(54) Title: IMAGE SENSOR UNIT AND IMAGING APPARATUS

FIG.4

(57) Abstract: An image sensor unit (3) includes a microlens array (31) and a sensor (32). The sensor includes a plurality of sensor regions (323) that respectively include pixels (322) having different sensitivities arranged in a matrix arrangement. The pixels (322) at corresponding positions of the plurality of sensor regions (323) have identical sensitivities. Each of the microlenses (311) of the microlens array (31) is arranged to direct the light to a corresponding one of the plurality of sensor regions (323) of the sensor (32). The pixels (322cl) in a first row or column of the matrix arrangement of each of the plurality of sensor regions (323) have a first light sensitivity, the pixels (322c2, 322c3) in a second row or column of the matrix arrangement of each of the plurality of sensor regions (323) have a second light sensitivity different from the first light sensitivity, and the first and second light sensitivities are different from the light sensitivities of the pixels (322) in rows or columns of the matrix arrangement other than the first and second rows or columns of the matrix arrangement of each of the plurality of sensor regions (323).

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IMAGE SENSOR UNIT AND IMAGING APPARATUS

FIELD

5   The present disclosure generally relates to an image
       sensor unit and an imaging apparatus that includes such an
       image sensor unit.

BACKGROUND

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       Plenoptic cameras are able to measure the amount of light
       traveling along each bundle of rays that intersects a
       sensor, by arranging a microlens array between a main lens
       and the sensor. The light field can be post-processed to
15   reconstruct images of a scene from different viewpoints.
       As a result, a user can change a focal point of the images.
       Compared to conventional cameras, the plenoptic camera can
       obtain additional optical information components for
       achieving the reconstruction of the images of the scene
20   from the different viewpoints by post-processing.

       A challenge in HDR (High Dynamic Range) imaging may be to
       capture at least two images of the scene with different
       exposures, in order to enable dynamic range extension.
25   Therefore, dynamic scenes (or videos) cannot be processed
       with a satisfactory, or sufficiently high dynamic range
       according to the conventional cameras.

       On the other hand, the plenoptic imaging has introduced an
30   efficient way to capture several images of the scene
       simultaneously, providing a tool to capture multiple images
       of static (or still) scenes or dynamic scenes.

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The images of the scene captured by the plenoptic camera must undergo view demultiplexing, that is, a data conversion from a two-dimensional (or 2D) raw image to a four-dimensional (or 4D) light-field image. The

5   demultiplexing process reorganizes pixels of the 2D raw image in such a way that all pixels capturing the light rays with a certain angle of incidence are stored in the same image in order to create the so-called "views", or "viewpoint images". Each viewpoint image is a projection

10   of the scene under a different light ray angle. A set of viewpoint images can create a block matrix in which a central viewpoint image stores the pixels capturing the light rays that pass through the central part of the main lens aperture. Angular information of the light rays is

15   given by relative pixel positions in the microlens images (i.e., the images that are formed under microlenses and on the sensor) with respect to the pixel that corresponds to the central view point (the centers of the microlens images).

20

The block matrix can be used to estimate depth information of objects within the scene. Once the depth information is known, an image processing method can manipulate every object simultaneously on every viewpoint image. The HDR

25   imaging is one example of such an image processing method. When a depth map of the scene is known, different exposures of the scene from different light ray angles can be used in various multi-frame HDR imaging methods to extend the dynamic range of the captured image.

30

For example, "OV10640", Color CMOS 1.3-megapixel (1280x1080) High Dynamic Range (HDR) High Definition Image Sensor, 'http://www.ovt.com/products/sensor.php?id=151',

proposes a split-pixel technology in which some pixels have low sensitivity responses. However, the proposed split-pixel technology results in the loss of achievable spatial resolution of the camera. In addition,

5   neighboring pixels sample different spatial positions, thereby reducing the accuracy of the post-processing performed by the HDR imaging methods.

On the other hand, Todor Georgiev et al., "Rich Image

10 Capture with Plenoptic Cameras", ICCP 2010, proposes two approaches for the HDR imaging with plenoptic type 2. A first approach varies an aperture size of the microlenses in order to capture different exposures of the scene, and a second approach filters the main lens in order to vary

15 the amount of light irradiated on the microlenses. However, according to the proposed first and second approaches, each demultiplexed view contains pixels from different exposures, and not pixels of a unique sensitivity. The second approach is reported in Todor

20 Georgiev et al. to be poorer than the first approach, in terms of the quality of the results. Furthermore, according to the first approach, the dynamic range extension is limited by the lower bound on the aperture size, since the small aperture of the microlenses

25 introduces diffraction blur.

Accordingly, it is conventionally difficult to simultaneously capture different exposures of a scene in one shot without lowering the spatial resolution. More

30 particularly, it is conventionally difficult to simultaneously enable high and low exposure captures of the scene.

SUMMARY

According to an aspect of the present disclosure, an image
sensor unit may include a microlens array including a
5   plurality of microlenses arranged in a two-dimensional
array; and a sensor, including a plurality of pixels
arranged in a two-dimensional array, and configured to
receive light through the microlens array, wherein the
sensor includes a plurality of sensor regions that are
10   arranged in a two-dimensional array and respectively
include pixels having different sensitivities arranged in
a matrix arrangement, wherein the pixels at corresponding
positions of the plurality of sensor regions have
identical sensitivities, and wherein each of the
15   microlenses of the microlens array is arranged to direct
the light to a corresponding one of the plurality of
sensor regions of the sensor, the pixels in a first row or
column of the matrix arrangement of each of the plurality
of sensor regions have a first light sensitivity, the
20   pixels in a second row or column of the matrix arrangement
of each of the plurality of sensor regions have a second
light sensitivity different from the first light
sensitivity, the first and second light sensitivities are
different from the light sensitivities of the pixels in
25   rows or columns of the matrix arrangement other than the
first and second rows or columns of the matrix arrangement
of each of the plurality of sensor regions.

