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Datasheet for the decision
of 7 April 2022

Case Number:	T 0855/16 - 3.5.04
Application Number:	11182727.5
Publication Number:	2403233
IPC:	H04N5/225, G02B27/58, H04N1/40, H04N13/02, G06T7/00
Language of the proceedings:	EN

Title of invention:
Image processing apparatus and method

Applicant:
Samsung Electronics Co., Ltd.

Headword:

Relevant legal provisions:
RPBA 2020 Art. 13(1), 13(2)
EPC Art. 56, 84, 123(2)

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Keyword:

Main request and second auxiliary request - amendment after
summons - exceptional circumstances (yes) - admitted - added
subject-matter (yes)
First auxiliary request - amendment to appeal case - amendment
prima facie gives rise to new objections (yes) - not admitted
Third auxiliary request - admitted - clarity (yes) - added
subject-matter (no) - inventive step - (yes)

Decisions cited:

Catchword:

Case Number: T 0855/16 - 3.5.04

D E C I S I O N
of Technical Board of Appeal 3.5.04
of 7 April 2022

Appellant: Samsung Electronics Co., Ltd.
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Decision under appeal: **Decision of the Examining Division of the
                             European Patent Office posted on 30 October 2015
                             refusing European patent application
                             No. 11182727.5 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chair   B. Willems
Members: A. Seeger
                 B. Müller

Summary of Facts and Submissions

I.   The appeal is against the examining division's decision
        to refuse European patent application No. 11 182 727.5,
        published as EP 2 403 233 A1.

        The current application is a divisional application to
        European patent application No. 09 171 559.9 (earlier
        application), published as EP 2 175 632 A1.

II.   The prior-art documents cited in the decision under
        appeal included the following:

        D0:   Ren Ng et al: "*Light Field Photography with a
              Hand-held Plenoptic Camera*", Stanford Tech
              Report CTSR, February 2005, pages 1 to 11,
              XP 008138449

        D1:   Sung Cheol Park et al: "*Super-Resolution Image
              Reconstruction: A Technical Overview*", IEEE
              Signal Processing Magazine, vol. 20, no. 3,
              May 2003, pages 21 to 36, doi: 10.1109/MSP.
              2003.1203207, XP 011097476

        D2:   Edward H. Adelson et al: "*Single Lens Stereo with
              a Plenoptic Camera*", IEEE Transactions on Pattern
              Analysis and Machine Intelligence, vol. 14,
              no. 2, February 1992, pages 99 to 106,
              XP 000248474

        D3:   Wai-San Chan et al: "*Super-resolution
              reconstruction in a computational compound-eye
              imaging system*", Multidimensional Systems and
              Signal Processing, vol. 18, no. 2-3,

23 February 2007, pages 83 to 101, doi: 10.1007/
s11045-007-0022-3, XP 019506577

III.   The application was refused on the following grounds.

(a) Claims 1 and 10 of the then main request did not
    meet the requirements of Article 123(2) EPC and the
    subject-matter of these claims lacked novelty over
    the disclosure of document D1 or document D3
    (Article 54(1) and (2) EPC).

(b) Claim 1 of the then auxiliary request did not meet
    the requirements of Article 84 EPC and
    Article 123(2) EPC and the subject-matter of this
    claim lacked inventive step over the combined
    disclosures of documents D1 and D0
    (Article 56 EPC).

IV.   The applicant ("appellant") filed notice of appeal.
        With the statement of grounds of appeal, the appellant
        withdrew the main request on which the impugned
        decision was based and made the auxiliary request on
        which the impugned decision was based its sole request.

V.   The board issued a communication under Rule 100(2) EPC.
        In this communication the board expressed the following
        preliminary opinion, *inter alia*.

(a) The feature of claim 1 "*wherein each pixel is
    associated with a microlens of said microlens array
    such that all the light that passes through its
    associated microlens and through a corresponding
    sub-aperture on the main lens, and such that all
    rays passing through the sub-aperture on the main
    lens are focused through corresponding pixels under
    different microlenses, wherein the set of*

corresponding pixels constitutes an image frame"
defined a sub-aperture image in a manner commonly
known to the person skilled in the art of plenoptic
cameras.

The description, page 15, penultimate paragraph to
page 16, first paragraph, together with Figures 6A
and 6B, disclosed that a standard image and a
reference image as specified in claim 1 were both
sub-aperture images.

Hence, using common general knowledge, the person
skilled in the art would have directly and
unambiguously derived the quoted feature of claim 1
from the application as filed.

(b) The person skilled in the art would have understood
the quoted feature of claim 1 as specifying a sub-
aperture image of a plenoptic camera. The quoted
feature of claim 1 was thus clear to the person
skilled in the art.

(c) Claim 1 was unclear, but for reasons other than
those stated in the decision under appeal. These
reasons were as follows.

(i)   The feature of claim 1 reading "*at least
one light field data constituting the
standard image frame*" was unclear because
the quoted phrase implied that one sub-
aperture image, such as the standard image
frame, could be generated from multiple
light field data.

