

CERTIFICATION

I, Takayoshi Hongo, Toranomon East Bldg., No. 7-13, Nishi-Shimbashi 1-chome, Minato-ku, Tokyo, Japan, do hereby certify that I am conversant with the English and Japanese languages and am a competent translator thereof, and I further certify that to the best of my knowledge and belief the attached English translation is a true and accurate translation made by me of the Japanese Unexamined Patent Application Publication JP 11-261868 published on September 24, 1999.

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(54) [Title of the Invention] FISHEYE LENS CAMERA APPARATUS,
AND IMAGE DISTORTION CORRECTION METHOD AND IMAGE EXTRACTION
METHOD THEREFOR

(57) [Abstract]

[Object] The present invention relates to a fisheye lens camera apparatus, and an image distortion correction method and an image extraction method therefor, in which an image deformation process of correcting distortion of a fisheye lens image is performed at high speed in a case where a fisheye lens camera is installed at any installation angle, and a moving figure such as a person's figure is detected and is extracted accurately so as to be displayed on a monitor television or the like with high accuracy.

[Solving Means] A configuration is provided in which an image captured by a fisheye lens 1-1 and a CCD imaging device 1-2 is stored in a picture memory 1-3, and an image correction processing unit 1-4 operates coordinate transform for correcting an installation angle of a fisheye lens camera and coordinate transform for correcting distortion of a fisheye lens image in combination with each other, and a fisheye lens image of equal area projection is transformed through mapping at high speed. In addition, a configuration is provided in which weighting corresponding to a region in the fisheye lens image is performed, a feature amount of a person's figure or the like is extracted, and a display area is extracted.

[Claims]

[Claim 1]

A fisheye lens camera apparatus comprising:

an image correction processing unit that corrects distortion of an image captured by a fisheye lens camera, wherein the image correction processing unit operates coordinate transform for correcting an installation angle of the fisheye lens camera and coordinate transform for correcting distortion of a fisheye lens image in combination with each other.

[Claim 2]

The fisheye lens camera apparatus according to claim 1, wherein the image correction processing unit operates coordinate transform for correcting distortion of a fisheye lens image of equal area mapping.

[Claim 3]

A fisheye lens camera apparatus comprising:

an image correction processing unit that corrects distortion of an image captured by a fisheye lens camera, wherein parameters for correcting distortion of a fisheye lens image, such as a central position of a displayed image, an aspect ratio of the fisheye lens image, and a radius of a fisheye lens image area, are extracted from the captured fisheye lens image itself, and distortion of the fisheye lens image is corrected using the parameters.

[Claim 4]

A fisheye lens camera apparatus which extracts a moving figure from an image captured by a fisheye lens camera, wherein regions are unified using a mutual positional relationship in a fisheye lens image so as to extract a region in which the figure varies.

[Claim 5]

A fisheye lens camera apparatus which extracts a moving figure from an image captured by a fisheye lens camera, wherein a fisheye lens image is transformed into a transversely long picture having a panorama form, a signal of an inter-frame difference of the picture or a signal in which an inter-frame difference and an in-frame difference are combined is extracted, a region is extracted using the signal, and regions of a plurality of moving figures are extracted together.

[Claim 6]

A fisheye lens camera apparatus which extracts a moving figure from an image captured by a fisheye lens camera, wherein an operation of extracting a feature amount of a signal of an inter-frame difference, a signal in which an inter-frame difference and an in-frame difference are combined, or the like is performed based on a picture of a fisheye lens image, and, in a region extraction process for a feature detection region, address transform between polar coordinates and orthogonal coordinates is performed and inside of the picture of the

fish-eye lens image is scanned, so as to extract regions of a plurality of moving figures from a picture of a circular fish-eye lens image.

[Claim 7]

A fisheye lens camera apparatus which extracts a moving figure from an image captured by a fisheye lens camera, wherein, in relation to regions of a plurality of persons' figures obtained from a picture of a fisheye lens image, a shape of each person's figure is normalized, color information in the shape of each figure is stored, and a picture for individually tracking a plurality of moving persons' figures is created based on the color information of each figure.

[Claim 8]

A fisheye lens camera apparatus which extracts a moving figure from an image captured by a fisheye lens camera, wherein a region is extracted based on a feature amount multiplied by weighting factors which are different depending on an extent of distortion of a central part and a peripheral part of the fish-eye lens image.

[Claim 9]

The fish-eye lens camera apparatus according to claim 8, wherein a non-extracted region is masked by further giving a different value thereto as the weighting factor so as to correspond to the region in a picture of the fish-eye lens image, and the region is extracted.

[Claim 10]

An image distortion correction method for a fisheye lens camera, of correcting distortion of an image captured by the fisheye lens camera, comprising:

a step of operating coordinate transform for correcting an installation angle of the fisheye lens camera and coordinate transform for correcting distortion of a fisheye lens image in combination with each other.

[Claim 11]

The image distortion correction method for the fisheye lens camera, of correcting distortion of the image captured by the fisheye lens camera according to claim 10, wherein the step of operating coordinate transform includes a step of operating coordinate transform for correcting distortion of a fisheye lens image of equal area mapping.

[Claim 12]

An image distortion correction method for a fisheye lens camera, of correcting distortion of an image captured by the fisheye lens camera, comprising:

a step of extracting parameters for correcting distortion of a fisheye lens image, such as a central position of a displayed image, an aspect ratio of the fisheye lens image, and a radius of a fisheye lens image area, from a captured fisheye lens image itself, and correcting distortion of the fisheye lens image using the parameters.

[Claim 13]

An image extraction method for a fisheye lens camera, of extracting a moving figure from an image captured by the fisheye lens camera, comprising:

a step of unifying regions using a mutual positional relationship in a fisheye lens image so as to extract a region in which the figure varies.

[Claim 14]

An image extraction method for a fisheye lens camera, of extracting a moving figure from an image captured by the fisheye lens camera, comprising:

a step of transforming a fisheye lens image into a transversely long picture having a panorama form, extracting a signal of an inter-frame difference of the picture or a signal in which an inter-frame difference and an in-frame difference are combined, extracting a region using the signal, and extracting regions of a plurality of moving figures together.

[Claim 15]

An image extraction method for a fisheye lens camera, of extracting a moving figure from an image captured by the fisheye lens camera, comprising:

a step of performing an operation of extracting a feature amount of a signal of an inter-frame difference, a signal in which an inter-frame difference and an in-frame difference are combined, or the like based on a picture of a fisheye lens image,

and performing address transform between polar coordinates and orthogonal coordinates and scanning inside of the picture of the fisheye lens image, in a region extraction process for a feature detection region, so as to extract regions of a plurality of moving figures from a picture of a circular fisheye lens image.

[Claim 16]

An image extraction method for a fisheye lens camera, of extracting a moving figure from an image captured by the fisheye lens camera, comprising:

a step of normalizing a shape of each person's figure, storing color information in the shape of each figure, and creating a picture for individually tracking a plurality of moving persons' figures based on the color information of each figure, in relation to regions of a plurality of persons' figures obtained from a picture of a fisheye lens image.

[Claim 17]

An image extraction method for a fisheye lens camera, of extracting a moving figure from an image captured by the fisheye lens camera, comprising:

a step of extracting a region based on a feature amount multiplied by weighting factors which are different depending on an extent of distortion of a central part and a peripheral part of the fisheye lens image.

[Claim 18]

The image extraction method for the fisheye lens camera according to claim 17, wherein the step of extracting a region includes a step of masking a non-extracted region by further giving a different value thereto as the weighting factor so as to correspond to the region in the picture of the fisheye lens image, and extracting the region.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a fisheye lens camera apparatus, and an image distortion correction method and an image extraction method therefor, and particularly to a fisheye lens camera apparatus, and an image distortion correction method and an image extraction method therefor in a video conference system, a remote monitoring system, or the like which captures an image with a fisheye lens camera and cuts a part of the image so as to be displayed on a monitor television.

[0002]

A fisheye lens has an angle of view of about 180 degrees and projects an image of a wide range, but the image is distorted in a barrel form, and, particularly, the distortion is notable in a peripheral part thereof. The present invention is to use the fact that an imaging range of the fisheye lens is wide, and to cut an attentional part of an image in the image captured by a single fisheye lens camera so as to correct distortion

of the image, thereby displaying the corrected image on a monitor television screen.

[0003]

In addition, the present invention is to detect a figure that has movements such as a person intruding in a picture which is taken through reflection by a fisheye lens camera, to automatically determine a monitor display region (cut region) of the figure so as to track the moving figure, and is to be appropriately used in a camera apparatus of a remote monitoring system or a video conference system.

