be replaced with the following equation (10).

$$(10) \text{ fl} = L/\tan \theta H$$

[0072]

Moreover, the following equation (11) represents the vertical angle of view α of the missing area subtracted from the vertical angle of view θH of the display image.

$$(11) \theta H - \alpha = \text{atan} ((L - n)/\text{fl})$$

[0073]

The following equation (12) represents α as obtained by substituting equation (10) for fl in the above equation (11).

$$(12) \alpha = \theta H - \text{atan} ((Ln)/(L/\tan \theta H))$$

[0074]

The drive amount $t - \alpha$ in the tilt direction is calculated using the vertical angle of view α of the missing area thus obtained, and the CPU 205 instructs the drive unit 209 to drive the calculated drive amount $t - \alpha$ in the tilt direction. The drive unit 209 drives the imaging unit 210 to rotate in each direction on the basis of the drive amount in the pan direction and the drive amount in the tilt direction in the instructions from the CPU 205.

[0075]

Returning to Figure 6, in step S5 the CPU 205 instructs the image processing unit 206 to create a first display image with a focal length fl. That is, the image forming unit 201 forms an optical image in the surveillance target range on the imaging surface of the imaging element 202, the imaging element 202 photoelectrically converts the optical image in the surveillance target range imaged on the imaging surface, and the image generation unit 203 generates a first captured image from the electrical signal photoelectrically converted by the imaging element 202. The image storage unit 204 temporarily stores the first captured image. The image processing unit

206 reads the first captured image stored in the image storage unit 204 on the basis of instructions from the CPU 205, and creates a first display image at a focal length f_l in which distortion from the first captured image has been corrected. The first display image thus created is stored in the image storage unit 204.

[0076]

Figure 8 shows an example of a first captured image. The first captured image SG1 shown in Figure 8 is captured by driving the imaging unit 210 the drive amount p in the pan direction input from the controller 3, and driving the imaging unit 210 the drive amount $t - \alpha$ in the tilt direction, obtained as the angle of view α subtracted from the drive amount t in the tilt direction. That is, the image generation unit 203 generates the first captured image SG1 upon being driven by the drive unit 209 by the driving amount p in the pan direction and by the driving amount $t - \alpha$ in the tilt direction. As shown in Figure 8, the first captured image SG1, captured by the image forming unit 201, which has a foveated lens, is distorted into a barrel shape.

[0077]

Figure 9 shows an example of a first display image. The image processing unit 206 creates the first display image HG1 by correcting the distortion in the first captured image SG1 shown in Figure 8. As shown in Figure 9, there are missing areas KR that are not displayed in the upper and lower parts of the first display image HG1 as a result of distortion correction processing. As Figure 9 also shows, the first display image HG1 is an image shifted downward from the tilt-direction drive amount t input from the controller 3 by the amount of the vertical angle of view of a missing area.

[0078]

Returning to Figure 6, in step S6 the CPU 205 instructs the drive unit 209 as to the drive amount in the tilt direction. The tilt-direction drive amount in the instruction from the CPU 205 is 2α , i.e. twice the vertical angle of view α of a missing area.

[0079]

In step S7, the CPU 205 instructs the image processing unit 206 to create a second display image having the same focal length f_l as the first display image and shifted upward by the vertical angles of view of the two missing areas. That is, the image generation unit 203 generates a second captured image on the basis of the electric signal photoelectrically converted by the imaging element 202, and the generated second captured image is temporarily stored in the image storage unit 204. The image processing unit 206 creates a second display image with a focal length f_l , in which distortion from the second captured image stored in the image storage unit 204 has been corrected on the basis of instruction from the CPU 205.

[0080]

Figure 10 shows an example of a second captured image. The second captured image SG2 shown in Figure 10 is an image captured by driving the imaging unit 210 in the tilt direction by a drive amount 2α , i.e. further shifting upward by the vertical angles of view α of the two missing areas. That is, the image generation unit 203 generates the second captured image SG2 upon the additional driving thereof by the drive unit 209 by a driving amount 2α in the tilt direction. As shown in Figure 10, the second captured image SG2, captured by the image forming unit 201, which has a foveated lens, is distorted into a barrel shape.

[0081]

Figure 11 shows an example of a second display image. The image processing unit 206 creates the second display image HG2 by correcting the distortion in the first captured image SG2 shown in Figure 10. As shown in Figure 11, there are missing areas KR that are not displayed in the upper and lower parts of the second display image HG2 as a result of distortion correction processing. As Figure 11 also shows, the second display image HG2 is an image shifted upward by the amount of the vertical angle of view of the two missing areas.

