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(54) Title: A METHOD FOR OBTAINING AT LEAST ONE SUB-APERTURE IMAGE BEING ASSOCIATED WITH ONE VIEW

(57) Abstract: In one embodiment, it is proposed a method for obtaining at least one sub-aperture image being associated with one view, from raw light field data corresponding to recorded data by an array of pixels sensors positioned behind an array of micro-lenses in a light field camera, each of said pixel sensor recording a linear mixing of up to four different views. The method is remarkable in that it comprises applying a signal separation process on said raw data by using an inverse of a mixing matrix A, said mixing matrix comprising coefficients that convey weighting information of said up to four different views recorded by a pixel sensor.

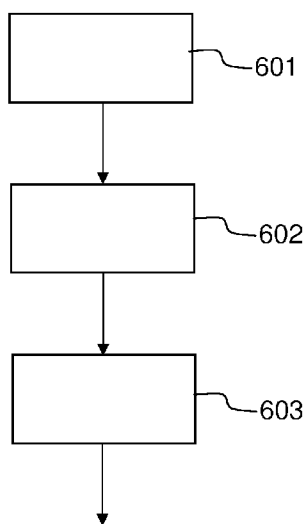


FIG.6



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A method for obtaining at least one sub-aperture image being associated with one view

Technical Field

The disclosure relates to the processing of raw data obtained by a plenoptic camera (also named a light field camera).

5 Background

This section is intended to introduce the reader to various aspects of art, which may be related to various aspects of the present invention that are described and/or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present invention. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

The development of plenoptic camera that enable to perform refocusing a posteriori is a hectic research subject. In order to achieve such refocusing, it is needed to perform some shifting and adding operations on several sub-aperture images (that correspond to images of a same scene obtained from different acquisition angles at a same time, a sub-aperture image being also named a viewpoint image), as explained for example in the article entitled "Light Field Photography with a Hand-held Plenoptic Camera" by Ren Ng et al, in the Stanford Tech Report CTSR 2005-02. In order to obtain a sub-aperture image from raw data obtained/acquired by a plenoptic camera, usually the processing which is done consists of obtaining the same pixel under each of the micro-lenses comprised in the plenoptic camera (a micro-lens generating a micro image, also named a lenslet image), and gathering these obtained pixels in order to define a sub-aperture image. However, such processing for obtaining a set of sub-aperture images from raw data is based on the hypothesis that each sensor pixel positioned behind the microlenses array only record one viewpoint pixel image, as mentioned in the Chapter 3.3 of the Phd dissertation thesis entitled "Digital Light Field Photography" by Ren Ng, published in July 2006, due to the fact that the coordinates of the center of a micro-image formed by a microlens have only integer values (i.e. there is a perfect match between a micro image (or lenslet image) and the image

sensors/pixels sensors). From a mathematical point of view (and in view of the figures 2 and 3 in the present document), such processing from raw data to a set of sub-aperture images can be formulated as follows:

$$V_{n,m}[k, l] = R_{l,k}[m, n]$$

- 5 Where $V_{n,m}$ denotes a sub-aperture image, and $R_{l,k}$ denotes a micro-image (also noted μ -image), with $n \in \llbracket 0, N - 1 \rrbracket$, $m \in \llbracket 0, M - 1 \rrbracket$, $l \in \llbracket 0, L - 1 \rrbracket$, and $k \in \llbracket 0, K - 1 \rrbracket$.

However, it should be noted that the hypothesis previously formulated is not always verified. Indeed, the micro-image $R_{l,k}$ may be misaligned with the sensor array. Therefore, the sub-apertures images extraction process (such process is also named a demultiplexing process or
10 also a decoding process as detailed in the article "Accurate Disparity Estimation for Plenoptic Images" by N. Sabater et al., published in ECCV Workshop 2014) from the raw data is not as accurate as it should be. Hence, it is necessary to improve the extraction process in order to determine correctly the set of sub-aperture images. In order to solve this issue, a technique described in the document **US 2014/0146184** proposes to perform a calibration for correcting
15 the misalignment.

The proposed technique is an alternative to the one of document **US 2014/0146184**.

Summary of the disclosure

References in the specification to "one embodiment", "an embodiment", "an example embodiment", indicate that the embodiment described may include a particular feature,
20 structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments
25 whether or not explicitly described.

The present disclosure is directed to a method for obtaining at least one sub-aperture image being associated with one view, from raw light field data corresponding to recorded data by an array of pixels sensors positioned behind an array of micro-lenses in a light field camera, each of said pixel sensor recording a linear mixing of up to four different views. The method is remarkable in that it comprises applying a signal separation process on said raw data by using an inverse of a mixing matrix A, said mixing matrix comprising coefficients that convey weighting information of said up to four different views recorded by a pixel sensor.

In a preferred embodiment, the method is remarkable in that said coefficients are defined according to positions, in said array of pixels, of micro-lenses images centers.

In a preferred embodiment, the method is remarkable in that said applying comprises multiplying said recorded data, represented by a column vector, by said inverse of said mixing matrix A.

In a preferred embodiment, the method is remarkable in that said signal separation is a blind signal separation.

Indeed, in one embodiment of the disclosure, it is possible to apply a blind separation technique. Indeed, such kind of technique can be efficient for recovering a sub-aperture image. Blind separation technique has been successfully applied in the processing of image data as explained in the article entitled: "Blind separation of superimposed shifted images using parameterized joint diagonalization" by Be'ery E. and Yeredor A., and published in IEEE Trans Image Process. 2008 Mar;17(3):340-53, where blind separation of source images from linear mixtures is done.

In a preferred embodiment, the method is remarkable in that said coefficients are obtained by performing a calibration process on said light field camera.

According to an exemplary implementation, the different steps of the method are implemented by a computer software program or programs, this software program comprising software instructions designed to be executed by a data processor of a relay module according

to the disclosure and being designed to control the execution of the different steps of this method.

Consequently, an aspect of the disclosure also concerns a program liable to be executed by a computer or by a data processor, this program comprising instructions to command the execution of the steps of a method as mentioned here above.

This program can use any programming language whatsoever and be in the form of a source code, object code or code that is intermediate between source code and object code, such as in a partially compiled form or in any other desirable form.