(ii)   In the feature of claim 1 reading "*light
field data of a reference image frame among
said at least one reference image frame*

respectively corresponding to the at least one light field data [constituting the standard image frame]" it was not clear what was meant in technical terms by a "correspondence" between light field data of different sub-aperture images, namely a standard image frame and a reference image frame.

(iii)   The term "*the one reference image frame*" in claim 1 lacked an antecedent.

VI.   By letter dated 21 September 2020, the appellant filed amended claims according to a main request and an auxiliary request.

VII.   In a communication under Article 15(1) of the Rules of Procedure of the Boards of Appeal in the 2020 version (RPBA 2020; see OJ EPO 2019, A63), the board diverged from its preliminary opinion concerning the feature of claim 1 quoted under point V.(a) above.

(a) The board expressed the preliminary view that, because of this feature, the subject-matter of claim 1 of all requests did not meet the requirements of Article 84 EPC and Article 123(2) EPC.

(b) In addition, the board raised objections under Article 123(2) EPC concerning the further amendments to claim 1 of the main request and the auxiliary request filed by letter dated 21 September 2020. The board objected that claim 1 of all the requests encompassed the option that the reference image used to determine a point spread function was not the same reference image from which a convolution of the standard image frame

with this point spread function was subtracted. This option was contrary to the disclosure in the description, page 13, lines 3 to 11.

VIII.   By letter dated 7 March 2022, the appellant filed claims according to a main request and first to fifth auxiliary requests to replace the previous main request and the previous auxiliary request.

IX.   On 7 April 2022, oral proceedings took place before the board.

During the oral proceedings, the appellant filed sets of claims according to a "sixth auxiliary request", a "seventh auxiliary request" of 12:51 hours and a "seventh auxiliary request" of 14:04 hours.

The appellant had the following final requests. The appellant requested that the decision under appeal be set aside and that a European patent be granted on the basis of the claims of the main request filed with the letter dated 7 March 2022, or, alternatively, on the basis of the claims of
-    the first auxiliary request filed during the oral proceedings of 7 April 2022 as "sixth auxiliary request",
-    the second auxiliary request filed with the letter dated 7 March 2022, or
-    the third auxiliary request filed during the oral proceedings of 7 April 2022, i.e. the request filed at 14:04 hours as "seventh auxiliary request", with claim 2 deleted, the remaining claims renumbered.

The appellant withdrew all other pending requests.

At the end of the oral proceedings, the chair announced the board's decision.

X.   Claim 1 of the main request reads as follows:

"An image processing apparatus, comprising:

- a light field data capturer, wherein the light field data capturer includes:

    a first optical unit adapted to form an image of an object, said first optical unit comprising a main lens;

    a photosensor array adapted to capture light rays, said photosensor array comprising a plurality of pixels, said photosensor array being configured to detect light incident thereon and to generate light data output; and

    a second optical unit located between the main lens and the photosensor array adapted to separate light rays based on direction of the light rays and to direct the light rays toward the photosensor array, said second optical unit comprising a microlens array;

wherein light rays from a single point on the object in an imaged scene arrive at a single convergence point in a focal plane of the microlens array, and wherein a separation distance between the main lens and the microlens array is selected within a depth of field of the microlens;

wherein each pixel is associated with a microlens of said microlens array such that:

- all the light that passes through a pixel passes
  through its associated microlens and through a
  corresponding sub-aperture on the main lens, and
- all rays passing through the sub-aperture on the
  main lens are focused on corresponding pixels under
  different microlenses, wherein the set of
  corresponding pixels constitutes an image frame;

- a data processor for processing image data and to
calculate an image of said scene using said light data
output, said data processor comprising:

an image frame determiner adapted to determine one
standard image frame and at least one reference
image frame, said one standard image frame and said
at least one reference image frame corresponding to
different sub-apertures on the main lens;

a point spread function determiner adapted to
determine a respective point spread function based
on sub-pixel displacement between the standard
image frame and a respective reference image frame
among the at least one reference image frame,
wherein the sub-pixel displacement on which a
respective point spread function is based is a
location difference between light field data
constituting the standard image frame and light
field data constituting the respective reference
image frame;

an image interpolator adapted to interpolate the
standard image frame to generate a high-resolution
standard image frame having a higher resolution
than the standard image frame; and

an image restorer comprising a residual value generator and an image updater, said residual value generator being configured to generate an image by subtracting, from one reference image frame among the at least one reference image frame, the convolution of the high-resolution standard image frame with the point spread function determined based on said standard image frame and said one reference image frame, said image updater being configured to update the high-resolution standard image frame using said generated image."

