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Heo et al.

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(54) **METHOD AND APPARATUS FOR PROCESSING ARRAY IMAGE**

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H04N 23/667	(2023.01)
H04N 23/84	(2023.01)
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(52) **U.S. Cl.**

CPC ***H04N 23/957*** (2023.01); ***H04N 23/651*** (2023.01); ***H04N 23/667*** (2023.01); ***H04N 23/843*** (2023.01); ***H04N 23/951*** (2023.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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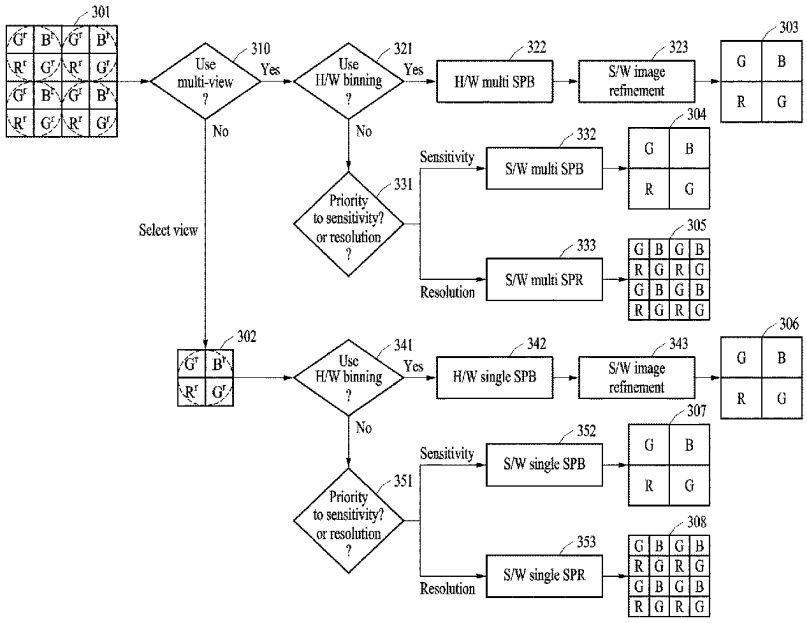
(57) **ABSTRACT**

An image processing method includes: based on an imaging device generating an input array image of a multi-view through an array lens, determining a first setting parameter indicating whether to use the multi-view or a single view selected from the multi-view; determining a second setting parameter indicating whether a priority is assigned to sensitivity enhancement based on pixel binning or to resolution enhancement based on pixel interpolation; determining an image processing mode based on the first setting parameter and the second setting parameter; and generating an output image by performing image processing on the input array image based on a processing procedure that is based on the determined image processing mode.

20 Claims, 16 Drawing Sheets



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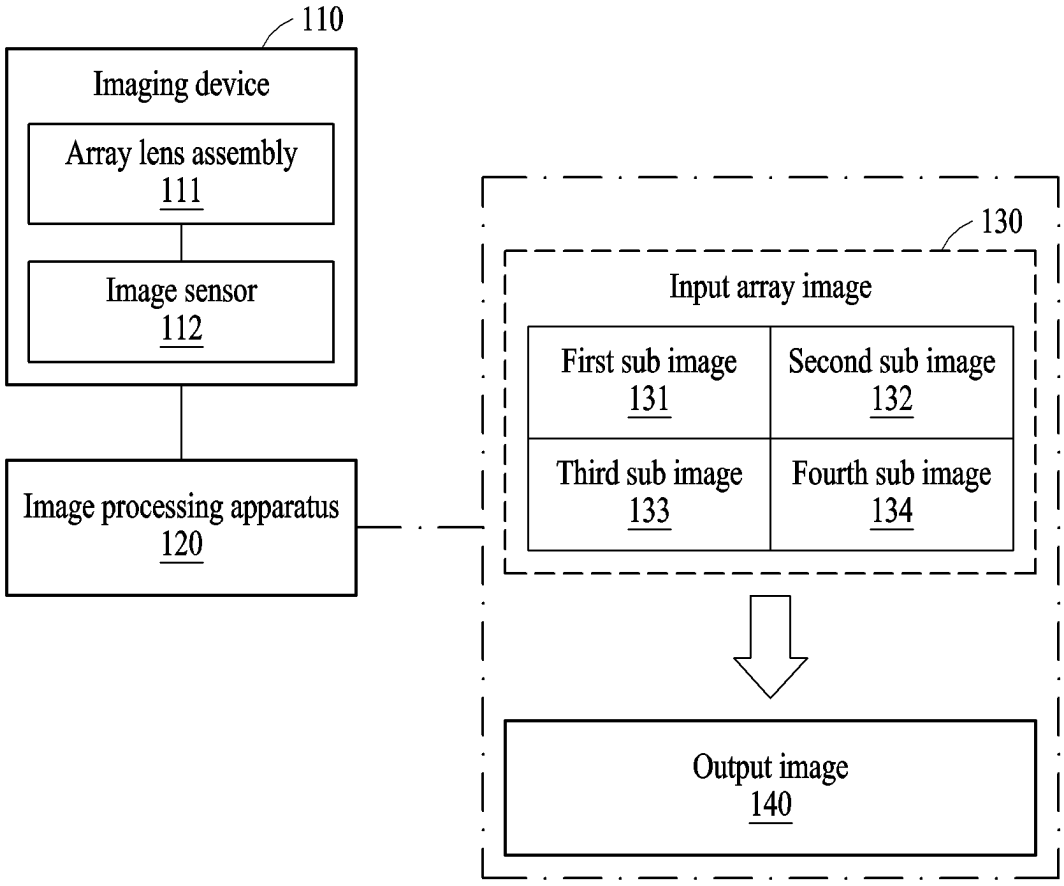
110
Imaging device
Array lens assembly
111
Image sensor
112
Image processing apparatus
120
130
Input array image
First sub image
131
Second sub image
132
Third sub image
133
Fourth sub image
134
Output image
140

FIG. 1A

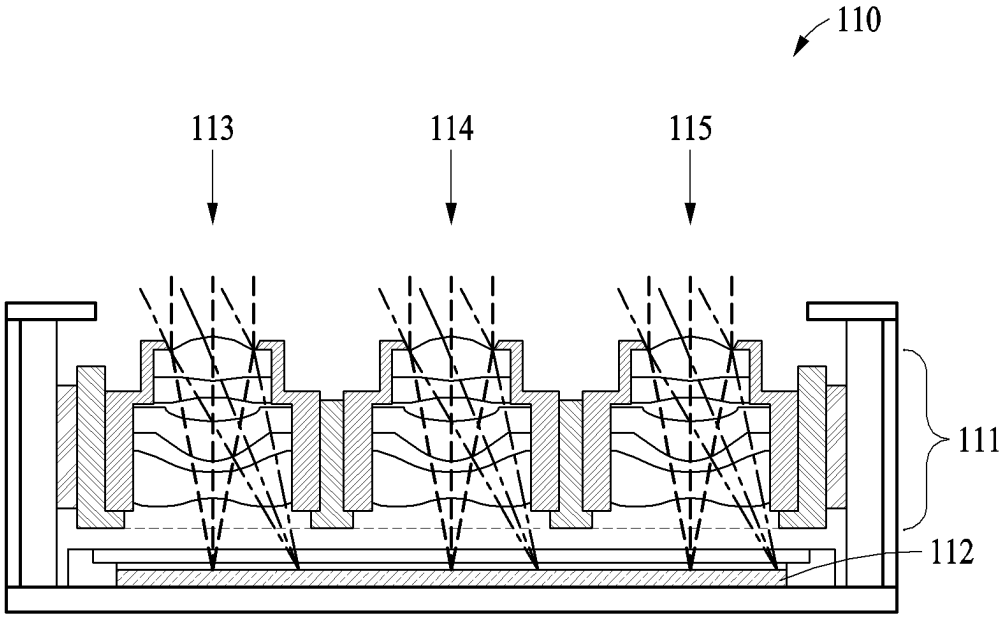

FIG. 1B

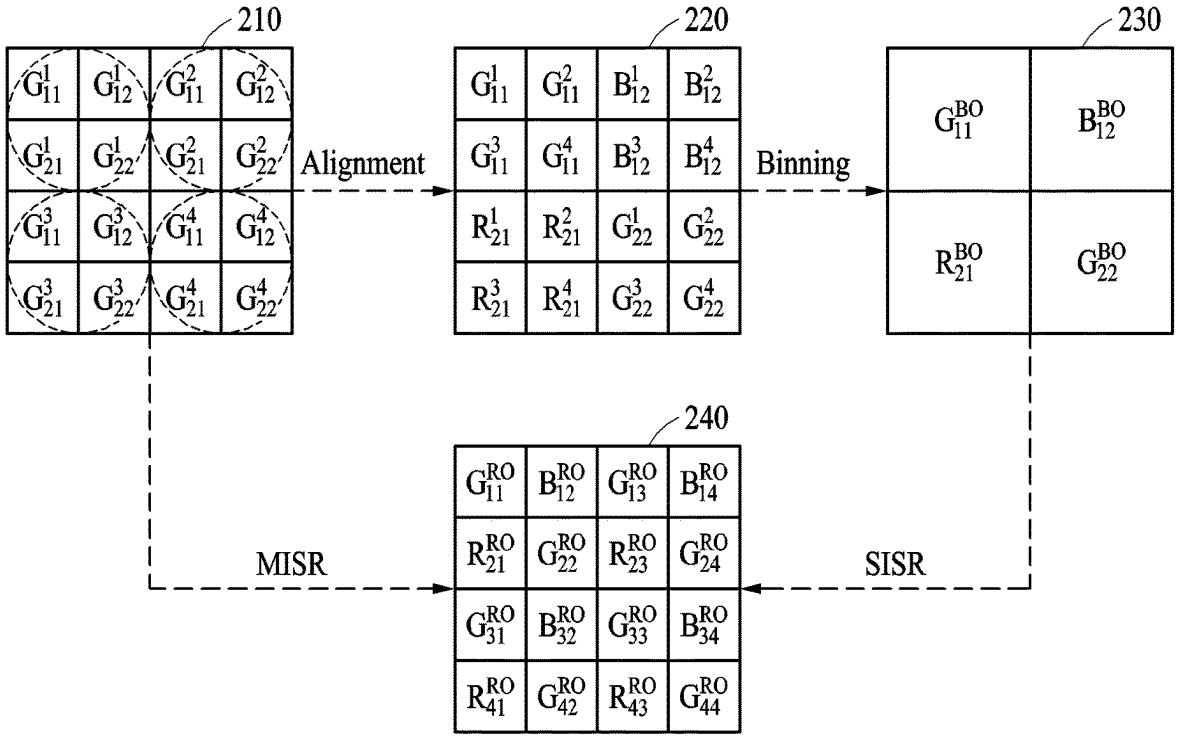

FIG. 2

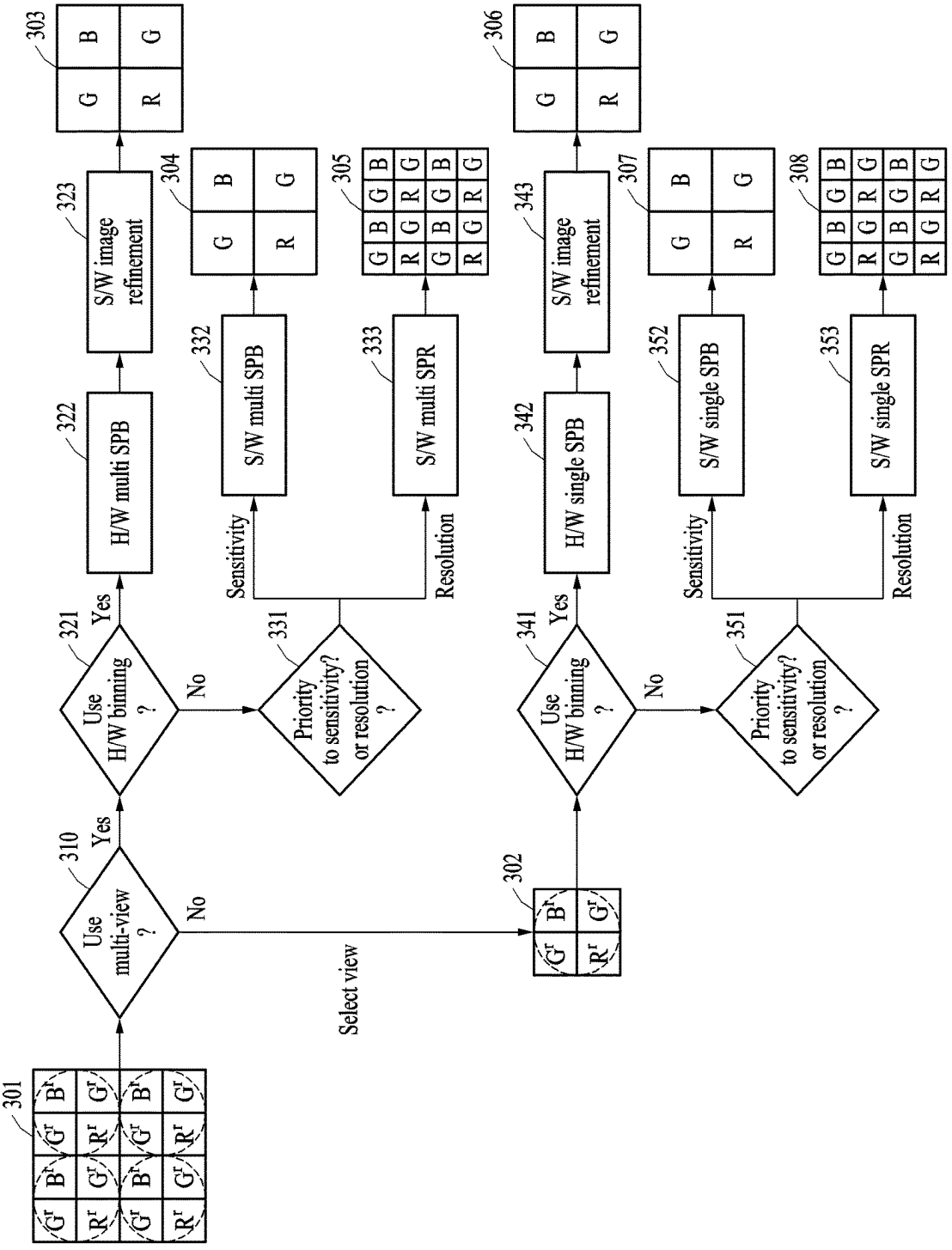
301
310
Use multi-view ?
Yes
No
Select view
302
321
Use H/W binning ?
Yes
No
322
H/W multi SPB
323
S/W image refinement
303
331
Priority to sensitivity? or resolution ?
Sensitivity
Resolution
332
S/W multi SPB
333
S/W multi SPR
304
305
341
Use H/W binning ?
Yes
No
342
H/W single SPB
343
S/W image refinement
306
351
Priority to sensitivity? or resolution ?
Sensitivity
Resolution
352
S/W single SPB
353
S/W single SPR
307
308