The disclosure also concerns an information medium readable by a data processor and comprising instructions of a program as mentioned here above.

The information medium can be any entity or device capable of storing the program. For example, the medium can comprise a storage means such as a ROM (which stands for "*Read Only Memory*"), for example a CD-ROM (which stands for "*Compact Disc - Read Only Memory*") or a microelectronic circuit ROM or again a magnetic recording means, for example a floppy disk or a hard disk drive.

Furthermore, the information medium may be a transmissible carrier such as an electrical or optical signal that can be conveyed through an electrical or optical cable, by radio or by other means. The program can be especially downloaded into an Internet-type network.

Alternately, the information medium can be an integrated circuit into which the program is incorporated, the circuit being adapted to executing or being used in the execution of the method in question.

According to one embodiment, an embodiment of the disclosure is implemented by means of software and/or hardware components. From this viewpoint, the term "module" can correspond in this document both to a software component and to a hardware component or to a set of hardware and software components.

A software component corresponds to one or more computer programs, one or more sub-programs of a program, or more generally to any element of a program or a software program capable of implementing a function or a set of functions according to what is described here below for the module concerned. One such software component is executed by a data processor of a physical entity (terminal, server, etc.) and is capable of accessing the hardware resources of this physical entity (memories, recording media, communications buses, input/output electronic boards, user interfaces, etc.).

Similarly, a hardware component corresponds to any element of a hardware unit capable of implementing a function or a set of functions according to what is described here below for the module concerned. It may be a programmable hardware component or a component with an integrated circuit for the execution of software, for example an integrated circuit, a smart card, a memory card, an electronic board for executing firmware etc. In a variant, the hardware component comprises a processor that is an integrated circuit such as a central processing unit, and/or a microprocessor, and/or an Application-specific integrated circuit (ASIC), and/or an Application-specific instruction-set processor (ASIP), and/or a graphics processing unit (GPU), and/or a physics processing unit (PPU), and/or a digital signal processor (DSP), and/or an image processor, and/or a coprocessor, and/or a floating-point unit, and/or a network processor, and/or an audio processor, and/or a multi-core processor. Moreover, the hardware component can also comprise a baseband processor (comprising for example memory units, and a firmware) and/or radio electronic circuits (that can comprise antennas) which receive or transmit radio signals. In one embodiment, the hardware component is compliant with one or more standards such as ISO/IEC 18092 / ECMA-340, ISO/IEC 21481 / ECMA-352, GSMA, StLoPaN, ETSI / SCP (Smart Card Platform), GlobalPlatform (i.e. a secure element). In a variant, the hardware component is a Radio-frequency identification (RFID) tag. In one embodiment, a hardware component comprises circuits that enable Bluetooth communications, and/or Wi-fi communications, and/or Zigbee communications, and/or USB communications and/or Firewire communications and/or NFC (for Near Field) communications.

It should also be noted that a step of obtaining an element/value in the present document can be viewed either as a step of reading such element/value in a memory unit of an electronic device or a step of receiving such element/value from another electronic device via communication means.

5 In another embodiment of the disclosure, it is proposed an electronic device for obtaining at least one sub-aperture image being associated with one view, from raw light field data corresponding to recorded data by an array of pixels sensors positioned behind an array of micro-lenses in a light field camera, each of said pixel sensor recording a linear mixing of up to four different views. The electronic device comprises a memory and at least one processor coupled
10 to the memory, and the at least one processor is remarkable in that it is configured to apply a signal separation process on said raw data by using an inverse of a mixing matrix A , said mixing matrix comprising coefficients that convey weighting information of said up to four different views recorded by a pixel sensor.

In a variant, the electronic device is remarkable in that said coefficients are defined
15 according to positions, in said array of pixels, of micro-lenses images centers.

In a variant, the electronic device is remarkable in that said at least one processor is further configured to multiply said recorded data, represented by a column vector, by said inverse of said mixing matrix A .

In a variant, the electronic device is remarkable in that said signal separation is a blind
20 signal separation.

In a variant, the electronic device is remarkable in that said at least one processor is further configured to perform a calibration of said light field camera in order to obtain said coefficients.

Brief description of the drawings

The above and other aspects of the invention will become more apparent by the following detailed description of exemplary embodiments thereof with reference to the attached drawings in which:

- 5 - Figure 1 presents schematically the main components comprised in a plenoptic camera that enable the acquisition of raw light field data on which the present technique can be applied;
- Figure 2 presents, in a schematic way, a micro-lens array comprising *K.L* micro-lenses comprised in a plenoptic camera;
- 10 - Figure 3 presents a set of sub-aperture images (also named a matrix of views) obtained from the demultiplexing process applied on raw data acquired by a plenoptic camera;
- Figure 4 presents, based on a schematic representation of the pixel sensors array, the terminology and notations that is used to described one embodiment of the disclosure;
- Figures 5(A) and (B) focus on views recorded by a pixel in relation with the position of a micro-lens;
- 15 - Figure 6 depicts a method for obtaining at least one sub-aperture image from raw data acquired by a plenoptic camera, according to one embodiment of the disclosure;
- Figure 7 presents an example of a device that can be used to perform one or several steps of methods disclosed in the present document.

Detailed description

20 The figure 1 presents schematically the main components comprised in a plenoptic camera that enable the acquisition of raw light field data on which the present technique can be applied.

More precisely, a plenoptic camera comprises a main lens referenced 101, and a sensor array (i.e., an array of pixel sensors (for example a sensor based on CMOS technology)),
25 referenced 104. Between the main lens 101 and the sensor array 104, a micro-lens array referenced 102, that comprises a set of micro-lenses referenced 103, is positioned. It should be noted that optionally some spacers might be located between the micro-lens array around each lens and the sensor to prevent light from one lens to overlap with the light of other lenses at the

sensor side. In one embodiment, all the micro-lenses have the same focal. In another embodiment, the micro-lens can be classified into at least three groups of micro-lenses, each group being associated with a given focal, different for each group. Moreover, in a variant, the focal of a micro-lens is different from the ones positioned at its neighborhood; such configuration enables the enhancing of the plenoptic camera's depth of field. It should be noted that the main lens 101 can be a more complex optical system as the one depicted in figure 1 (as for example the optical system described in figures 12 and 13 of document **GB2488905**) Hence, a plenoptic camera can be viewed as a conventional camera plus a micro-lens array set just in front of the sensor as illustrated in the figure 1. The light rays passing through a micro-lens cover a part of the sensor array that records the radiance of these light rays. The recording by this part of the sensor defines a micro-lens image.