According to another aspect of the present disclosure, an
30   imaging apparatus may include an optical system including
at least a lens; and an image sensor unit described above,
wherein the microlens array of the image sensor unit is
configured to receive the light through the optical system.

The object and advantages of the present disclosure will
be realized and attained by means of the elements and
combinations particularly pointed out in the claims.

5

It is to be understood that both the foregoing general
description and the following detailed description are
exemplary and explanatory and are not restrictive of the
invention, as claimed.

10

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram illustrating an example of an imaging
apparatus in one embodiment of the present disclosure;

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FIG. 2 is a plan view schematically illustrating an
example of sensing regions arranged on a sensing surface
of a sensor;

20   FIG. 3 is a plan view schematically illustrating another
example of the sensing regions arranged on the sensing
surface of the sensor;

FIG. 4 is a plan view schematically illustrating a first
25   exemplary implementation of sensing regions arranged on a
part of the sensing surface of the sensor; and

FIG. 5 is a plan view schematically illustrating a second
exemplary implementation of sensing regions arranged on a
30   part of the sensing surface of the sensor.

DESCRIPTION OF EMBODIMENTS

Embodiments of the present disclosure will be described
with reference to the accompanying drawings.

A description will now be given of an image sensor unit
5   and an imaging apparatus, in each embodiment according to
the present disclosure.

FIG. 1 is a diagram illustrating an example of the imaging
apparatus in one embodiment of the present disclosure. An
10   imaging apparatus 1 in this embodiment forms a plenoptic
camera, for example. The imaging apparatus 1 illustrated
in FIG. 1 may include an optical system 2, an image sensor
unit 3, and a processor 4.

15   The optical system includes a diffuser 21, a main lens 22,
and a field lens 23. The diffuser 21 diffuses the light
from an object 100 prior to reaching the microlens array
31. This diffuser 21 may be omitted, if preferred. The
main lens 22 receives light from the object 100 in an
20   object field of the main lens 22 and passes the light
through an image field of the main lens 22. The field
lens 23 is arranged between the main lens 22 and the
microlens array 31, and adjusts focused light from the
main lens 22 so as to appear to be focused from infinity.
25

The image sensor unit 3 includes a microlens array 31 and
a sensor 32. The microlens array 31 includes a plurality
of microlenses 311 arranged in a two-dimensional array.
The sensor 32 may include a color filter 321 provided on a
30   sensing surface thereof. The color filter 321 may include
filters of each of the colors red, green, and blue in a
preferred arrangement, such as a Bayer arrangement, for
example. This color filter 321 may be omitted, if

preferred.

FIG. 2 is a plan view schematically illustrating an
example of sensor regions arranged on the sensing surface
5   of the sensor. As illustrated in FIG. 2, the sensor 32
includes a plurality of pixels 322 arranged in a two-
dimensional array, and receives the light from the object
100 through the microlens array 31. The sensor 32 forms a
plurality of sensor regions 323 that are arranged in a
10   two-dimensional array and respectively include pixels 322
having mutually different sensitivities arranged in a
matrix arrangement including M rows by N columns, where M
and N are natural numbers greater than two. The sensor
regions 323 are sometimes also referred to as "microlens
15   images" or "blocks". In presence of the field lens 23,
the shape and size of each of the sensor regions 323 are
the same, and the number and arrangement of the pixels 322
within each of the sensor regions 323 are the same. In
this example, the plurality of sensor regions 323 are
20   arranged in a linearly aligned rectangular matrix
arrangement in directions in which the rows and the
columns extend. The pixels 322 at corresponding positions
of the plurality of sensor regions 323 have identical
sensitivities in currently available plenoptic cameras.
25

The pixels 322 in at least one row or column of each of
the plurality of sensor regions 323, located at
corresponding positions of the plurality of sensor regions
323, in a vicinity of a center of each of the plurality of
30   sensor regions 323, may have identical sensitivities, as
will be described later in conjunction with exemplary
implementations. Here, the sensitivity of pixel can be
generally interpreted as "the conversion rate between the

number of photons that hit the pixel and the output
signal". If the fill factor of a pixel is considered, it
is refined as "the conversion rate between the number of
photons that hit the light sensitive area of pixel and the
5   output signal". The fill factor of a pixel may be defined
as "the ratio of light sensitive area to total area of the
pixel". This definition relies on a fact that some part
of a pixel is generally dedicated to a circuit element of
image sensor, thus not all area of the pixel is used for
10   detecting light but only the light sensitive area of the
pixel contributes to detect the light.

The various, different sensitivities of the pixels 322 may
be achieved using pixels 322 that are manufactured to have
15   different sensitivities. Pixels manufactured to have
different sensitivities are known, as described in
"http://image-sensors-world.blogspot.fr/2014/11/on-semi-
presents-emccd-with-per-pixel.html", for example, and such
pixels may be used for the pixels 322 having the various,
20   different sensitivities described above.