FIG. 3

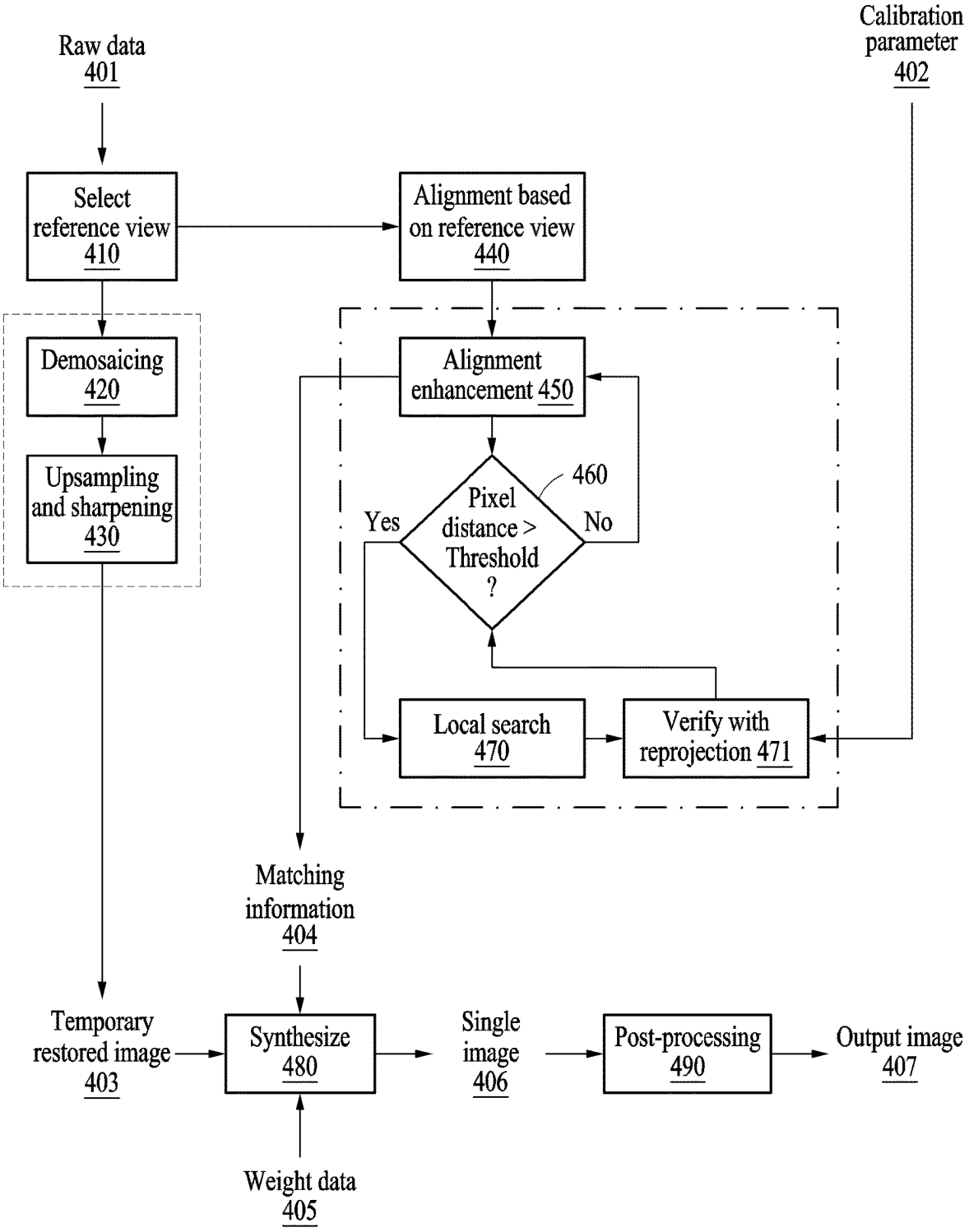
Raw data
401
Calibration parameter
402
Select reference view
410
Alignment based on reference view
440
Demosaicing
420
Alignment enhancement 450
Upsampling and sharpening
430
460
Pixel distance > Threshold ?
Yes
No
Local search
470
Verify with reprojection 471
Matching information
404
Temporary restored image
403
Synthesize
480
Single image
406
Post-processing
490
Output image
407
Weight data
405

FIG. 4

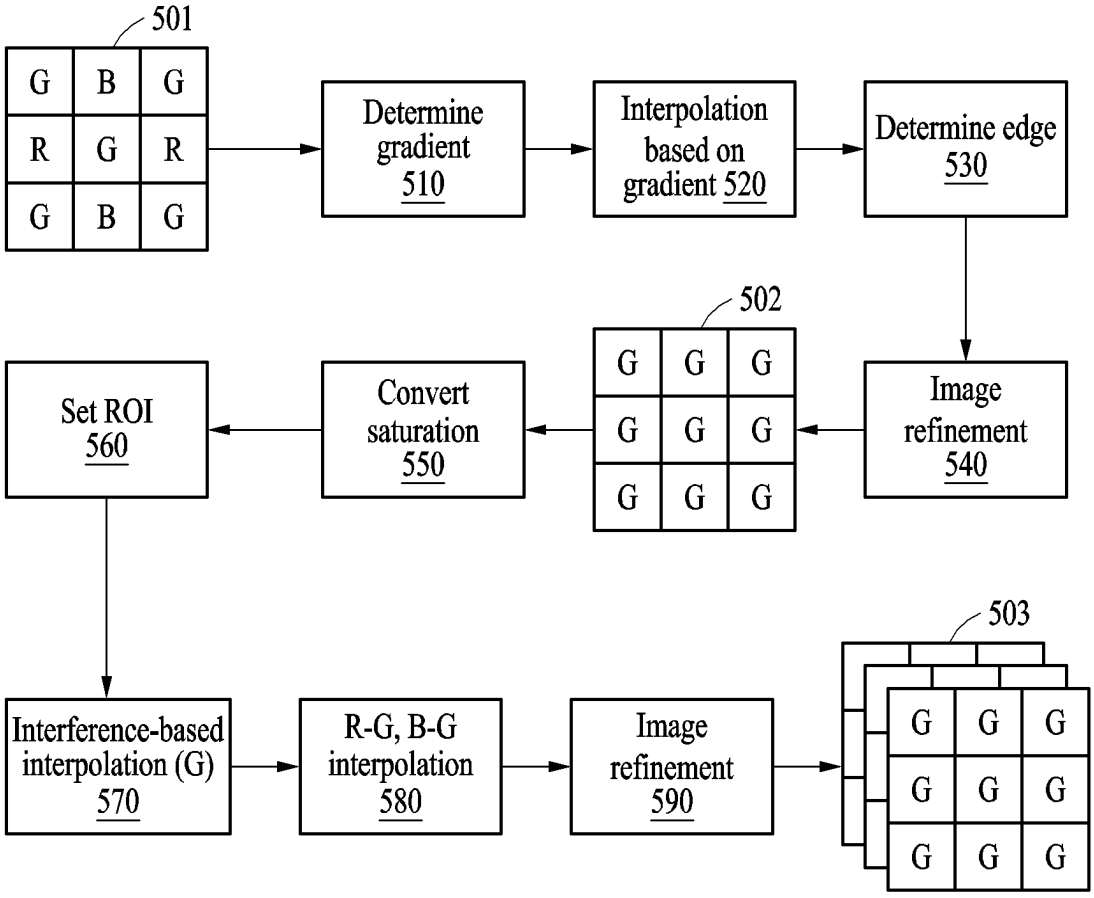
501
G B G
R G R
G B G
Determine gradient 510
Interpolation based on gradient 520
Determine edge 530
502
G G G
G G G
G G G
Image refinement 540
Convert saturation 550
Set ROI 560
Interference-based interpolation (G) 570
R-G, B-G interpolation 580
Image refinement 590
503
G G G
G G G
G G G

FIG. 5A

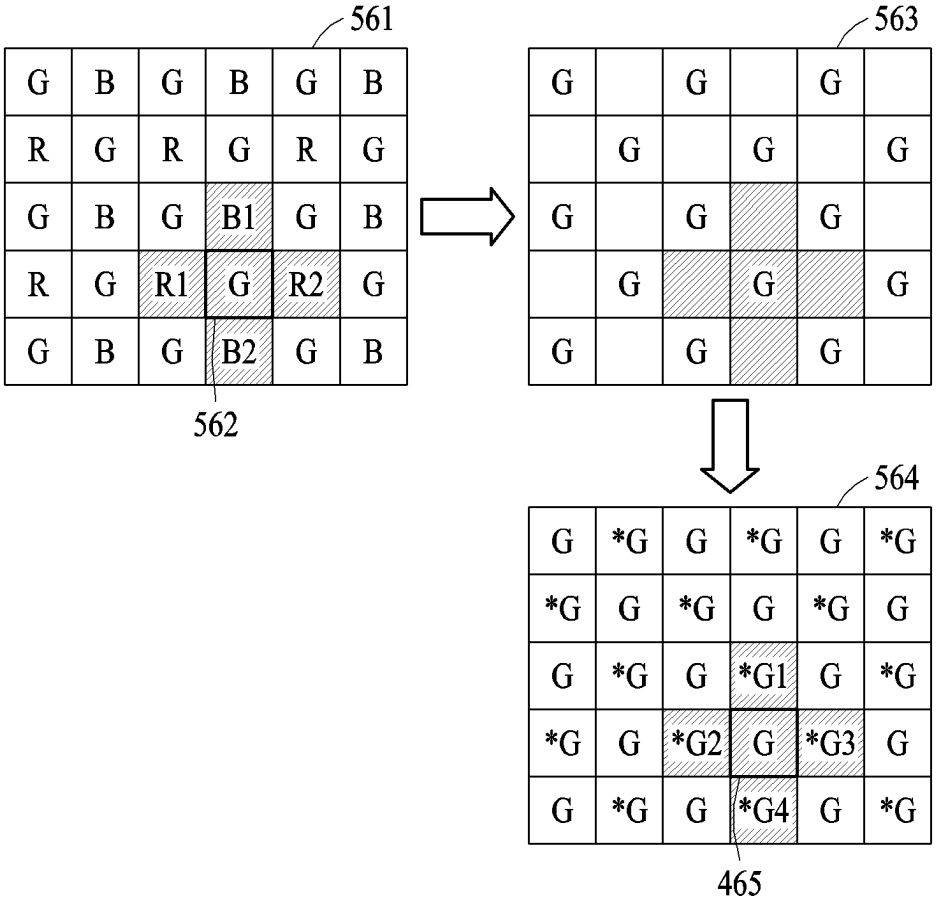
561
G B G B G B
R G R G R G
G B G B1 G B
R G R1 G R2 G
G B G B2 G B
562
563
G G G
G G G
G G G
G G G
G G G
564
G *G G *G G *G
*G G *G G *G G
G *G G *G1 G *G
*G G *G2 G *G3 G
G *G G *G4 G *G
465

FIG. 5B

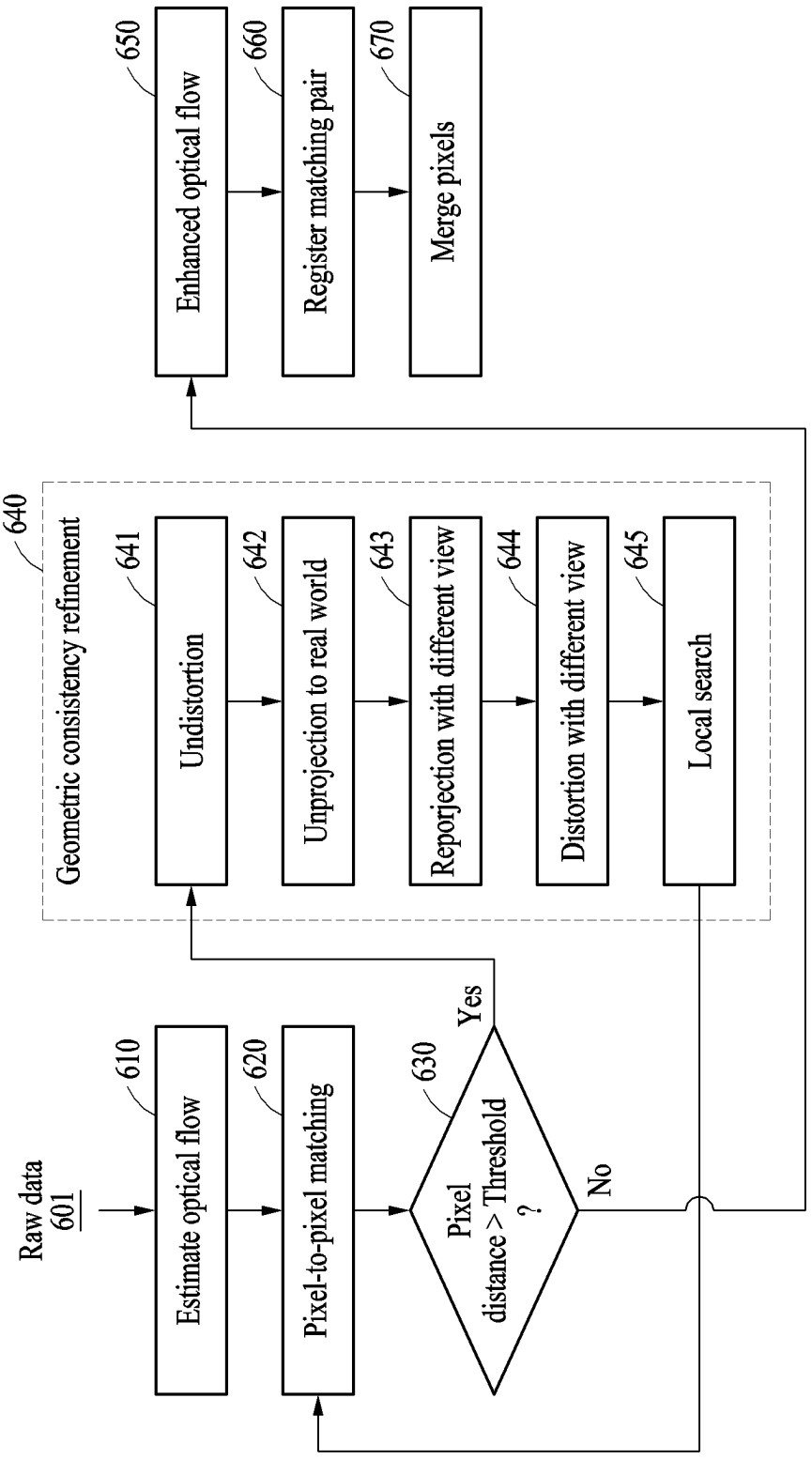
Raw data
601
610
Estimate optical flow
620
Pixel-to-pixel matching
630
Pixel distance > Threshold ?
Yes
No
640
Geometric consistency refinement
641
Undistortion
642
Unprojection to real world
643
Reporjection with different view
644
Distortion with different view
645
Local search
650
Enhanced optical flow
660
Register matching pair
670
Merge pixels

FIG. 6

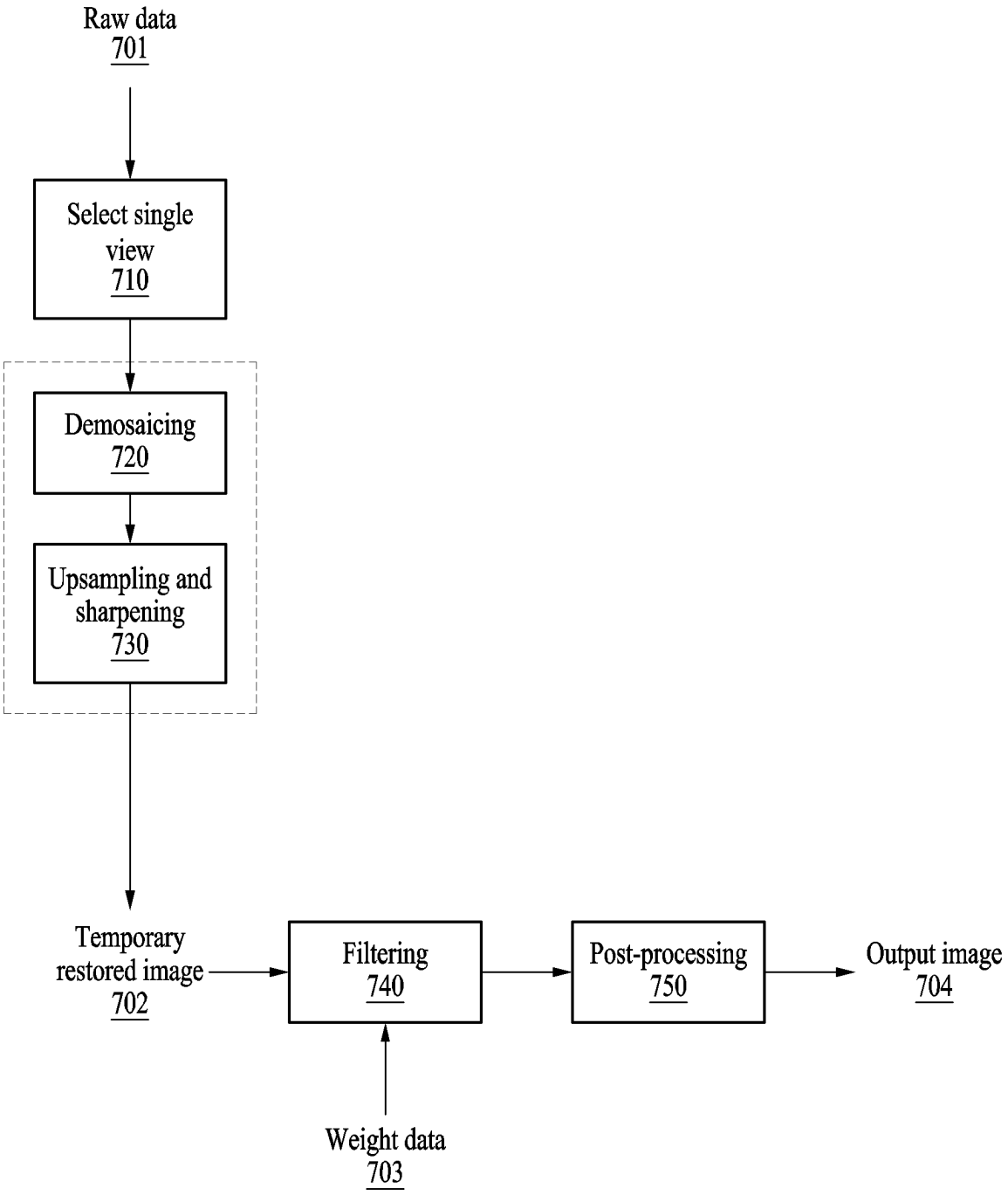
Raw data
701
Select single view
710
Demosaicing
720
Upsampling and sharpening
730
Temporary restored image
702
Filtering
740
Post-processing
750
Output image
704
Weight data
703