[0082]

Returning to Figure 6, in step S8 the CPU 205 instructs the image synthesis unit 207 to synthesize the first display image HG1 and the second display image HG2. The image synthesis unit 207 creates a synthesized image GG by synthesizing a synthesis area GR1 of the first display image HG1 (see Figure 9) and a synthesis area GR2 of the second display image HG2 (see Figure 11), and the synthesized image thus created is stored in the image storage unit 203 [sic]. The synthesis area GR1 is an image of the upper half of the synthesized image GG, an image $K \times L/2$ in size, with $(0, n)$ as the origin. The synthesis area GR2 is an image of the lower half of

the synthesized image GG, an image $K \times L/2$ in size, with $(0, L/2 - n)$ as the origin. Meanwhile, n is the number of pixels in the vertical direction of the missing area in the first display image HG1, K is the number of pixels in the horizontal direction in the first display image HG1, and L is the number of pixels in the vertical direction in the first display image HG1. The synthesized image stored in the image storage unit 203 [sic] is output to the controller 3 via the I/O unit 208, and displayed on the image display unit 31 of the controller 3.

[0083]

Figure 12 shows an example of a synthesized image. The image synthesis unit 207 synthesizes the synthesis area GR1 in the first display image HG1 shown in Figure 9 and the synthesis area GR2 in the second display image HG2 shown in Figure 11 to create a synthesized image GG. The synthesized image GG is an image produced through driving by the drive amount p in the pan direction and driving by the drive amount t in the tilt direction. As shown in Figure 12, a synthesized image GG obtained by synthesizing the synthesis area GR1 in the first display image HG1 and the synthesis area GR2 in the second display image HG2 is displayed on the image display unit 31 of the controller 3 as a display image, thus enabling provision of an image in which the missing areas KR caused by converting the captured image into the display image are corrected.

[0084]

Returning to Figure 6, in step S9 the CPU 205 determines whether an end signal transmitted from the controller 3 has been detected. The end signal is a signal for ending the imaging of the surveillance target area; it is input by using the input unit of the controller 3, and output to the CPU 205 via the I/O unit 208. When the end signal is detected in this case (YES in step S9), the process ends, and when the end signal is not detected (NO in step S9), the process returns to step S2, a display image is output to the controller 3, and processing is performed from step S2 forward.

[0085]

Although in the present embodiment two display images are created by driving the imaging unit 210 vertically in the tilt direction, and an image without missing areas is created by synthesizing the two created display images, the present invention is not particularly limited to this, and an image without missing areas may be created through creation of a plurality of display images by driving the imaging unit 210 to the left and right in the pan direction to create images that do not have missing areas by synthesis of a plurality of created display images that do not have missing areas.

[0086]

When the imaging unit 210 is driven in the tilt direction only, the correction may be performed using a part of the image of the previous frame. That is, when the imaging unit 210 is driven in the tilt direction only, the correction is performed by synthesizing an image excluding the missing area of the display image of the previous frame and an image excluding the defective area of the display image of the next frame. In that case, it is not necessary to retake the image for the correction, and the missing area can be corrected at a high speed.

[0087]

In this way, an optical image is formed on the imaging surface in which the resolution is higher at the center of the captured image and lower at the periphery than at the center, a captured image is generated on the basis of the electric signal output from the imaging element 202, the generated captured image is converted into a display image for display, inconvertible areas (missing areas) in the display image that are produced during conversion of the captured image to the display image are corrected through use of a part of the display image captured separately, so that the inconvertible areas in the display image can be corrected and displayed, and a display image with high resolution can thus be created.

[0088]

Since inconvertible areas in the display image that are produced in conversion from the captured image to the display image are corrected using a part of the display image obtained through use of the drive unit 209 to drive the imaging unit 210 in a predetermined direction, the inconvertible areas can be corrected and displayed in the

display image for display, thus enabling creation of a display image with high resolution.

Second embodiment:

Next to be described is a surveillance camera in the second embodiment of the present invention. In the first embodiment, inconvertible areas in the display image that are produced in conversion from the captured image to the display image were corrected using a part of the display image obtained through use of the drive unit 209 to drive the imaging unit 210 in a predetermined direction, but in the second embodiment, various information is synthesized and displayed in the inconvertible areas of the display image. The surveillance system 1 and the surveillance camera 2 in the second embodiment have features similar to those of the surveillance system 1 and the surveillance camera 2 shown in Figures 1 and 2. Figure 13 is a block diagram showing the configuration of the surveillance system 2 in the first embodiment.

