DESCRIPTION

TITLE OF INVENTION

IMAGE PROCESSING APPARATUS, IMAGING APPARATUS, AND CONTROL METHODS THEREOF

TECHNICAL FIELD

[0001] The present invention relates to an image processing apparatus, an imaging apparatus, and control methods thereof.

BACKGROUND ART

[0002] An imaging apparatus capable of capturing a plurality viewpoint images at the same time by recording light beams having passed through different pupil regions of an imaging lens is known. NPL 1 has disclosed an imaging apparatus using an image sensor in which one microlens and a plurality of divided photoelectric converters are formed in one pixel. In this image sensor, the divided photoelectric converters receive light beams having passed through different pupil partial regions of an imaging lens through one microlens, thereby implementing so-called pupil division. Accordingly, an output signal is equivalent to LF (Light Field) data containing light intensity spatial distribution information and angle distribution information, so a plurality of viewpoint images can be obtained.

[0003] NPL 1 has also disclosed a refocusing technique capable of changing the focus position (also called the in-focus position) of a captured image after imaging by generating a synthetic image formed on a virtual plane different from an imaging plane by using the obtained LF data.

CITATION LIST

NON PATENT LITERATURE

[0004]

NPL 1: Ren. Ng, and seven others, "Light Field Photography with a Hand-Held

[0013] A first lens group 101 includes, for example, a zoom lens forming an image formation optical system, and is arranged at the distal end of the image formation optical system, and held to be movable forward and backward in the optical-axis direction. A shutter 102 includes a stop, and adjusts the amount of light entering an image sensor 107 during imaging by adjusting the aperture diameter of the stop. When capturing a still image, the shutter 102 functions as a shutter for adjusting the exposure time. The shutter 102 and a second lens group 103 forming the image formation optical system together move forward and backward in the optical-axis direction, and implement a magnification varying action (zooming function) in cooperation with the forward/backward movement of the first lens group 101.

[0014] A third lens group 105 includes, for example, a focusing lens forming the image formation optical system, and performs focusing by the forward/backward movement in the optical-axis direction. An optical element 106 includes an optical low-pass filter, and reduces a false color and moire of a captured image. The image sensor 107 includes, for example, an image sensor formed by a CMOS photosensor and peripheral circuits, and is arranged on the image formation plane of the image formation optical system.

[0015] A zoom actuator 111 includes a driving device for causing the forward/backward movements of the first and second lens groups 101 and 103, and drives the first and second lens groups 101 and 103 forward and backward in the optical-axis direction by pivoting a cam cylinder (not shown). A diaphragm shutter actuator 112 includes a driving device for causing the operation of the shutter 102, and controls the aperture diameter and shutter operation of the shutter 102 under the control of a diaphragm shutter driver 128. A focus actuator 114 includes a driving device for causing the forward/backward movement of the third lens group 105, and performs focusing by driving the third lens group 105 forward

and backward in the optical-axis direction.

[0016] An illuminating device 115 includes an object illuminating electronic flash for imaging. For example, the illuminating device 115 is a flash illuminating device using a xenon tube, or an illuminating device including an LED which continuously emits light. An auxiliary light emitting unit 116 includes an AF auxiliary light emitting device, and projects an image of a mask having a predetermined aperture pattern onto a field through a light projecting lens, thereby improving the focus detectability for a dark object or low-contrast object.

[0017] A controller 121 includes a CPU (or MPU), ROM, and RAM, and controls each unit of the whole digital camera 100 by loading a program stored in the ROM in the RAM and executing the program, thereby executing a series of operations such as AF, imaging, image processing, and recording. The controller 121 can also include an A/D converter, D/A converter, communication interface circuit, and the like. Furthermore, the controller 121 can have a function as a display controller for controlling contents to be displayed on a display unit 131, and can also execute processing to be executed by an image processor 125 instead of the image processor 125.

[0018] An electronic flash controller 122 includes a control circuit or control module, and controls the lighting of the illuminating device 115 in synchronism with an imaging operation. An auxiliary light driver 123 controls the lighting of the auxiliary light emitting unit 116 in synchronism with a focus detecting operation. An image sensor driver 124 controls the imaging operation of the image sensor 107, A/D-converts an obtained image signal, and transmits the converted signal to the controller 121. The image processor 125 performs processing such as γ conversion, color interpolation, and JPEG compression on the image obtained by the image sensor 107.

the first to fourth corrected viewpoint images, and generate a refocused image corresponding to a non-integral shift amount, as needed.

[0156] (Image Displacement Distribution)

An image displacement distribution of a viewpoint image according to this embodiment will be explained. An image displacement distribution in the pupil dividing direction in the horizontal direction is the same as that of the first embodiment, so an explanation thereof will be omitted. An image displacement distribution in the pupil dividing direction in the vertical direction will be explained.

[0157] The viewpoint change processing unit 155 moves a two-dimensional image by k pixels in only the pupil dividing direction in the vertical direction, and obtains the difference between a pixel of the first viewpoint image A0 and the third viewpoint image C0. Accordingly, a correlation calculation of adding a plurality of rows is defined by equation (18).

[0158]

$$k \geq 0 \qquad COR'(k) = \sum_{j}^{nj} \sum_{i}^{ni} \left| A0_{i(j+k)} - C0_{ij} \right|$$

$$k < 0 \qquad COR'(k) = \sum_{j}^{nj} \sum_{i}^{ni} \left| A0_{ij} - C0_{i(j+k)} \right| \qquad (18)$$

where A0ij and C0ij respectively represent the luminances of the ith pixels in the jth columns of the first viewpoint image A0 and third viewpoint image C0. Also, ni is a number representing the number of pixels to be used in the calculation, and nj is the number of image pairs in the column direction as targets of the correlation calculation.

[0159] The viewpoint change processing unit 155 calculates k which minimizes COR'(k) shown in equation (18) as the image displacement amount. Note that