FIG. 7

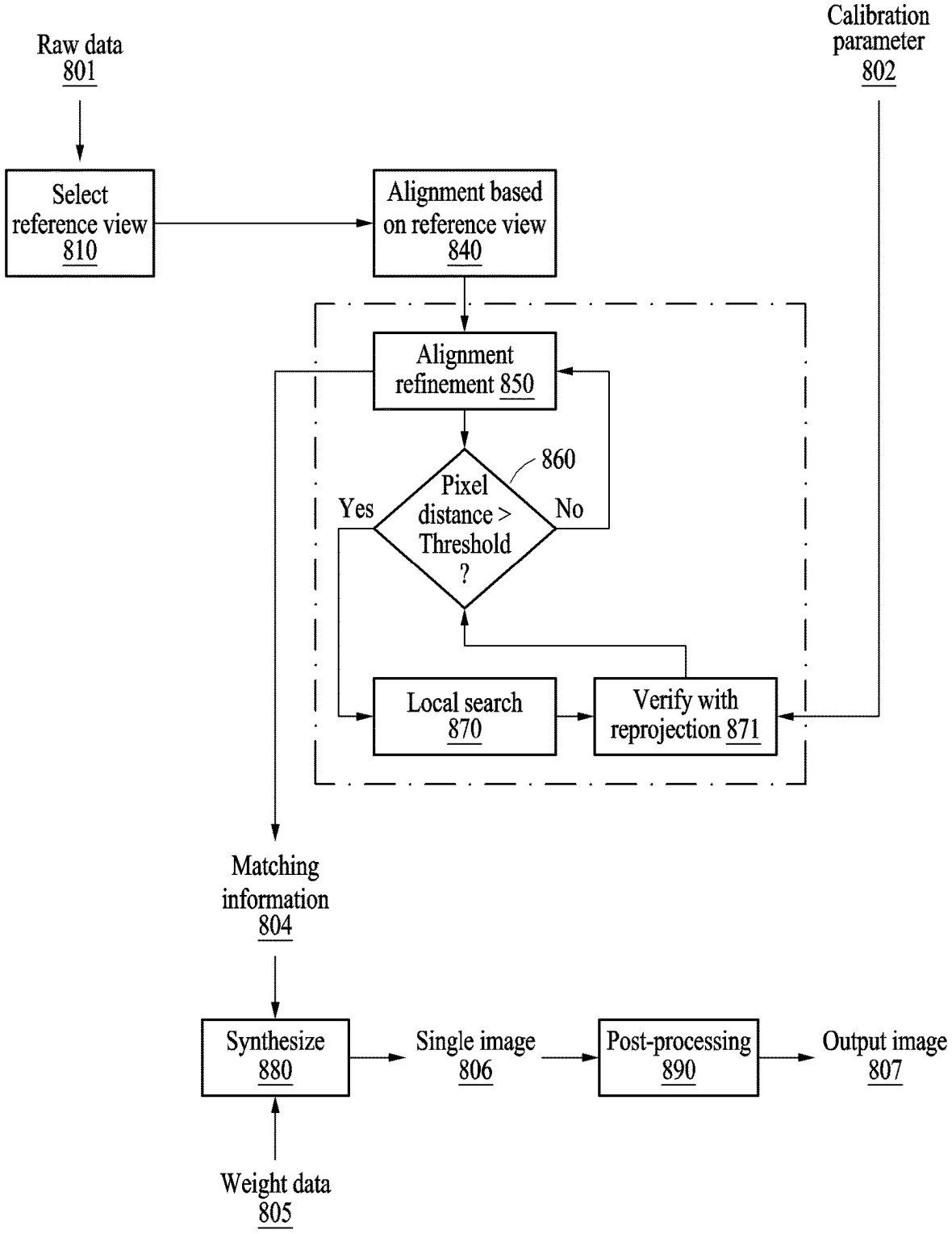
Raw data
801
Calibration parameter
802
Select reference view
810
Alignment based on reference view
840
Alignment refinement 850
860
Pixel distance > Threshold ?
Yes
No
Local search
870
Verify with reprojection 871
Matching information
804
Synthesize
880
Single image
806
Post-processing
890
Output image
807
Weight data
805

FIG. 8

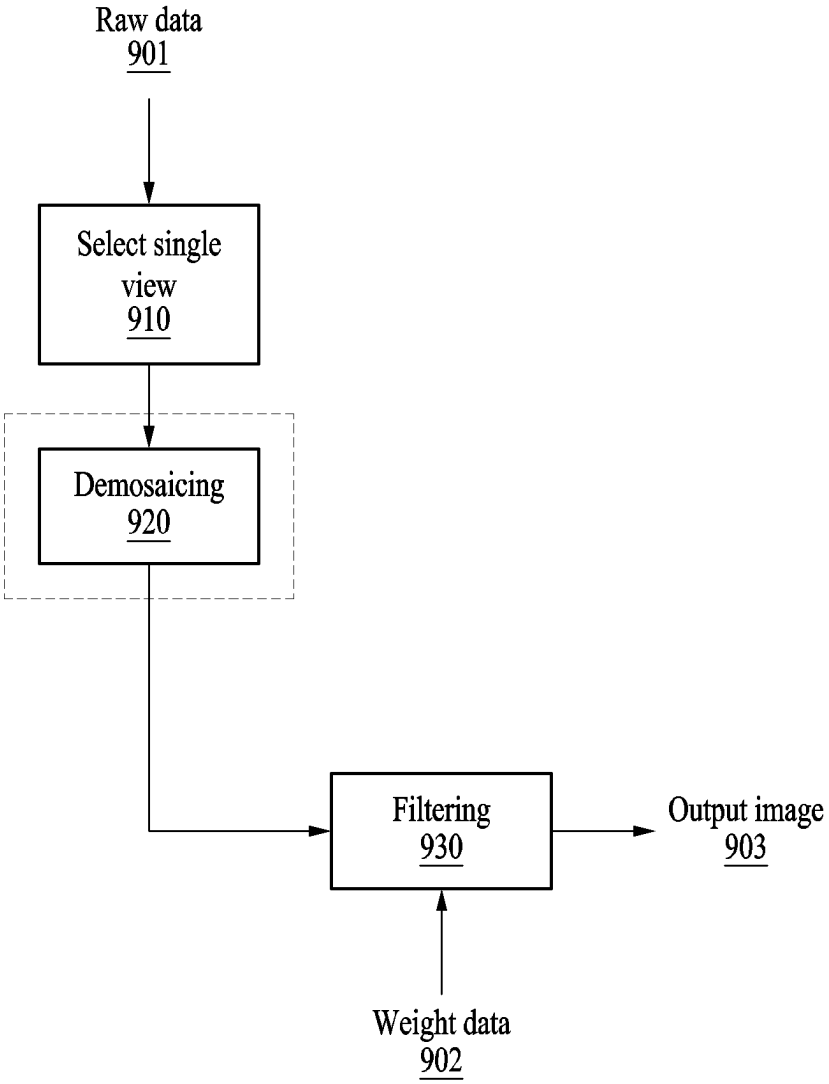
Raw data
901
Select single view
910
Demosaicing
920
Filtering
930
Output image
903
Weight data
902

FIG. 9

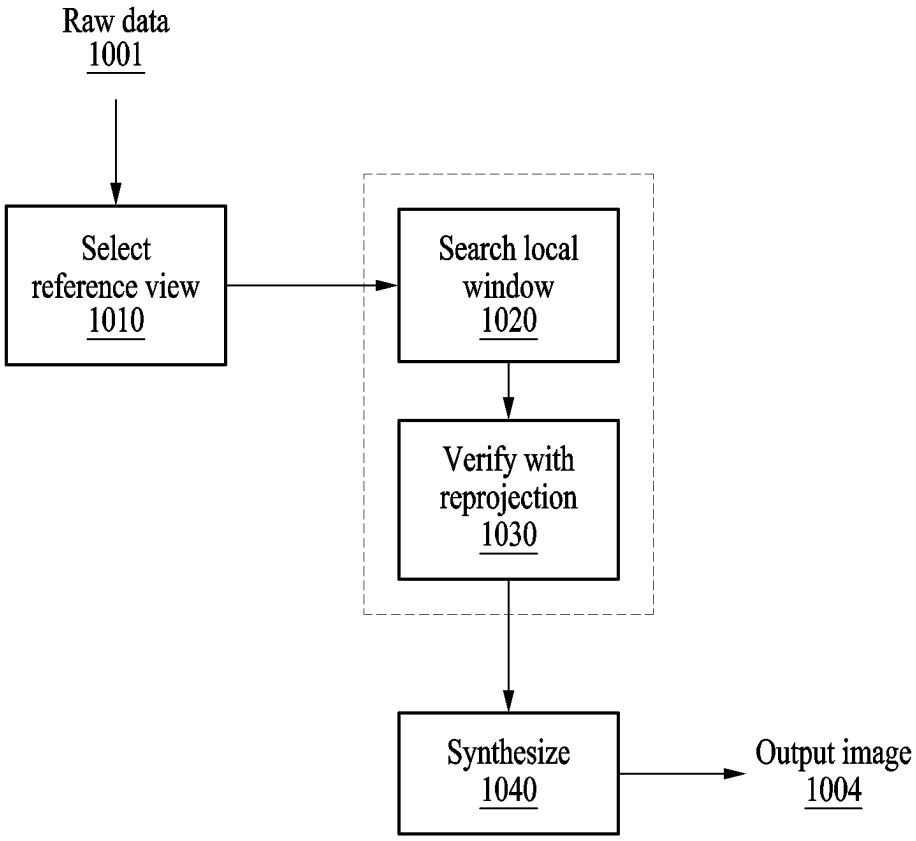
Raw data
1001
Select reference view
1010
Search local window
1020
Verify with reprojection
1030
Synthesize
1040
Output image
1004

FIG. 10

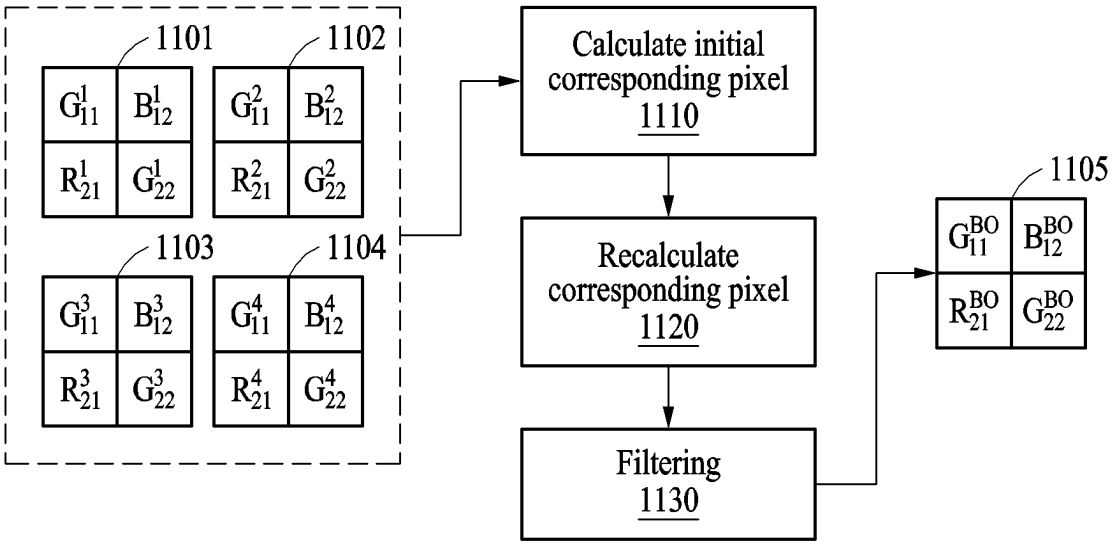
1101
1102
1103
1104
1105
G_{11}^{1} B_{12}^{1} R_{21}^{1} G_{22}^{1}
G_{11}^{2} B_{12}^{2} R_{21}^{2} G_{22}^{2}
G_{11}^{3} B_{12}^{3} R_{21}^{3} G_{22}^{3}
G_{11}^{4} B_{12}^{4} R_{21}^{4} G_{22}^{4}
Calculate initial corresponding pixel 1110
Recalculate corresponding pixel 1120
Filtering 1130
G_{11}^{BO} B_{12}^{BO} R_{21}^{BO} G_{22}^{BO}

FIG. 11A

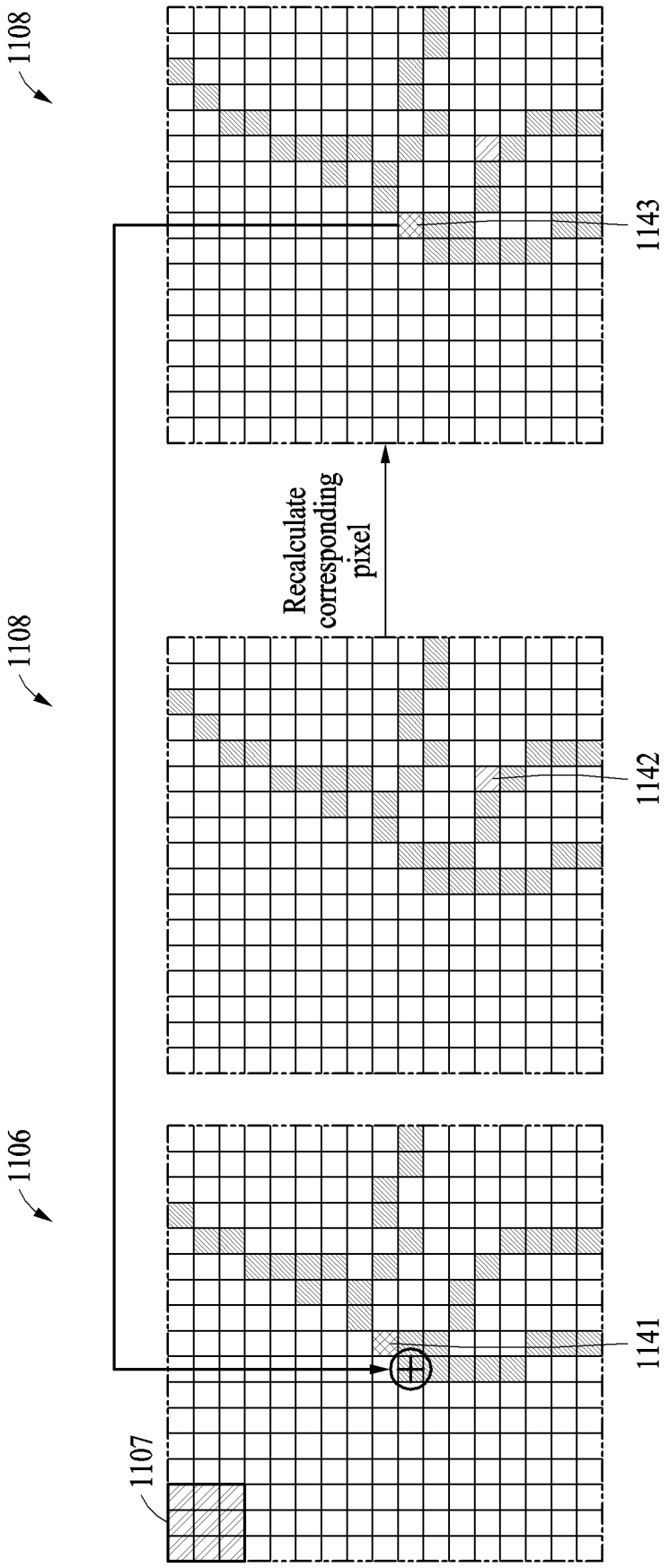
1108
1143
Recalculate corresponding pixel
1108
1142
1106
1141
1107