[0089]

As shown in Figure 13, the surveillance system 1 in the second embodiment comprises a surveillance camera 2, a controller 3, and a GPS 5. The surveillance camera 2 in the second embodiment comprises an image forming unit 201, an imaging element 202, an image generation unit 203, an image storage unit 204, a central processing unit (CPU) 205, an image processing unit 206, an input/output (I/O) unit 208, a drive unit 209, a text information synthesis unit 211, and an image information synthesis unit 212. An imaging unit 210 comprises the image forming unit 201 and the imaging element 202, and a control unit 220 comprises the image generation unit 203, the image storage unit 204, the CPU 205, the image processing unit 206, the I/O unit 208, the text information synthesis unit 211, and the image information synthesis unit 212. The imaging information synthesis unit 240 (corresponding to the information synthesis unit) includes a text information synthesis unit 211 and an image information synthesis unit 212. The surveillance camera 2 in the second embodiment has nearly the same features as the surveillance camera 2 in the first embodiment shown in Figure 5, and thus only features differing therefrom will be described below.

[0090]

The imaging information synthesis unit 240 is for synthesizing information pertinent to the imaging apparatus in a missing area of the display image, and includes a text information synthesis unit 211 and an image information synthesis unit 212.

[0091]

The text information synthesis unit 211 synthesizes text or text information such as a text-based graphic in the missing area KR in the display image created by the image processing unit 206. The text information is various information pertinent to the imaging apparatus, for example such information on operation of the imaging apparatus as the drive amount in the pan direction, the drive amount in the tilt direction, and the zoom level of the imaging unit 210, as well as such information as the current time and positional information as to the position in which the imaging apparatus is installed. Positional information is information on the latitude and longitude at which the imaging apparatus is installed, information on the direction in which the imaging apparatus is facing, information on the altitude at which the imaging apparatus is installed, etc. The positional information is information measured by a global positioning system 5 (GPS) that measures the three-dimensional position of the surveillance camera 2, and is input via the I/O unit 208. The text information displayed in the missing area is not limited to the above, and various other information desired by the user may be provided.

[0092]

The image information synthesis unit 212 synthesizes image information as to an image included in the display image in a missing area KR of the display image created by the image processing unit 206. Specifically, the image information synthesis unit 212 enlarges a predetermined area of the display image created by the image processing unit 206, and synthesizes the enlarged image in the missing area KR of the display image. The range of the predetermined area to be enlarged on the display image is specified by the controller 3, and the image within the specified range on the display image is enlarged and synthesized in the missing area of the display image. In the present embodiment, an area specified by the controller 3 is taken to be the predetermined area to be enlarged in the display image, but the present invention is not specifically limited to this, and for example a preset area or the central area of the display image would also be acceptable. When the display image is an image obtained by cutting out a predetermined area of the captured image, the image information may be an image representing the area cut out from the captured image as the display image.

[0093]

Next to be described is the operation of the surveillance camera 2 in the second embodiment. Figure 14 is a

flowchart showing the operation of the surveillance camera 2 in the second embodiment.

[0094]

The processing from step S11 to step S13 is the same as the processing from step S1 to step S3 shown in Figure 6, and a description thereof is thus omitted.

[0095]

In step S14, the CPU 205 instructs the drive unit 209 as to the drive amount in the pan direction and the drive amount in the tilt direction. The instruction as to drive amount in the pan direction given by the CPU 205 is the drive amount p output from the controller 3, and the drive amount in the tilt direction instruction given by the CPU 205 is the drive amount t output from the controller 3. In step S15, the CPU 205 converts the zoom level z input from the controller 3 via the I/O unit 208 to a focal length fl.

[0096]

In step S16, the CPU 205 instructs the image processing unit 206 to create a display image having the converted focal length fl. The image processing unit 206 creates a second display image with a focal length fl, in which distortion from the second captured image stored in the image storage unit 204 has been corrected on the basis of instruction from the CPU 205. In this case, the top and bottom of the display image include missing areas where no image is displayed.

[0097]

In step S17, the CPU 205 instructs the text information synthesis unit 211 to synthesize the text information regarding the surveillance camera 2 in the missing area of the display image. The text information synthesis unit 211 synthesizes the text information with a missing area of the display image created by the image processing unit 206.

[0098]

In step S18, the CPU 205 instructs the image information synthesis unit 212 to synthesize an enlarged image, in which a predetermined area is enlarged, in a missing area of the display image. The image information synthesis unit 212 enlarges the image in a predetermined area inside the display area, and synthesizes the enlarged image with the missing area of the display image.

[0099]

The processing in step S19 is the same as the processing in step S9 shown in Figure 6, and a description thereof is therefore omitted.