Alternatively, the pixels 322 may be given the various,
different sensitivities by using a filter 321A illustrated
in FIG. 1 or the like, arranged between the microlens
25   array 31 and the sensor 32, that varies a single
sensitivity of the pixels 322 into the various, different
sensitivities. The filter 321A may be manufactured to
have a pattern in accordance with a pattern of the various,
different sensitivities of the pixels 322 to be achieved.
30   For example, the filter 321A may be provided on the color
filter 321, or on the sensing surface of the sensor 32.
Further, the filter 321A may be formed by the color filter
321, that is, functions of the color filter 321 and

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functions of the filter 321A may be integrated within a
single filter.

FIG. 3 is a plan view schematically illustrating another
5   example of the sensor regions arranged on the sensing
surface of the sensor. In FIG. 3, those parts that are the
same as those corresponding parts in FIG. 2 are designated
by the same reference numerals, and a description thereof
will be omitted. In this example, the plurality of sensor
10   regions 323 are linearly arranged in a staggered
arrangement in the directions in which the rows and the
columns extend.

Each of the microlenses 311 of the microlens array 31 is
15   arranged to direct the light to a corresponding one of the
plurality of sensor regions 323 of the sensor 32. In
addition, because of the lens properties of the
microlenses 311, each of the microlenses 311 of the
microlens array 31 directs the light to a circular area
20   (or microlens image) 324, indicated by one-dot chain lines
in FIGs. 2 and 3, within the corresponding one of the
plurality of sensor regions 323 of the sensor 32.

In this example, the sensor regions 323 have a square
25   shape, and the circular area 324 fits within each
corresponding, square sensor region 323. Preferably, an
outer contour of the circular area 324 forms an inscribed
circle with respect to the corresponding, square sensor
region 323. Hence, amongst all of the pixels 322 within
30   each sensing region 323, only the pixels 322 located
substantially inside the circular area 324 contribute to
the imaging. In other words, a pixel area (or sensing
area) of each pixel 322 that contributes to the imaging is

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located substantially inside the circular area 324.

The center of each of the plurality of sensor regions 323
matches a center of the corresponding circular area 324,
5   that is, a center of the corresponding microlens image 311.

The processor 4 may be formed by any known and suitable
hardware, or software, or a combination of hardware and
software. For example, the processor 4 may be formed by
10   dedicated hardware such as a processing circuit, or by a
programmable processing unit such as a CPU (Central
Processing Unit) that executes a program stored in a
memory thereof.

15   The processor 4 may perform a process on signals output
from each of the plurality of sensor regions 323 of the
sensor 32, including signals of the pixels 322 having
different sensitivities. The process of the processor 4
may include digitizing the signals into digital signals,
20   and extracting, from the digital signals, a plurality of
viewpoint images sensed by the plurality of sensor regions
323 and corresponding to different viewpoints. The
process of the processor 4 may further include
synthesizing at least two of the plurality of viewpoint
25   images, for example. The process of the processor 4 may
enable extraction of depth information from the signals
output from the sensor 32, and enable a three-dimensional
display based on the depth information, for example.

30   A number of different sensitivities, S, of the pixels 322
in the sensor 32, may be represented by a formula $S = m - (L1 \times L2) + L1$, where m denotes a number of pixels 322
contributing to the imaging within the circular area 324,

L1 denotes a number of rows or columns of each of the
plurality of sensor regions 323, respectively formed by the
pixels 322 having identical sensitivities, and L2 denotes a
number of pixels 322 contributing to the imaging within
5   each of L1 rows or columns of each of the plurality of
sensor regions 323, formed by the pixels 322 having
identical sensitivities. As a result, this embodiment can
simultaneously capture different exposures of a scene in
one shot without lowering the spatial resolution of the
10   plenoptic data. More particularly, this embodiment can
simultaneously enable high and low exposure captures of the
scene.

The simultaneous capture of the different exposures of the
15   scene facilitates the HDR (High Dynamic Range) imaging for
the static scenes and the dynamic scenes. In this case, a
user does not need to consider low-light exposures and
manual exposure mode changes, for example. The high and
low exposure captures can all be made in one fixed mode,
20   for example, and the plenoptic camera can work in a wide
range of illumination conditions. Further, the image
capture for tetrachromatic people, for example, can easily
be implemented in the plenoptic camera.

25   Instead of changing the aperture of microlenses as proposed
in Todor Georgiev et al., "Rich Image Capture with
Plenoptic Cameras", ICCP 2010, the arrangement of the
sensor pixels in this embodiment are designed so that the
sensitivity of pixels vary on the sensor. In addition,
30   unlike the low spatial resolution of the split-pixel
technology proposed in "OV10640", Color CMOS 1.3-megapixel
(1280x1080) High Dynamic Range (HDR) High Definition Image
Sensor, 'http://www.ovt.com/products/sensor.php?id=151',

changing the pixel sensitivities of the plenoptic camera
(or light field camera) as in this embodiment does not
influence the spatial resolution and/or the angular
resolution of the captured light field.

Hence, in this embodiment, the sensor includes pixels
having several different sensitivities to light.
Restrictions (i)-(v) on the pixel arrangement design may be
as follows. The exemplary implementations consider a
typical type 1 plenoptic camera having 10 x 10 = 100 pixels
under each microlens, that is, within each sensing region
324. According to other examples, each sensing region may
comprise 20 x 20, 50 x 50 or even 100 x 100 pixels.

Restriction (i): In order to capture each viewpoint image
only by the pixels having the same sensitivity, all of the
pixels that are positioned at the same relative location
(that is, same coordinates relative to the microlens
center) within each of the sensing regions 324, and thus
belonging to the same viewpoint image, have the same
sensitivity.