FIG. 11B

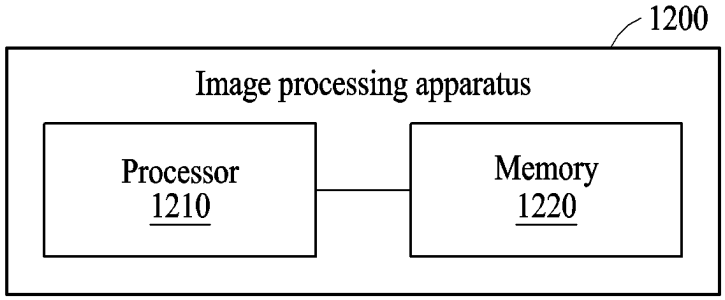
1200
Image processing apparatus
Processor
1210
Memory
1220

FIG. 12

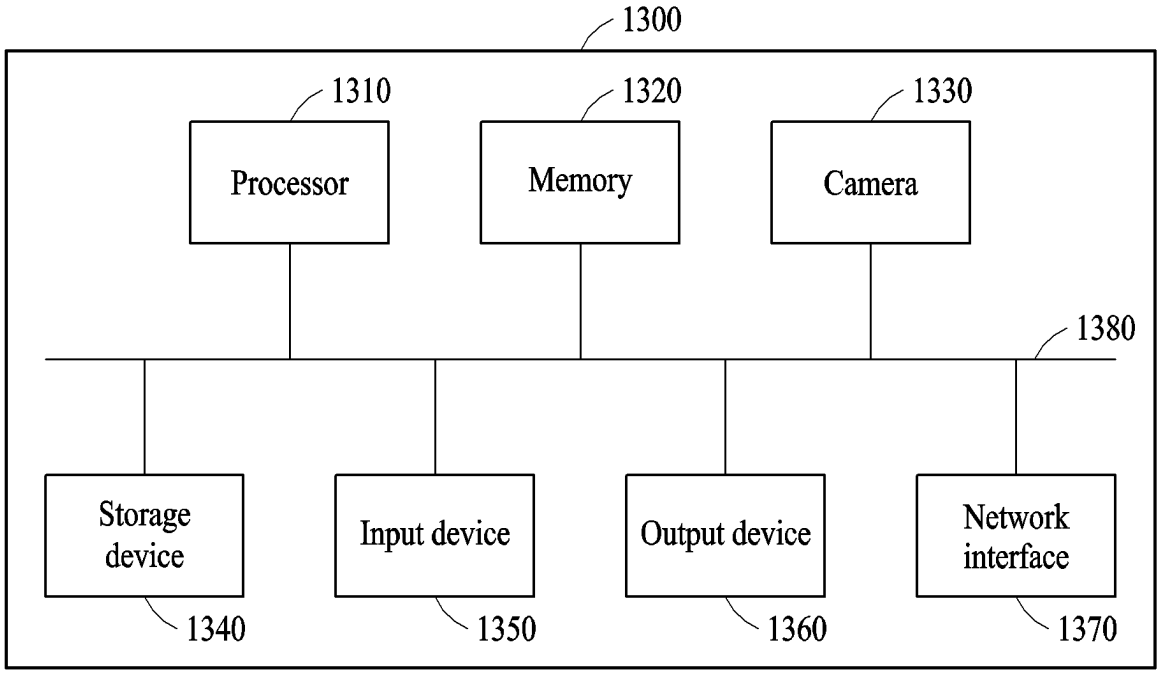
1300
1310
Processor
1320
Memory
1330
Camera
1380
Storage device
1340
Input device
1350
Output device
1360
Network interface
1370

FIG. 13

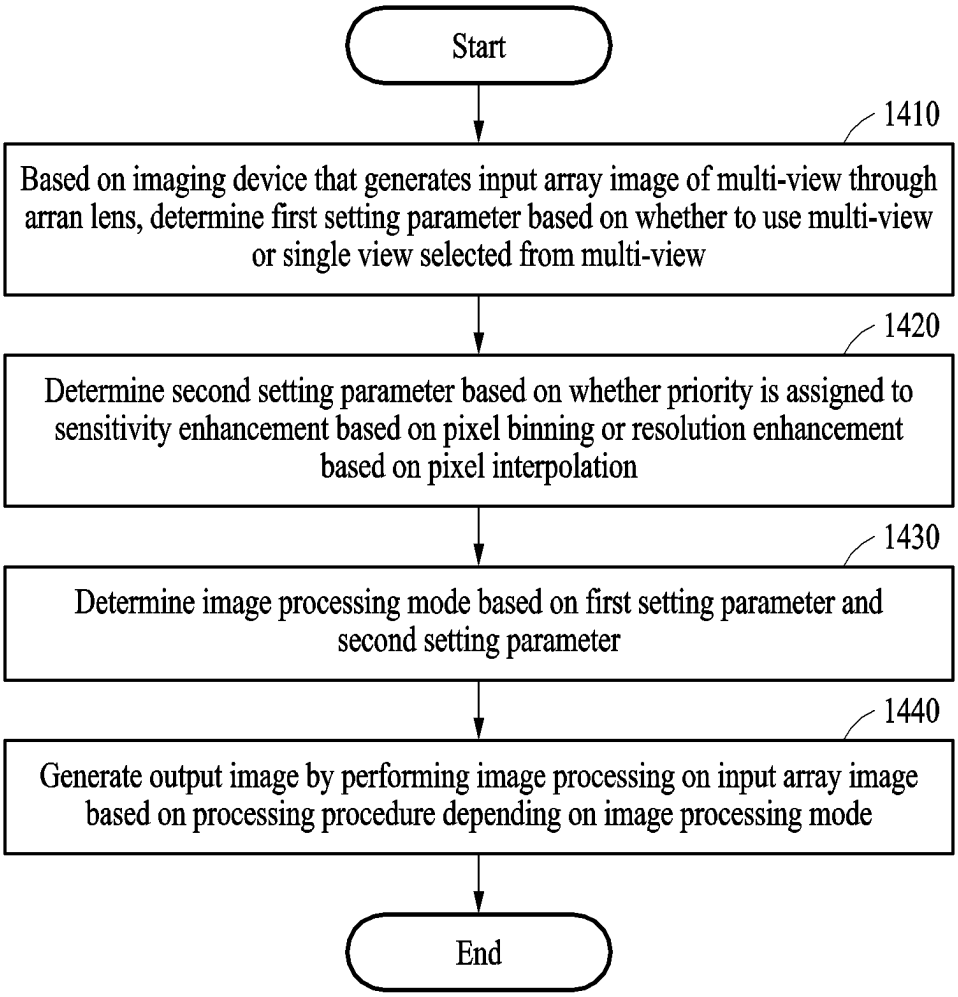
Start
1410
Based on imaging device that generates input array image of multi-view through arran lens, determine first setting parameter based on whether to use multi-view or single view selected from multi-view
1420
Determine second setting parameter based on whether priority is assigned to sensitivity enhancement based on pixel binning or resolution enhancement based on pixel interpolation
1430
Determine image processing mode based on first setting parameter and second setting parameter
1440
Generate output image by performing image processing on input array image based on processing procedure depending on image processing mode
End

FIG. 14

METHOD AND APPARATUS FOR PROCESSING ARRAY IMAGE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit under 35 USC § 119(a) of Korean Patent Application No. 10-2022-0136751, filed on Oct. 21, 2022, in the Korean Intellectual Property Office, the entire disclosure of which is incorporated herein by reference for all purposes.

BACKGROUND

1. Field

The following description relates to a method and apparatus for processing an array image.

2. Description of Related Art

Due to the development of optical technology and image processing technology, image capturing devices are utilized in a wide range of fields such as multimedia content production, security, and object recognition. For example, a capturing device may be mounted on a mobile device, a camera, a vehicle, or a computer to capture an image, recognize an object, or obtain data for controlling a device. The volume of the capturing device may be determined based on the size of a lens, the focal length of the lens, and the size of a sensor. When the volume of the capturing device is limited, a long focal length may be provided in a limited space by transforming a lens structure.

SUMMARY

This section is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This section is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

An image processing method may include: based on an imaging device generating an input array image of a multi-view through an array lens, determining a first setting parameter indicating whether to use the multi-view or a single view selected from the multi-view; determining a second setting parameter indicating whether a priority is assigned to sensitivity enhancement based on pixel binning or to resolution enhancement based on pixel interpolation; determining an image processing mode based on the first setting parameter and the second setting parameter; and generating an output image by performing image processing on the input array image based on a processing procedure that is based on the determined image processing mode.

The determined image processing mode may include: a first mode that is determined when the first setting parameter indicates to use the multi-view and the second setting parameter indicates the priority is assigned to the resolution enhancement, a second mode that is determined when the first setting parameter indicates to use the multi-view and the second setting parameter indicates the priority is assigned to the sensitivity enhancement, a fourth mode that is determined when the first setting parameter indicates to use the single view and the second setting parameter indicates the priority is assigned to the resolution enhancement, or a fifth mode that is determined when the first setting parameter indicates to use the single view and the second setting parameter indicates the priority is assigned to the sensitivity enhancement.

The processing procedure that is based on the first mode may include sub stages. The processing procedure that is based on the second mode, the fourth mode, or the fifth mode may only include some of the sub stages.

The sub stages may include: a first sub stage for performing demosaicing on raw data, a second sub stage for performing upsampling for resolution enhancement, a third sub stage for generating matching information of the multi-view, and a fourth sub stage for generating a synthesized image using the matching information.

The processing procedure that is based on the second mode may not include the first sub stage and the second sub stage. The processing procedure that is based on the fourth mode may not include the third sub stage and the fourth sub stage. The processing procedure that is based on the fifth mode may not include the second sub stage, the third sub stage, and the fourth sub stage.

The image processing method may further include: determining a third setting parameter indicating whether to use hardware logic-based binning processing. The determining the image processing mode may be further based on the third setting parameter.

The determined image processing mode may include: a first mode that is determined when the first setting parameter indicates to use the multi-view, the third setting parameter indicates to not use the hardware logic-based binning processing, and the second setting parameter indicates the priority is assigned to the resolution enhancement, a second mode that is determined when the first setting parameter indicates to use the multi-view, the third setting parameter indicates to not use the hardware logic-based binning processing, and the second setting parameter indicates the priority is assigned to the sensitivity enhancement, a third mode that is determined when the first setting parameter indicates to use the multi-view and the third setting parameter indicates to use the hardware logic-based binning processing, a fourth mode that is determined when the first setting parameter indicates to use the single view, the third setting parameter indicates to not use the hardware logic-based binning processing, and the second setting parameter indicates the priority is assigned to the resolution enhancement, a fifth mode that is determined when the first setting parameter indicates to use the single view, the third setting parameter indicates to not use the hardware logic-based binning processing, and the second setting parameter indicates the priority is assigned to the sensitivity enhancement, and a sixth mode that is determined when the first setting parameter indicates to use the single view and the third setting parameter indicates to use the hardware logic-based binning processing.

The third setting parameter may indicate to use the hardware logic-based binning processing in at least one of a low-illuminance environment or a video capturing mode.

The hardware logic-based binning processing may include: determining initial corresponding pixels between sub images that respectively correspond to different views of the input array image, extracting a refinement target from the initial corresponding pixels based on an intensity difference between the initial corresponding pixels, determining a new corresponding pixel for the refinement target by using a calibration parameter, and performing binning on final corresponding pixels through a weighted average of the final corresponding pixels that are based on the new corresponding pixel.

The first setting parameter may indicate to use the single view in response to a demand for low power.

A non-transitory computer-readable storage medium storing instructions that, when executed by a processor, may cause the processor to perform an image processing method including: based on an imaging device generating an input array image of a multi-view through an array lens, determining a first setting parameter indicating whether to use the multi-view or a single view selected from the multi-view; determining a second setting parameter indicating whether a priority is assigned to sensitivity enhancement based on pixel binning or to resolution enhancement based on pixel interpolation; determining an image processing mode based on the first setting parameter and the second setting parameter; and generating an output image by performing image processing on the input array image based on a processing procedure that is based on the determined image processing mode.

An image processing apparatus may include: a processor; and a memory configured to store instructions executable by the processor. In response to the instructions being executed by the processor, the processor may be configured to: based on an imaging device generating an input array image of a multi-view through an array lens, determine a first setting parameter indicating whether to use the multi-view or a single view selected from the multi-view, determine a second setting parameter indicating whether a priority is assigned to sensitivity enhancement based on pixel binning or to resolution enhancement based on pixel interpolation, determine an image processing mode based on the first setting parameter and the second setting parameter, and generate an output image by performing image processing on the input array image based on a processing procedure that is based on the determined image processing mode.

The determined image processing mode may include: a first mode that is determined when the first setting parameter indicates to use the multi-view and the second setting parameter indicates the priority is assigned to the resolution enhancement, a second mode that is determined when the first setting parameter indicates to use the multi-view and the second setting parameter indicates the priority is assigned to the sensitivity enhancement, a fourth mode that is determined when the first setting parameter indicates to use the single view and the second setting parameter indicates the priority is assigned to the resolution enhancement, or a fifth mode that is determined when the first setting parameter indicates to use the single view and the second setting parameter indicates the priority is assigned to the sensitivity enhancement.

The processing procedure that is based on the first mode may include sub stages. The processing procedure that is based on the second mode, the fourth mode, or the fifth mode may only include some of the sub stages.

The processor may be further configured to: determine a third setting parameter indicating whether to use hardware logic-based binning processing. The processor being configured to determine the image processing mode may be further based on the third setting parameter.

The determined image processing mode may include: a first mode that is determined when the first setting parameter indicates to use the multi-view, the third setting parameter indicates to not use the hardware logic-based binning processing, and the second setting parameter indicates the priority is assigned to the resolution enhancement, a second mode that is determined when the first setting parameter indicates to use the multi-view, the third setting parameter indicates to not use the hardware logic-based binning processing, and the second setting parameter indicates the priority is assigned to the sensitivity enhancement, a third mode that is determined when the first setting parameter indicates to use the multi-view and the third setting parameter indicates to use the hardware logic-based binning processing, a fourth mode that is determined when the first setting parameter indicates to use the single view, the third setting parameter indicates to not use the hardware logic-based binning processing, and the second setting parameter indicates the priority is assigned to the resolution enhancement, a fifth mode that is determined when the first setting parameter indicates to use the single view, the third setting parameter indicates to not use the hardware logic-based binning processing, and the second setting parameter indicates the priority is assigned to the sensitivity enhancement, and a sixth mode that is determined when the first setting parameter indicates to use the single view and the third setting parameter indicates to use the hardware logic-based binning processing.

The third setting parameter may indicate to use the hardware logic-based binning processing in at least one of a low-illuminance environment or a video capturing mode.

The hardware logic-based binning processing may include the processor being configured to: determine initial corresponding pixels between sub images respectively that correspond to different views of the input array image, extract a refinement target from the initial corresponding pixels based on an intensity difference between the initial corresponding pixels, determine a new corresponding pixel for the refinement target by using a calibration parameter, and perform binning on final corresponding pixels through a weighted average of the final corresponding pixels that are based on the new corresponding pixel.

The first setting parameter may indicate to use the single view in response to a demand for low power.

An electronic device may include: an imaging device configured to generate an input array image of a multi-view through an array lens, the input array image comprising sub images corresponding to the multi-view; and a processor configured to: determine a first setting parameter indicating whether to use the multi-view or a single view selected from the multi-view, determine a second setting parameter indicating whether a priority is assigned to sensitivity enhancement based on pixel binning or to resolution enhancement based on pixel interpolation, determine an image processing mode based on the first setting parameter and the second setting parameter, and generate an output image by performing image processing on the input array image based on a processing procedure that is based on the determined image processing mode.

Other features and aspects will be apparent from the following detailed description, the drawings, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A illustrates an example of configurations and operations of an imaging device and an image processing apparatus, according to one or more embodiments.