[0100]

Figure 15 shows an example of a display image of text information and image information displayed in missing areas. As shown in Figure 15, text information is synthesized in the missing area KRU in the upper part of the display image HG3, and an enlarged image is synthesized in the missing area KRD in the lower part of the display image HG3. The driving amount 301 of the imaging unit 210 in the pan direction, the driving amount 302 in the tilt direction, the zoom level 303, the current time 304, the latitude and longitude 305 at which the imaging apparatus is installed, and information on the orientation 306 in which the imaging apparatus is facing are displayed as text information in the missing area KRU on the upper part of the display image HG3 shown in Figure 15. The driving amount 301 in the pan direction is displayed as "P: 10" in Figure 15 because the imaging unit 210 is rotated by 10 cm in the pan direction, and the driving amount 302 in the tilt direction is displayed as "P [sic]: 20" because the imaging unit 210 is rotated by 20 cm in the tilt direction, and the zoom level 303 is displayed as "Z: 1 ×" is displayed because the imaging unit 210 is zoomed to actual size. The current time in Figure 15 is displayed as "12:34" because the current time is 12:34. Since the surveillance camera 2 is installed at a position of 135° east longitude 20° north latitude, "135° east longitude 20° north latitude" is displayed in Figure 15 as the latitude and longitude 305. The orientation 306 is displayed as "N" above and "S" below in the display image HG3 in Figure 15, since the imaging unit 210 is imaging a surveillance target area with a northerly orientation.

[0101]

An enlarged image WG in which the image of the region WR that is a part of the display image HG3 is displayed

in the missing area KRD in the lower part of the display image HG3 shown in Figure 15. The region WR to be enlarged and displayed is specified by an input unit (not shown) included in the controller 3. The input unit is, for example, a keyboard and mouse when the controller 3 comprises a personal computer.

[0102]

In the present embodiment, character information is synthesized in the missing area KRU in the upper part of the display image HG3 and an enlarged image is synthesized in the missing area KRD in the lower part of the display image HG3, but the present invention is not specifically limited to this, and an enlarged image may be synthesized in the missing area KRU in the upper part of the display image HG3, and the character information may be synthesized in the missing area KRD in the lower part of the display image HG3, or either text information or an expanded image can be synthesized in either the missing area KRU in the upper part of the display image HG3 or the missing area KRD in the lower part of the display image HG3.

[0103]

This enables effective use of inconvertible areas, even when the inconvertible areas are included in display images, which are images for display, since thereby optical images are formed on an imaging surface with high resolution in a central part of a captured image, and lower resolution in peripheral parts than in the central part; a captured image is generated on the basis of the electrical signals output from the imaging element 202; the generated captured image is converted to a display image for display; and predetermined information is synthesized in inconvertible areas (i.e. missing areas) in a display image that are produced during conversion from the captured image to the display image.

[0104]

It also enables display of text information concerning a display image together with the display image, thereby enabling effective use of an inconvertible area in a display image that is produced during conversion from the captured image to the display image, since text information is synthesized in the inconvertible area.

[0105]

Moreover, it enables display of an enlarged image of a part of a display image together with the display image, thereby enabling effective use of an inconvertible area in the display image that is produced during conversion from the captured image to the display image, since an enlarged image of a part of the display image is synthesized in the inconvertible area.

[0106]

In the present embodiment, the imaging apparatus is described as a surveillance camera, but the present invention is not specifically limited to this, and it may be, for example, a webcam or a vehicle-mounted camera.

[0107]

The specific embodiments described above mainly comprises an invention having the following features.

[0108]

(1) An imaging apparatus, characterized in comprising: an imaging element that photoelectrically converts an optical image, which is formed on an imaging surface in which a plurality of pixels are two-dimensionally arranged, to an electrical signal, pixel by pixel; an imaging unit comprising an image forming unit that forms an optical image, having a different resolution in a central part from that in a peripheral part of an image that is captured, on the imaging surface; a captured image generation unit that generates a captured image having a predetermined degree of distortion on the basis of the electrical signals output from the imaging element; a display image creation unit that converts the captured image generated by the captured image generation unit to a display image for display without distortion; and a display image correction unit that uses part of the display image, captured separately, to correct inconvertible areas in the display image that are produced during conversion from the captured image to the display image.

[0109]

By this configuration, optical images are formed on an imaging surface with high resolution in a central part of a captured image, and lower resolution in peripheral parts than in the central part, a captured image having a predetermined degree of distortion is generated on the basis of the electrical signals output from the imaging element the generated captured image is converted to a display image for display without distortion, and inconvertible areas in a display image that are produced during conversion from the captured image to the display image are corrected using a part of the display image that has been captured separately.

[0110]

(2) The imaging apparatus described in (1) above, characterized in additionally comprising a drive unit that drives the imaging unit vertically and horizontally, and in that the display image correction unit corrects the inconvertible areas of the display image, which are produced when the captured image is converted to a display

image, by synthesis of a first display image, obtained by using the drive unit to drive the imaging unit vertically, and a second display image, obtained by again using the drive unit to drive the imaging unit vertically.

[0111]

Through use of this configuration, inconvertible areas of the display image that are produced when the captured image is converted to a display image are corrected by synthesis of a first display image, obtained by using the drive unit to drive the imaging unit vertically, and a second display image, obtained by again using the drive unit to drive the imaging unit vertically.