Restriction (ii): In order to enable calculation of the
depth map, at least two views with the same exposure are
required. In order to increase the accuracy of disparity
estimation, at least one complete row or column in each of
the sensing regions is preferably formed by the pixels
having the same sensitivity. This sensitivity pattern of
the pixels allows for accurate pixel registration.

FIG. 4 is a plan view schematically illustrating a first
exemplary implementation of sensing regions arranged on a
part of the sensing surface of the sensor. In FIG. 4,

those parts that are the same as those corresponding parts
in FIG. 3 are designated by the same reference numerals,
and a description thereof will be omitted. The circular
areas 324 in a partial view of the sensor 32 correspond to

5   the microlens images. A central row of each of the
sensing regions 323, in a vicinity of the center 329, is
only formed by one type of pixels 322c1 having the same
sensitivity and indicated by hatching in FIG. 4. It
should be considered that the central row is in a vicinity

10   of the center 329 when at least one pixel of the row
touches the center 329 or when a pixel of the row which is
closest to the center 329 is located in the neighborhood
of the center 329, for example away from the center 329 in
a few of several pixels depending on the size of number of

15   the pixels. The pixels 322 in rows other than the central
row have mutually different sensitivities. In addition,
as indicated by marks "x" in FIG. 4, for example, the
pixels 322 that are positioned at the same relative
location within each of the sensing regions 323 (or

20   circular areas 324), and thus belonging to the same
viewpoint image, have the same sensitivity. Hence,
amongst 64 pixels (322 and 322c1) surrounded by a bold
solid line in FIG. 4 and contributing to the imaging
within the circular area 324 under each microlens 311,

25   only 8 pixels 322c1 have the same sensitivity, and it may
be calculated from the formula described above that the
pixels (322 and 322c1) contributing to the imaging within
each circular area 324 can have 64 − (1 x 8) + 1 = 57
different sensitivities.

30

In FIG. 4 and FIG. 5 which will be described later, it is
assumed for the sake of convenience that the 64 (= 8 x 8)
pixels in a square region surrounded by the bold line

contribute to the imaging, although the pixels at corners
of the square region may appear in these figures as not
being located substantially inside the circular area 324.

5   Restriction (iii): In order to allow continuous image
capture at different illumination levels, more
restrictions may be applied on the pixel arrangement
design. For example, each of a plurality of central rows
or columns in each of the sensing regions is preferably
10   formed by the pixels having the same sensitivity. This
sensitivity pattern of the pixels also allows for accurate
pixel registration. The depth map estimation may be
performed on the one of the central rows or columns that
best captures the scene, regarding the illumination level.
15
FIG. 5 is a plan view schematically illustrating a second
exemplary implementation of the sensing regions arranged
on a part of the sensing surface of the sensor. In FIG. 5,
those parts that are the same as those corresponding parts
20   in FIG. 3 are designated by the same reference numerals,
and a description thereof will be omitted. The circular
areas 324 in a partial view of the sensor 32 correspond to
the microlens images. Each of first, second, and third
central rows of each of the sensing regions 323, in a
25   vicinity of the center 329, is only formed by a
corresponding type of pixels 322c1, 322c2, and 322c3,
respetively, having the same sensitivity and indicated by
hatching in FIG. 5. The pixels 322 in rows other than the
first, second, and third central rows have mutually
30   different sensitivities. The sensitivities of the pixels
322c1, 322c2, and 322c3 may be determined by considering
two extreme lighting conditions, namely, very low
illumination and very high illumination corresponding to

high and low sensitivities, respectively, and one medium
lighting condition corresponding to a middle sensitivity
between the high and low sensitivities.

5   Hence, amongst 64 pixels (322, 322c1, 322c2, and 322c3)
surrounded by the bold solid line in FIG. 5 and
contributing to the imaging within the circular area 324
under each microlens 311, 8 pixels 322c1 have the same
sensitivity, 8 pixels 322c2 have the same sensitivity, 8
10 pixels 322c3 have the same sensitivity, but the
sensitivities of the pixels 322c1, 322c2, and 322c3 are
mutually different. Hence, it may be calculated from the
formula described above that the pixels (322, 322c1, 322c2,
and 322c3) contributing to the imaging within each circular
15 area 324 can have 64 -(3 x 8) + 3 = 43 different
sensitivities.

Restriction (iv): The color filter 321 may be provided on
the sensor 32 in order to sample scene chromatic content.
20 Knowing the microlens centers, the color filter 321 can be
designed to obtain the regular Bayer arrangement (or
pattern) on each view, for example. This color filter
design may be achieved in a case in which the diameter of
each microlens 311 corresponds to an exact odd number of
25 pixels 322. In a case in which the diameter of the
microlens 311 corresponds to an exact even number of pixels
322, a physical space of one pixel can be formed between
the microlenses 311 on the microlens grid. For accurate
recovery of the color content of views using the estimated
30 disparities, a method proposed in Mozhdeh Seifi et al,
"Disparity-Guided Demosaicking of Light-Field Images", ICIP
2014, for example, may be implemented so that the number of
sensitivities (or sensitiviry levels) can further be

reduced in order to obtain more than one view per exposure. Even in a case in which the number of sensitivity levels is divided by 2, for example, approximately 20 different exposures of the scene can be captured, which is far beyond
5   the reach of the conventional cameras.