XI.   Claim 1 of the first auxiliary request differs from claim 1 of the main request in that the following text has been added before the full stop:

"wherein the standard image frame and the at least one reference image frame are low-resolution images or sub-sampled images with reduced spatial resolution compared to the updated high-resolution standard image frame"

XII.   Claim 1 of the second auxiliary request differs from claim 1 of the main request in that the paragraph starting with "all rays passing through a given sub-aperture" reads as follows:

"all rays passing through a given sub-aperture on the main lens are focused on corresponding pixels under different microlenses, wherein the set of corresponding pixels constitutes an image frame for said given sub-aperture, wherein a relative position of the pixels originating from the microlenses of the microlens array in the set of corresponding pixels is the same for each image frame;"

XIII.   Claim 1 of the third auxiliary request differs from
        claim 1 of the main request in that the paragraph
        starting with "all rays passing through a given sub-
        aperture" reads as follows:

        "all rays passing through a given sub-aperture on the
        main lens are focused on corresponding pixels under
        different microlenses, wherein the photosensor array is
        configured such that the corresponding pixels for each
        sub-aperture on the main lens are output by the
        photosensor array as an image frame for that sub-
        aperture, wherein a relative position of pixels in each
        outputted image frame is the same for each image
        frame;"

XIV.   The appellant's arguments, insofar as they are relevant
        to the present decision, may be summarised as follows.

        Main request and second auxiliary request

        (a) The person skilled in the art would not interpret
            claim 1 as specifying that the order of pixels
            within a sub-aperture image was completely
            arbitrary. Such a sub-aperture image would have
            resulted in a completely distorted image of a
            scene. This did not make technical sense. The
            person skilled in the art would have excluded such
            nonsensical interpretations of the quoted feature
            of claim 1.

            However, the person skilled in the art would have
            understood that some modifications to the order of
            pixels in all the sub-aperture images made
            technical sense, e.g. flipping left/right or up/
            down. If these modifications were made to all the
            sub-aperture images in the same manner, they would

not have impeded super-resolution processing of
these images as specified in the remainder of
claim 1.

Hence, the generalisation of the pixel ordering as
specified in claim 1 was directly and unambiguously
derivable from the application as filed when
considered as a whole.

First auxiliary request

(b) The first auxiliary request was to be admitted
because it was a response to a new objection raised
by the board in its communication under
Article 15(1) RPBA 2020 and the amended feature in
claim 1 of this request had an evident basis in the
description as originally filed, page 10, lines 1
to 10.

XV.   In the decision under appeal, the examining division
held the following in relation to claim 1 of the first
auxiliary request then on file.

Added subject-matter

(a) The amendment to claim 1 specifying: "*wherein each
pixel is associated with a microlens of said
microlens array such that all the light that passes
through a pixel passes through its associated
microlens and through a corresponding sub-aperture
on the main lens, and such that all rays passing
through the sub-aperture on the main lens are
focused through corresponding pixels under
different microlenses, wherein the set of
corresponding pixels constitutes an image frame*"
introduced subject-matter extending beyond the

content of the application as filed because neither
this text nor any corresponding content could be
found in the application as filed (see decision
under appeal, point 3.2.1).

(b) The feature of claim 1 "*said residual value
generator being configured to generate an image*"
lacked a basis in the application as filed because,
according to the description and the original
claims, the residual value generator generated a
value, not an image (see decision under appeal,
point 3.2.2).

Clarity and support by the description

(c) Claim 1 was not clear because the functional
statement quoted under point (a) above did not
enable the person skilled in the art to determine
which technical features were necessary for
performing the stated function. These features
appeared to be contradictory (see decision under
appeal, point 3.3.1).

(d) Claim 1 was not supported by the description. The
features of the "*light field capturer*" equally
applied to a common digital camera having a sensor
with a microlens above each pixel. An image of such
a camera was a subset of light field data (see
decision under appeal, point 3.3.2).

Inventive step

(e) Document D1 was considered as the prior art closest
to the claimed subject-matter. Document D1
disclosed all the features of claim 1 relating to
the super-resolution method. The person skilled in

the art would have been aware that several low-
resolution images representing different "looks" at
the same scene (see D1, page 22, the sentence
bridging the left-hand and right-hand columns)
could be taken by a light field camera as disclosed
in Figure 4 of document D0. Hence, the person
skilled in the art would have regarded it as a
normal design option to include the camera from
document D0 in the process described in
document D1. This objection could have also been
based on document D3 in combination with
document D0 (see decision under appeal, point 3.4).

Reasons for the Decision

1.   The appeal is admissible.

2.   The invention

        A plenoptic camera captures light field information of
        a scene using a main lens and a microlens array in
        front of an image sensor. Several pixels on the image
        sensor are reserved for each microlens. Hence, a level
        of light captured by a pixel makes it possible to
        derive not only light-intensity information, but also
        light-direction information. This enables a user to
        change a focal plane of an image after this image has
        been captured (see Figure 1 and the description,
        page 1, lines 10 to 20).

        However, when a larger refocusing range is to be
        realised, i.e. from 1 m to infinity, a spatial
        resolution of only 300x300 pixels is obtained from an
        image sensor containing 4145x4145 pixels (see
        description, page 8, line 20 to page 9, line 15).

To increase the spatial resolution, the application in hand proposes applying super-resolution processing to low-resolution images captured by the plenoptic camera.

In super-resolution processing, several low-resolution images are combined to create one high-resolution image (see description, page 10, lines 11 to 30 and Figures 3B and 3C).

In the application in hand, the low-resolution images are sub-aperture images, i.e. images which are made up of light field data passing through a particular area or sub-aperture on the main lens (see description, page 16, lines 1 to 11 and Figure 3A).