[0112]

(3) The imaging apparatus described in (1) above, characterized in additionally comprising a drive unit that drives the imaging unit vertically and horizontally, and in that the display image correction unit corrects the inconvertible areas that are produced in the upper and lower parts of the display image when the captured image is converted to a display image by synthesis of an image that does not include the inconvertible areas of a first display image, obtained by using the drive unit to drive the imaging unit vertically, and an image that does not include inconvertible areas of a second display image obtained by using the drive unit to drive the imaging unit vertically.

[0113]

Through use of this configuration, inconvertible areas that are produced in the upper and lower parts of the display image when the captured image is converted to a display image are corrected by synthesis of an image that does not include inconvertible areas of a first display image obtained by using the drive unit to drive the imaging unit vertically and an image that does not include inconvertible areas of a second display image obtained by using the drive unit to drive the imaging unit vertically.

[0114]

(4) The imaging apparatus described in (1) above, characterized in additionally comprising a drive unit that drives the imaging unit vertically and horizontally, and in that the display image correction unit corrects the inconvertible areas that are produced in the upper and lower parts of the display image when the captured image is converted to a display image by synthesis therein of an image that does not include inconvertible areas of a plurality of display images obtained by using the drive unit to drive the imaging unit vertically.

[0115]

Through use of this configuration, inconvertible areas of the display image that are produced when the captured image is converted to a display image are corrected by synthesis of an image that does not include inconvertible areas of a plurality of display images obtained by using the drive unit to drive the imaging unit vertically.

[0116]

(5) An imaging apparatus, characterized in comprising: an imaging element that photoelectrically converts an optical image, which is formed on an imaging surface in which a plurality of pixels are two-dimensionally arranged, to an electrical signal, pixel by pixel; an imaging unit comprising an image forming unit that forms an optical image, having a different resolution in a central part from that in a peripheral part of the captured image, on the imaging surface; a captured image generation unit that generates a captured image having a predetermined degree of distortion on the basis of the electrical signals output from the imaging element; a display image creation unit that converts the captured image generated by the captured image generation unit to a display image for display without distortion; and an imaging information synthesis unit for synthesizing information pertinent to the imaging apparatus in an inconvertible area of the display image that is produced when the captured image is converted to a display image.

[0117]

Through use of this configuration, optical images are formed at high resolution on an imaging surface in a central part of a captured image and lower resolution in peripheral parts than in the central part, a captured image is generated on the basis of the electrical signals output from the imaging element, the generated captured image is converted to a display image for display; and imaging information is synthesized in inconvertible areas of a display image that are produced during conversion from the captured image to the display image.

[0118]

(6) An imaging system, characterized in being configured so that the imaging apparatus in any one of (1) to (5) above can communicate with a controller that comprises an image display unit for displaying an image via a communication network through use of communication units with which they are respectively provided, and in that the display image, when sent from the imaging apparatus to a controller, is displayed on an image display unit of the controller.

[0119]

Through use of this configuration, a display image created by the imaging apparatus is sent to the controller by the communication unit of the camera. Meanwhile, when a display image is sent from the imaging apparatus, the display image is received by the communication unit, and the display image is displayed on the image display unit of the controller.

[0120]

[Effect of the invention]

The invention set forth in Claim 1 enables correction and display of inconvertible areas in display images, which are images for display, and thus enables creation of high-resolution display images, since thereby optical images are formed on an imaging surface with high resolution in a central part of a captured image, and lower resolution in peripheral parts than in the central part; a captured image is generated on the basis of the electrical signals output from the imaging element; the generated captured image is converted to a display image for display; and inconvertible areas in a display image that are produced during conversion from the captured image to the display image are corrected using a part of the display image that has been captured separately.

[0121]

The invention set forth in Claim 2 enables correction and display of inconvertible areas in display images, which are images for display, and thus enables creation of high-resolution display images, since thereby a part of the display image that is obtained by using the drive unit to drive the imaging unit in a predetermined direction is used to correct inconvertible areas in a display image that are produced during conversion from the captured image to the display image.

[0122]

The invention set forth in Claim 3 enables effective use of inconvertible areas, even when the inconvertible areas are included in display images, which are images for display, since thereby optical images are formed on an imaging surface with high resolution in a central part of a captured image, and lower resolution in peripheral parts than in the central part; a captured image is generated on the basis of the electrical signals output from the imaging element 202; the generated captured image is converted to a display image for display; and predetermined information is synthesized in an inconvertible area in a display image that is produced during conversion from the captured image to the display image.

[0123]

The invention set forth in Claim 4 enables display of text information concerning a display image together with the display image, thereby enabling effective use of an inconvertible areas in a display image that are produced during conversion from the captured image to the display image, since text information is synthesized in an inconvertible area.