Restriction (v): The scene capture for tetrachromatic people may be considered. Very few in number, tetrachromatic people have 4 primitive color responses.
10   Therefore, using only 3 color channels may not satisfy the needs of these people. In order to adjust the HDR plenoptic camera to this case, one view (or even possibly one row or column of views) may be included in the information in the additional color channel. The only
15   adjustment is to use a suitable color filter in front of the pixels corresponding to each microlens, and it is still possible to capture approximately 20 different exposures of the scene.

20   As described above, the pixels 322 in at least one row or column of each of the plurality of sensor regions 323, located at corresponding positions of the plurality of sensor regions 323, in a vicinity of a center of each of the plurality of sensor regions 323, may have identical
25   sensitivities. Hence, the number of adjacent rows or columns in which the pixels 322 have identical sensitivities in each sensor region 323 may be one (1) as illustrated in FIG. 4, three (3) as illustrated in FIG. 5, or two (2) or four (4) or more, where the sensitivities of
30   the pixels 322 are different between such adjacent rows or columns.

It is to be noted that the plenoptic camera obtains several

exposures of the scene in one shot, and can easily work in a video mode, for example. Although the example of plenoptic type 1 is provided in this embodiment, the exact same approach can be used for plenoptic type 2 cameras, for

5   example. In the case of R-Series 3D cameras (or light field cameras) manufactured by Raytrix GmbH, for example, since the plenoptic function is not sampled on a regular grid, data re-gridding is required to obtain the matrix arrangement of views. Nevertheless, the sensor can be

10   designed accordingly in order to obtain different exposures of the scene on different views.

Although the exemplary implementations are numbered with, for example, "first," or "second," the ordinal numbers do

15   not imply priorities of the exemplary implementations. Many other variations and modifications will be apparent to those skilled in the art.

All examples and conditional language recited herein are

20   intended for pedagogical purposes to aid the reader in understanding the invention and the concepts contributed by the inventors to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions, nor does the organization

25   of such examples in the specification relate to a showing of the superiority and inferiority of the present principles. Although the embodiments of the present disclosure have been described in detail, it should be understood that the various changes, substitutions, and

30   alterations could be made hereto without departing from the scope of the invention.

CLAIMS:

1.   An image sensor unit (3) comprising:

        a microlens array (31) including a plurality of
microlenses (311) arranged in a two-dimensional array; and

        a sensor (32), including a plurality of pixels (322)
arranged in a two-dimensional array, and configured to
receive light through the microlens array,

        wherein the sensor includes a plurality of sensor
regions (323) that are arranged in a two-dimensional array
and respectively include pixels (322) having different
light sensitivities arranged in a matrix arrangement,

        wherein the pixels (322) at corresponding positions
of the plurality of sensor regions (323) have identical
light sensitivities, and

        wherein each of the microlenses (311) of the
microlens array (31) is arranged to direct the light to a
corresponding one of the plurality of sensor regions (323)
of the sensor (32),

        the pixels (322c1) in a first row or column of the
matrix arrangement of each of the plurality of sensor
regions (323) have a first light sensitivity,

        the pixels (322c2, 322c3) in a second row or column
of the matrix arrangement of each of the plurality of
sensor regions (323) have a second light sensitivity
different from the first light sensitivity,

        the   first   and   second   light   sensitivities   are
different from the light sensitivities of the pixels (322)
in rows or columns of the matrix arrangement other than
the   first   and   second   rows   or   columns   of   the   matrix
arrangement of each of the plurality of sensor regions
(323).

2.   The image sensor unit as claimed in claim 1, wherein
the pixels (322c3) in a third row or column of the
matrix arrangement of each of the plurality of sensor
regions (323) have a third light sensitivity different
from the first and second light sensitivities,
the first, second, and third light sensitivities are
different from the light sensitivities of the pixels (322)
in rows or columns of the matrix arrangement other than
the first, second, and third rows or columns of each of
the plurality of sensor regions (323),
the first, second, and third rows or columns are
adjacent to each other and are located to extend through
the central area of each of the plurality of sensor
regions (323).

3.   The image sensor unit as claimed in claim 1 or 2,
wherein the plurality of sensor regions (323) are arranged
in a linearly aligned matrix arrangement in directions in
which the rows and the columns extend.

4.   The image sensor unit as claimed in any of claims 1
to 3, wherein the plurality of sensor regions (323) are
linearly arranged in a staggered arrangement in directions
in which the rows and the columns extend.