3.   Main request and second auxiliary request - admittance (Article 13(2) RPBA 2020)

3.1   The main request and the second auxiliary request were filed after the notification of the summons to oral proceedings. These requests are therefore amendments within the meaning of Article 13(2) RPBA 2020.

3.2   The board raised new objections under Articles 84 and 123(2) EPC in the communication under Article 15(1) RPBA 2020. In response to this communication, the appellant filed the main request and the second auxiliary request with the aim of overcoming these new objections. This sequence of events may be regarded as exceptional circumstances within the meaning of Article 13(2) RPBA 2020. Exercising its discretion under this provision, the board thus decided to admit the main request and the second auxiliary request into the appeal proceedings.

4.   Main request and second auxiliary request – added
        subject-matter (Article 123(2) EPC)

4.1   According to the consistent interpretation of
        Article 123(2) EPC by the Enlarged Board of Appeal, any
        amendment can only be made within the limits of what
        the person skilled in the art would derive directly and
        unambiguously, using common general knowledge, and seen
        objectively and relative to the date of filing, from
        the whole of the description, claims and drawings as
        filed (see Case Law of the Boards of Appeal of the
        European Patent Office, 9th edition 2019 ("Case Law"),
        II.E.1.3.1).

        The replacement of a specific feature disclosed in the
        invention by a broad general statement is to be
        considered as an inadmissible amendment under
        Article 123(2) EPC when this general statement
        implicitly introduces for the first time specific
        features other than that originally disclosed (see Case
        Law, II.E.1.8.1).

4.2   Claim 1 of the main request and the second auxiliary
        request was amended to specify that "*all rays passing
        through the sub-aperture on the main lens are focused
        on corresponding pixels under different microlenses,
        wherein the set of corresponding pixels constitutes an
        image frame*".

4.3   Claim 1 thus defines an image frame as a set of
        corresponding pixels. A set does not have any ordering
        and, as a consequence, the pixels in this set can have
        any order.

        However, due to the arrangement of the main lens and
        the microlens array as shown in Figure 1 of the

application as originally filed, the order of pixels in a sub-aperture image is not arbitrary, but is strictly linked to the arrangement of the micro-lenses from which the pixels in the sub-aperture image originate. In the following point, this is set out in more detail.

4.4   From the geometrical relationship between the main lens and the microlens array shown in Figure 1, it follows that each ray starting from a certain sub-aperture (e.g. the uppermost/middle/lowermost ray in Figure 1) ends in a corresponding pixel behind a microlens on the sensor (e.g. the lowermost/middle/uppermost pixel). This applies to all microlenses.

For example, a ray starting from the uppermost sub-aperture in Figure 1 ends in the lowermost pixel behind each microlens.

The sub-aperture image for the uppermost sub-aperture will thus include all of these lowermost pixels behind each of the microlenses.

However, this sub-aperture image will not include all of these lowermost pixels in arbitrary positions. On the contrary, the positions of these lowermost pixels in the sub-aperture image will be set according to the positions of the corresponding microlenses. Only in this way can a sub-aperture image correspond to a conventional photograph that would have resulted if taken with that sub-aperture as the lens opening.

To be specific, two microlenses, A and B, of the microlens array 120 in Figure 1 are considered. One of these microlenses ("microlens A") is above the other ("microlens B"). Rays starting from the uppermost sub-aperture on the main lens are incident on both

microlenses. A first ray ends on a first lowermost
pixel behind microlens A. A second ray ends on a second
lowermost pixel behind microlens B. The first lowermost
pixel will then be above the second lowermost pixel in
the sub-aperture image of the uppermost sub-aperture.

This shows that the order of pixels in a sub-aperture
image is not arbitrary, but is strictly linked to the
arrangement of the micro-lenses from which the pixels
in the sub-aperture image originate.

4.5   Therefore, the board finds that the feature quoted
under point 4.2 above, according to which the pixels
within a sub-aperture image can be in any order, is not
directly and unambiguously derivable from the
application as originally filed.

4.6   The appellant argued that the person skilled in the art
would not have interpreted claim 1 as specifying that
the order of pixels within a sub-aperture image was
completely arbitrary. This would have resulted in a
completely distorted image of a scene, which did not
make technical sense.

However, the person skilled in the art would have
understood that some modifications to the order of
pixels in all the sub-aperture images made technical
sense, e.g. flipping left/right or up/down. If these
modifications were made in all the sub-aperture images
in the same manner, they would not have impeded super-
resolution processing of these images as specified in
the remainder of claim 1.

Hence, the generalisation of the pixel ordering as
specified in claim 1 was directly and unambiguously

derivable from the application as filed when considered
as a whole (see point XIV.(a) above).

4.7   The board is not convinced by this argument because
        this generalisation of pixel ordering would implicitly
        introduce, for the first time, the presence of means
        for flipping left/right or up/down to arrive at pixel
        ordering other than that dictated by the microlens
        arrangement. Such means are not disclosed in the
        application as originally filed, however.

4.8   This applies regardless of whether
        (a) the relative positions of pixels can change per
            sub-aperture image, which is an option in claim 1
            of the main request, or
        (b) these relative positions are the same for each sub-
            aperture image, as in claim 1 of the second
            auxiliary request, specifying that "*a relative
            position of the pixels originating from the
            microlenses of the microlens array in the set of
            corresponding pixels is the same for each image
            frame*".