More details related to plenoptic camera can be found out in the Section 4 entitled "*Image formation of a Light field camera*" in the article entitled "*The Light Field Camera: Extended Depth of Field, Aliasing, and Super resolution*" by Tom E. Bishop and Paolo Favaro, published in the IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 34, N°5, in May 2012.

The figure 2 presents, in a schematic way, a micro-lens array comprising $K.L$ micro-lenses (i.e. an array of L rows of micro-lenses and K columns of micro-lenses), and each micro-lens is associated with a part of the pixel sensors array. For example, such part of the pixel sensors array can be a rectangular comprising $M.N$ pixel sensors. Usually, the light rays passing through a micro-lens defines/generates a micro-image that is recorded within the part of the pixel sensors array associated with said micro-lens. Indeed, by malapropism, the micro-image and this part of the pixel sensors are considered as equivalent terms. Hence, for example $R_{l,k}$ denotes a micro-image (also noted μ -image) positioned at row referenced l , and column referenced k . Therefore, it is possible to obtain from raw data (corresponding to the data recorded by the $L.K.N.M$ pixels that are positioned below/under the $K.L$ microlenses), a number of $N.M$ sub-aperture images, each sub-aperture image comprising $K.L$ pixels (as depicted in the figure 3, which represents a set (referenced 300) of sub-aperture images; such set is also named a matrix of views in the prior art).

For reminders, a sub-aperture image corresponds to an image of the object space from a given view (i.e. it can be viewed as a sampling of the pupil). In theory, when the micro-lens array and the pixel sensor array are perfectly aligned, the pixels from the raw data and the pixels from the sub-aperture images are linked by the following equation:

$$5 \quad V_{n,m}[k,l] = R_{l,k}[m,n]$$

where $V_{n,m}$ denotes a sub-aperture image positioned at row referenced n and column referenced m in the matrix of views referenced 300, and $R_{l,k}$ denotes a micro-image (also noted μ -image). Hence $V_{n,m}[k,l]$ corresponds to the pixel located at position (k,l) in the sub-aperture image $V_{n,m}$.

10 It should be noted that rearranging μ -images into sub-aperture images requires to know precisely the location of the μ -images. In the following we denote $(c_{k,l}^x, c_{k,l}^y)$ the coordinates of the μ -center $\mathbf{c}_{k,l}$ i.e. the center of the μ -image (k,l) .

In the literature, most approaches propose de-mosaicking of the raw sensor image at first step, before having any insight of the scene geometry. This induces irrelevant interpolations
15 between samples within μ -images. To circumvent this, disparity-guided de-mosaicking has been proposed in the article entitled "Accurate Disparity Estimation for Plenoptic Images" by Neus Sabater et al., published in the conference proceedings of the Workshop on Light Fields for Computer Vision, ECCV 2014, but that solution relies on nearest integer coordinates, which lessens the accuracy of the reconstructed sub-aperture images.

20 It is proposed a new approach to the generation of matrices of views that handles sub-pixel position for μ centers and plenoptic samples, while keeping interpolations consistent with physics.

The figure 4 presents, based on a schematic representation of the pixel sensors array, the terminology and notations that is used to describe one embodiment of the disclosure.

25 Indeed, in view of the figure 4, the following notation is used:

coordinates (i, j) correspond to horizontal and vertical integer coordinates in the raw sensor picture;

coordinates (k, l) corresponds to horizontal and vertical indices of a μ -image;

coordinates (m, n) correspond to horizontal and vertical indices of a sub-aperture image;

5 coordinates (x, y) correspond to horizontal and vertical real (a priori non-integers) coordinates in a μ -image.

Besides, the following integers are defined:

K and L respectively denote the width and height of the μ -lens array. In the case of hexagonal patterns, one dimension is doubled so that every lens presents integer indices.

10 W and H respectively denote the width and height of the sensor.

M and N respectively denote the width and height of a μ -image. In the case of a square pattern, $M = \lfloor \frac{W}{K} \rfloor$ and $N = \lfloor \frac{H}{L} \rfloor$, where $\lfloor . \rfloor$ denotes the floor function. In the case of a row-major hexagonal pattern, note that $M = \lfloor \frac{2W}{K} \rfloor$. In the case of a column-major hexagonal pattern, note that $N = \lfloor \frac{2H}{L} \rfloor$.

15 Usually, camera calibration provides the positions of μ -centers $\{(c_{k,l}^x, c_{k,l}^y) \in \mathbb{R}^2\}_{\substack{1 \leq k \leq K \\ 1 \leq l \leq L}}$.

These positions are a priori not integers.

Pixels positions (i, j) can be turned into:

The indices (k, l) of the μ -image they belong;

20 their relative (a priori non-integer) position $(x, y) \in \mathbb{R}^2$ with regards to corresponding μ -centers $(c_{k,l}^x, c_{k,l}^y)$.

Pixels also have a color channel (Red or Green or Blue, or Lightness, or Infra-red or whatever) and an intensity.

In the ideal case, each pixel of the sensor is associated with a unique view as detailed for example in the figure 5(A) which focuses on the μ -image R_{kl} , where for example it is shown that a unique view is associated with (or recorded by) a pixel. However, in the coordinate system relative to the μ -image, pixels have a priori non-integer coordinates. Physically, this means that pixels integrate photons originating from different parts of the pupil that are sampled in separate views. For example, in the figure 5(B), it is depicted another plenoptic camera in which a pixel receives and records the contribution of several different views. In the worst case (as presented in the figure 5(B)), a pixel records information coming from up to four different views.