[0004]

[Related Art]

Fig. 13 is a diagram illustrating a configuration of a fisheye lens camera apparatus in the related art, and a remote monitoring system and a video conference system using the same. Fig. 13(a) shows a configuration of the fisheye lens camera apparatus, Fig. 13(b) shows the remote monitoring system using the fisheye lens camera apparatus, and Fig. 13(c) shows the video conference system using the fisheye lens camera apparatus.

[0005]

In the same figures, the reference numeral 13-10 indicates the fisheye lens camera apparatus, the reference numeral 13-1 indicates a fisheye lens, the reference numeral 13-2 indicates a CCD imaging device, the reference numeral 13-3

indicates a picture memory (frame memory), the reference numeral 13-4 indicates an image correction processing circuit, and the reference numeral 13-5 indicates a corrected picture (NTSC) output circuit.

[0006]

The fisheye lens 13-1 optically projects an object at an angle of view of about 180 degrees, the CCD imaging device 13-2 generates an electrical image signal from the optical picture, and the picture memory (frame memory) 13-3 stores the image signal in the frame unit.

[0007]

The image correction processing circuit 13-4 corrects a distorted image of the fisheye lens so as to recover an original image with respect to a monitor display region, and the corrected picture (NTSC) output circuit 13-5 outputs the corrected image signal as a normal television picture signal of an NTSC format or the like.

[0008]

Since the fisheye lens has a wide angle of view, a remote monitoring system or a video conference system which obtains pictures of areas with a wide range can be constituted by a camera apparatus using the lens. As shown in Figs. 13(b) and 13(c), the system can be configured by the fisheye lens camera apparatus 13-10 in which an encoding device 13-20 is installed, or a fisheye lens camera apparatus 13-30 with an encoding device

by transmitting a picture signal via a public network 13-40, and by displaying the image signal on a monitor television screen 13-60 or the like via a decoding device 13-50. However, since the fisheye lens has a wide angle of view, distortion of a picture is large, and thus the distortion is required to be corrected for display on the monitor television screen 13-60 or the like.

[0009]

Fig. 14 is an explanatory diagram of correction of distortion of a fisheye lens camera image in the related art. In the same figure, the reference numeral 14-1 indicates a virtual image frame, the reference numeral 14-2 indicates a virtual hemispherical face, and the reference numeral 14-3 indicates a fisheye lens imaging screen. In addition, it is assumed that the fisheye lens is located at the origin O of a three-dimensional space indicated by x, y and z axes, and the fisheye lens is located facing the z axis direction.

[0010]

In addition, if the virtual hemispherical face 14-2 is an orthographic projection formula lens, and a focal length thereof is f, the hemispherical face is a hemispherical face of a virtual hemisphere with a radius f, and a planar part thereof is located on the x-y plane, and a center thereof is located at the position of the origin O.

[0011]

The virtual image frame 14-1 is a frame on a virtual plane perpendicular to a direction of view vector DOV (Direction of View) from the position (origin) of the fisheye lens toward a object to be photographed and has a rim with a predetermined size, and a picture in this range is cut from a fisheye lens image and is displayed on the monitor television screen as described below. In other words, the frame has a rim with the same size as that of a rim of a display frame of the monitor television or the like.

[0012]

In addition, the image frame 14-1 includes two-dimensional coordinate axes (p,q) which have a point intersecting the direction of view vector DOV in the frame as an origin, and a point in the virtual image frame 14-1 is expressed by the coordinate components (p,q).

[0013]

A figure (fisheye lens image) projected by the fisheye lens is classified into several types depending on a projection formula of the lens, and, hereinafter, an orthographic projection formula fisheye lens will be described.

[0014]

It is assumed that a figure which is viewed through the virtual hemispherical face 14-2 from the position (the origin O) at which the fisheye lens is located is attached to the virtual hemispherical face 14-2 as it is. In addition, a figure

in which the figure on the three-dimensional space attached to the hemispherical face 14-2 is vertically (from the z direction toward the origin) crushed and attached onto a plane of a two-dimensional space formed by the x axis and y axis of the figure is an image of the orthographic projection formula fisheye lens.

[0015]

Further, an image of the fisheye lens is actually formed at vertically and horizontally reversed positions, but a relative relationship of a distortion of the figure does not vary, and, thus, for simplification of description, it is assumed that an image is formed as described above.

[0016]

A plane of the two-dimensional space obtained by vertically crushing the figure on the hemispherical face 14-2 is the fisheye lens imaging screen 14-3, and an image inside the circle of the fisheye lens imaging screen 14-3 is an image captured by the fisheye lens. The outer rectangular rim is an outside line of the entire imaging screen obtained from the CCD imaging device.

[0017]

Since an image of the fisheye lens is distorted, if an image captured by the fisheye lens camera is to be displayed, a part thereof is required to be cut so as to be corrected to a normal image. Therefore, a frame corresponding to a

displayed frame is assumed as the virtual image frame 14-1.

[0018]

It is assumed that the direction of the z axis in which the fisheye lens is oriented is an upper direction of the vertical line, a vertex angle (zenith angle) formed by the direction of view vector DOV and the z axis is set to ϕ , and an azimuth angle formed with a reference axis (the x axis or the y axis) of the horizontal plane is set to θ . In addition, a focal length (a radius of the circle of the fisheye lens image) is set to f, a rotation angle of an image frame is set to ω , and a magnification ratio is set to m. The magnification ratio m is $m=D/f$ when a distance from the position (the origin O) of the fisheye lens to the origin in the image frame 14-1 is set to D.

[0019]

A correspondence relationship between a point (x,y) in the fisheye lens imaging plane 14-3 and a point (p,q) in the image frame 14-1 is expressed by a relation of Equation (1).

[0020]

[Equation 1]

$$\left. \begin{aligned} x &= \frac{R(pA - qB + mR \sin \phi \sin \theta)}{\sqrt{p^2 + q^2 + m^2 R^2}} \\ y &= \frac{R(pC - qD - mR \sin \phi \sin \theta)}{\sqrt{p^2 + q^2 + m^2 R^2}} \\ A &= (\cos \omega \cos \theta - \sin \omega \sin \theta \cos \phi) \\ B &= (\sin \omega \cos \theta + \cos \omega \sin \theta \cos \phi) \\ C &= (\cos \omega \sin \theta + \sin \omega \cos \theta \cos \phi) \\ D &= (\sin \omega \sin \theta - \cos \omega \cos \theta \cos \phi) \end{aligned} \right\} \dots (1)$$

[0021]

A distortion of the fisheye lens image is corrected using the correspondence relationship of Equation (1) so as to recover an original image which can be displayed on the monitor television screen. In other words, first, the image frame 14-1 is localized, and a region (cut region) displayed on the monitor is determined. This localization operation is set by inputting a vertex angle ϕ , an azimuth angle θ , a rotation angle ϕ , and a magnification ratio m to the image correction processing circuit 13-4 from an external device.

[0022]

The image correction processing circuit 13-4 obtains the point (x, y) in the fisheye lens imaging plane 14-3 corresponding to the point (p, q) in the image frame 14-1 using the relation of Equation (1), reads a color information signal of the point from the picture memory (frame memory) 13-3, and writes the color information signal to an output picture memory (not shown) having an address corresponding to the point (p, q) in the image frame 14-1.

[0023]

The color information transmission operation between the picture memories is performed for all points (p, q) in the image frame 14-1 so as to sequentially send a color information signal to the corrected picture (NTSC) output circuit 13-5 from the output picture memory, and thus the corrected picture (NTSC) output circuit 13-5 can display an image of a real object target without distortion when viewed through the rim of the virtual image frame 14-1 from the origin O. (Refer to the specification of U.S. Patent No. 5,185,667, and the like.)

[0024]

[Problems to be Solved by the Invention]

The above-described distortion correction of a fisheye lens image is a correction when a targeted fisheye lens forms an orthographic projection figure, and an operation of coordination transform is more complex in a fisheye lens which forms a figure of the equal area mapping and is frequently used as an actual fisheye lens.

[0025]

In the operation of the distortion correction of a fisheye lens image, an operation of coordinate transform for each coordinate point of a displayed image frame is performed, and thus an operation amount is enormous, and if a resolution of an image increases, an operation amount further increases. Thus, an amount of the operation of coordinate transform is

required to be as small as possible.