[0124]

The invention set forth in Claim 5 enables display of an enlarged image of a part of a display image together with the display image, thereby enabling effective use of an inconvertible area in the display image that is produced during conversion from the captured image to the display image, since an enlarged image of a part of the display image is synthesized in the inconvertible area.

[Brief explanation of the drawings]

Figure 1 is a block diagram of a surveillance system in the present embodiment.

Figure 2 is an external view of the surveillance camera used in the surveillance system.

Figure 3 shows the characteristics of a lens used in the surveillance camera.

Figure 4 shows an example of an image obtained by imaging with a surveillance camera.

Figure 5 is a block diagram showing the configuration of a surveillance system in the first embodiment.

Figure 6 is a flowchart illustrating the operation of a surveillance camera in the first embodiment.

Figure 7 is a diagram illustrating a method of calculating the vertical angle of view of a missing area.

Figure 8 shows an example of a first captured image.

Figure 9 shows an example of a first display image.

Figure 10 shows an example of a second captured image.

Figure 11 shows an example of a second display image.

Figure 12 shows an example of a synthesized image.

Figure 13 is a block diagram showing the configuration of a surveillance system in the second embodiment.

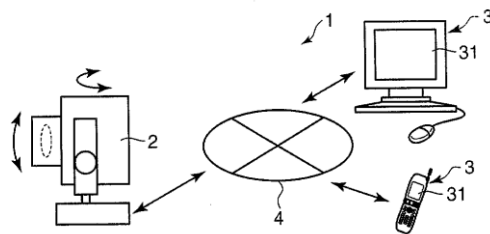
Figure 14 is a flowchart showing the operation of the surveillance camera 2 in the second embodiment. Figure 15 shows an example of a display image of text information and image information displayed in missing areas.

Figure 16 shows the size of an optical image with respect to the imaging surface of an imaging element.

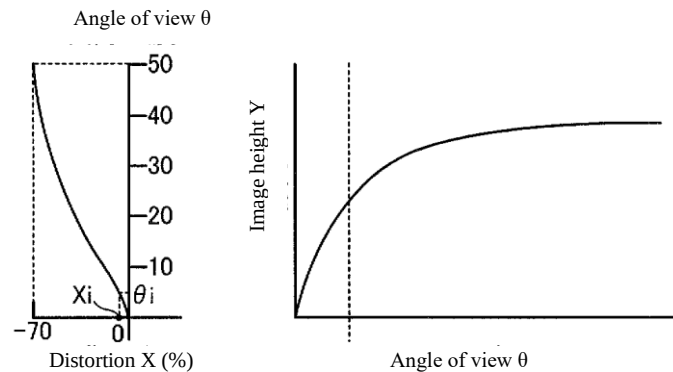
[Explanation of symbols]

- 1 Surveillance system
- 2 Digital camera
- 3 Controller
- 4 Communication network
- 5 GPS
- 31 Image display unit
- 201 Image forming unit
- 202 Imaging element
- 203 Image generation unit
- 204 Image storage unit
- 205 CPU
- 206 Image processing unit
- 207 Image synthesis unit
- 208 I/O unit
- 209 Drive unit
- 210 Imaging unit
- 220 Control unit

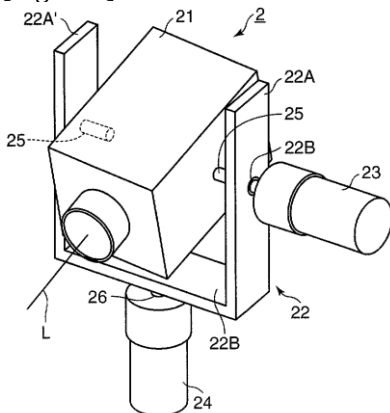
[Figure 1]



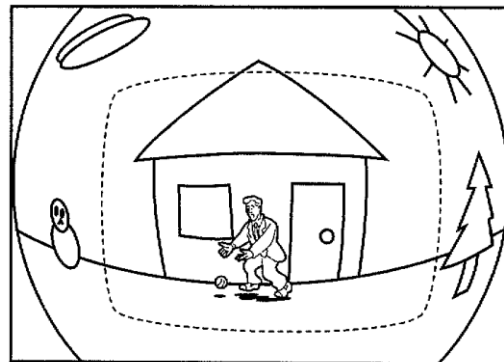
[Figure 3]



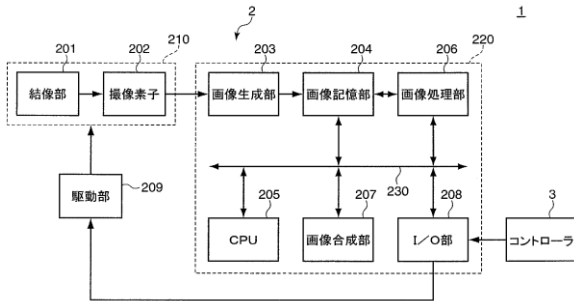
[Figure 2]