4.9   Therefore, the board finds that the feature of claim 1
        quoted under point 4.2 above is a generalisation which
        cannot be directly and unambiguously derived from the
        application as filed.

        Hence, claim 1 according to the main request and the
        second auxiliary request does not meet the requirements
        of Article 123(2) EPC.

5.   First auxiliary request - admittance
        (Article 13(1) and (2) RPBA 2020)

5.1   The first auxiliary request was filed during the oral
        proceedings. The first auxiliary request is therefore
        an amendment within the meaning of both Article 13(1)
        and (2) RPBA 2020, with paragraph 1 applying to
        amendments after the grounds of appeal were filed and
        paragraph 2 also applying to amendments made at a later
        stage, i.e. after notification of a summons to oral
        proceedings.

        Article 13(1) and (2) RPBA 2020 implement the second
        and third levels of the convergent approach applicable
        in appeal proceedings, respectively (see Supplementary
        publication 2, OJ EPO 2020, explanatory remarks on
        Article 13(1) and (2), first paragraphs, first
        sentences). At the third level of the convergent
        approach, which follows the second level, Article 13(1)
        RPBA 2020 also applies. The board may therefore also
        rely on criteria applicable at the second level of the
        convergent approach, i.e. as set out in Article 13(1)
        RPBA 2020 (cf. Supplementary publication 2, OJ
        EPO 2020, explanatory remarks on Article 13(2), fourth
        paragraph).

5.2   In the event of an amendment to a patent application,
        Article 13(1) RPBA 2020 prescribes that the board
        exercises its discretion in view of whether the
        appellant has demonstrated that any such amendment,
        prima facie, overcomes the issues raised by the board
        and does not give rise to new objections.

5.3   Claim 1 contains the following amended feature:
        "*wherein the standard image frame and the at least one
        reference image frame are low-resolution images or sub-
        sampled images with reduced spatial resolution compared
        to the updated high-resolution standard image frame*".

As a basis for this amended feature the appellant referred to the description as originally filed, page 10, lines 1 to 10 (see point XIV.(b) above).

However, this passage of the description compares the low-resolution images or sub-sampled images with an image taken with an ordinary camera. This passage of the description does not provide a comparison with an "*updated high-resolution standard image frame*", i.e. a frame generated by interpolating a sub-aperture image taken with a plenoptic camera.

Therefore, the board finds that the appellant has not demonstrated that the amendment to claim 1, prima facie, does not give rise to a new objection of added subject-matter (Article 123(2) EPC).

5.4   In view of this, the board, exercising its discretion relying on the criteria set out in Article 13(1) RPBA 2020, decided not to admit the first auxiliary request into the appeal proceedings.

6.   Third auxiliary request - admittance
        (Article 13(1) and (2) RPBA 2020)

6.1   The third auxiliary request was filed during the oral proceedings. Hence, the third auxiliary request is an amendment within the meaning of Article 13 RPBA 2020 for the same reasons as those set out under point 5.1 above.

6.2   The board considers the third auxiliary request to be a response to the objection under Article 123(2) EPC, which was raised for the first time in the board's communication under Article 15(1) RPBA 2020 and reiterated during the oral proceedings. Therefore, the

circumstances leading to this amendment may be
considered exceptional. Furthermore, the board finds
that this amendment overcomes all the objections and
does not give rise to new ones (see sections 7. to 9.
below). Therefore, the board exercised its discretion
under Article 13 RPBA 2020 in deciding to admit the
third auxiliary request into the appeal proceedings.

7.   Third auxiliary request - added subject-matter
        (Article 123(2) EPC and Article 76(1) EPC)

7.1   The features of claim 1 have the following basis in the
        claims and the description as originally filed of the
        current application and the earlier application (the
        description as originally filed being the same for the
        current application and the earlier application).

        An image processing apparatus (see page 4, lines 6
        to 8: "*image processing apparatus includes a light
        field data capturer 140 and a data processor 150*"),
        comprising:

        - a light field data capturer, wherein the light field
        data capturer includes:

            a first optical unit adapted to form an image of an
            object (see the original claim 10 in the current
            application and the original claim 11 in the
            earlier application), said first optical unit
            comprising a main lens (see page 4, lines 8 to 10:
            "*The light field data capturer 140 may include a
            main lens*");

            a photosensor array adapted to capture light rays
            (see the original claim 10 in the current
            application and the original claim 11 in the

earlier application), said photosensor array comprising a plurality of pixels (see page 8, lines 22 to 23: "*a sensor containing 4145x4145 pixels*"), said photosensor array being configured to detect light incident thereon and to generate light data output (see page 4, lines 26 to 32: "*The photosensor array 130 detects light incident thereon and generates an output processed by using at least one of several components. The output light data is sent to the data processor*"); and

a second optical unit located between the main lens and the photosensor array adapted to separate light rays based on direction of the light rays and to direct the light rays toward the photosensor array (see the original claim 10 in the current application and the original claim 11 in the earlier application), said second optical unit comprising a microlens array (see page 4, lines 8 to 10: "*a microlens array 120*");