[0026]

In addition, since the above-described distortion correction of a fisheye lens image is performed on the premise that the fisheye lens camera is vertically located, for example, being installed on a desk so as to be directly oriented toward a ceiling, or being installed on a ceiling so as to be directly oriented toward a floor, the fisheye lens camera cannot be installed through free selection of an installation angle thereof. On the other hand, if the fisheye lens camera is installed on a wall sideways or is installed at a tilt angle at the corner of a ceiling, there are many cases where an imaging region such as a monitoring region is included in a more effective imaging area of a fisheye lens image.

[0027]

Further, a picture taken using the fisheye lens camera actually varies depending on characteristics of an individual fisheye lens camera. This difference in the characteristics of the fisheye lens camera is left as an image distortion in a converted image and is displayed even if image transform is performed using distortion correction of a fisheye lens image.

[0028]

In the related art, correction of horizontal deviation of a fisheye lens image in an imaging screen of the CCD image device or correction of an aspect ratio caused by a structure

of the CCD imaging device, which is a picture parameter of the fisheye lens camera, is required to be manually performed.

[0029]

In addition, in a tracking type remote monitoring system using the fisheye lens camera, detection of a person's figure or the like and determination of a monitor display region (cut region) are required to be automatically performed, but a method of merely determining a monitor display region (cut region) using a difference between frames of a fisheye lens image is limited to detection in a case where a moving object is only one, and, in a case where a plurality of objects move in the region, pictures for tracking the respective objects cannot be created.

[0030]

In addition, a fisheye lens image has a difference in brightness or in an extent of distortion between a central part and a peripheral part thereof, and thus has a disadvantage in that an image displayed on the monitor also becomes unnatural according to a variation in a cut region on tracking.

[0031]

An object of the present invention is to perform an image deformation process of distortion correction of a fisheye lens image at high speed in a case where a fisheye lens camera is installed at any installation angle, and to detect and extract a moving figure such as a person's figure captured by the

fish-eye lens camera with high accuracy, so as to be displayed on a monitor television or the like with high accuracy.

[0032]

[Means for Solving the Problems]

A fish-eye lens camera apparatus of the present invention includes (1) an image correction processing unit that corrects distortion of an image captured by a fish-eye lens camera, in which the image correction processing unit operates coordinate transform for correcting an installation angle of the fish-eye lens camera and coordinate transform for correcting distortion of a fish-eye lens image in combination with each other. In addition, (2) the image correction processing unit operates coordinate transform for correcting distortion of a fish-eye lens image of equal area mapping.

[0033]

Further, (3) in a fish-eye lens camera apparatus including an image correction processing unit that corrects distortion of an image captured by a fish-eye lens camera, parameters for correcting distortion of a fish-eye lens image, such as a central position of a displayed image, an aspect ratio of the fish-eye lens image, and a radius of a fish-eye lens image area, are extracted from the captured fish-eye lens image itself, and distortion of the fish-eye lens image is corrected using the parameters.

[0034]

In addition, (4) in a fish-eye lens camera apparatus which extracts a moving figure from an image captured by a fish-eye lens camera, regions are unified using a mutual positional relationship in a fish-eye lens image so as to extract a region in which the figure varies.

[0035]

Further, (5) in a fish-eye lens camera apparatus which extracts a moving figure from an image captured by a fish-eye lens camera, a fish-eye lens image is transformed into a transversely long picture having a panorama form, a signal of an inter-frame difference of the picture or a signal in which an inter-frame difference and an in-frame difference are combined is extracted, a region is extracted using the signal, and regions of a plurality of moving figures are extracted together.

[0036]

In addition, (6) in a fish-eye lens camera apparatus which extracts a moving figure from an image captured by a fish-eye lens camera, an operation of extracting a feature amount of a signal of an inter-frame difference, a signal in which an inter-frame difference and an in-frame difference are combined, or the like is performed based on a picture of a fish-eye lens image, and, in a region extraction process for a feature detection region, address transform between polar coordinates and orthogonal coordinates is performed and inside of the

picture of the fisheye lens image is scanned, so as to extract regions of a plurality of moving figures from a picture of a circular fisheye lens image.

[0037]

Further, (7) in a fisheye lens camera apparatus which extracts a moving figure from an image captured by a fisheye lens camera, in relation to regions of a plurality of persons' figures obtained from a picture of a fisheye lens image, a shape of each person's figure is normalized, color information in the shape of each figure is stored, and a picture for individually tracking a plurality of moving persons' figures is created based on the color information of each figure.

[0038]

In addition, (8) in a fisheye lens camera apparatus which extracts a moving figure from an image captured by a fisheye lens camera, a region is extracted based on a feature amount multiplied by weighting factors which are different depending on an extent of distortion of a central part and a peripheral part of the fisheye lens image. Further, (9) a non-extracted region is masked by further giving a different value thereto as the weighting factor so as to correspond to the region in a picture of the fisheye lens image, and the region is extracted.

[0039]

Further, an image distortion correction method for a

fish-eye lens camera of the present invention, (10) of correcting distortion of an image captured by the fish-eye lens camera, includes a step of operating coordinate transform for correcting an installation angle of the fish-eye lens camera and coordinate transform for correcting distortion of a fish-eye lens image in combination with each other. Further, (11) in the image distortion correction for a fish-eye lens camera, the step of operating coordinate transform includes a step of operating coordinate transform for correcting distortion of a fish-eye lens image of equal area mapping in correcting distortion of an image captured by the fish-eye lens camera.

[0040]

In addition, an image distortion correction method for a fish-eye lens camera, (12) of correcting distortion of an image captured by the fish-eye lens camera, includes a step of extracting parameters for correcting distortion of a fish-eye lens image, such as a central position of a displayed image, an aspect ratio of the fish-eye lens image, and a radius of a fish-eye lens image area, from a captured fish-eye lens image itself, and correcting distortion of the fish-eye lens image using the parameters, in correcting distortion of an image captured by the fish-eye lens camera.

[0041]

Further, an image extraction method for a fish-eye lens camera of the present invention, (13) of extracting a moving

figure from an image captured by the fisheye lens camera, includes a step of unifying regions using a mutual positional relationship in a fisheye lens image so as to extract a region in which the figure varies.

[0042]

In addition, (14) an image extraction method of extracting a moving figure from an image captured by the fisheye lens camera, includes a step of transforming a fisheye lens image into a transversely long picture having a panorama form, extracting a signal of an inter-frame difference of the picture or a signal in which an inter-frame difference and an in-frame difference are combined, extracting a region using the signal, and extracting regions of a plurality of moving figures together.

[0043]

Further, (15) an image extraction method of extracting a moving figure from an image captured by the fisheye lens camera, includes a step of performing an operation of extracting a feature amount of a signal of an inter-frame difference, a signal in which an inter-frame difference and an in-frame difference are combined, or the like based on a picture of a fisheye lens image, and performing address transform between polar coordinates and orthogonal coordinates and scanning inside of the picture of the fisheye lens image, in a region extraction process for a feature

detection region, so as to extract regions of a plurality of moving figures from a picture of a circular fisheye lens image.

[0044]

In addition, (16) an image extraction method of extracting a moving figure from an image captured by the fisheye lens camera includes a step of normalizing a shape of each person's figure, storing color information in the shape of each figure, and creating a picture for individually tracking a plurality of moving persons' figures based on the color information of each figure, in relation to regions of a plurality of persons' figures obtained from a picture of a fisheye lens image.

[0045]

Further, (17) an image extraction method of extracting a moving figure from an image captured by the fisheye lens camera includes a step of extracting a region based on a feature amount multiplied by weighting factors which are different depending on an extent of distortion of a central part and a peripheral part of the fisheye lens image.

[0046]

In addition, (18) the step of extracting a region includes a step of masking a non-extracted region by further giving a different value thereto as the weighting factor so as to correspond to the region in a picture of the fisheye lens image, and extracting the region.

[0047]

[Embodiments of the Invention]

Fig. 1 is a diagram illustrating a configuration of a fisheye lens camera apparatus according to an embodiment of the present invention. In the same figure, the reference numeral 1-1 indicates a fisheye lens, the reference numeral 1-2 indicates a CCD imaging device, the reference numeral 1-3 indicates a picture memory (frame memory), the reference numeral 1-4 indicates an image correction processing unit, the reference numeral 1-41 indicates a camera installation angle correction unit, the reference numeral 1-42 indicates a pan/tilt angle rotation correction unit, the reference numeral 1-43 indicates a zoom correction unit, the reference numeral 1-44 indicates a picture interpolation creation unit, and the reference numeral 1-5 indicates a corrected picture (NTSC) output circuit.