Therefore, by formalizing and generalizing this observation, it appears that a relationship (also called equation 1 in the following) linking the raw data (i.e. the data recorded by the pixels) and sub-aperture images can be established:

$R(i, j) = \alpha\beta \cdot V_{[y],[x]}(k, l) + \alpha\bar{\beta} \cdot V_{[y],[x]}(k, l) + \bar{\alpha}\beta \cdot V_{[y],[x]}(k, l) + \bar{\alpha}\bar{\beta} \cdot V_{[y],[x]}(k, l)$, with again:

R denoting the raw sensor picture;

$(i, j) \in \mathbb{N}^2$ the pixel position in the raw picture;

$(k, l) \in \mathbb{N}^2$ the corresponding the μ -image indices in the raw picture;

$(x, y) \in \mathbb{R}^2$ the relative (a priori non-integer) pixel coordinates in the μ -image with regards to μ -center position $(c_{k,l}^x, c_{k,l}^y) \in \mathbb{R}^2$.

$[\cdot]$ and $\lceil \cdot \rceil$ respectively denoting floor and ceiling functions, and where

$\alpha = x - [x]$ and $\bar{\alpha} = 1 - \alpha = \lceil x \rceil - x$

$\beta = y - [y]$ and $\bar{\beta} = 1 - \beta = \lceil y \rceil - y$

Now let us consider both the raw image and the matrix of views as $(KLMN)$ -row vectors.

Let also m and n respectively denote the integer parts of x and y : $m = [x]$ and $n = [y]$

We can write down equation 1 as a matrix product:

$$\mathbf{R} = \mathbf{A} \cdot \mathbf{V}$$

$$\begin{pmatrix} \vdots \\ R[i,j] \\ \vdots \end{pmatrix} = \begin{pmatrix} \dots & \alpha\beta & \dots & \bar{\alpha}\beta & \dots & \alpha\bar{\beta} & \dots & \bar{\alpha}\bar{\beta} & \dots \end{pmatrix} \cdot \begin{pmatrix} \vdots \\ V_{n,m}[k,l] \\ \vdots \\ V_{n,m+1}[k,l] \\ \vdots \\ V_{n+1,m}[k,l] \\ \vdots \\ V_{n+1,m+1}[k,l] \\ \vdots \end{pmatrix}.$$

With $R[i,j]$ being the $(j \cdot KM + i)^{th}$ line of vector \mathbf{R}

$V_{n,m}[k,l]$ being the $((n \cdot L + l) \cdot KM + (m \cdot K + k))^{th}$ line of vector \mathbf{V}

5 And \mathbf{A} being a square $KLMN \times KLMN$ matrix.

Some remarks concerning the matrix \mathbf{A} can be done:

- the matrix \mathbf{A} is sparse; indeed, each line of \mathbf{A} presents at most four (possibly two or one only) nonzero coefficients;
 - the matrix \mathbf{A} is invertible and its rank is $KLMN$. Note the size of \mathbf{A} is not necessarily
- 10 $W \times H$. Some lines must be removed if they correspond to black pixels that don't belong to any μ -image.

In the monochrome case, sub-aperture images can be recovered straightforwardly:

$$\mathbf{A}^{-1} \cdot \mathbf{R} = \mathbf{V}$$

15 In the RGB case, \mathbf{R} can be considered a $KLMN \times 3$ vector, whose coefficients are only partially known:

$$\mathbf{R} = \begin{pmatrix} \vdots \\ ? g ? \\ ? ? b \\ r ? ? \\ \vdots \end{pmatrix}$$

In this case, color planes of the sub-aperture images can only be partially recovered, and de-mosaicking is performed.

In one embodiment of the disclosure, the coefficients of the mixing matrix A can be obtained from a calibration process.

5 The figure 6 depicts a method for obtaining at least one sub-aperture image from raw data acquired by a plenoptic camera, according to one embodiment of the disclosure.

In a step, referenced 601, an electronic device obtains either a mixing matrix A or an inverse of said mixing matrix, said mixing matrix comprising coefficients that convey weighting information (related to different views) that details proportion of views recorded by a pixel
10 sensor.

In a step referenced 602, the electronic device executes a signal separation process on said raw data by using an inverse of a mixing matrix A . Hence, in the case that in step 601, only the mixing matrix is obtained, an inversion step has to be done by said electronic device.

Then, in a step referenced 603, the electronic device generates a matrix of views or a set
15 of sub-aperture images to be stored on a memory unit and/or to be transmitted to another electronic device.

The figure 7 presents an example of an electronic device that can be used to perform one or several steps of methods disclosed in the present document.

Such device referenced 700 comprises a computing unit (for example a CPU, for "*Central Processing Unit*"), referenced 701, and one or more memory units (for example a RAM (for "*Random Access Memory*") block in which intermediate results can be stored temporarily during the execution of instructions a computer program, or a ROM block in which, among other things, computer programs are stored, or an EEPROM ("*Electrically-Erasable Programmable Read-Only Memory*") block, or a flash block) referenced 702. Computer programs are made of instructions
25 that can be executed by the computing unit. Such device 700 can also comprise a dedicated unit, referenced 703, constituting an input-output interface to allow the device 700 to communicate

with other devices. In particular, this dedicated unit 703 can be connected with an antenna (in order to perform communication without contacts), or with serial ports (to carry communications "contact"). It should be noted that the arrows in the figure 7 signify that the linked unit can exchange data through buses for example together.

5 In an alternative embodiment, some or all of the steps of the method previously described, can be implemented in hardware in a programmable FPGA ("*Field Programmable Gate Array*") component or ASIC ("*Application-Specific Integrated Circuit*") component.

 In an alternative embodiment, some or all of the steps of the method previously described, can be executed on an electronic device comprising memory units and processing
10 units as the one disclosed in the figure 7.