FIG. **1**B illustrates an example of a configuration of the imaging device, according to one or more embodiments.

FIG. **2** illustrates an example of a change in pixel data based on image processing, according to one or more embodiments.

FIG. **3** illustrates an example of a process of determining an image processing mode and a result of each image processing mode, according to one or more embodiments.

FIG. **4** illustrates an example of an image processing process of multi spread pixel remosaic (SPR), according to one or more embodiments.

FIG. **5**A illustrates an example of a demosaicing operation based on region of interest (ROI) detection, according to one or more embodiments.

FIG. **5**B illustrates an example of an operation of determining a gradient value, according to one or more embodiments.

FIG. **6** illustrates an example of a matching information refinement operation using an optical flow, according to one or more embodiments.

FIG. **7** illustrates an example of an image processing process of single SPR, according to one or more embodiments.

FIG. **8** illustrates an example of an image processing process of multi SPR, according to one or more embodiments.

FIG. **9** illustrates an example of an image processing process of single spread pixel binning (SPB), according to one or more embodiments.

FIG. **10** illustrates an example of an image processing process of hardware (H/W) logic-based SPB, according to one or more embodiments.

FIG. **11**A illustrates an example of a binning operation of H/W logic-based SPB, according to one or more embodiments.

FIG. **11**B illustrates an example of a searching operation of corresponding pixels, according to one or more embodiments.

FIG. **12** illustrates an example of a configuration of an image processing apparatus, according to one or more embodiments.

FIG. **13** illustrates an example of a configuration of an electronic device, according to one or more embodiments.

FIG. **14** illustrates an example of an image processing method according to one or more embodiments.

Throughout the drawings and the detailed description, unless otherwise described or provided, the same drawing reference numerals will be understood to refer to the same elements, features, and structures. The drawings may not be to scale, and the relative size, proportions, and depiction of elements in the drawings may be exaggerated for clarity, illustration, and convenience.

DETAILED DESCRIPTION

The following detailed structural or functional description is provided as an example only and various alterations and modifications may be made to the examples. The examples are not construed as limited to the disclosure and should be understood to include all changes, equivalents, and replacements within the idea and the technical scope of the embodiments.

Terms, such as first, second, and the like, may be used herein to describe components. Each of these terminologies is not used to define an essence, order or sequence of a corresponding component but used merely to distinguish the corresponding component from other component(s). For example, a first component may be referred to as a second component, and similarly the second component may also be referred to as the first component.

It should be noted that if it is described that one component is "connected", "coupled", or "joined" to another component, a third component may be "connected", "coupled", and "joined" between the first and second components, although the first component may be directly connected, coupled, or joined to the second component.

The singular forms "a", "an", and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises/comprising" and/or "includes/including" when used herein, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components and/or groups thereof.

As used herein, "at least one of A and B", "at least one of A, B, or C," and the like, each of which may include any one of the items listed together in the corresponding one of the phrases, or all possible combinations thereof.

Unless otherwise defined, all terms used herein including technical or scientific terms have the same meaning as commonly understood by one of ordinary skill in the art to which examples belong. Terms, such as those defined in commonly used dictionaries, are to be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art, and are not to be interpreted in an idealized or overly formal sense unless expressly so defined herein.

Hereinafter, examples will be described in detail with reference to the accompanying drawings. When describing the examples with reference to the accompanying drawings, like reference numerals refer to like components and a repeated description related thereto will be omitted.

FIG. **1**A illustrates an example of configurations and operations of an imaging device and an image processing apparatus, according to one or more embodiments. Referring to FIG. **1**A, an imaging device **110** may include an array lens assembly **111** and an image sensor **112**. The array lens assembly **111** may include a layer of at least one lens array. Each layer may include a lens array including a plurality of individual lenses. For example, a lens array may include individual lenses arranged in, for example, a 2*2 array or a 3*3 array. Each layer may include the same lens arrangement.

The image sensor **112** may be a single image sensor or multiple image sensors provided in a number corresponding to the lens arrangement. The image sensor **112** may generate an input array image **130**. The input array image **130** may include sub images **131** to **134** based on the lens arrangement of the array lens assembly **111**. The sub images **131** to **134** in a 2*2 arrangement are based on an assumption that the array lens assembly **111** has a 2*2 lens arrangement. Hereinafter, an example of the array lens assembly **111** in the 2*2 lens arrangement is described. However, the lens arrangement of the array lens assembly **111** is not limited to 2*2.

An image processing apparatus **120** may generate an output image **140** based on the sub images **131** to **134**. In an example, the image processing apparatus **120** may use the sub images **131** to **134** as a whole. The image processing apparatus **120** may generate an output image **140** by merging the sub images **131** to **134**. Merging may include binning-based merging and remosaic-based merging. Binning-based merging may improve sensitivity. Remosaic-based merging may improve resolution. For example, the output image **140** by remosaic-based merging may have four times the resolution of each of the sub images **131** to **134**. According to an example, the image processing apparatus **120** may partially use the sub images **131** to **134**. For example, the image processing apparatus **120** may select a sub image (e.g., the sub image **131**) of a view from the sub images **131** to **134**

of a multi-view and may generate the output image **140** from the selected sub image (e.g., the sub image **131**).

As the multi-view, the single view, binning-based merging, and remosaic-based merging, various options may exist in the process of deriving the output image **140** from the input array image **130**. The image processing apparatus **120** may process the input array image **130** with an appropriate option by considering various factors, such as user settings, a system status, and a capture status. Various options may be parameterized by setting parameters, and image processing modes may be defined based on parameter values of the setting parameters. The image processing apparatus **120** may process the input array image **130** with an image processing mode based on parameter values of setting parameters.

FIG. **1**B illustrates an example of a configuration of the imaging device, according to one or more embodiments. Referring to FIG. **1**B, the imaging device **110** may include the array lens assembly **111** and the image sensor **112**. The imaging device **110** may include a plurality of apertures **113** to **115**. The imaging device **110** may generate sub images based on the arrangement of the plurality of apertures **113** to **115**. FIG. **1**B illustrates an example of a lens arrangement in a 3*3 array type. In this example, 3*3 sub images may be obtained. However, 3*3 is only an example, and a different array type, such as 2*2 may be used. The imaging device **110** may correspond to an array lens device. An array lens technique is a technique for obtaining a plurality of small images having the same angle of view using a camera including a plurality of lenses having a short focal length. The thickness of a camera module may decrease through the array lens technique.

An array lens may be used in various technical fields. The array lens may reduce the size of a camera by dividing a large sensor and a large lens for a large sensor into an array type. For example, when the length (in other words, the height) of a first camera is L based on an assumption that an angle of view is A, a focal length is f, and an image size is D, the length of a second camera based on an assumption that an angle of view is A, a focal length is f/2, and the image size is D/2 may decrease to L/2. The resolution of the second camera may decrease to ¼ compared to the first camera. When the second camera is configured by a 2*2 lens array and one output image is generated, the resolution of the output image may be the same as the first camera. More specifically, 4 sub images may be generated by the 2*2 lens array and an image having the same resolution as the first camera may be derived by synthesizing the four sub images.

FIG. **2** illustrates an example of a change in pixel data based on image processing, according to one or more embodiments. Referring to FIG. **2**, an input array image **210** may be generated through an array lens assembly. The input array image **210** may include sub images corresponding to different views. The input array image **210** may include the sub images in the form of raw data. In the raw data, a pixel of each color channel may be arranged in a pattern based on a color filter array (CFA).

The CFA may be arranged between a lens and an image sensor, and a signal of each channel may be separated through the CFA. Hereinafter, an example that the CFA includes a Bayer pattern is described, however, different patterns other than the Bayer pattern may be used. In this example, the input array image **210** may include image data based on an R-G-G-B 2*2 Bayer pattern. As illustrated in FIG. **2**, a pixel of each channel may be represented by R_{mn}^{k}, G_{mn}^{k}, and B_{mn}^{k}. k may denote an identifier of a sub image where each pixel belongs to and m and n may denote an identifier of a location in a sub image where each pixel belongs to. In the images **210** and **220**, k=1, k=2, k=3, and k=4 may denote sub images of each view. In images **230** and **240**, k=BO may represent a binning result and k=RO may represent a remosaic result.

Result data **220** may be determined through alignment of the input array image **210**. Pixels at corresponding positions may be identified through an alignment operation. In the input array image **210**, a dashed circle may represent an aperture and a view may vary depending on the aperture. In the input array image **210**, pixels at a corresponding position may be spaced apart from each other. Such pixels may be identified through the alignment operation. For example, pixels G_{11}^{1}, G_{11}^{2}, G_{11}^{3}, and G_{11}^{4} at a corresponding position may be grouped into one group through the alignment operation. Corresponding pixels (e.g., the pixels G_{11}^{1}, G_{11}^{2}, G_{11}^{3}, and G_{11}^{4}) of the same group may be merged into one pixel (e.g., a pixel G_{11}^{BO}) of the result data **230** of a binning operation through the binning operation. Such a merging process may be referred to as binning-based merging.

Remosaic-based merging, which is distinguished from the binning-based merging, may exist. Result data **240** may be determined based on remosaic-based merging. According to an example, a temporary restored image of each view may be determined by demosaicing and upsampling a sub image of each view of the input array image **210**, and the result data **240** may be determined through merging the temporary restored image of each view. The result data **240** of the remosaic-based merging may have an enhanced resolution compared to each sub image of the input array image **210**.

In the remosaic operation, multi-view images, such as the input array image **210**, or a single view image, such as the result data **240**, may be used as an input. When multi-view images are used as inputs, the remosaic operation may be referred to as multi image super resolution (MISR). When a single view image is used as an input, a merging operation may be referred to as single image super resolution (SISR). MISR may require a merging operation of corresponding pixels of multi-view images. However, since corresponding pixels do not exist in a single view image, SISR may not require the merging operation. Although FIG. **2** illustrates an example of performing SISR from the result data **230**, SISR may be performed from a sub image of any single view of the input array image **210**.

FIG. **3** illustrates an example of a process of determining an image processing mode and a result of each image processing mode, according to one or more embodiments. Referring to FIG. **3**, various processing options of an input array image **301** may be determined and the input array image **301** may be processed based on the processing options. The processing options may be determined through setting parameters. For example, the setting parameters may include at least one of a first setting parameter indicating whether to use a multi-view or a single view, a second setting parameter indicating whether a priority is assigned to sensitivity enhancement based on pixel binning or to resolution enhancement based on pixel interpolation, and a third setting parameter indicating whether hardware (H/W) logic-based binning processing is used.

When the first setting parameter instructs to use the multi-view, image processing of the input array image **301** may be performed through any one of H/W multi spread pixel binning (SPB), software (S/W) multi SPB, and S/W multi spread pixel remosaic (SPR). When the second setting parameter instructs to use the single view, image processing of the input array image **301** may be performed through any one of H/W single SPB, S/W single SPB, and S/W single

SPR. The S/W multi SPR may be referred to as a first image processing mode or a first mode, the S/W multi SPB may be referred to as a second image processing mode or a second mode, the H/W multi SPB may be referred to as a third image processing mode or a third mode, the S/W single SPR may be referred to as a fourth image processing mode or a fourth mode, the S/W single SPB may be referred to as a fifth image processing mode or a fifth mode, and the H/W single SPB may be referred to as a sixth image processing mode or a sixth mode. In each of the image processing modes, image processing may be performed based on setting parameters of each of the image processing modes.

SP in the terms SPB and SPR may represent that corresponding pixels are dispersed. In the case of a tetra-cell, 2*2 corresponding pixels may form one pixel group. In the case of a nona-cell, 3*3 corresponding pixels may form one pixel group and in the case of a chameleon-cell, 4*4 corresponding pixels may form one pixel group. In addition, various cell types may exist. Unlike the tetra-cell, the nona-cell, and the chameleon-cell, corresponding pixels are dispersed in the input array image **301**. For binning or remosaicing the dispersed pixels, a technique that is different from binning and remosaicing of neighboring pixels, such as the nona-cell, may be applied.

Through operations **310**, **321**, **331**, **341**, and **351**, a parameter value and an image processing mode may be determined. In operation **310**, whether a multi-view is used may be determined. Through operation **310**, the first setting parameter indicating whether to use a multi-view or a single view may be determined. When a parameter value of the first setting parameter is set to use the multi-view, operation **321** may be performed. The multi-view may help improve image quality, however, power consumption may increase while processing the multi-view. When there is a demand for low power, a single view may be used. For example, based on user settings or system requirements, the demand for low power may arise. For example, a user who desires to minimize power consumption and use a battery for a long time may reflect the demand for low power in the system setting. For example, when management of power consumption is required, such as when a battery level drops below a threshold, the system may generate the demand for low power.

In operation **321**, whether H/W binning is used may be determined. Through operation **321**, the third setting parameter indicating whether H/W logic-based binning processing is used may be determined. H/W logic-based binning processing may be used based on a lighting state or a video capture state. For example when the input array image **301** is captured in a low-illuminance environment or the input array image **301** corresponds to a video frame based on video capturing, the third setting parameter may be determined to use H/W logic-based binning processing. H/W logic-based binning processing may be performed through a H/W logic. The H/W logic may be configured to perform a binning operation in a relatively lightweight manner.

When a parameter value of the third setting parameter is set to use the H/W logic, operation **322** may be performed. In operation **322**, H/W multi SPB may be performed based on the third image processing mode. S/W image enhancement of operation **323** may be performed, as necessary. Result data **303** may be generated based on image processing of the third image processing mode. Post-processing may be applied to the result data **303**, as necessary. As a result of post-processing, an output image based on the result data **303** may be determined. When a parameter value of the third setting parameter is set to not use the H/W logic, operation **331** may be performed.

In operation **331**, whether a priority is assigned to sensitivity or resolution may be determined. Through operation **331**, the second setting parameter indicating whether the priority is assigned to sensitivity enhancement based on pixel binning or to resolution enhancement based on pixel interpolation may be determined. When the priority is assigned to the sensitivity, sensitivity enhancement using pixel binning may be performed. In this case, pixel binning may be performed based on S/W and may be distinguished from H/W-based binning processing. The priority may be determined based on user settings or system requirements. For example, when a user prefers an image with low noise, the user may assign the priority to sensitivity through user settings and when a user prefers a high-resolution image, the user may assign the priority to resolution through user settings. For example, the user settings may be controlled through a capture option. For example, the system may adjust the priority based on a lighting state. For example, the system may assign the priority to resolution in an environment with sufficient light and may assign the priority to sensitivity in an environment with insufficient light.

When the priority is assigned to sensitivity, S/W multi SPB based on the second image processing mode may be performed in operation **332**. S/W multi SPB may more delicately perform binning compared to H/W multi SPB. For example, a delicate operation may be applied to a process of calculating corresponding pixels, a filtering process, and the like. Result data **304** may be generated based on image processing of the second image processing mode. Post-processing may be applied to the result data **304** as necessary and an output image based on the result data **304** may be determined. When the priority is assigned to resolution, S/W multi SPR may be performed based on the first image processing mode in operation **333**. Result data **305** may be generated based on image processing of the first image processing mode. Post-processing may be applied to the result data **305** as necessary and an output image based on the result data **305** may be determined. Resolution enhancement may be performed through upsampling or super resolution (SR) of S/W multi SPR. The result data **305** may have a higher resolution than the result data **303** and the result data **304**. For example, the resolution of the result data **305** may be enhanced by four times.

When a parameter value of the first setting parameter is set to use a single view, operation **341** may be performed. A single view image **302** to be used for generating an output image may be selected from the input array image **301**. The single view image **302** may correspond to a sub image of a single view among multi-view sub images of the input array image **301**. For example, the single view image **302** may be selected based on a user selection, random selection, image quality, and the like. For example, a sub image of a view having the smallest defect or distortion may be selected to be the single view image **302**.

In operation **341**, whether H/W binning is used may be determined. Through operation **341**, the third setting parameter indicating whether H/W logic-based binning processing is used may be determined. H/W logic-based binning processing may be used based on a lighting state or a video capture state. H/W logic-based binning processing may be performed through a H/W logic. The H/W logic may be configured to perform a binning operation in a relatively lightweight manner.

When a parameter value of the third setting parameter is set to use the H/W logic, operation **342** may be performed.