5.   An imaging apparatus (1) comprising:
an optical system (2) including at least a lens (22);
and
an image sensor unit (3) as claimed in any of claims
1 to 4,
wherein the microlens array (31) of the image sensor
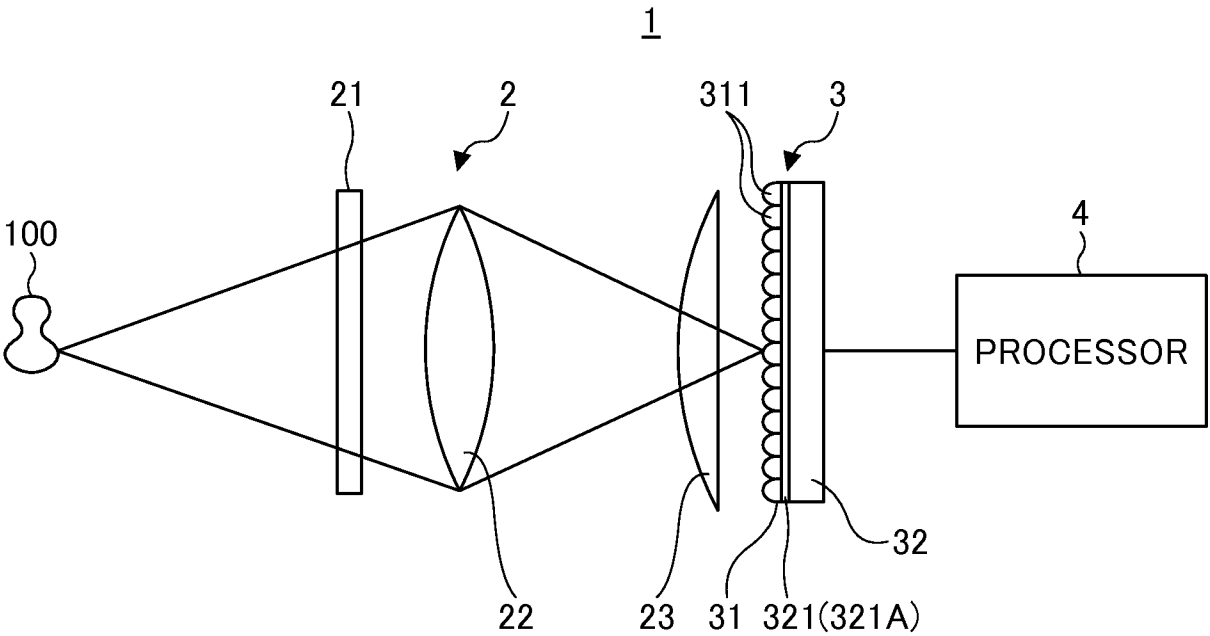unit (3) is configured to receive the light through the
optical system (2).

6.   The imaging apparatus (1) as claimed in claim 5,
wherein the optical system (2) includes a main lens (22)
configured to receive the light from an object (100) in an
5   object field of the main lens and to pass the light
through an image field of the main lens.

7.   The imaging apparatus (1) as claimed in claim 5 or 6,
further comprising:
10   a processor (4) configured to perform a process on
signals output from each of the plurality of sensor
regions (323) of the sensor (32), including signals of the
pixels (322) having different sensitivities.

15   8.   The imaging apparatus (1) as claimed in claim 7,
wherein the process of the processor (4) includes
         digitizing the signals into digital signals, and
         extracting, from the digital signals, a plurality of
viewpoint images sensed by the plurality of sensor regions
20   (323) and corresponding to different viewpoints.