[0048]

An image of a wide range is optically captured by the fisheye lens 1-1, an electrical image signal is generated from the optical image by the CCD imaging device 1-2, and the picture memory (frame memory) 1-3 stores the image signal in the frame unit.

[0049]

The image correction processing unit 1-4 performs a process of correcting an image distorted by the fisheye lens

so as to recover an original image, and the corrected picture (NTSC) output circuit 1-5 outputs a signal of the corrected image as a television picture signal of a normal NTSC format or the like. In addition, this signal may be encoded by an encoding device so as to be transmitted and to be displayed as a picture at a remote location.

[0050]

The camera installation angle correction unit 1-41 of the image correction processing unit 1-4 corrects an installation angle of the fisheye lens camera apparatus oriented in any direction; the pan/tilt angle rotation correction unit 1-42 controls a rotation angle of a pan/tilt angle of a picture display area (cut area); the zoom correction unit 1-43 controls a magnification ratio of a displayed picture; and the picture interpolation creation unit 1-44 interpolates an interval between coordinate points, and performs a process of correcting distortion of an image of a picture display area (cut area) so as to recover an original image.

[0051]

Fig. 2 is an explanatory diagram of a picture taken by the fisheye lens camera according to the embodiment of the present invention. Fig. 2(a) shows a fisheye lens image img in a case where the fisheye lens camera is oriented directly upward; Fig. 2(b) schematically shows a state in which the

fish-eye lens image img which is a display target is mapped onto a plane of an image frame frm; and Fig. 2(c) is a diagram in which the sphere of Fig. 2(b) is viewed in the y axis direction. In a case where the fish-eye lens image img is an orthographic projection formula image, the fish-eye lens image img of Fig. 2(a) is an image in which the sphere of Fig. 2(b) is viewed from the z axis direction.

[0052]

If the fish-eye lens camera is assumed to be located upward (in the z axis direction) at the origin of the x axis, the y axis, and the z axis, first, a picture reflected by the fish-eye lens camera can be analyzed assuming a state in which the picture is attached to inside of a sphere with a radius which is a distance R from the origin.

[0053]

As above, a distance to an object is disregarded, and the image img captured by the fish-eye lens camera may be regarded as mapping of an image incident from a specific direction (r, θ, ϕ) to a point (x'', y'') expressed by a mapping transformation of Equation (2) in the two-dimensional x-y plane. In Equation (2), θ indicates an azimuth angle, ϕ indicates a vertex angle (zenith angle), and L indicates a distance (image height) from the origin O when an image incident at the vertex angle ϕ is formed on a fish-eye lens image.

[0054]

[Equation 2]

$$\left. \begin{array}{l} x'' = L \cos \theta \\ y'' = L \sin \theta \end{array} \right\} \dots \dots (2)$$

[0055]

In other words, the fish-eye lens image img may be considered as mapping to two-dimensional (x'', y'') from a point of the three-dimensional coordinate (r, θ, ϕ) . The distance (image height) L is different depending on a projection formula of the fish-eye lens, and is expressed as in Equation (3-1) in a case of the above-described orthographic projection formula, expressed as in Equation (3-2) in a case of equal area projection, and expressed as in Equation (3-3) in a case of equal distance projection. In addition, f indicates a focal length of the lens.

[0056]

[Equation 3]

$$\begin{array}{ll} L = f \sin \phi & \dots \dots (3-1) \\ L = 2f \sin \frac{\phi}{2} & \dots \dots (3-2) \\ L = f \phi & \dots \dots (3-3) \end{array}$$

[0057]

In Fig. 2(b), if an azimuth angle of the image frame frm displayed through distortion correction is indicated by θ , and a vertex angle thereof is indicated by ϕ , a pan/tilt operation of the displayed image corresponds to displaying a picture projected thereonto when this virtual image frame frm is

rotated in the three-dimensional coordinates.

[0058]

In other words, a coordinate of a point of the fisheye lens image *img* corresponding to a coordinate of each point arranged on a raster in the image frame *frm* is specified, and a color information signal of the point having the coordinate is made to correspond to a color information signal of a point having a coordinate of the display frame *frm*, and thus it is possible to perform a correction process of transforming the fisheye lens image *img* to an original image. In a case where the camera is oriented directly upward or directly downward, a predetermined amount of the azimuth angle θ may be changed through a pan operation of the image frame *frm*, and a predetermined amount of the vertex angle ϕ may be changed through a tilt operation thereof, thereby performing mapping of a color information signal of a two-dimensional coordinate in a corresponding fisheye lens image *img*.

[0059]

Fig. 3 is an explanatory diagram of an image captured by the fisheye lens camera oriented in the transverse direction. The same figure shows a case where the fisheye lens camera is oriented in the x axis direction. In this case, the fisheye lens image *img* is formed on the vertical plane.

[0060]

Also in this case, an image without distortion can be

displayed through distortion correction as described above, but, if transform of the fisheye lens image as a picture right above is performed, a rotation direction is different from an actual direction of pan/tilt of the picture when the pan/tilt operation is performed. In other words, in a case of the picture right above, the tilt operation is performed by changing the angle ϕ with the z axis, but the tilt operation is not performed even by changing the angle ϕ when the fisheye lens camera is oriented in the transverse direction.

[0061]

For this reason, first, before the distortion correction is performed, an orientation of the fisheye lens camera, that is, a camera installation angle is corrected. This correction process is performed by the above-described camera installation angle correction unit 1-41.

[0062]

Fig. 4 is an explanatory diagram of correction of a fisheye lens camera image oriented in the transverse direction. As shown in Fig. 3, in a case where the fisheye lens camera is oriented in the direction of the x axis which is a transverse axis, the coordinate system is rotated toward the y axis by 90 degrees in advance such that the fisheye lens image plane *img* is rotated and moved to a position intersecting the z axis in the vertical direction, and thus it is possible to perform a process equivalent to a case of the above-described image

right above for a pan/tilt operation. In other words, a tilt operation can be performed by changing the angle ϕ , and a pan operation can be performed by changing the angle θ .

[0063]

Although the example shown in Fig. 4 relates to a case where the fisheye lens camera is oriented in the transverse direction, in a case where, when the fisheye lens camera is oriented in any direction of upward, downward, transverse and tilt directions, a coordinate system having a vertical direction as a z' axis is set to (x', y', z') , a coordinate of a point on an image frame frm is indicated by (x', y', z') , an angle formed by a point (x', y', z') on the image frame frm and an orientation (z axis direction) of the fisheye lens camera is indicated by ϕ , an angle formed by the point (x', y', z') on the image frame frm and the x axis is indicated by θ , and an angle formed by the point (x', y', z') on the image frame frm and the y axis is indicated by ρ , rotation coordinate transform is performed using a rotation matrix expression of Equation (4) such that a pan/tilt operation direction can conform to that of an actual picture. Here, the matrices R_x , R_z and R_y of the rotation matrix expression of Equation (4) are matrices which respectively give rotation toward the x axis, the y axis, and the z axis, and the matrix R_x gives rotation corresponding to a camera angle.

[0064]

[Equation 4]

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = R_x \cdot R_y \cdot R_z \cdot \begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} \left\{ \begin{array}{l} R_x = \begin{bmatrix} \cos \theta & -\sin \theta & 0 \\ \sin \theta & \cos \theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \\ R_y = \begin{bmatrix} \cos \phi & 0 & -\sin \phi \\ 0 & 1 & 0 \\ \sin \phi & 0 & \cos \phi \end{bmatrix} \\ R_z = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos \rho & -\sin \rho \\ 0 & \sin \rho & \cos \rho \end{bmatrix} \end{array} \right\} \dots (4)$$

[0065]

The rotation matrix expression of the above Equation (4) is calculated once in relation to the same azimuth angle and camera angle (vertex angle), and thus a coordinate after being rotated can be obtained as (x, y, z) . Next, mapping of this point to a point (x'', y'') of the fisheye lens image on the two-dimensional coordinates is calculated such that a point on the image frame can be made to correspond to a point on the fisheye lens image. The increase in a calculation amount for an installation angle of the fisheye lens camera is caused by generating a rotation matrix only once, and is thus slight.

[0066]

The mapping from a three-dimensional coordinate point (x, y, z) to a point $P(x'', y'')$ of the fisheye lens image on the two-dimensional coordinates is first performed by transforming the point (x, y, z) into a point (r, θ, ϕ) expressed

in polar coordinates. This transform can be performed using a polar coordinate transform expression of Equation (5).