In operation **342**, H/W single SPB may be performed based on the sixth image processing mode. Different H/W logics may be used for H/W multi SPB and H/W single SPB. For example, a H/W logic of H/W multi SPB may search for corresponding pixels from multi-view sub images of the input array image **301** and may perform binning of the corresponding pixels. For example, the H/W logic of H/W single SPB may perform filtering (e.g., self bilateral filtering) on the single view image **302**. S/W image enhancement of operation **343** may be performed, as necessary. Result data **306** may be generated based on image processing of the fourth image processing mode. Post-processing may be applied to the result data **306**, as necessary. As a result of post-processing, an output image based on the result data **306** may be determined.

When a parameter value of the third setting parameter is set to not use the H/W logic, operation **351** may be performed. In operation **351**, whether a priority is assigned to sensitivity or resolution may be determined. Through operation **351**, the second setting parameter indicating whether the priority is assigned to sensitivity enhancement based on pixel binning or to resolution enhancement based on pixel interpolation may be determined. When the priority is assigned to the sensitivity, sensitivity enhancement using S/W-based pixel binning may be performed.

When the priority is assigned to sensitivity, S/W single SPB based on the fifth image processing mode may be performed in operation **342**. S/W single SPB may more delicately perform binning compared to H/W single SPB. For example, demosaicing based on region of interest (ROI) detection may be added. Result data **307** may be generated through the fifth image processing mode. Post-processing may be applied to the result data **307** as necessary, and an output image based on the result data **307** may be determined. When the priority is assigned to resolution, S/W single SPR may be performed based on the fourth image processing mode in operation **353**. Result data **308** may be generated through the fourth image processing mode. Post-processing may be applied to the result data **308** as necessary, and an output image based on the result data **308** may be determined. Resolution enhancement may be achieved through upsampling or SR of S/W single SPR. The result data **308** may have a higher resolution than the result data **306** and the result data **307**. For example, the resolution of the result data **308** may be enhanced by four times. The result data **308** may have the same resolution as the result data **305**.

A processing procedure of the first image processing mode may include a plurality of sub stages. For example, the sub stages may include a first sub stage for performing demosaicing on raw data, a second sub stage for performing upsampling for resolution enhancement, a third sub stage for generating matching information of the multi-view, and a fourth sub stage for generating a synthesized image using the matching information. Each processing procedure of the second image processing mode, the fourth image processing mode, and the fifth image processing mode may include some of the sub stages. For example, in the processing procedure of the second image processing mode, the first sub stage and the sub second stage may be excluded. For example, in the processing procedure of the fourth image processing mode, the third sub stage and the fourth sub stage may be excluded. For example, in the processing procedure of the fifth image processing mode, the second sub stage, third sub stage, and the fourth sub stage may be excluded.

FIG. **4** illustrates an example of an image processing process of multi SPR, according to one or more embodiments. Referring to FIG. **4**, in operation **410**, a reference view may be selected from views of raw data **401**. In operation **420**, demosaicing based on the raw data **401** may be performed and in operation **430**, upsampling and sharpening based on result data of demosaicing may be performed. A temporary restored image **403** may be determined based on upsampling and sharpening. Based on upsampling, each image may be enlarged by 4 times (horizontally 2 times and vertically 2 times). Operations **420** and **430** may be performed on each view.

In operation **440**, alignment based on the reference view may be performed. Alignment may be performed based on an optical flow using a neural network model. The optical flow may correspond to a dense optical flow. In operation **450**, alignment refinement may be performed. The optical flow may be refined through alignment refinement. In operation **460**, a pixel distance of corresponding pixels may be compared to a threshold. Based on the comparison result, a refinement target having a pixel distance greater than the threshold may be selected from the corresponding pixels, in operation **470**, a local search for geometric consistency refinement for the refinement target may be performed, and in operation **471**, a new pixel of the refinement target may be verified through reprojection. A calibration parameter **402** may be used for reprojection. The geometric consistency refinement may not require iterative image rectification for depth estimation of each array lens camera. Accordingly, explicit geometric warping and correction may be omitted. When pixel distances of all corresponding pixels are less than the threshold, alignment refinement may be finished and matching information **404** may be determined.

In operation **480**, a synthesis of the temporary restored image **403** may be performed based on the matching information **404** and the weight data **405**. The synthesis may be performed through pixel fusion between each pixel of the reference view of the temporary restored image **403** and corresponding pixels of the other views. As a result of the synthesis, a single image **406** may be generated. In operation **490**, post-processing, such as deblurring, may be performed on the single image **406**. Deblurring may include optical blur kernel estimation and blur estimation. A neural network model may be used for deblurring. Based on the post-processing, an output image **407** may be determined. The output image **407** may correspond to an RGB or a Bayer.

FIG. **5**A illustrates an example of a demosaicing operation based on ROI detection, according to one or more embodiments. Referring to FIG. **5**A, temporary G channel data **502** may be determined based on raw data **501** through operations **510** to **540**. In operation **510**, a gradient may be determined based on the raw data **501**. G channel pixels may be extracted from the raw data **501** and for an empty space between the G channel pixels (in other words, a space where R channel pixels and B channel pixels exist in the raw data **501**), a gradient in the vertical direction and a gradient in the horizontal direction may be determined.

In operation **520**, gradient-based interpolation may be performed. Interpolation may be performed in a smaller direction of the gradient in the vertical direction and the gradient in the horizontal direction. A gradient value in each direction and an interpolation value of a target pixel may be calculated in various ways. For example, when values of 3*3 grid cells are defined as C_{11} to C_{33}, a gradient value V in the vertical direction of C_{22} may be determined through C_{12} to C_{32} and a gradient value H in the horizontal direction of C_{22} may be determined through C_{21} to C_{23}. When V is greater than H, it may be determined that C_{22}=H/2. When V is less

than H, it may be determined that C_{22}=V/2. However, various interpolation methods may exist.

In operation **530**, edge information may be determined and in operation **540**, image refinement may be performed. Operations **530** and **540** may apply to G channel data and the temporary G channel data **502** may be determined through operations **530** and **540**. The edge information may include the gradient value and a Laplacian value. The gradient value may be a primary derivative value determined based on a neighboring pixel value of operation **520** and the Laplacian value may be a secondary derivative value determined based on a neighboring pixel value of a neighboring pixel. Since there is no original G channel information in a space two pixels apart from a space between the original G channel pixels (in other words, a space where the R channel pixels and the B channel pixels exist in the raw data **501**), R channel information or B channel information may be used as the original G channel information when obtaining the Laplacian value. For example, image refinement may include interpolation in a diagonal direction using edge information in the diagonal direction. In this example, interpolation may represent refinement through interpolation.

When the temporary G channel data **502** is determined, final color data **503** may be determined through operations **550** to **590**. The final color data **503** may include final R channel data, final G channel data, and final B channel data.

In operation **550**, an ROI may be set. The ROI may be set in the temporary G channel data **502**. The ROI may include an interference region where an artifact may highly occur, such as a Moire region. The ROI may be set based on pixels in which a G channel signal is dominant among the R channel signal, G channel signal, and B channel signal. Whether the G channel signal is dominant may be determined based on a difference between a first gradient value of a predetermined pixel location of the temporary G channel data **502** and a second gradient value of a corresponding pixel location of the raw data **501**. For example, when the difference is less than a threshold, it may be determined that the G channel signal is dominant at the corresponding pixel location. For example, it may be assumed that the raw data **501** belongs to a first sub image of the sub images. A first gradient value based on an interpolation result using a G channel signal around a first pixel of the first sub image and a second gradient value based on an R channel signal and a B channel signal around the first pixel may be determined. In this example, the interpolation result using a G channel signal may represent the temporary G channel data **502**. When a difference between the first gradient value and the second gradient value is less than a threshold, the ROI may be set based on the first pixel.

In operation **560**, interpolation based on interference recognition on the temporary G channel data **502** may be performed. Interpolation based on interference recognition may include forward interpolation and cross interpolation. The forward interpolation may be interpolation in the smaller gradient direction, as described in operation **520**. The cross interpolation may be interpolation in the vertical direction with respect to the forward interpolation. In other words, the cross interpolation may be interpolation in the greater gradient direction. For example, in the example of the 3*3 grid described above, it may be determined that when V>H, C_{22}=V/2 and when V<H, C_{22}=H/2. In this example, interpolation may represent refinement through interpolation. Such interpolation may suppress an artifact while maintaining an edge of an ROI, such as a Moire region. A result of operation **560** may correspond to final G channel data.

In operation **570**, R-G channel data and B-G channel data may be determined through chroma conversion. According to an example, operation **570** may be performed before operation **560** or operation **550**. The R-G channel data may be determined by subtracting each pixel value of final R channel data from each pixel value of R channel data extracted from the raw data **501**. The B-G channel data may be determined by subtracting each pixel value of final R channel data from each pixel value of R channel data extracted from the raw data **501**.

In operation **580**, interpolation may be performed on the R-G channel data and the B-G channel data. Interpolation of operation **580** may correspond to interpolation of operations **510** and **520**. For the R-G channel data, interpolation in the smaller gradient direction may be performed on pixels other than R-G pixels and for the B-G channel data, interpolation in the smaller gradient direction may be performed on pixels other than B-G pixels. Then, temporary R channel data and temporary B channel data may be determined by adding final R channel data to the R-G channel data and the B-G channel data. The final R channel data and final B channel data may be determined by applying image refinement of operation **590** to the temporary R channel data and the temporary B channel data. The final color data **503** including the final R channel data, the final G channel data, and the final B channel data may correspond to a demosaicing result.

FIG. **5**B illustrates an example of an operation of determining a gradient value, according to one or more embodiments. Referring to FIG. **5**B, G channel data **563** may be extracted from raw data **561** including an R channel signal, a G channel signal, and a B channel signal. Temporary G channel data **564** may be determined through gradient-based interpolation (e.g., interpolation of operation **520** of FIG. **5**A) on the G channel data **563**. In the temporary G channel data **564**, a symbol * may be displayed on a pixel generated by interpolation. A first pixel **562** of the raw data **561** may exist at the same location as a second pixel **465** of the temporary G channel data **564**. The location may be referred to as a target pixel location.

Whether the target pixel location is included in the ROI may be determined through a comparison between a first gradient value based on interpolation using the temporary G channel data **564** and a second gradient value based on interpolation using the raw data **561**. The first gradient value may be determined based on a gradient in the vertical direction using *G1 and *G4 of the temporary G channel data **564** and a gradient in the horizontal direction using *G2 and *G3. For example, a sum of absolute values of two gradient values may be determined to be the first gradient value. The second gradient value may be determined based on a gradient in the vertical direction using B1 and B2 of the raw data **561** and a gradient in the horizontal direction using R1 and R2. For example, a sum of absolute values of two gradient values may be determined to be the second gradient value. When the difference between the first gradient value and the second gradient value is less than a threshold, the ROI may be set such that a target location of a second pixel **465** is included in the ROI. By the same way, it may be determined whether other pixels of the temporary G channel data **564** are included in the ROI.

The example of using the R-G-G-B Bayer pattern as the CFA is described with reference to FIGS. **5**A and **5**B. According to an example, a different pattern may be used as a CFA. For example, instead of an R-G-G-B arrangement, a

different pattern arranged in a first channel signal-a second channel signal-the second channel signal-a third channel signal may be used. In this example, the order of channel signals may correspond to the upper left, upper right, lower left, and lower right of a 2*2 array of the CFA, respectively, For example, an R-C-C-B arrangement, a Cy-Y-Y-M arrangement, and a Cy-Y-Y-R arrangement may be used. In this example, C may denote a clear (C) channel signal, Cy may denote a cyan (Cy) channel signal, Y may denote a yellow (Y) channel signal, and M may denote a magenta (M) channel signal. The second channel signal, which is a dominant color, may be used as G channel data in the Bayer pattern example. For example, when using an R-C-C-B pattern instead of the Bayer pattern, temporary C channel data may be generated in response to a C channel signal and final C channel data may be determined through interference recognition interpolation based on the temporary C channel data. Then, final R channel data and final B channel data may be determined through interpolation on R-C channel data and B-C channel data. Demosaicing in a similar manner may apply to other patterns.

FIG. **6** illustrates an example of a matching information refinement operation using an optical flow, according to one or more embodiments. Referring to FIG. **6**, in operation **610**, an optical flow may be estimated using a neural network model. The optical view may include matching information based on a view difference between sub images of pixels. The optical flow may represent a difference between pixel locations based on a view difference rather than a difference between pixel locations based on a movement over time. In operation **620**, pixel-to-pixel matching may be performed based on the matching information. In operation **630**, a pixel distance based on the matching result may be compared to a threshold. The pixel distance may represent a distance between corresponding pixels. When a pixel distance of corresponding pixels is greater than the threshold, the corresponding pixels may be extracted as a refinement target and geometric consistency refinement **640** may be applied to the corresponding pixels.

The geometric consistency refinement **640** may include operations **641** to **645**. Hereinafter, an example of the geometric consistency refinement **640** on a first refinement target including a first pixel of a first temporary restored image and a second pixel of a second temporary restored image is described.

In operation **641**, undistortion may be performed on the first pixel. In operation **642**, an undistortion result may be unprojected to the real world. The undistortion and unprojection may be performed based on a first calibration parameter. For example, undistortion may be based on a first intrinsic parameter and unprojection may be based on a first extrinsic parameter (e.g., a rotation parameter and a translation parameter). Through operations **641** and **642**, a corresponding pixel of the real world corresponding to the first pixel of the first temporary restored image may be determined.

In operation **643**, the corresponding pixel may be reprojected to a different view. In operation **644**, distortion may be performed on a reprojection result. The reprojection and distortion may be based on a second calibration parameter. For example, reprojection may be based on a second extrinsic parameter (e.g., a rotation parameter and a translation parameter) and distortion may be based on a second intrinsic parameter. Through operations **643** and **644**, a temporary pixel of the second temporary restored image corresponding to a corresponding pixel of the real world may be determined.

In operation **645**, a local search may be performed based on a location of the temporary pixel in the second temporary restored image. The matching information may be refined by replacing at least some of target pixels included in the refinement targets based on the local search. Through the local search, for a predetermined range, a search in a predetermined manner may be performed. A new second pixel of the second temporary restored image may be determined through the local search. A matching target of the first pixel of the first refinement target may be updated to the new second pixel.

An array lens camera may be divided into sub camera elements based on involvement of generation of sub images. A calibration parameter may have a different parameter value for a different sub camera element. For example, when a first sub image is generated through a first lens assembly of an array lens assembly and a second sub image is generated through a second lens assembly of the array lens assembly, the first lens assembly and the second lens assembly may be different sub camera elements and different parameter values thereof may be derived. In the example described above, when the first temporary restored image is based on the first sub image, the first calibration parameter, the first intrinsic parameter, and the first extrinsic parameter may be derived for the first lens assembly. When the second temporary restored image is based on the second sub image, the second calibration parameter, the second intrinsic parameter, and the second extrinsic parameter may be derived for the second lens assembly.

When the geometric consistency refinement **640** is finished, operation **620** may be performed again. The pixel matching of operation **620** and the geometric consistency refinement **640** may be repeated until pixel distances of all corresponding pixels decrease to be less than a threshold. When the pixel distances of all corresponding pixels are less than the threshold, a refined optical flow may be determined in operation **650**. In this example, refinement may represent the geometric consistency refinement **640**. In operation **660**, corresponding pixels based on the refined optical flow may be registered and in operation **670**, pixel merging may be performed.

Any one of views of sub images may be designated as a reference view. Among temporary restored images, a temporary restored image having the reference view may be referred to as a reference image. The temporary restored images may be merged based on the reference image. Each pixel of an output image may be determined based on a weighted sum of each pixel of the other images of the temporary restored images and corresponding pixels of the remaining images of the temporary restored images. The matching information may be determined by refined matching information. For example, a weighted sum of a first pixel of the reference image and a second pixel of the other image may be determined based on at least one of a first weight based on a difference between an intensity of the first pixel and an intensity of the second pixel, a second weight based on a pixel distance between the first pixel and the second pixel, and a third weight based on whether the first pixel and the second pixel correspond to raw data.