Claims

1. A method for obtaining at least one sub-aperture image being associated with one view, from raw light field data corresponding to recorded data by an array of pixels sensors positioned behind an array of micro-lenses in a light field camera, each of said pixel sensor recording a linear mixing of up to four different views, and the method is characterized in that it comprises applying a signal separation process on said raw data by using an inverse of a mixing matrix A , said mixing matrix comprising coefficients that convey weighting information of said up to four different views recorded by a pixel sensor.
2. The method for obtaining according to claim 1, wherein said coefficients are defined according to positions, in said array of pixels, of micro-lenses images centers.
3. The method for obtaining according to any of claims 1 and 2, wherein said applying comprises multiplying said recorded data, represented by a column vector, by said inverse of said mixing matrix A .
4. The method for obtaining according to claim 1, wherein said signal separation is a blind signal separation.
5. The method for obtaining according to any claims 1 to 3, wherein said coefficients are obtained by performing a calibration process on said light field camera.
6. A computer-readable and non-transient storage medium storing a computer program comprising a set of computer-executable instructions to implement a method for processing raw light field data when the instructions are executed by a computer, wherein the instructions comprise instructions, which when executed, configure the computer to perform a method of claims 1 to 5.

- 5
7. An electronic device for obtaining at least one sub-aperture image being associated with one view, from raw light field data corresponding to recorded data by an array of pixels sensors positioned behind an array of micro-lenses in a light field camera, each of said pixel sensor recording a linear mixing of up to four different views, said electronic device comprising a memory and at least one processor coupled to the memory, the at least one processor being characterized in that it is configured to apply a signal separation process on said raw data by using an inverse of a mixing matrix A , said mixing matrix comprising coefficients that convey weighting information of said up to four different views recorded by a pixel sensor.
- 10
8. The electronic device for obtaining according to claim 7, wherein said coefficients are defined according to positions, in said array of pixels, of micro-lenses images centers.
- 15
9. The electronic device for obtaining according to any of claims 7 and 8, wherein said at least one processor is further configured to multiply said recorded data, represented by a column vector, by said inverse of said mixing matrix A .
- 20
10. The electronic device for obtaining according to claim 7, wherein said signal separation is a blind signal separation.
11. The electronic device for obtaining according to any claims 7 to 9, wherein said at least one processor is further configured to perform a calibration of said light field camera in order to obtain said coefficients.