[0067]

[Equation 5]

$$\left. \begin{aligned} r &= \sqrt{x^2 + y^2 + z^2} \\ \theta &= \tan^{-1}(x/y) = \cos^{-1}(x/\sqrt{x^2 + y^2}) \\ \phi &= \cos^{-1}(z/r) = \tan^{-1}(\sqrt{x^2 + y^2}/z) \end{aligned} \right\} \dots (5)$$

[0068]

Further, a fisheye lens of an equal area mapping formula is expressed by an expression of Equation (3-2), and this equation is assigned to Equation (2) so as to obtain an expression of Equation (6). The expression of Equation (6) is simplified as in an expression of Equation (7) using a relation of $x^2 + y^2 + z^2 = x'^2 + y'^2 + z'^2 = r^2$, Equation (5), and further a basic expression of a trigonometric function.

[0069]

[Equation 6]

$$\left. \begin{aligned} x'' &= 2f \sin \frac{\phi}{2} \cos \theta \\ y'' &= 2f \sin \frac{\phi}{2} \cos \theta \end{aligned} \right\} \dots (6)$$

[0070]

[Equation 7]

$$\left. \begin{aligned} u &= \frac{\sqrt{2} f x \sqrt{r-z}}{\sqrt{r} \sqrt{x^2 + y^2}} = \frac{\sqrt{2} f x \sqrt{r-z}}{\sqrt{r} \sqrt{r^2 - z^2}} = \frac{\sqrt{2} f x}{\sqrt{r} (r+z)} \\ v &= \frac{f y \sqrt{r-z}}{\sqrt{r} \sqrt{x^2 + y^2}} = \frac{f y \sqrt{r-z}}{\sqrt{r} \sqrt{r^2 - z^2}} = \frac{\sqrt{2} f y}{\sqrt{r} (r+z)} \end{aligned} \right\} \dots (7)$$

[0071]

In this way, in the correction of a fisheye lens camera installation angle, before an image transform process is performed, first, a coordinate (x', y', z') of the rectangular region of the image frame firm is transformed into a coordinate (x, y, z) through rotation coordinate transform, and, then, a point having the coordinate (x, y, z) is transformed into a point (x'', y'') on coordinates of the fisheye lens image. In addition, a component of the z axis corresponds to a zoom ratio, and two-dimensional-two-dimensional transform from (x, y) to (x'', y'') is basically performed. A coordinate transformation regarding the expression of Equation (7) is aimed at reducing the number of calculations by calculating coordinate transform according to a coordinate axis rotation and mapping transform according to characteristics of the fisheye lens at one time.

[0072]

Here, the point (x'', y'') on the coordinates of the fisheye lens image obtained through the above-described operation is indicated by (u, v) . In order to smoothly interpolate this coordinate point (u, v) , the following interpolation process is performed. Color information signal components of three colors of a picture signal are indicated by Y, U, and V, those components of the point (u, v) are indicated by $Y_{u,v}$, $U_{u,v}$, and $V_{u,v}$, values which become an integer by omitting decimal points of the coordinate components u and v of the point (u, v) are indicated by u_0 and v_0 , and a value of the color information

signal Y in a point having the coordinate (u0,v0) is indicated by Yu0v0. Similarly, the same content is indicated by Uu0v0 and Vu0v0 for the color information signals U and V. In addition, values obtained by rounding up decimal points of the coordinate components u and v are respectively indicated by u1 and v1, and values of the color information signals Y, U and V having a coordinate corresponding thereto are respectively indicated by Yu1v1, Uu1v1, and Vu1v1. Further, decimal parts of the coordinate components u and v are respectively indicated by du and dv.

[0073]

An input picture signal is interpolated and is mapped using a linear transform expression of Equation (8), and thus a smooth image can be displayed.

[0074]

[Equation 8]

$$\left. \begin{aligned} Y_{u,v} &= (1-du)(1-dv) \cdot Y_{u0v0} + du(1-dv) \cdot Y_{u0v1} \\ &\quad + (1-du)dv \cdot Y_{u1v0} + dudy \cdot Y_{u1v1} \\ U_{u,v} &= (1-du)(1-dv) \cdot U_{u0v0} + du(1-dv) \cdot U_{u0v1} \\ &\quad + (1-du)dv \cdot U_{u1v0} + dudy \cdot U_{u1v1} \\ V_{u,v} &= (1-du)(1-dv) \cdot V_{u0v0} + du(1-dv) \cdot V_{u0v1} \\ &\quad + (1-du)dv \cdot V_{u1v0} + dudy \cdot V_{u1v1} \end{aligned} \right\} \dots (8)$$

[0075]

Next, a description will be made of a method of automatically extracting an image central position (Xbase, Ybase) and a value f corresponding to the focal length,

which are parameters of the fisheye lens camera, from an imaging area of the fisheye lens camera. The above-described parameters are parameters used in distortion correction of a fisheye lens camera image.

[0076]

Fig. 5 is an explanatory diagram of extraction of parameters of the fisheye lens camera. In the same figure, the reference numeral 5-1 indicates an imaging area of the fisheye lens camera, and the reference numeral 5-2 indicates a fisheye lens image area. The circular fisheye lens image area 5-2 is observed in the imaging area 5-1 of the camera using a circular image fisheye lens. The fisheye lens image area 5-2 is observed at a predetermined position in the camera imaging area 5-1, and light does not reach the outer circumference of the fisheye lens image area 5-2, and thus the area has very low luminance.

[0077]

Therefore, a histogram regarding each of the horizontal and vertical directions is extracted with respect to the entire camera imaging area 5-1, so as to measure a position of the fisheye lens image area and a radius thereof.

[0078]

Appropriate threshold values Th and Tv are set for a horizontal direction histogram Hh(n) and a vertical direction histogram Hv(n), and histograms are measured from both ends

of the imaging area screen so as to search for points which initially exceed the threshold values T_v and T_h .

[0079]

Two points of the points are extracted for each of the horizontal and vertical directions, and points of a left end X_{left} and a right end X_{right} of the fisheye lens image area can be detected from the horizontal histogram. In addition, points of an upper end Y_{up} and a lower end Y_{down} of the fisheye lens image area can be detected from the vertical histogram.

[0080]

A radius R_h in the horizontal direction and a radius R_v in the vertical direction can be extracted using Equation (9) from the respective positions of the left end X_{left} , the right end X_{right} , Y_{up} , and the lower end Y_{down} of the fisheye lens image area. In addition, the image central position (X_{base}, Y_{base}) can be extracted using Equation (10).

[0081]

[Equation 9]

$$\left. \begin{aligned} R_h &= (X_{right} - X_{left}) / 2 \\ R_v &= (Y_{down} - Y_{up}) / 2 \end{aligned} \right\} \dots \dots (9)$$

[0082]

[Equation 10]

$$\left. \begin{aligned} X_{base} &= (X_{right} + X_{left}) / 2 \\ Y_{base} &= (Y_{down} + Y_{up}) / 2 \end{aligned} \right\} \dots \dots (10)$$

[0083]

Although the fisheye lens image area 5-2 is basically circular, and thus the radius R_h in the horizontal direction and the radius R_v in the vertical direction are the same as each other as $R_h = R_v$, there may be a difference between the radius R_h in the horizontal direction and the radius R_v in the vertical direction due to a difference between aspect ratios in the vertical and horizontal directions of the imaging device such as a CCD in some cases.

[0084]

The radius R of the fisheye lens image area 5-2 is originally a value defined based on the focal length f of the fisheye lens, and is expressed by Equation (11-1), for example, in an orthographic projection formula fisheye lens and is expressed by Equation (11-2) in an equal area projection formula fisheye lens.

[0085]

[Equation 11]

$$R = f \dots \dots (11-1)$$

$$R = \sqrt{2} f \dots \dots (11-2)$$

[0086]

Therefore, in the above-described calculation of the expression of Equation (6) for obtaining the point (x'', y'') on the coordinates of the fisheye lens image, in a case where there is a difference between the radius R_h in the horizontal direction and the radius R_v in the vertical direction, an

identical value as a value of the focal length f is not used, but a value of f may be corrected by assigning a value of the radius R_h in the horizontal direction or the radius R_v in the vertical direction to a value of R of Equation (11-1) or Equation (11-2) for each direction, thereby performing distortion correction of the fisheye lens in consideration of a difference between the aspect ratios.

[0087]

Fig. 6 is a diagram illustrating a configuration of a moving figure detection device according to a first embodiment of the present invention. In the same figure, the reference numeral 6-1 indicates a fisheye lens camera, the reference numerals 6-2 and 6-3 indicate frame buffers, the reference numerals 6-4 and 6-5 indicate inter-frame difference calculation units, the reference numeral 6-6 indicates a region weighting table, and the reference numeral 6-7 indicates a region extraction unit.