[Figure 4]

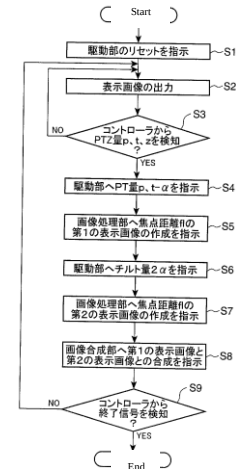


[Figure 5]



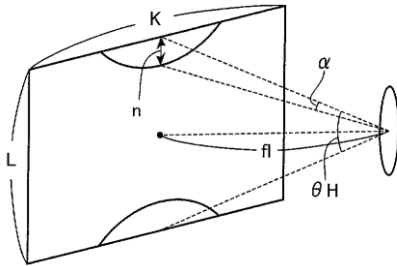
3: Controller
201: Image forming unit
202: Imaging element
203: Image generation unit
204: Image storage unit
206: Image processing unit
207: Image synthesis unit
208: I/O unit
209: Drive unit

[Figure 6]

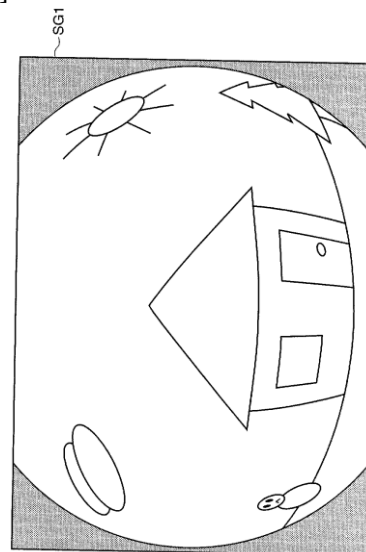


S1: Drive unit instructed to reset
S2: Display image output
S3: PTZ amounts p , t , and z from controller detected?
S4: Drive unit instructed as to p and $t - \alpha$
S5: Image processing unit instructed to create a first display image with focal length fl
S6: Drive unit 209 instructed as to tilt amount 2α
S7: Image processing unit instructed to create a second display with focal length fl
S8: Image synthesis unit instructed to synthesize first and second display images
S9: End signal from controller detected?

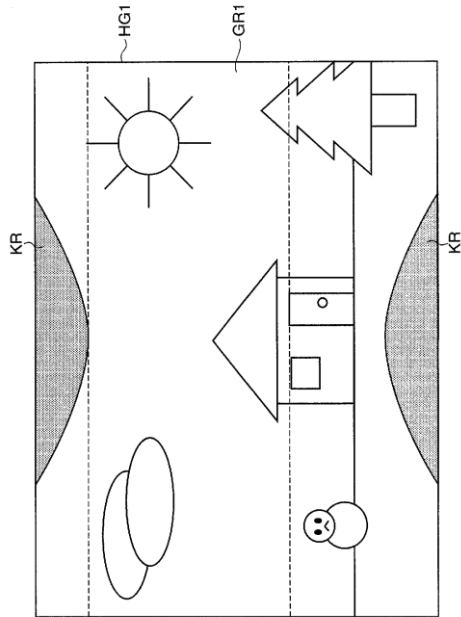
[Figure 7]



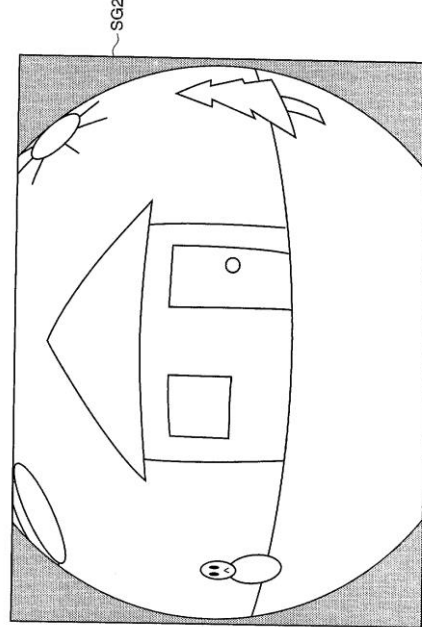
[Figure 8]



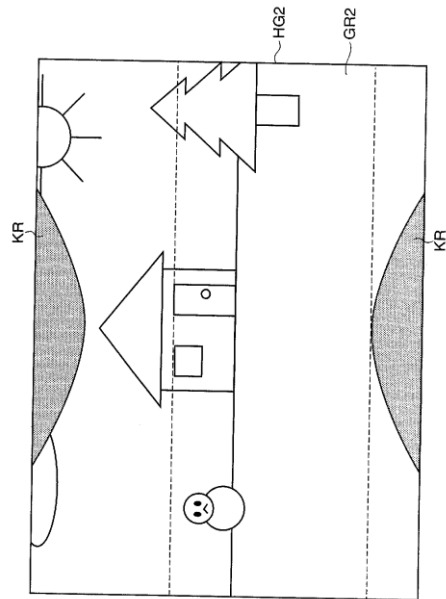
[Figure 9]