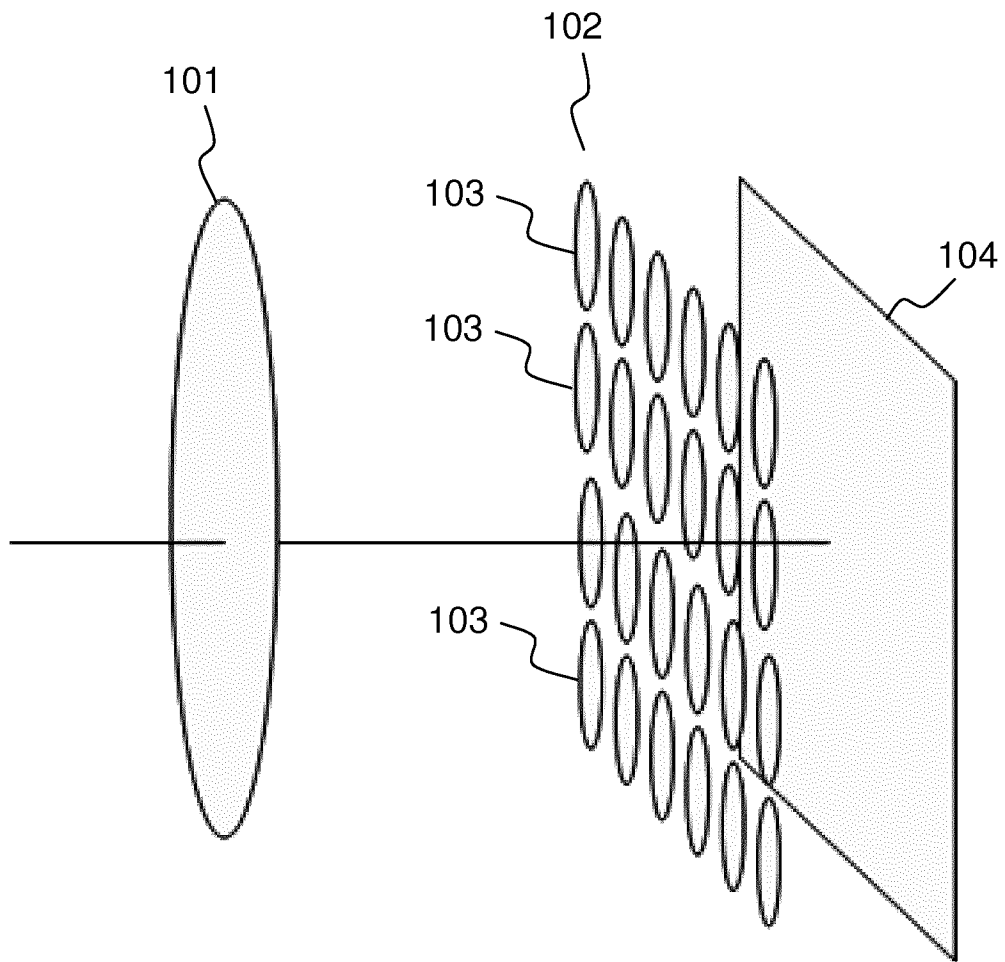


FIG.1

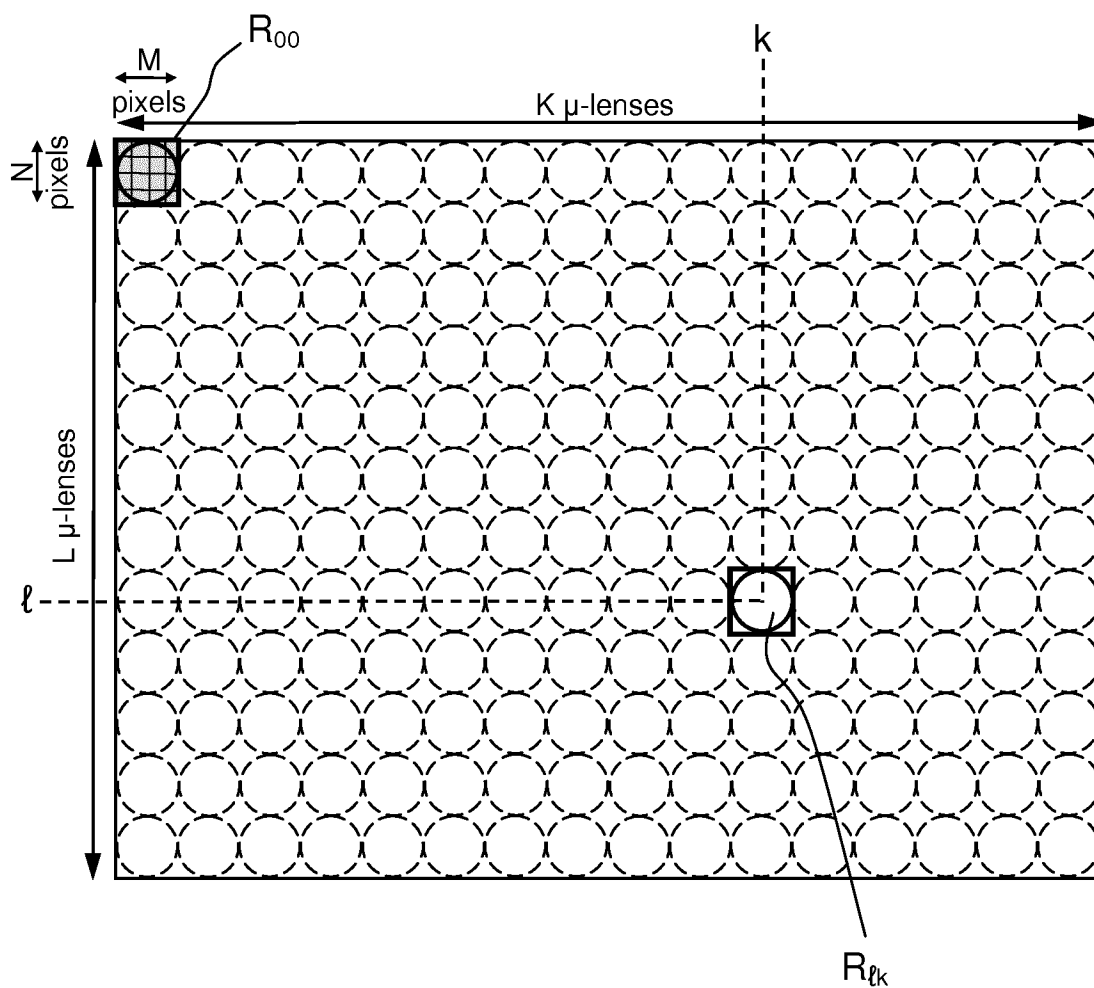


FIG.2