wherein light rays from a single point on the object in an imaged scene arrive at a single convergence point in a focal plane of the microlens array (see page 4, lines 19 to 21: "*Light rays from a single point on an object 105 in an imaged scene can arrive at a single convergence point in a focal plane of the microlens array 120*"), and wherein a separation distance between the main lens and the microlens array is selected within a depth of field of the microlens (see page 7, lines 21 to 24: "*A separation distance 's' between the main lens 110 and the microlens array 120 may be selected within the depth of field of the microlens*");

wherein each pixel is associated with a microlens of said microlens array such that all the light that

passes through a pixel passes through its associated
microlens (see page 5, line 31 to page 6, line 2:
"*microlenses in the microlens array 120 and
photosensors in the photosensor array 130 may be
positioned such that light propagating through each
microlens toward the photosensor array does not overlap
with light propagating through adjacent microlenses*")
and through a corresponding sub-aperture on the main
lens (see page 15, lines 22 to 24: "*Fig. 6B shows that
the sensed LR data (e.g., light field data) is data
that has passed through sub-apertures of the main lens
620*"), all rays passing through a given sub-aperture on
the main lens are focused on corresponding pixels under
different microlenses (see page 15, lines 11 to 16:
"*Fig. 6A shows a light signal from objects 611 and 612
of a scene 610 passing through a main lens 620 having 9
sub-apertures and a light signal passing through each
sub-aperture of the main lens 620 incident on a light
pixel corresponding to the number of sub-apertures in a
light sensor 630*" and Figure 6A), wherein the
photosensor array is configured such that the
corresponding pixels for each sub-aperture on the main
lens are output by the photosensor array as an image
frame for that sub-aperture (see page 16, lines 1 to 3:
"*an image frame made up of light field data passing
through a 5th sub-aperture is determined as the
standard image frame*"), wherein a relative position of
pixels in each outputted image frame is the same for
each image frame (see page 16, lines 9 to 11: "*light
field data passing through the 6th sub-aperture is
determined to have a pixel shift of 0.125 with respect
to the standard image frame*");

- a data processor for processing image data and to
calculate an image of said scene using said light data
output (see page 5, lines 7 to 9: "*The data

processor 150 is configured to process image data and
to calculate an image of a scene"), said data processor
comprising:

an image frame determiner adapted to determine one
standard image frame and at least one reference
image frame (see the original claim 1 in both the
current application and the earlier application),
said one standard image frame and said at least one
reference image frame corresponding to different
sub-apertures on the main lens (see page 15,
line 29 to page 16, line 11: "*Fig. 6C shows an*
example of sub-pixel displacement of reference
image frames with respect to a standard image
frame ... it is assumed that an image frame made up
of light field data passing through a 5th sub-
aperture is determined as the standard image
frame ... an image frame consisting of light field
data passing through the 6th sub-aperture is
determined to have a pixel shift of 0.125 with
respect to the standard image frame"; see
Figures 6A to 6C);

a point spread function determiner adapted to
determine a respective point spread function based
on sub-pixel displacement between the standard
image frame and a respective reference image frame
among the at least one reference image frame (see
the original claim 1 in both the current
application and the earlier application), wherein
the sub-pixel displacement on which a respective
point spread function is based is a location
difference between light field data constituting
the standard image frame and light field data
constituting the respective reference image frame
(see page 12, lines 4 to 8: "*The sub-pixel*

displacement may be a location difference between
at least one light field data constituting the
standard image frame and light field data of a
reference image frame");

an image interpolator adapted to interpolate the
standard image frame to generate a high-resolution
standard image frame having a higher resolution
than the standard image frame (see the original
claim 1 in both the current application and the
earlier application); and

an image restorer (see the original claim 1 in both
the current application and the earlier
application) comprising a residual value generator
and an image updater (see page 13, lines 1 and 2:
"*the image restorer 440 may include a residual*
value generator 442 and an image updater 444" and
Figure 4: 440), said residual value generator being
configured to generate an image by subtracting,
from one reference image frame among the at least
one reference image frame, the convolution of the
high-resolution standard image frame with the point
spread function determined based on said standard
image frame and said one reference image frame,
said image updater being configured to update the
high-resolution standard image frame using said
generated image (see page 13, lines 3 to 14: "*The*
residual value generator 442 generates a residual
value using the generated high-resolution standard
image frame, one of the reference image frames, and
the point spread function based on the one
reference image frame and the standard image frame.
Here, the residual value may a value of the one
reference image frame (i.e. observed image) minus
the convolution of the high-resolution standard

*image frame with the point spread function (i.e.,
estimated image). The image updater 444 updates the
high-resolution standard image frame using the
residual value*").

7.2   Dependent claims 2 to 4 of the third auxiliary request
        correspond to the original claims 4, 5 and 8 in the
        current application and to the original claims 5, 6
        and 9 in the earlier application, respectively.