The weighted sum may be performed based on bilateral filtering. Bilateral filtering may include self bilateral filtering and cross bilateral filtering. According to an example, pixel merging may be performed through self bilateral filtering and/or cross bilateral filtering. Based on self bilateral filtering, in one view, a pixel may be merged with surrounding pixels. Self bilateral filtering may be performed through Equations 1 to 4 shown below. Equation 1 shown below may

represent a weight based on a pixel intensity difference of the reference view. The pixel intensity may represent a pixel value.

$$w^1_{pq_22} = \exp\left(-\frac{(G^1_{pq} - G^1_{22})^2}{\sigma^2}\right) \quad \text{[Equation 1]}$$

In Equation 1, $w_{pq_22}{}^1$ may denote a weight based on a pixel intensity difference between $G_{pq}{}^1$ and $G_{22}{}^1$, $G_{22}{}^1$ may denote a pixel intensity of a center pixel, $G_{pq}{}^1$ may denote a pixel intensity of a neighboring pixel of $G_{22}{}^1$, and σ may denote a standard deviation. As illustrated in FIG. **9**, p and q may have values of 1 to 3, respectively. $G_{pq}{}^1$ may include $G_{22}{}^1$. According to Equation 1, as the pixel intensity difference decreases, the weight may increase.

Equation 2 shown below may represent a weight based on a pixel distance of the reference view.

$$w^1_{d_22} = \exp\left(-\frac{D(G^1_{pq} - G^1_{22})^2}{\sigma^2}\right) \quad \text{[Equation 2]}$$

In Equation 2, $w_{d_22}{}^1$ may denote a weight based on a distance between $G_{22}{}^1$ and $G_{pq}{}^1$, $D(G_{pq}{}^1–G_{22}{}^1)$ may denote a distance between $G_{pq}{}^1$ and $G_{22}{}^1$, and σ may denote a standard deviation. According to Equation 2, as the distance decreases, the weight may increase.

Equation 3 shown below may represent a fusion weight based on a pixel distance and a difference of pixel intensities of the reference view.

$$w_{pq_d}{}^1 = w_{pq_22}{}^1 * w_{d_22}{}^1 \quad \text{[Equation 3]}$$

In Equation 3, $w_{pq_d}{}^1$ may denote a fusion weight. A neighboring pixel may be selected by (p, q).

Equation 4 shown below may represent a pixel merging result of the reference view based on the fusion weight of the reference view.

$$G^1_{22} = \frac{\sum_{p,q} G^1_{p,q} * w^1_{pq_d}}{\sum_{p,q} w^1_{pq_d}} \quad \text{[Equation 4]}$$

In Equation 4, $G_{22}{}^1$ may denote a merged pixel value of the reference view, $G_{p.q}{}^1$ may denote a pixel of the reference view selected by (p, q), and $w_{pq_d}{}^1$ may denote a fusion weight of the selected pixel. p and q may have values of 1 to 3, respectively. Through transformation of Equations 1 to 4, a weight and a pixel merging result of other views may be determined.

Based on cross bilateral filtering, each pixel of a predetermined view and a corresponding pixel of a different view may be merged. The corresponding pixel may be determined through matching information. Referring to FIG. **9**, G channel data of a temporary restored image of the reference view may be converted into G channel data of an observation grid through the matching information. For example, the reference view may correspond to a first view of a first sub image and the observation grid may correspond to a second view of a second sub image. A pixel (x, y) of the G channel data of the reference view may be converted into a pixel (x+δx, y+δy) of the G channel data of the observation grid through matching information of (δx, δy).

When δx or δy is not an integer, the pixel (x+δx, y+δy) may not match with predetermined coordinates. According to examples, cross bilateral filtering may be performed while assuming a target grid based on integers δx and δy and a difference between the target grid and the observation grid may be covered through interpolation using a weight. Such cross bilateral filtering may be performed through Equations 5 to 8 shown below. Equation 5 shown below may represent a weight based on a pixel intensity difference of the reference view and a second view of the observation grid.

$$w^{1_2}_{i_22} = \exp\left(-\frac{(G^2_{22} - G^1_{22})^2}{\sigma^2}\right) \quad \text{[Equation 5]}$$

In Equation 1, $w_{i_22}{}^{1_2}$ may denote a weight based on a pixel intensity difference between $G_{22}{}^2$ and $G_{22}{}^1$, $G_{22}{}^1$ may denote a pixel intensity of a predetermined pixel of the reference view, $G_{22}{}^2$ may denote a pixel intensity of a corresponding pixel of the second view, and **6** may denote a standard deviation. The corresponding pixel may be determined through matching information. According to Equation 5, as the pixel intensity difference decreases, the weight may increase.

Equation 6 shown below may represent a weight based on a pixel distance of the second view of the observation grid and the reference view.

$$w^{1_2}_{d_22} = \exp\left(-\frac{D(G^2_{22} - G^1_{22})^2}{\sigma^2}\right) \quad \text{[Equation 6]}$$

In Equation 6, $w_{d_22}{}^{1_2}$ may denote a weight based on a distance between $G_{22}{}^2$ and $G_{22}{}^1$, $D(G_{22}{}^2–G_{22}{}^1)$ may denote a distance between $G_{22}{}^2$ and $G_{22}{}^1$, and σ may denote a standard deviation. In cross bilateral filtering, a function D may output a value close to "0" as a distance value decreases and the distance value is close to an integer value obtained by rounding down the distance value. According to Equation 6, as the distance decreases and the distance is close to an integer, the weight may increase.

Equation 7 shown below may represent a fusion weight based on a pixel distance and a pixel intensity difference of the second view of the observation grid and the reference view.

$$w_{i_d}{}^{1_2} = w_{i_22}{}^{1_2} * w_{d_22}{}^{1_2} \quad \text{[Equation 7]}$$

In Equation 7, $w_{i_d}{}^{1_2}$ may denote a fusion weight.

Equation 8 shown below may represent a pixel merging result of the reference view based on the fusion weight.

$$G^{1_final}_{22} = \frac{\sum_i G^1_i \cdot w^{1_i}_{i_d}}{\sum_i w^{1_i}_{i_d}} \quad \text{[Equation 8]}$$

In Equation 4, $G_{22}{}^{1_final}$ may denote a merged pixel value of the reference view, $G_i{}^1$ may denote a pixel of each view selected by i, and $w_{i_d}{}^{1_i}$ may denote a fusion weight of the selected pixel. i may denote an identifier of a view. For example, in the case of four sub images, i may have a value of 1 to 4. A fusion weight associated with a third view and a fourth view may be obtained by transforming Equations 5 to 7.

According to examples, a high weight may be assigned to pixels having the originality. Equations 9 to 11 shown below may represent fusion weights based on a relationship between the reference view and the other views.

$$w_{i_d}^{1_2}=w_{i_22}^{1_2}*w_{d_22}^{1_2} \quad \text{[Equation 9]}$$

$$w_{i_d}^{1_3}=w_{i_22}^{1_3}*w_{d_22}^{1_3} \quad \text{[Equation 10]}$$

$$w_{i_d}^{1_4}=w_{i_22}^{1_4}*w_{d_22}^{1_4} \quad \text{[Equation 11]}$$

Equation 12 shown below may represent a new fusion weight additionally considering originality to the existing fusion weights of Equations 9 to 11.

$$w_{i_d}^{1_final}=\Sigma_i w_{i_d}^{1_i}*w_o^i \quad \text{[Equation 12]}$$

In Equation 12, $w_{i_d}^{1_final}$ may denote a new fusion weight and w_o^i may denote a originality weight. w_o^i may represent a higher weight in case where a target pixel has originality compared to a case where the target pixel does not have originality. When $w_{i_d}^{1_final}$ applies to Equation 8 shown above, pixel merging based on the first weight based on the pixel intensity difference, the second weight based on the pixel distance, and the third weight based on the originality may be performed.

FIG. **7** illustrates an example of an image processing process of single SPR, according to one or more embodiments. Referring to FIG. **7**, in operation **710**, a reference view may be selected from views of raw data **701**. For example, the single view image may be selected based on user selection, random selection, image quality, and the like. For example, a sub image of a view having the smallest defect or distortion may be selected to be the single view image. In operation **720**, demosaicing based on the single view image may be performed and in operation **730**, upsampling and sharpening based on result data of demosaicing may be performed. A temporary restored image **702** may be determined based on upsampling and sharpening. The size of the temporary restored image **702** may be 4 times (2 times horizontally and 2 times vertically) greater than the single view image.

In operation **740**, filtering of the temporary restored image **702** may be performed based on weight data **703**. For example, self bilateral filtering may be performed. The weight data **703** may assign a high weight to pixels having originality. In operation **750**, post-processing, such as deblurring, may be performed on the filtering result. Based on the post-processing, an output image **704** may be determined. The output image **704** may correspond to an RGB or a Bayer.

FIG. **8** illustrates an example of an image processing process of multi SPR, according to one or more embodiments. Referring to FIG. **8**, in operation **810**, a reference view may be selected from views of raw data **801**. In operation **840**, alignment based on the reference view may be performed. In operation **850**, alignment refinement may be performed. The optical flow may be refined through alignment refinement. In operation **860**, a pixel distance of corresponding pixels may be compared to a threshold. Based on the comparison result, a refinement target having a pixel distance greater than the threshold may be selected from the corresponding pixels, in operation **870**, a local search for geometric consistency refinement for the refinement target may be performed, and in operation **871**, a new pixel of the refinement target may be verified through reprojection. A calibration parameter **802** may be used for reprojection. When pixel distances of all corresponding pixels are less than the threshold, alignment refinement may be finished and matching information **804** may be determined.

In operation **880**, a synthesis of sub images of the input array image corresponding to the raw data **801** may be performed based on the matching information **804** and the weight data **805**. The synthesis may be performed based on a color version of the sub images. The color version may be derived through a general demosaicing operation. The synthesis may be performed through pixel fusion between each pixel of the reference view of the sub images and corresponding pixels of the other views. As a result of the synthesis, a single image **806** may be generated. In operation **890**, post-processing, such as deblurring, may be performed on the single image **806**. Based on the post-processing, an output image **807** may be determined. The output image **807** may correspond to an RGB or a Bayer.

FIG. **9** illustrates an example of an image processing process of single spread pixel binning (SPB), according to one or more embodiments. Referring to FIG. **9**, in operation **910**, a single view may be selected from views of raw data **901**. In operation **920**, demosaicing may be performed based on the single view image and in operation **930**, filtering may be performed on a result of demosaicing based on weight data **902**. For example, self bilateral filtering may be performed. The weight data **902** may assign a high weight to pixels having originality. The output image **903** may correspond to an RGB or a Bayer.

FIG. **10** illustrates an example of an image processing process of H/W logic-based SPB, according to one or more embodiments. Referring to FIG. **10**, in operation **1010**, a reference view may be selected from views of raw data **1001**. Based on focal plane information of an input array image and a calibration parameter of an imaging device, initial corresponding pixels between sub images respectively corresponding to different views in the input array image corresponding to the raw data **1001** may be determined. The calibration parameter may include an extrinsic parameter and an intrinsic parameter of the imaging device. The extrinsic parameter may include information of a relationship between individual lens assemblies. Through operations **1020** and **1030**, the initial corresponding pixels may be verified. In operation **1020**, a local window search may be performed and in operation **1030**, verification through reprojection may be performed. Through operations **1020** and **1030**, final corresponding pixels may be determined. The output image **1004** may be determined through synthesis of the final corresponding pixels in operation **1040**. The synthesis may include a weighted average of the final corresponding pixels. The output image **1004** may correspond to a binning result.

FIG. **11**A illustrates an example of a binning operation of H/W logic-based SPB, according to one or more embodiments. Referring to FIG. **11**A, a reference view may be selected from sub images **1101** to **1104**. For example, a first view of the first sub image **1101** may be selected to be the reference view. In operation **1110**, initial corresponding pixels between sub images **1101** to **1104** may be calculated based on focal plane information of an input array image corresponding to the sub images **1101** to **1104** and a calibration parameter of an imaging device that generated the input array image.

In operation **1120**, recalculation of the corresponding pixels may be performed. Among corresponding pixels, a pixel having an intensity difference greater than or equal to a threshold may be extracted as a refinement target. A new corresponding pixel for the refinement target may be determined using the calibration parameter. For example, when a

first corresponding pair includes a first pixel of the first sub image **1101** and a second pixel of the second sub image **1102** and an intensity difference between the first pixel and the second pixel is greater than or equal to a threshold, the first corresponding pair may be extracted as the refinement target. A third pixel in the second sub image **1102** may be selected by performing reprojection on the first pixel by using the calibration parameter. In this case, geometric consistency refinement **640** of FIG. **6** may be applied to reprojection. The third pixel may be determined to be a new corresponding pixel of the first pixel. To reduce computations, operation **1120** may be performed on some channels (e.g., a Gr channel), and operation **1130** may be performed on all channels (e.g., a Gr channel, an R channel, a B channel, and a Gb channel).

Based on final corresponding pairs including a corresponding pair of the first pixel and the third pixel, filtering of operation **1130** may be performed. The filtering may include a weighted average. For example, through a weighted average of the corresponding pixels (e.g., pixels G_{11}^{1}, G_{11}^{2}, G_{11}^{3}, and G_{11}^{4}), each pixel (e.g., a pixel G_{11}^{BO}) of a binning result **1105** may be determined. An intensity difference and/or a distance difference between the corresponding pixels may be used as a weight. A H/W logic that performs operations **1110**, **1120**, and **1130** may be implemented. Through the H/W logic, H/W SPB (e.g., H/W multi SPB) may be performed.

FIG. **11**B illustrates an example of a searching operation of corresponding pixels, according to one or more embodiments. Referring to FIG. **11**B, a first pixel **1141** of a first sub image **1106** of a first view and a second pixel **1142** of a second sub image **1108** of a second view may be determined to be an initial corresponding pixel. Due to an intensity difference between the first pixel **1141** and the second pixel **1142**, a corresponding pair of the first pixel **1141** and the second pixel **1142** may be selected to be a refinement target. A third pixel **1143** may be selected to be a new corresponding pixel through recalculation for the refinement target. Through a local search using a local window **1107**, the third pixel **1143** may be found.

According to an example, binning of H/W logic-based SPB may be performed through Equation 13 shown below.

$$Gr_{spb} = \frac{\sum_{i=0}^{3} Gr_i \cdot w_i}{\sum_{i=0}^{3} w_i} \quad \text{[Equation 13]}$$

In Equation 13, Gr_{spb} may denote a pixel of a binning result, Gr_i may denote a pixel of a sub image that is a binning target, and w_i may denote a weight. In an example, the weight may be expressed as shown in Equation 14 below.

$$w_i = \exp\left(-\frac{(Gr_i - Gr_0)^2}{\sigma^2}\right) \quad \text{[Equation 14]}$$

In Equation 14, Gr_0 may denote a pixel of a reference view and Gr_i may denote a pixel of the remaining view. Although Equation 14 shows an example of a weight based on a pixel intensity, a different weight, such as pixel distance, may be used.

FIG. **12** illustrates an example of a configuration of an image processing apparatus, according to one or more embodiments. Referring to FIG. **12**, an image processing apparatus **1200** may include a processor **1210** and a memory **1220**. The memory **1220** is connected to the processor **1210** and may store instructions executable by the processor **1210**, data to be operated by the processor **1210**, or data processed by the processor **1210**. The memory **1220** may include a non-transitory computer-readable medium (for example, a high-speed random access memory) and/or a non-volatile computer-readable medium (for example, at least one disk storage device, a flash memory device, or another non-volatile solid-state memory device).

The processor **1210** may execute instructions to perform the operations described herein with reference to FIGS. **1** to **11**, FIG. **13**, and FIG. **14**. For example, based on an imaging device configured to generate an input array image of a multi-view through an array lens, the processor **1210** may determine a first setting parameter based on whether to use a multi-view or a single view selected from the multi-view, may determine a second setting parameter based on whether a priority is assigned to sensitivity enhancement based on pixel binning or to resolution enhancement based on pixel interpolation, may determine an image processing mode based on the first setting parameter and the second setting parameter, and may generate an output image by performing image processing on the input array image based on a processing procedure based on the image processing mode. In addition, the description provided with reference to FIGS. **1** to **11**, FIG. **13**, and FIG. **14** may apply to the image processing apparatus **1200**.

FIG. **13** illustrates an example of a configuration of an electronic device, according to one or more embodiments. Referring to FIG. **13**, an electronic device **1300** may include a processor **1310**, a memory **1320**, a camera **1330**, a storage device **1340**, an input device **1350**, an output device **1360**, and a network interface **1370** that may communicate with each other via a communication bus **1380**. For example, the electronic apparatus **1300** may be implemented as at least a portion of, for example, a mobile device such as a mobile phone, a smartphone, a personal digital assistant (PDA), a netbook, a tablet computer, a laptop computer, and the like, a wearable device such as a smart watch, a smart band, smart glasses, and the like, a home appliance such as a television (TV), a smart TV, a refrigerator, and the like, a security device such as a door lock and the like, and a vehicle such as an autonomous vehicle, a smart vehicle, and the like. The electronic device **1300** may structurally and/or functionally include at least a portion of the imaging device **110** of FIGS. **1**A and **1**B, the image processing apparatus **120** of FIG. **1**A, and the image processing apparatus **1200** of FIG. **12**.