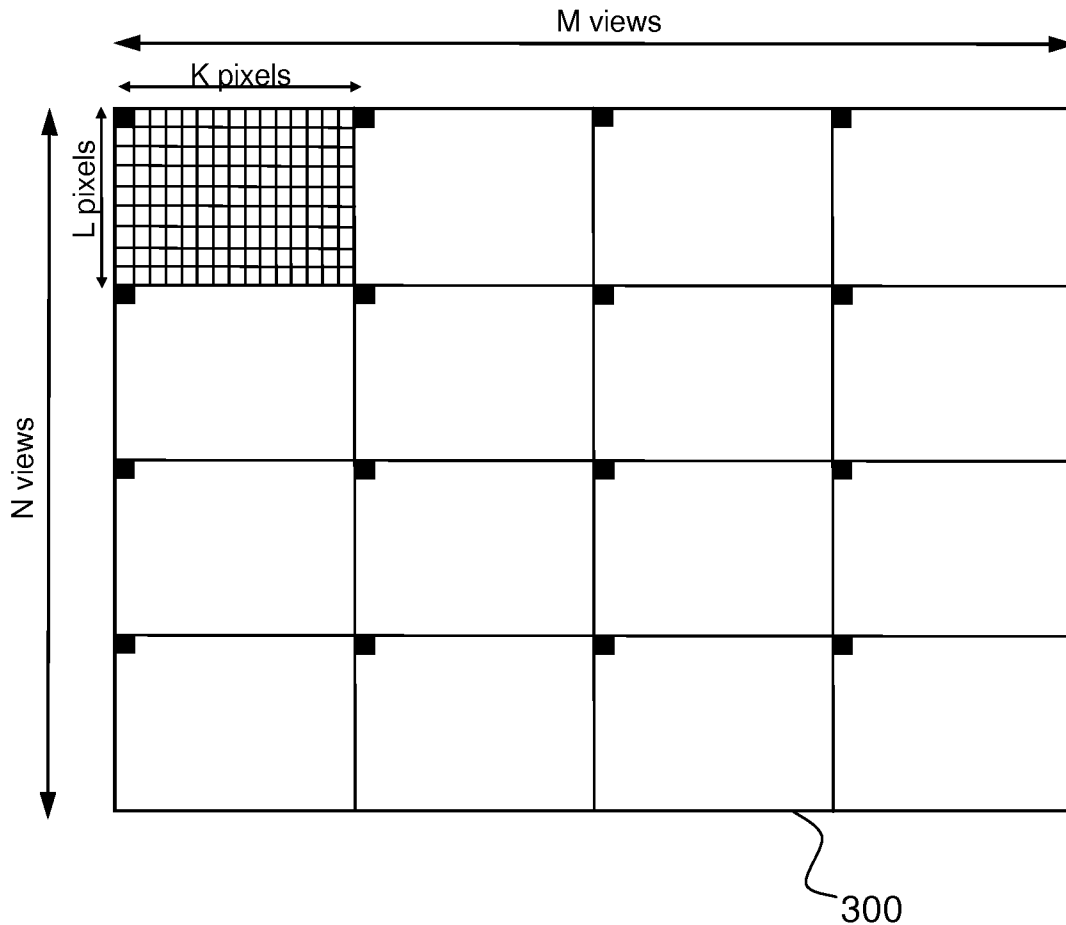


FIG.3

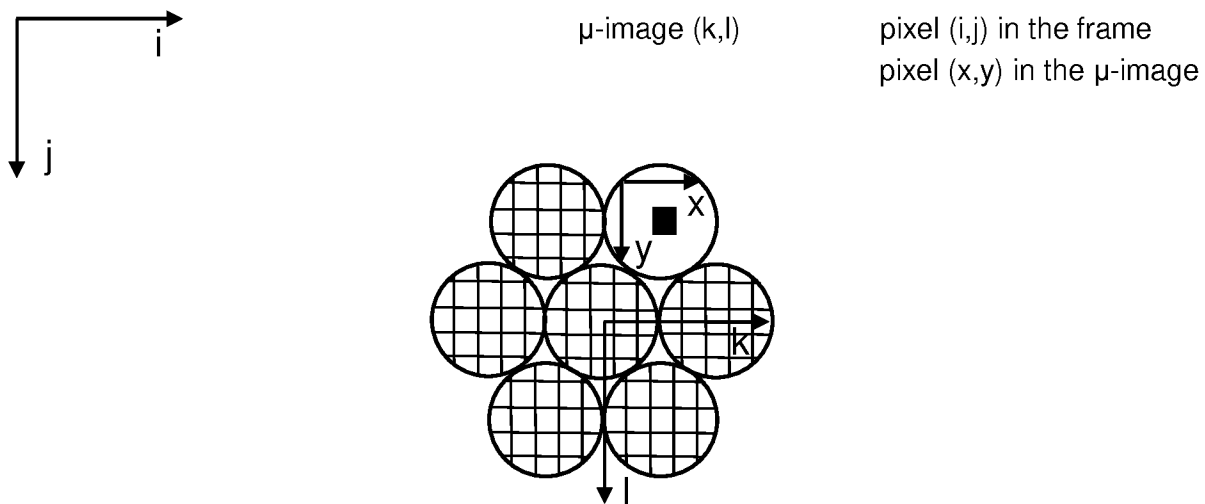
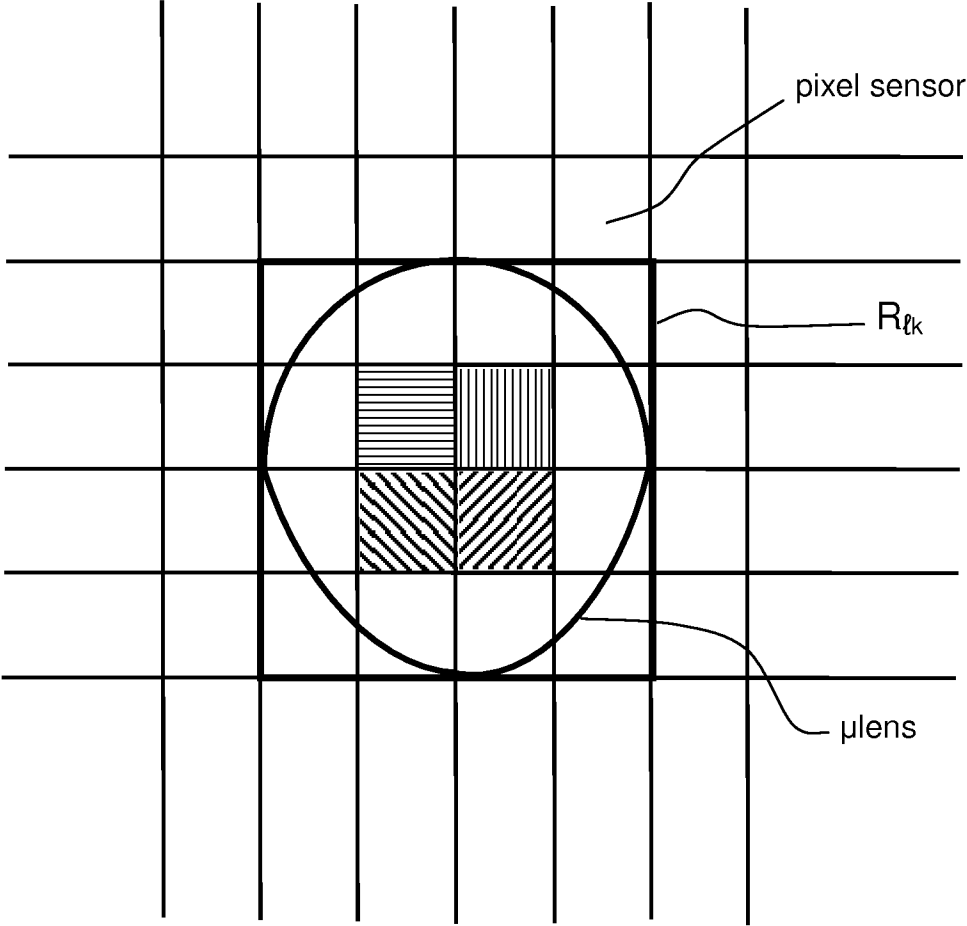