9.   The imaging apparatus (1) as claimed in claim 8,
wherein the process of the processor (4) further includes
         synthesizing at least two of the plurality of
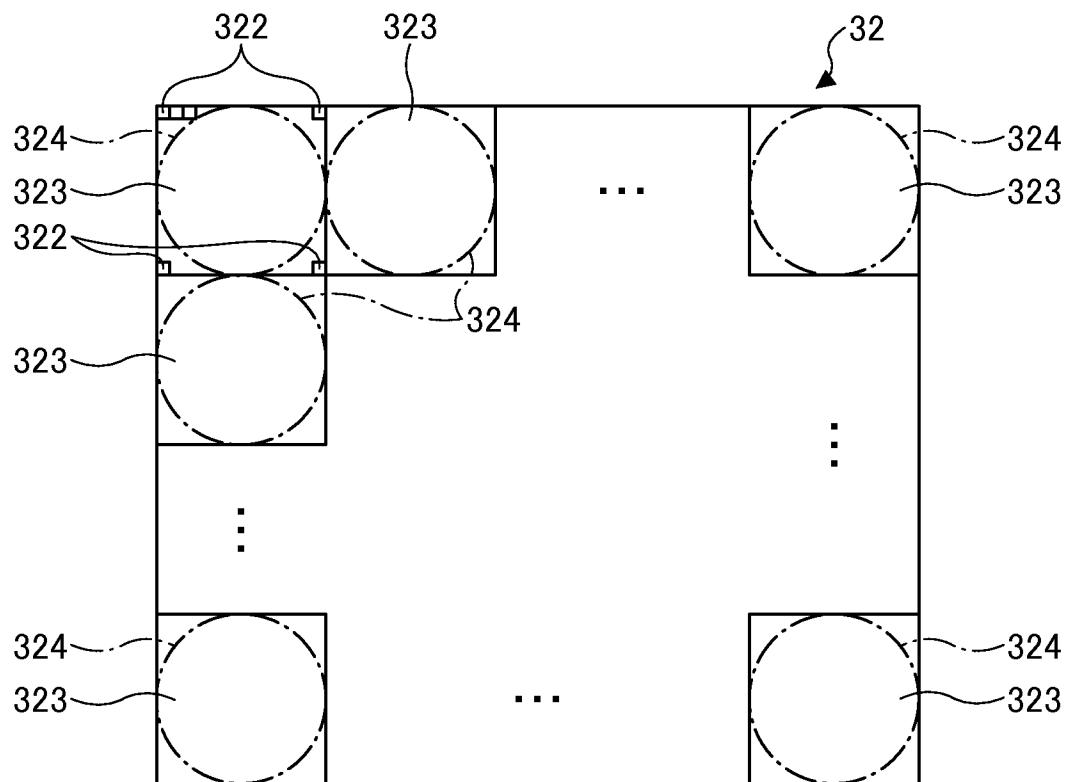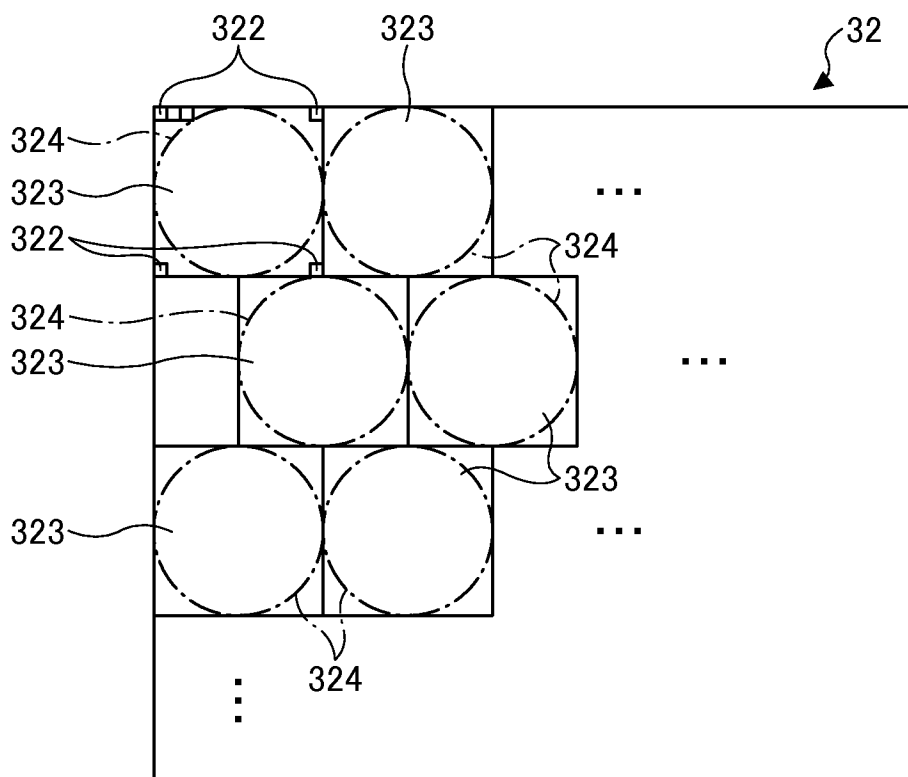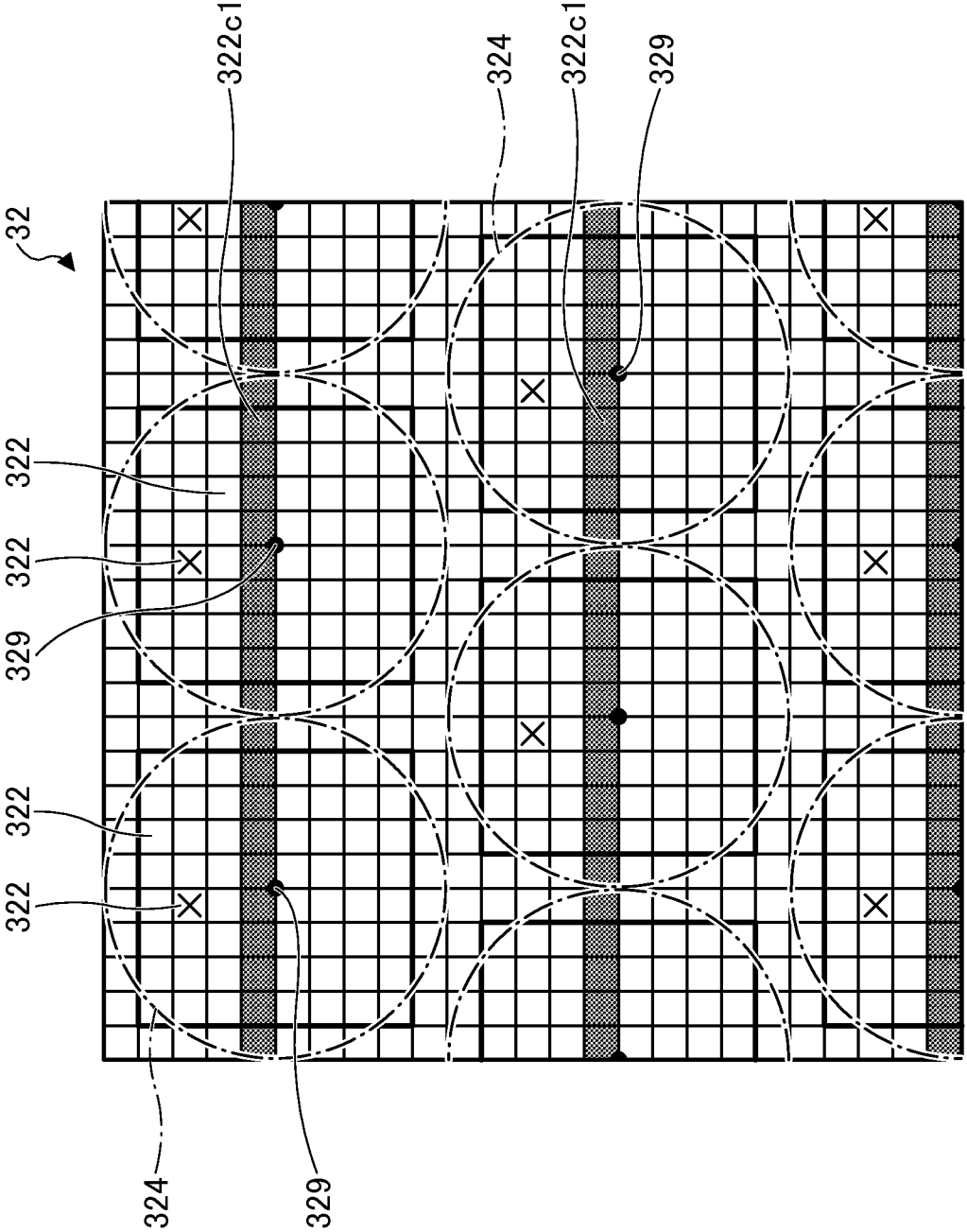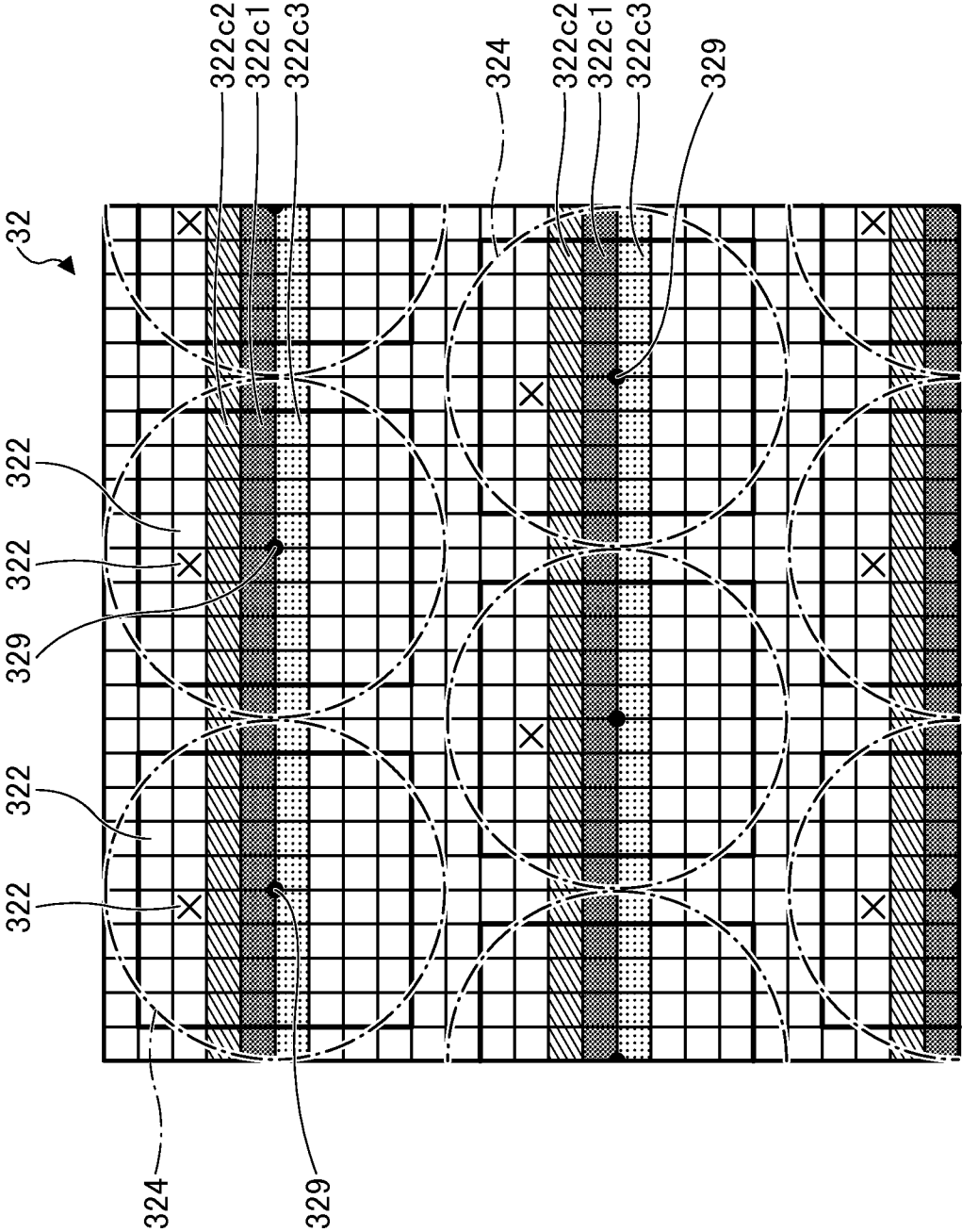25   viewpoint images.