        Dependent claim 5 of the third auxiliary request is
        based on the original claim 9 in the current
        application and the original claim 10 in the earlier
        application. Dependent claim 5 was amended to specify
        that the point spread function is "*determined for the
        another one of the at least one reference image frame*".
        This amendment means that another point spread function
        is determined once another reference image frame is
        used to update the high-resolution standard image
        frame. This amendment is based on the description,
        page 13, lines 15 to 20: "*the point spread function
        based on the other one of the reference image frames
        and the standard image frame*".

7.3   In the decision under appeal, the examining division
        objected that an amendment reading "*wherein each pixel
        is associated with a microlens of said microlens array
        such that all the light that passes through a pixel
        passes through its associated microlens and through a
        corresponding sub-aperture on the main lens, and such
        that all rays passing through the sub-aperture on the
        main lens are focused through corresponding pixels
        under different microlenses, wherein the set of
        corresponding pixels constitutes an image frame*"
        introduced subject-matter which extended beyond the
        content of the application as filed. Neither the quoted

text nor its content could be found in the application
as filed (see point XV.(a) above).

This objection does not apply to claim 1 of the third
auxiliary request, since only part of the quoted text
but not the entirety thereof is included in this claim.

7.4   In the decision under appeal the examining division
        objected that the feature of claim 1 "*said residual
        value generator being configured to generate an image*"
        lacked a basis in the application as filed because,
        according to the description and the original claims,
        the residual value generator generated a value, not an
        image (see point XV.(b) above).

        The board does not consider this objection to be
        justified because the description, page 13, lines 11
        to 14 discloses "*The image updater 444 updates the
        high-resolution standard image frame using the residual
        value (i.e., the image obtained by subtracting the
        estimated image from the observed image)*" (emphasis
        added by the board).

7.5   The board finds that the objection under
        Article 123(2) EPC raised against claim 1 of the main
        request and the second auxiliary request (see
        section 4. above) does not apply to claim 1 of the
        third auxiliary request. This objection arose from the
        fact that, according to claim 1 of the main request and
        the second auxiliary request, an image frame was
        specified as a set of pixels, wherein the pixels within
        this set could have had any order. This is not the case
        in claim 1 of the third auxiliary request. Claim 1 of
        the third auxiliary request specifies that "*the
        corresponding pixels for each sub-aperture on the main
        lens are output by the photosensor array as an image*

frame", i.e. without any change in their order.
Furthermore, claim 1 specifies that "*all rays passing
through a given sub-aperture on the main lens are
focused on corresponding pixels under different
microlenses*". Hence, the positions of the corresponding
pixels in the image frame are implied by the starting
points of each of the rays, namely a given sub-aperture
on the main lens, and a further point on which each of
the rays are incident, namely the relevant microlens.

7.6   Claim 1 specifies that the "*residual value generator
        being configured to generate an image by subtracting,
        from one reference image frame among the at least one
        reference image frame, the convolution of the high-
        resolution standard image frame with the point spread
        function determined based on said standard image frame
        and said one reference image frame*" (emphasis added by
        the board). Hence, claim 1 specifies that the reference
        image used to determine a point spread function is the
        same reference image from which a convolution of the
        standard image frame with this point spread function is
        subtracted. This is in line with the disclosure in the
        description, page 13, lines 3 to 11. The objection of
        added subject-matter raised in the board's
        communication under Article 15(1) RPBA 2020 (see
        point VII.(b) above) has thus been resolved.

7.7   In view of the above, the claims of the third auxiliary
        request do not contain subject-matter which extends
        beyond the content of the application as filed or the
        earlier application as filed. Therefore, these claims
        meet the requirements of Article 123(2) EPC and
        Article 76(1) EPC.

8.   Third auxiliary request - clarity and support by the
        description (Article 84 EPC)

8.1   In the decision under appeal the examining division
       objected that the functional statement quoted under
       point 7.3 above did not enable the person skilled in
       the art to determine which technical features were
       necessary for performing the stated function. These
       features appeared contradictory (see point XV.(c)
       above).

       This objection does not apply to claim 1 of the third
       auxiliary request, since only part of the quoted text
       but not the entirety thereof is included in this claim.

8.2   In the decision under appeal the examining division
       objected that claim 1 of the auxiliary request then on
       file was not supported by the description because the
       feature of the "*light field data capturer*" according to
       claim 1 equally applied to a common digital camera
       having a sensor with a microlens above each pixel (see
       point XV.(d) above).

       The board is not convinced by this objection and holds
       that the term "*light field data*" is a specific
       expression known in the art to distinguish data
       including light-direction information from data
       including only light-intensity information. Hence, the
       person skilled in the art of plenoptic cameras would
       not interpret the feature of a "*light field data
       capturer*" as including a common digital camera.

8.3   The board finds that the passage of claim 1 "*the
       standard image frame and a respective reference image
       frame among the at least one reference image frame,
       wherein the sub-pixel displacement on which a
       respective point spread function is based is a location
       difference between light field data constituting the*

*standard image frame and light field data constituting
the respective reference image frame*" clearly specifies
that there is one standard image frame and potentially
multiple reference image frames each constituted by
respective light field data. The same applies
accordingly to dependent claims 5 and 6. Hence, the
objections of lack of clarity raised in the board's
communication under Rule 100(2) EPC (see points V.(c)
(i) to (iii) above) have been resolved.