FIG.4





-  view 1
-  view 2
-  view 3
-  view 4

FIG.5A

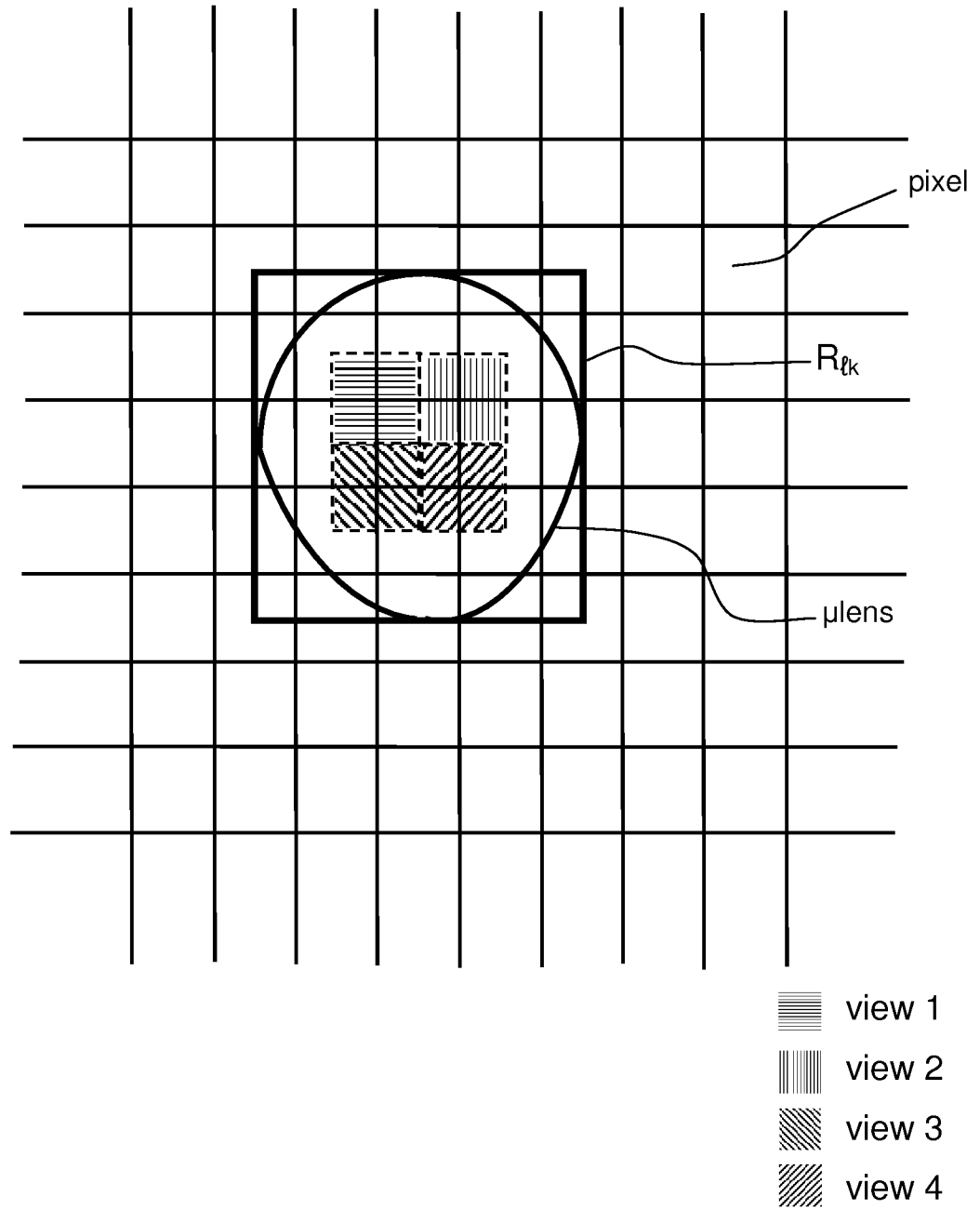


FIG.5B

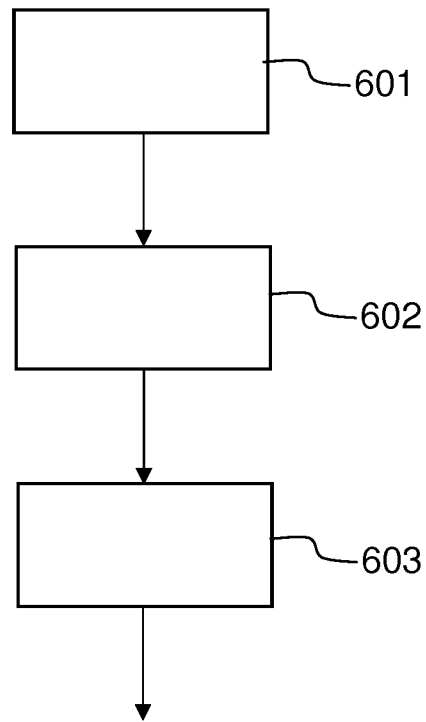


FIG.6

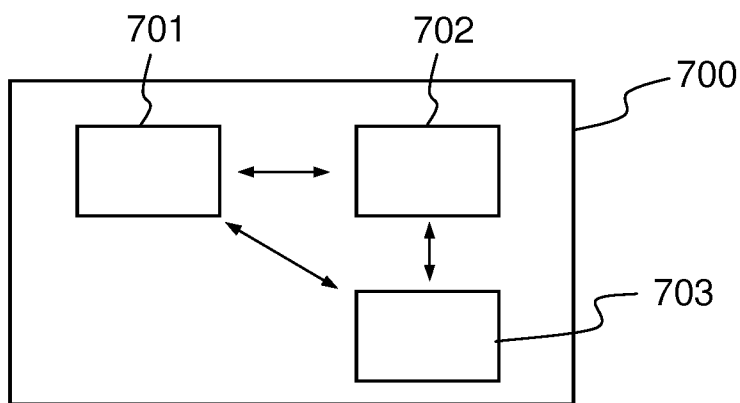


FIG.7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/068312

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06T5/50
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)
G06T

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>CHO DONGHYEON ET AL: "Modeling the Calibration Pipeline of the Lytro Camera for High Quality Light-Field Image Reconstruction", 2013 IEEE INTERNATIONAL CONFERENCE ON COMPUTER VISION, IEEE, 1 December 2013 (2013-12-01), pages 3280-3287, XP032572834, ISSN: 1550-5499, DOI: 10.1109/ICCV.2013.407 [retrieved on 2014-02-28] abstract Section 4, lines 1-2 of 1st paragraph and Section 4.3, 1st paragraph Section 3.2, 1st paragraph and Section 4, lines 1-2</p> <p style="text-align: center;">----- -/--</p>	1-3,5-9, 11

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>
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Date of the actual completion of the international search 20 September 2017	Date of mailing of the international search report 04/10/2017
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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 Nicolau, Stephane
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/068312

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2013/167758 A1 (CANON KK [JP]; VANDAME BENOIT [FR]) 14 November 2013 (2013-11-14) p. 15, line 13. p. 7, lines 2-3 and p. 52 line 29 to p. 53 line 5. p. 7, Equation 11 and lines 2-3 -----	1-3,6-9
X,P	EP 3 094 076 A1 (THOMSON LICENSING [FR]) 16 November 2016 (2016-11-16) paragraph [0010]. paragraph [0098]. p. 8 lines 8-10. paragraph [0037] -----	1,2,5-8, 11

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/068312

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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			GB 2501950 A	13-11-2013
			WO 2013167758 A1	14-11-2013

EP 3094076	A1	16-11-2016	EP 3094076 A1	16-11-2016
			US 2016337632 A1	17-11-2016