The processor **1310** executes functions and instructions for execution in the electronic device **1300**. For example, the processor **1310** may process instructions stored in the memory **1320** or the storage device **1340**. The processor **1310** may perform operations of FIGS. **1** to **12** and FIG. **14**. The memory **1320** may include a computer-readable storage medium or a computer-readable storage device. The memory **1320** may store instructions to be executed by the processor **1310** and may store related information while software and/or an application is executed by the electronic device **1300**.

The camera **1330** may capture a photo and/or a video. The camera **1330** may include an array lens assembly. For example, the camera **1330** may include the imaging device **110** of FIGS. **1**A and **1**B. The storage device **1340** may include a computer-readable storage medium or a computer-readable storage device. The storage device **1340** may store more information than the memory **1320** for a long time. For example, the storage device **1340** may include a magnetic

hard disk, an optical disc, a flash memory, a floppy disk, or other types of non-volatile memory known in the art.

The input device **1350** may receive an input from the user in traditional input manners through a keyboard and a mouse and in new input manners such as a touch input, a voice input, and an image input. For example, the input device **1350** may include a keyboard, a mouse, a touch screen, a microphone, or any other device that detects the input from the user and transmits the detected input to the electronic device **1300**. The output device **1360** may provide an output of the electronic device **1300** to the user through a visual, auditory, or haptic channel. The output device **1360** may include, for example, a display, a touch screen, a speaker, a vibration generator, or any other device that provides the output to the user. The network interface **1370** may communicate with an external device through a wired or wireless network.

FIG. **14** illustrates an example of an image processing method according to one or more embodiments. Referring to FIG. **14**, in operation **1410**, an image processing apparatus may determine, based on an imaging device configured to generate an input array image of a multi-view through an array lens, a first setting parameter based on whether to use the multi-view or a single view selected from the multi-view, in operation **1420**, may determine a second setting parameter based on whether a priority is assigned to sensitivity enhancement based on pixel binning or to resolution enhancement based on pixel interpolation, in operation **1430**, may determine an image processing mode based on the first setting parameter and the second setting parameter, and in operation **1440**, may generate an output image by performing image processing on the input array image based on a processing procedure based on the image processing mode.

The image processing mode may include at least one of a first mode that is used when the multi-view is used and the priority is set to the resolution enhancement, a second mode that is used when the multi-view is used and the priority is set to the sensitivity enhancement, a fourth mode that is used when the single view is used and the priority is set to the resolution enhancement, and a fifth mode that is used when the single view is used and the priority is set to the sensitivity enhancement.

A processing procedure of the first mode may include sub stages, and each processing procedure of the second mode, the fourth mode, and the fifth mode may include some of the sub stages. The sub stages may include a first sub stage for performing demosaicing on raw data, a second sub stage for performing upsampling for resolution enhancement, a third sub stage for generating matching information of the multi-view, and a fourth sub stage for generating a synthesized image using the matching information. In the processing procedure of the second mode, the first sub stage and the second sub stage may be excluded, in the processing procedure of the fourth mode, the third sub stage and the fourth sub stage may be excluded, and in the processing procedure of the fifth mode, the second sub stage, the third sub stage, and the fourth sub stage may be excluded.

The image processing apparatus may further perform determining a third setting parameter based on whether H/W logic-based binning processing is used. Operation **1430** may include determining the image processing mode based on the first setting parameter, the second setting parameter, and the third setting parameter.

The image processing mode may include at least one of a first mode that is used when the multi-view is used, the H/W logic-based binning processing is not used, and the priority is assigned to resolution enhancement, a second mode that is used when the multi-view is used, the H/W logic-based binning processing is not used, and the priority is assigned to sensitivity enhancement, a third mode that is used when the multi-view is used and the H/W logic-based binning processing is used, a fourth mode that is used when the single view is used, the H/W logic-based binning processing is not used, and the priority is assigned to resolution enhancement, a fifth mode that is used when the single view is used, the H/W logic-based binning processing is not used, and the priority is assigned to sensitivity enhancement, and a sixth mode that is used when the single view is used and the H/W logic-based binning processing is used.

In at least some of a low-illuminance environment or a video capturing mode, the third setting parameter may be determined to use the H/W logic-based binning processing. The H/W logic-based binning processing may include determining initial corresponding pixels between sub images respectively corresponding to different views of the input array image, extracting a refinement target from the initial corresponding pixels based on an intensity difference between the initial corresponding pixels, determining a new corresponding pixel for a refinement target by using a calibration parameter, and performing binning on final corresponding pixels through a weighted average of the final corresponding pixels based on the new corresponding pixel.

The first setting parameter may be determined to use the single view in response to a demand for low power.

In addition, descriptions provided with reference to FIGS. **1** to **13** may apply to the image processing method of FIG. **14**.

The examples described herein may be implemented using H/W components, software components and/or combinations thereof. A processing device may be implemented using one or more general-purpose or special-purpose computers, such as, for example, a processor, a controller and an arithmetic logic unit (ALU), a DSP, a microcomputer, an FPGA, a programmable logic unit (PLU), a microprocessor or any other device capable of responding to and executing instructions in a defined manner. The processing device may run an operating system (OS) and one or more software applications that run on the OS. The processing device also may access, store, manipulate, process, and create data in response to execution of the software. For purpose of simplicity, the description of a processing device is used as singular; however, one skilled in the art will appreciate that a processing device may include multiple processing elements and multiple types of processing elements. For example, the processing device may include a plurality of processors, or a single processor and a single controller. In addition, different processing configurations are possible, such as parallel processors.

The software may include a computer program, a piece of code, an instruction, or some combination thereof, to independently or uniformly instruct or configure the processing device to operate as desired. Software and data may be embodied permanently or temporarily in any type of machine, component, physical or pseudo equipment, computer storage medium or device, or in a propagated signal wave capable of providing instructions or data to or being interpreted by the processing device. The software also may be distributed over network-coupled computer systems so that the software is stored and executed in a distributed fashion. The software and data may be stored by one or more non-transitory computer-readable recording mediums.

The methods according to the above-described example embodiments may be recorded in non-transitory computer-

readable media including program instructions to implement various operations of the above-described example embodiments. The media may also include, alone or in combination with the program instructions, data files, data structures, and the like. The program instructions recorded on the media may be those specially designed and constructed for the purposes of example embodiments, or they may be of the kind well-known and available to those having skill in the computer software arts. Examples of non-transitory computer-readable media include magnetic media such as hard disks, floppy disks, and magnetic tape; optical media such as CD-ROM discs, DVDs, and/or Blue-ray discs; magneto-optical media such as optical discs; and hardware devices that are specially configured to store and perform program instructions, such as read-only memory (ROM), random access memory (RAM), flash memory (e.g., USB flash drives, memory cards, memory sticks, etc.), and the like. Examples of program instructions include both machine code, such as produced by a compiler, and files containing higher-level code that may be executed by the computer using an interpreter.

The above-described devices may be configured to act as one or more software modules in order to perform the operations of the above-described examples, or vice versa.

A number of example embodiments have been described above. Nevertheless, it should be understood that various modifications may be made to these example embodiments. For example, suitable results may be achieved if the described techniques are performed in a different order and/or if components in a described system, architecture, device, or circuit are combined in a different manner and/or replaced or supplemented by other components or their equivalents.

Accordingly, other implementations are within the scope of the following claims.

What is claimed is:

1. An image processing method comprising:

based on an imaging device generating an input array image of a multi-view through an array lens, determining a first setting parameter indicating whether to use the multi-view or a single view selected from the multi-view;

determining a second setting parameter indicating whether a priority is assigned to sensitivity enhancement based on pixel binning or to resolution enhancement based on pixel interpolation;

determining an image processing mode based on the first setting parameter and the second setting parameter; and

generating an output image by performing image processing on the input array image based on a processing procedure that is based on the determined image processing mode.

2. The image processing method of claim **1**, wherein the determined image processing mode comprises:

a first mode that is determined when the first setting parameter indicates to use the multi-view and the second setting parameter indicates the priority is assigned to the resolution enhancement,

a second mode that is determined when the first setting parameter indicates to use the multi-view and the second setting parameter indicates the priority is assigned to the sensitivity enhancement,

a fourth mode that is determined when the first setting parameter indicates to use the single view and the second setting parameter indicates the priority is assigned to the resolution enhancement, or

a fifth mode that is determined when the first setting parameter indicates to use the single view and the second setting parameter indicates the priority is assigned to the sensitivity enhancement.

3. The image processing method of claim **2**,

wherein the processing procedure that is based on the first mode comprises sub stages, and

wherein the processing procedure that is based on the second mode, the fourth mode, or the fifth mode comprises only some of the sub stages.

4. The image processing method of claim **3**, wherein the sub stages comprise:

a first sub stage for performing demosaicing on raw data,

a second sub stage for performing upsampling for resolution enhancement,

a third sub stage for generating matching information of the multi-view, and

a fourth sub stage for generating a synthesized image using the matching information.

5. The image processing method of claim **4**,

wherein the processing procedure that is based on the second mode does not include the first sub stage and the second sub stage,

wherein the processing procedure that is based on the fourth mode does not include the third sub stage and the fourth sub stage, and

wherein the processing procedure that is based on the fifth mode does not include the second sub stage, the third sub stage, and the fourth sub stage.

6. The image processing method of claim **1**, further comprising:

determining a third setting parameter indicating whether to use hardware logic-based binning processing,

wherein the determining the image processing mode is further based on the third setting parameter.

7. The image processing method of claim **6**, wherein the determined image processing mode comprises:

a first mode that is determined when the first setting parameter indicates to use the multi-view, the third setting parameter indicates to not use the hardware logic-based binning processing, and the second setting parameter indicates the priority is assigned to the resolution enhancement,

a second mode that is determined when the first setting parameter indicates to use the multi-view, the third setting parameter indicates to not use the hardware logic-based binning processing, and the second setting parameter indicates the priority is assigned to the sensitivity enhancement,

a third mode that is determined when the first setting parameter indicates to use the multi-view and the third setting parameter indicates to use the hardware logic-based binning processing,

a fourth mode that is determined when the first setting parameter indicates to use the single view, the third setting parameter indicates to not use the hardware logic-based binning processing, and the second setting parameter indicates the priority is assigned to the resolution enhancement,

a fifth mode that is determined when the first setting parameter indicates to use the single view, the third setting parameter indicates to not use the hardware logic-based binning processing, and the second setting parameter indicates the priority is assigned to the sensitivity enhancement, and

a sixth mode that is determined when the first setting parameter indicates to use the single view and the third setting parameter indicates to use the hardware logic-based binning processing.

8. The image processing method of claim **6**, wherein the third setting parameter indicates to use the hardware logic-based binning processing in at least one of a low-illuminance environment or a video capturing mode.

9. The image processing method of claim **6**, wherein the hardware logic-based binning processing comprises:

determining initial corresponding pixels between sub images that respectively correspond to different views of the input array image,

extracting a refinement target from the initial corresponding pixels based on an intensity difference between the initial corresponding pixels,

determining a new corresponding pixel for the refinement target by using a calibration parameter, and

performing binning on final corresponding pixels through a weighted average of the final corresponding pixels that are based on the new corresponding pixel.

10. The image processing method of claim **1**, wherein the first setting parameter indicates to use the single view in response to a demand for low power.

11. A non-transitory computer-readable storage medium storing instructions that, when executed by a processor, cause the processor to perform an image processing method comprising:

Based on an imaging device generating an input array image of a multi-view through an array lens, determining a first setting parameter indicating whether to use the multi-view or a single view selected from the multi-view;

determining a second setting parameter indicating whether a priority is assigned to sensitivity enhancement based on pixel binning or to resolution enhancement based on pixel interpolation;

determining an image processing mode based on the first setting parameter and the second setting parameter; and

generating an output image by performing image processing on the input array image based on a processing procedure that is based on the determined image processing mode.

12. An image processing apparatus comprising:

a processor; and

a memory configured to store instructions executable by the processor,

wherein, in response to the instructions being executed by the processor, the processor is configured to:

based on an imaging device generating an input array image of a multi-view through an array lens, determine a first setting parameter indicating whether to use the multi-view or a single view selected from the multi-view,

determine a second setting parameter indicating whether a priority is assigned to sensitivity enhancement based on pixel binning or to resolution enhancement based on pixel interpolation,

determine an image processing mode based on the first setting parameter and the second setting parameter, and

generate an output image by performing image processing on the input array image based on a processing procedure that is based on the determined image processing mode.

13. The image processing apparatus of claim **12**, wherein the determined image processing mode comprises:

a first mode that is determined when the first setting parameter indicates to use the multi-view and the second setting parameter indicates the priority is assigned to the resolution enhancement,

a second mode that is determined when the first setting parameter indicates to use the multi-view and the second setting parameter indicates the priority is assigned to the sensitivity enhancement,

a fourth mode that is determined when the first setting parameter indicates to use the single view and the second setting parameter indicates the priority is assigned to the resolution enhancement, or

a fifth mode that is determined when the first setting parameter indicates to use the single view and the second setting parameter indicates the priority is assigned to the sensitivity enhancement.

14. The image processing apparatus of claim **13**,

wherein the processing procedure that is based on the first mode comprises sub stages, and

wherein the processing procedure that is based on the second mode, the fourth mode, or the fifth mode comprises only some of the sub stages.

15. The image processing apparatus of claim **12**, wherein the processor is further configured to:

determine a third setting parameter indicating whether to use hardware logic-based binning processing,

wherein the processor being configured to determine the image processing mode is further based on the third setting parameter.

16. The image processing apparatus of claim **15**, wherein the determined image processing mode comprises:

a first mode that is determined when the first setting parameter indicates to use the multi-view, the third setting parameter indicates to not use the hardware logic-based binning processing, and the second setting parameter indicates the priority is assigned to the resolution enhancement,

a second mode that is determined when the first setting parameter indicates to use the multi-view, the third setting parameter indicates to not use the hardware logic-based binning processing, and the second setting parameter indicates the priority is assigned to the sensitivity enhancement,

a third mode that is determined when the first setting parameter indicates to use the multi-view and the third setting parameter indicates to use the hardware logic-based binning processing,

a fourth mode that is determined when the first setting parameter indicates to use the single view, the third setting parameter indicates to not use the hardware logic-based binning processing, and the second setting parameter indicates the priority is assigned to the resolution enhancement,

a fifth mode that is determined when the first setting parameter indicates to use the single view, the third setting parameter indicates to not use the hardware logic-based binning processing, and the second setting parameter indicates the priority is assigned to the sensitivity enhancement, and

a sixth mode that is determined when the first setting parameter indicates to use the single view and the third setting parameter indicates to use the hardware logic-based binning processing.

17. The image processing apparatus of claim **15**, wherein the third setting parameter indicates to use the hardware

logic-based binning processing in at least one of a low-illuminance environment or a video capturing mode.

18. The image processing apparatus of claim **15**, wherein the hardware logic-based binning processing comprises the processor being configured to:

determine initial corresponding pixels between sub images respectively that correspond to different views of the input array image,

extract a refinement target from the initial corresponding pixels based on an intensity difference between the initial corresponding pixels,

determine a new corresponding pixel for the refinement target by using a calibration parameter, and

perform binning on final corresponding pixels through a weighted average of the final corresponding pixels that are based on the new corresponding pixel.

19. The image processing apparatus of claim **12**, wherein the first setting parameter indicates to use the single view in response to a demand for low power.

20. An electronic device comprising:

an imaging device configured to generate an input array image of a multi-view through an array lens, the input array image comprising sub images corresponding to the multi-view; and

a processor configured to:

determine a first setting parameter indicating whether to use the multi-view or a single view selected from the multi-view,

determine a second setting parameter indicating whether a priority is assigned to sensitivity enhancement based on pixel binning or to resolution enhancement based on pixel interpolation,

determine an image processing mode based on the first setting parameter and the second setting parameter, and

generate an output image by performing image processing on the input array image based on a processing procedure that is based on the determined image processing mode.

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