[0088]

A signal of an image captured by the fisheye lens camera 6-1 is stored in the first frame buffer 6-2, and the image signal stored in the first frame buffer 6-2 is stored in the second frame buffer 6-3. An image signal one frame before is stored in the second frame buffer 6-3.

[0089]

In addition, based on an image signal output from the

first frame buffer 6-2 and an image signal output from the second frame buffer 6-3, the first inter-frame difference calculation unit 6-4 calculates a difference between frames thereof, and outputs an inter-frame difference signal having a great value related to a moving figure to the second inter-frame difference calculation unit 6-5.

[0090]

Based on the inter-frame difference signal output from the first inter-frame difference calculation unit 6-4 and a value corresponding to a region output from the region weighting table 6-6, the second inter-frame difference calculation unit 6-5 performs weighting corresponding to the region on the inter-frame difference signal, and outputs a resultant signal to the region extraction unit 6-7.

[0091]

The region extraction unit 6-7 detects a moving figure on the basis of the inter-frame difference signal having undergone the weighting corresponding to the region, so as to output a detection flag signal and also to extract a detected region, thereby outputting region information.

[0092]

Fig. 7 is a diagram illustrating a configuration of a moving figure detection device according to a second embodiment of the present invention. In the same figure, the reference numeral 7-1 indicates a fisheye lens camera, the reference

numerals 7-2 and 7-3 indicate frame buffers, the reference numeral 7-4 indicates an inter-frame difference calculation unit, the reference numeral 7-5 indicates an in-frame difference calculation unit, the reference numeral 7-6 indicates a moving contour extraction unit, the reference numeral 7-7 indicates a region weighting table, the reference numeral 7-8 indicates a region extraction determining unit, and the reference numeral 7-9 indicates a region extraction unit.

[0093]

A signal of an image captured by the fisheye lens camera 7-1 is stored in the first frame buffer 7-2, and the image signal stored in the first frame buffer 7-2 is stored in the second frame buffer 7-3. An image signal one frame before is stored in the second frame buffer 7-3.

[0094]

In addition, based on an image signal output from the first frame buffer 7-2 and an image signal output from the second frame buffer 7-3, the inter-frame difference calculation unit 7-4 calculates a difference between frames thereof, and outputs an inter-frame difference signal having a great value related to a moving figure to the moving contour extraction unit 7-6.

[0095]

The in-frame difference calculation unit 7-5 calculates

a difference in a frame of an image signal which is output from the first frame buffer 7-2, and outputs an in-frame difference signal, which has a great value in a contour part of a figure, to the moving contour extraction unit 7-6.

[0096]

The moving contour extraction unit 7-6 linearly combines the inter-frame difference signal from the inter-frame difference calculation unit 7-4 with the in-frame difference signal from the in-frame difference calculation unit 7-5 so as to generate a signal of a moving figure of which a contour part is emphasized, and outputs the signal to the region extraction determining unit 7-8.

[0097]

Based on the signal of the moving figure of which the contour part is emphasized, output from the moving contour extraction unit 7-6, and a value corresponding to a region output from the region weighting table 7-7, the region extraction determining unit 7-8 performs weighting corresponding to the region on the signal of the moving figure, and outputs a resultant signal to the region extraction unit 7-9.

[0098]

The region extraction unit 7-9 detects the moving figure on the basis of the signal of the moving figure having undergone the weighting corresponding to the region, so as to output a

detection flag signal and also to extract a detected region, thereby outputting region information.

[0099]

The moving figure detection devices according to the embodiments of the present invention shown in Figs. 6 and 7 perform weighting on a picture signal so as to correspond to a region when extracting the region of a moving figure, so as to reduce influence of detected parameter signals due to distortion of an image caused by the fisheye lens.

[0100]

In other words, typically, in a case of calculating an inter-frame difference $D_n(x,y)$ between a picture signal $P_n(x,y)$ of an n-th frame and a picture signal $P_{n-1}(x,y)$ of a (n-1)-th frame, the calculation is performed using Equation (12), but, in the present invention, the region weighting tables 6-6 and 7-7 are provided which store a weighting factor $W(x,y)$ for extracting a feature corresponding to a region of the fisheye lens image, and a process of extracting a moving figure is performed using a value $G_n(x,y)$ obtained by multiplying the inter-frame difference $D_n(x,y)$ by the weighting factor $W(x,y)$.

$$D_n(x,y) = P_n(x,y) - P_{n-1}(x,y) \quad \dots (12)$$

[0101]

In other words, if the inter-frame difference signal output from the first inter-frame difference calculation unit 6-4 shown in Fig. 6, or a signal obtained by linearly combining

the inter-frame difference with the in-frame difference, output from the moving contour extraction unit 7-6 shown in Fig. 7 is assumed as a feature amount $D_n(x,y)$ for extracting a moving figure, a product $G_n(x,y)$ of the feature amount $D_n(x,y)$ and the weighting factor $W(x,y)$ corresponding to a region of the fisheye lens image is used as a feature amount for extracting a moving figure, using Equation (13).

$$G_n(x,y) = W(x,y) \cdot D_n(x,y) \quad \dots (13)$$

[0102]

As such, through the process of performing extracting using the feature amount $G_n(x,y)$ which is weighted so as to correspond to a region of a fisheye lens image, it is possible to perform corresponding equivalent mask and emphasis operations for each region in a fisheye lens image area.

[0103]

Fig. 8 is an explanatory diagram of the weighting factor $W(x,y)$ corresponding to a region of a fisheye lens image. The same figure shows an example in which a region in a fisheye lens image is divided into three regions 8-1, 8-2 and 8-3, a weighting factor 0 is allocated to the region 8-1, a weighting factor 1 is allocated to the region 8-2, and a weighting factor 2 is allocated to the region 8-3.

[0104]

In the peripheral part of the fisheye lens image, a region having the same area is displayed smaller than in the central

part. For this reason, accuracy of detecting a moving figure is reduced in the peripheral part, but a weighting factor $W(x,y)$ of the peripheral part is set to a great value, and thus it is possible to compensate for the accuracy reduction in the peripheral part. In addition, since there is a high probability that there is a person's figure in the peripheral part, a great value is set in the peripheral part, and a value close to 0 is set in the central part.

[0105]

Further, since an imaging area is very wide in the fisheye lens camera, illumination or the like frequently directly enters the imaging area. Also in this case, an intense difference in luminance may be compensated for by an equivalent region mask so as to reduce errors in detecting a moving figure.

[0106]

The region extraction units 6-7 and 7-9 compare a feature amount which is weighted so as to correspond to a region with a preset threshold value (Thm) so as to perform a figure detection determining process of a person's figure or the like. A region extraction process accompanied by the figure detection determining process is performed on the entire screen of the fisheye lens image.

[0107]

Fig. 9 is a diagram illustrating an example of a figure of a person or the like of which a region is extracted. Fig.

9(a) shows a fisheye lens image area and shows an example of a fisheye lens image in a case where the fisheye lens camera is located upward on a desk or the like, and four persons are seated around the camera. The reference numerals 9-1 to 9-4 respectively indicate a person's figure detection area (A) to a person's figure detection area (D). Fig. 9(b) shows a shape of the person's figure of the fisheye lens image, and, in a case where the person is photographed from the bottom by the fisheye lens, this causes such a shape as a substantially trapezoidal shape in which the body bottom part is long and the parietal is short, and a person's figure can be normalized to this shape.

[0108]

When an image of the fisheye lens image area as shown in Fig. 9(a) is raster-scanned so as to detect a point having a large feature amount as a person's figure, a figure having a shape such as a substantially trapezoidal shape is searched for downward from the point, and a region thereof is cut.

[0109]

A size and a shape of the cut region are combined so as to determine whether or not the region is a region of a person's figure. The same process is performed on a plurality of regions together, and, when a plurality of persons' figures are detected, the plurality of persons' figures are cut together.

[0110]

In addition, the respective parameters for a parietal, a body bottom part, and a body height of a person as shown in Fig. 9(b) and color data inside thereof may be sampled for each cut region in horizontal and vertical directions, thereby generating a database for identifying a person's figure for each image.

[0111]

In relation to a process of extracting a region of a person's figure from the extracted feature amount, a typical algorithm for extracting a region from a camera picture may be basically used, but the fisheye lens image is circularly distorted and is disposed, and thus coordinate transform is required to be performed.