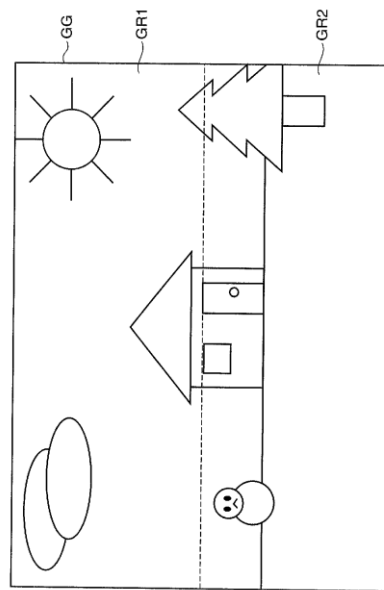
[Figure 10]



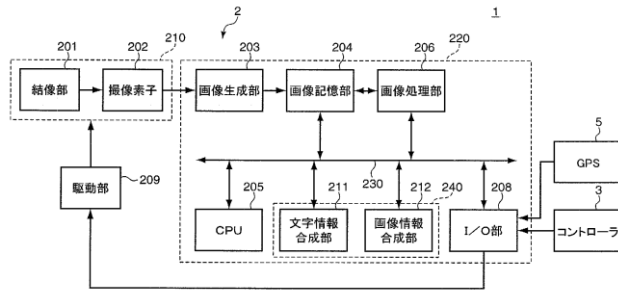
[Figure 11]



[Figure 12]

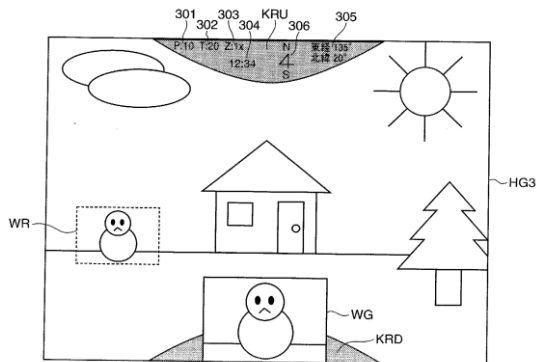


[Figure 13]



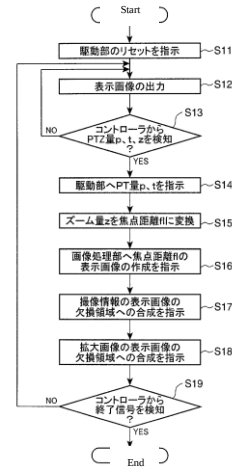
- 3: Controller
201: Image forming unit
202: Imaging element
203: Image generation unit
204: Image storage unit
206: Image processing unit
208: I/O unit
209: Drive unit
211: Text information synthesis unit
212: Image information synthesis unit

[Figure 15]



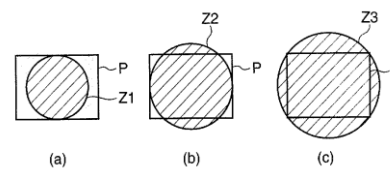
305: 135° east longitude 20° north latitude

[Figure 14]



- S11: Drive unit instructed to reset
S12: Display image output
S13: PTZ amounts p, t, and z from controller detected?
S14: Drive unit instructed as to p and t
S15: Zoom level z converted to focal length fl
S16: Image processing unit instructed to create a display image with focal length fl
S17: Instructions to synthesize imaging information a missing area of the display image
S18: Instructions to synthesize an enlarged image in a missing area of the display image
S19: End signal from controller detected?

[Figure 16]



Continued from the front page

(51) Int. Cl. ⁷

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5C076 AA12 AA16 AA21 AA22 AA23 BA06

DECLARATION OF JEROME CONWAY

I, Jerome CONWAY, declare the following:

1. I am over 18 years of age and competent to make this declaration.
2. I am a qualified Japanese to English translator with more than 25 years of experience.
3. I have translated into English the attached document identified as "Japanese Unexamined Patent Application Publication No. JP2004-289225A," bearing a publication date of October 14, 2004.
4. I affirm that the translated text has been translated and edited to the best of my ability and knowledge to accurately reflect the content, meaning, and style of the original text. I hereby certify under penalty of perjury under the laws of the United States of America that the foregoing constitutes, pursuant to my knowledge and belief, a true and correct translation of the original document.
5. I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: July 31, 2024


Jerome CONWAY