FIG.1

FIG.2

FIG.3

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FIG.4

4/4

FIG.5

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04N5/235   H04N5/225   H04N5/355
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 8 228 417 B1 (GEORGIEV TODOR G [US] ET AL) 24 July 2012 (2012-07-24) column 30, line 26 - column 32, line 32 column 12, line 46 - column 14, line 17 figures 6,7,21-22,28,37A-41B -----	1-9
Y	EP 2 566 151 A1 (PANASONIC CORP [JP]) 6 March 2013 (2013-03-06) paragraph [0015] - paragraph [0070] figures 1-14 -----	1,5-7
Y	US 2012/268643 A1 (IMAMURA NORIHIRO [JP]) 25 October 2012 (2012-10-25) paragraph [0042] - paragraph [0062] paragraph [0121] figures 1-7,23A ----- -/--	1,5-7

[X] Further documents are listed in the continuation of Box C.   [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
9 February 2016	16/02/2016

| Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016 | Authorized officer Potin, Delphine |

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 2014/253767 A1 (KATO SATOSHI [JP] ET AL) 11 September 2014 (2014-09-11) paragraph [0028] - paragraph [0036] figures 1-5 -----	1-9
A	JP 2013 258602 A (OLYMPUS CORP) 26 December 2013 (2013-12-26) paragraph [0006] - paragraph [0049] figures 1-13 -----	1-9

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