[0112]

There are the following two methods as coordinate transform methods. The first method is a method in which mapping transform is performed on a fisheye lens image so as to generate a coordinate-transformed picture as a panorama picture of 360 degrees. In this method, a circular fisheye lens imaging area is transformed into a rectangular area.

[0113]

The second method is a method in which typical raster scanning for extracting a region is performed, and only a coordinate system during the scanning is transformed from an orthogonal coordinate (x,y) to a polar coordinate (r,θ) . In

other words, a process of extracting a region is performed using $x=r\cos\theta$ and $y=r\sin\theta$.

[0114]

The first method has a disadvantage in which a large volume of memory for development to a panorama picture is necessary but may employ a region extraction process for a normal image as it is after the transform is performed. In the second method, a region extraction process is performed while performing coordinate transform at all times, but only a memory amount for providing a fisheye lens image which is an original image is required as a memory amount to be used, and thus a compact system can be built.

[0115]

In addition, a feature amount is extracted, and a process of unifying regions is performed using a known mutual relationship of pictures such as a vertical relationship. For example, in a case of a fisheye lens camera oriented directly upward, regions are unified using a positional relationship of a picture in which a center of a fisheye lens image is set to an upper side, and a periphery thereof is set to a lower side, and a region in which the unified region varies from a background image to a person's figure is extracted.

[0116]

In relation to a process of tracking a moving figure such as invasion of a person, lattice points for vertically and

horizontally equally dividing a person region having a substantially cut trapezoidal shape into a predefined division number are calculated, and color information signals at the lattice points are preserved as a feature amount of the person's figure. In addition, a process of registering the feature amount of the person's figure and a process of cutting the person's figure are repeatedly performed with any time interval, and thus each person's figure can be individually tracked even in a case where a plurality of persons' figures are in the fisheye lens camera imaging area.

[0117]

Fig. 10 is a flowchart illustrating a process of determining a person's figure extraction position according to an embodiment of the present invention. First, a command for a process of cutting a person's figure or the like in a fisheye lens image is given (10-1); a feature amount of the person's figure is extracted (10-3) based on an inter-frame difference or an inter-frame difference and an in-frame difference through a loop process for frames (10-2); a weighting process corresponding to the region in the fisheye lens image is performed (10-4); a raster loop process in a fisheye lens screen is performed (10-5) so as to detect a feature point (10-6); coordinate transform of the fisheye lens image is performed on an area having a substantially trapezoidal shape so as to perform a process of extracting the

feature point (10-7) and to determine whether or not there is a feature point (10-8); if there is a feature point, the extracted point is erased (10-9), and a maximum value and a minimum value of a region of (x,y) coordinates are stored (10-10); it is determined whether or not a line is a final line (10-11); and, if the line is a final line, the flow finishes (10-12).

[0118]

If there is no feature point in the determination (10-8) of whether or not there is a feature point, it is determined whether or not there are feature points in a plurality of continuous lines (10-13); if there are no continuous feature points, the number of regions is counted and the person regions are stored (10-14); and the flow proceeds to the above-described determination (10-11) of whether or not a line is a final line.

[0119]

If a plurality of continuous lines are not continuously located in the determination (10-13) of whether or not there are feature points in a plurality of continuous lines, the flow returns to the above-described process (10-6) of detecting a feature point. In addition, if the line is not a final line in the determination (10-11) of whether or not a line is a final line, the flow returns to the above-described process (10-6) of detecting a feature point.

[0120]

If a region where there is the person's figure is extracted, parameters for displaying a corrected fisheye lens image can be obtained from the region. Fig. 11 is an explanatory diagram of a configuration of cutting a region and creating a display screen according to an embodiment of the present invention. In the same figure, the reference numeral 11-1 indicates a region extraction unit, the reference numeral 11-2 indicates a region cutting unit, the reference numeral 11-3 indicates a fisheye lens image parameter determination unit, and the reference numeral 11-4 indicates a display screen creation unit.

[0121]

The region extraction unit 11-1 is the same as the region extraction units 6-7 and 7-9 shown in Figs. 6 and 7, detects a person's figure or the like on the basis of a feature amount, and outputs a detection flag signal and a region information signal when the region is extracted. The detection flag signal may be used as a signal for warning or notification. The region information signal is output to the region cutting unit 11-2.

[0122]

The region cutting unit 11-2 cuts the region on the basis of the region information signal, and the fisheye lens image parameter determination unit 11-3 determines parameters for displaying a corrected fisheye lens image for the entire cut

region, and sends signals of the parameters to the screen creation unit 11-4. The screen creation unit 11-4 generates a display screen on the basis of the signals of the parameters and outputs a picture signal.

[0123]

Here, for simplification, a description will be made of determination of the parameters of the fisheye lens image in a case of a camera angle which is oriented directly upward. As parameters for correcting a fisheye lens image, an azimuth angle θ , a vertex angle ϕ , and a magnification ratio m of an image frame are required.

[0124]

For example, it is assumed that the person's figure detection area (B) 9-2 of Fig. 9(a) is extracted from a region of the fisheye lens image so as to be displayed. In this case, an angle α regarding the central position of the person's figure detection area (B) 9-2 and an angle (solid angle) β of interposing the person's figure detection area (B) 9-2 from the center O of the fisheye lens image are calculated. In addition, a distance L from the center O of the fisheye lens image to the region uppermost part is calculated.

[0125]

An azimuth angle θ and a vertex angle ϕ of an image frame which displays the person's figure detection area (B) 9-2 can be obtained based on the angle α and the distance L. In other

words, the azimuth angle θ is the same as the angle α as $\theta=\alpha$. In addition, the vertex angle ϕ can be obtained using Equation (3-1) to Equation (3-3) from a ratio of the radius R of the fisheye lens image and the distance L . Further, m which is a zoom ratio can be obtained using the solid angle β between the left and right ends of the region and the center O of the fisheye lens image. Based on these parameters, a display region of each person is cut so as to correct distortion of the fisheye lens image, and a picture signal is sent to a monitor television or the like.

[0126]

Fig. 12 is a diagram illustrating a picture obtained by combining images captured by a single fisheye lens camera. A state is schematically shown in which, as described above, person's figures are extracted from a fisheye lens image on the basis of feature amounts thereof, a distortion correction process is performed on the extracted images, and a single monitor television screen is divided into four so as to display the extracted person's figures.

[0127]

[Effects of the Invention]

As described above, according to the present invention, since a picture is obtained by the fisheye lens camera having a wide angle of view of about 180 degrees, an area of a wide range can be monitored with a single camera, and thus it is

possible to reduce the number of cameras to be installed and to correct the image at high speed with high accuracy for display.

[0128]

In addition, coordinate transform for correcting an installation angle of the fisheye lens camera and coordinate transform for correcting distortion of a fisheye lens image are operated in combination with each other, and thus it is possible to perform the image correction operation process at high speed regardless of an installation angle. Further, parameters for correcting distortion of a fisheye lens image are extracted from the captured fisheye lens image itself so as to correct distortion of the fisheye lens image, and thus it is possible to perform stable distortion correction with respect to adjustment on installation or aged deterioration.

[0129]

Since a region is extracted based on a feature amount multiplied by weighting factors which are different depending on an extent of distortion of a central part and a peripheral part of the fisheye lens image, a person's figure can be stably detected in the peripheral part with a large extent of distortion, and a non-extracted region is masked by further giving a different value thereto as the weighting factor so as to correspond to the region in a picture of the fisheye lens image, and thus it is possible to remove unstable factors in

a process of extracting a person's figure or the like in advance.

[0130]

In addition, any part is cut from an image of a wide range captured by the fisheye lens camera and is displayed on a monitor television screen, and thus a degree of freedom of creating a picture is large, and it is possible to improve convenience through application to a camera of a remote monitoring system or a video conference system.

[0131]

In addition, it is possible to configure an electronic tracking type remote monitoring system or a video conference system which detects a figure that has movements such as a person intruding in a picture which is obtained through reflection by the fisheye lens camera, and automatically determines a monitor display region (cut region) of the figure so as to track the moving figure with smooth motion.

[Brief Description of Drawings]

[Fig. 1] Fig. 1 is a diagram illustrating a configuration of a fisheye lens camera apparatus according to an embodiment of the present invention.

[Fig. 2] Fig. 2 is an explanatory diagram of a picture taken by the fisheye lens camera according to the embodiment of the present invention.

[Fig. 3] Fig. 3 is an explanatory diagram of an image captured

by the fisheye lens camera oriented in a transverse direction.

[Fig. 4] Fig. 4 is an explanatory diagram of correction of a fisheye lens camera image oriented in the transverse direction.