8.4   In view of the above, the claims of the third auxiliary
        request are clear and supported by the description
        (Article 84 EPC).

9.   Third auxiliary request - inventive step
        (Article 56 EPC)

9.1   According to Article 56 EPC, "*[a]n invention shall be
        considered as involving an inventive step if, having
        regard to the state of the art, it is not obvious to a
        person skilled in the art*". It is established case law
        that the "problem and solution approach" is an
        appropriate tool for assessing whether claimed subject-
        matter fulfils the requirements of Article 56 EPC (see
        Case Law, I.D.2).

        Furthermore, the closest prior art for assessing
        inventive step is normally a prior-art document
        disclosing subject-matter conceived for the same
        purpose or aiming at the same objective as the claimed
        invention and having the most relevant technical
        features in common, i.e. requiring the minimum of
        structural modifications (see Case Law, I.D.3.1).

9.2   Claim 1 specifies an image processing apparatus, in
        particular a plenoptic camera, in which a special form

of super-resolution processing is applied to captured
images.

Therefore, the board finds that the prior art closest
to the subject-matter of claim 1 needs to be a document
disclosing a plenoptic camera, namely either
document D0 or document D2.

The board is not convinced by the examining division's
approach of selecting document D1, disclosing the
special form of super-resolution processing, as the
closest prior art (see point XV.(e) above), because
this leads to a situation in which all the structural
elements of a plenoptic camera are distinguishing
features.

9.3   The board holds that the subject-matter of claim 1
        differs from the disclosure of either document D0 or
        document D2 in that the former specifies a particular
        structure of a data processor including an image frame
        determiner, a point spread function determiner, an
        image interpolator and an image restorer. This
        particular structure implements a way to increase the
        resolution of captured images.

9.4   The board thus finds that, starting from either
        document D0 or document D2, the objective technical
        problem to be solved may be regarded as that of
        increasing the spatial resolution of an image captured
        by a plenoptic camera. The person skilled in the art is
        given an incentive to address this problem, i.e. the
        fact that a plenoptic camera without additional image
        processing has an insufficient spatial resolution, for
        example by document D2, section V, first paragraph:
        "*will offer a spatial resolution of only 100x100*".

9.5   The board finds that for the person skilled in the art
        faced with this problem, the particular solution,
        specified in claim 1, namely that of applying super-
        resolution processing by using the information from
        other sub-aperture images to increase the resolution of
        a standard sub-aperture image, would not have been
        obvious. The reasons are as follows.

        First, it is not obvious to combine either document D0
        or document D2 with document D1. As a requirement for
        applying super-resolution processing, document D1
        states that multiple low-resolution images are captured
        from the same scene. In particular, document D1 states
        on page 22, right column, first paragraph: "*To obtain
        different looks at the same scene, some relative scene
        motions must exist from frame to frame via multiple
        scenes or video sequences. Multiple scenes can be
        obtained from one camera with several captures or from
        multiple cameras located in different positions*". In a
        plenoptic camera a scene is captured in one go with a
        single camera. Hence, there are neither several
        captures nor multiple cameras (see point XV.(e) above).

        Second, even if the person skilled in the art were to
        combine the disclosure of either document D0 or
        document D2 with the disclosure of document D1, this
        would not have led to all the features of claim 1. In
        document D1 the point spread function is a spatial
        averaging operator describing a sensor (see D1,
        page 24, right column, first full paragraph).
        Document D1 does not disclose adapting a point spread
        function to a displacement between two selected low-
        resolution frames, one being called a standard frame
        and the other being called a reference frame.

9.6   As a consequence, the board concludes that the subject-
        matter of claim 1 according to the third auxiliary
        request is not obvious when starting from either
        document D0 or document D2.

9.7   Moreover, the board cannot see any other document or
        combination of documents on file on the basis of which
        the person skilled in the art would have arrived at the
        claimed subject-matter.

        In particular, document D3 is not an appropriate
        starting point, contrary to the examining division's
        opinion (see point XV.(e) above). The camera disclosed
        in document D3 has no main lens and document D3 does
        not disclose the specific super-resolution technique of
        iterative back-projection requiring an image
        interpolator and an image restorer. Hence, starting
        from document D3, both structural and algorithmic
        modifications would have been needed to arrive at the
        subject-matter of claim 1. This is not obvious.

9.8   It follows that the subject-matter of claim 1 involves
        an inventive step within the meaning of Article 56 EPC.

9.9   Claims 2 to 5 are dependent claims. Therefore, their
        subject-matter also involves an inventive step.

10.   Conclusion

        The main request and the second auxiliary request are
        not allowable because claim 1 of these requests does
        not meet the requirements of Article 123(2) EPC.

        The first auxiliary request was not admitted into the
        appeal proceedings under Article 13 RPBA 2020.

The set of claims according to the third auxiliary
request meets the requirements of the EPC.

Order

For these reasons it is decided that:

1.   The decision under appeal is set aside.

2.   The case is remitted to the examining division with the
        order to grant a patent on the basis of the claims of
        the third auxiliary request and a description to be
        adapted thereto.

The Registrar: The Chair:

A. Chavinier Tomsic   B. Willems

Decision electronically authenticated