[Fig. 5] Fig. 5 is an explanatory diagram of extraction of parameters of the fisheye lens camera.

[Fig. 6] Fig. 6 is a diagram illustrating a configuration of a moving figure detection device according to a first embodiment of the present invention.

[Fig. 7] Fig. 7 is a diagram illustrating a configuration of a moving figure detection device according to a second embodiment of the present invention.

[Fig. 8] Fig. 8 is an explanatory diagram of a weighting factor $W(x,y)$ corresponding to a region of a fisheye lens image.

[Fig. 9] Fig. 9 is a diagram illustrating an example of a figure of a person or the like of which a region is extracted.

[Fig. 10] Fig. 10 is a flowchart illustrating a process of determining a person's figure extraction position according to an embodiment of the present invention.

[Fig. 11] Fig. 11 is an explanatory diagram of a configuration of cutting a region and creating a display screen according to an embodiment of the present invention.

[Fig. 12] Fig. 12 is a diagram illustrating a picture obtained by combining images captured by a single fisheye lens camera.

[Fig. 13] Fig. 13 is a diagram illustrating a configuration

of a fisheye lens camera apparatus in the related art, and a remote monitoring system and a video conference system using the same.

[Fig. 14] Fig. 14 is an explanatory diagram of correction of distortion of a fisheye lens camera image in the related art.

[Reference Numerals]

- 1-1 FISHEYE LENS
- 1-2 CCD IMAGING DEVICE
- 1-3 PICTURE MEMORY (FRAME MEMORY)
- 1-4 IMAGE CORRECTION PROCESSING UNIT
- 1-41 CAMERA INSTALLATION ANGLE CORRECTION UNIT
- 1-42 PAN/TILT ANGLE ROTATION CORRECTION UNIT
- 1-43 ZOOM CORRECTION UNIT
- 1-44 PICTURE INTERPOLATION CREATION UNIT
- 1-5 CORRECTED PICTURE (NTSC) OUTPUT CIRCUIT

Fig. 1

DIAGRAM ILLUSTRATING CONFIGURATION OF FISHEYE LENS CAMERA APPARATUS ACCORDING TO EMBODIMENT OF THE PRESENT INVENTION

- 1-1 FISHEYE LENS
- 1-2 CCD IMAGING DEVICE
- 1-3 PICTURE MEMORY (FRAME MEMORY)
- 1-4 IMAGE CORRECTION PROCESSING UNIT
- 1-41 CAMERA INSTALLATION ANGLE CORRECTION UNIT
- 1-42 PAN/TILT ANGLE ROTATION CORRECTION UNIT
- 1-43 ZOOM CORRECTION UNIT
- 1-44 PICTURE INTERPOLATION CREATION UNIT
- 1-5 CORRECTED PICTURE (NTSC) OUTPUT CIRCUIT

Fig. 2

EXPLANATORY DIAGRAM OF PICTURE TAKEN BY FISHEYE LENS CAMERA ACCORDING TO EMBODIMENT OF THE PRESENT INVENTION

Fig. 3

EXPLANATORY DIAGRAM OF IMAGE CAPTURED BY FISHEYE LENS CAMERA ORIENTED IN TRANSVERSE DIRECTION

Fig. 4

EXPLANATORY DIAGRAM OF CORRECTION OF FISHEYE LENS CAMERA IMAGE ORIENTED IN TRANSVERSE DIRECTION
ROTATION OF ENTIRE COORDINATE SYSTEM

Fig. 5

EXPLANATORY DIAGRAM OF EXTRACTION OF PARAMETERS OF FISHEYE LENS
CAMERA

Fig. 6

DIAGRAM ILLUSTRATING CONFIGURATION OF MOVING FIGURE DETECTION
DEVICE ACCORDING TO FIRST EMBODIMENT OF THE PRESENT INVENTION

6-1: FISHEYE LENS CAMERA

PICTURE SIGNAL

6-2: FRAME BUFFER

6-3: FRAME BUFFER

6-4: INTER-FRAME DIFFERENCE CALCULATION UNIT

FRAME DIFFERENCE SIGNAL

6-5: INTER-FRAME DIFFERENCE CALCULATION UNIT

6-6: REGION WEIGHTING TABLE

6-7: REGION EXTRACTION UNIT

DETECTION FLAG

REGION INFORMATION

Fig. 7

DIAGRAM ILLUSTRATING CONFIGURATION OF MOVING FIGURE DETECTION
DEVICE ACCORDING TO SECOND EMBODIMENT OF THE PRESENT INVENTION

7-1: FISHEYE LENS CAMERA

PICTURE SIGNAL

7-2: FRAME BUFFER

7-3: FRAME BUFFER

7-4: INTER-FRAME DIFFERENCE CALCULATION UNIT

7-5: IN-FRAME DIFFERENCE CALCULATION UNIT

7-6: MOVING CONTOUR EXTRACTION UNIT

7-7: REGION WEIGHTING TABLE

7-8: REGION EXTRACTION DETERMINING UNIT

7-9: REGION EXTRACTION UNIT

DETECTION FLAG

REGION INFORMATION

Fig. 8

EXPLANATORY DIAGRAM OF WEIGHTING FACTOR $W(x,y)$ CORRESPONDING
TO REGION OF FISHEYE LENS IMAGE

FISHEYE LENS IMAGING AREA

DETECTED REGION OF WEIGHTING FACTOR 2

DETECTED REGION OF WEIGHTING FACTOR 1

DETECTED REGION OF WEIGHTING FACTOR 0

Fig. 9

DIAGRAM ILLUSTRATING EXAMPLE OF FIGURE OF PERSON OR THE LIKE
OF WHICH REGION IS EXTRACTED

(a)

9-1: PERSON'S FIGURE DETECTION AREA (A)

FISHEYE LENS IMAGING AREA

9-2: PERSON'S FIGURE DETECTION AREA (B)

AREA (B) CENTER

9-3: PERSON'S FIGURE DETECTION AREA (C)

9-4: PERSON'S FIGURE DETECTION AREA (D)

(b)

PARIETAL LENGTH

BODY HEIGHT

BODY BOTTOM PART LENGTH

Fig. 10

FLOWCHART ILLUSTRATING PROCESS OF DETERMINING PERSON'S FIGURE
EXTRACTION POSITION ACCORDING TO EMBODIMENT OF THE PRESENT
INVENTION

10-1: PROCESS OF CUTTING PERSON'S FIGURE IN FISHEYE LENS IMAGE

10-2: START FRAME PROCESSING

10-3: EXTRACT FEATURE AMOUNT OF PERSON'S FIGURE (INTER-FRAME
DIFFERENCE/IN-FRAME DIFFERENCE)

10-4: PROCESS OF WEIGHTING CORRESPONDING TO FISHEYE LENS

10-5: RASTER LOOP PROCESS IN SCREEN

10-6: DETECT FEATURE POINT

10-7: EXTRACT FEATURE POINT FOR TRAPEZOIDAL AREA (FISHEYE LENS
COORDINATE TRANSFORM)

10-8: IS THERE FEATURE POINT?

10-9: ERASE FEATURE POINT

10-10: STORE MAXIMUM VALUE AND MINIMUM VALUE OF x AND y REGIONS

10-13: ARE PLURAL LINES CONTINUOUSLY LOCATED?

10-14: STORE PERSON REGION (COUNT NUMBER OF REGIONS)

10-11: FINAL LINE?

10-12: END

Fig. 11

EXPLANATORY DIAGRAM OF CONFIGURATION OF CUTTING REGION AND
CREATING DISPLAY SCREEN ACCORDING TO EMBODIMENT OF THE PRESENT
INVENTION

11-1: REGION EXTRACTION UNIT

DETECTION FLAG (WARNING, NOTIFICATION)

REGION INFORMATION

11-2: REGION CUTTING UNIT

11-3: FISHEYE LENS IMAGE PARAMETER DETERMINATION UNIT

11-4: DISPLAY SCREEN CREATION UNIT

Fig. 12

DIAGRAM ILLUSTRATING PICTURE OBTAINED BY COMBINING IMAGES
CAPTURED BY SINGLE FISHEYE LENS CAMERA

Fig. 13

DIAGRAM ILLUSTRATING CONFIGURATION OF FISHEYE LENS CAMERA
APPARATUS IN THE RELATED ART, AND REMOTE MONITORING SYSTEM AND
VIDEO CONFERENCE SYSTEM USING THE SAME

Fig. 14

EXPLANATORY DIAGRAM OF CORRECTION OF DISTORTION OF FISHEYE LENS
CAMERA IMAGE IN THE RELATED ART