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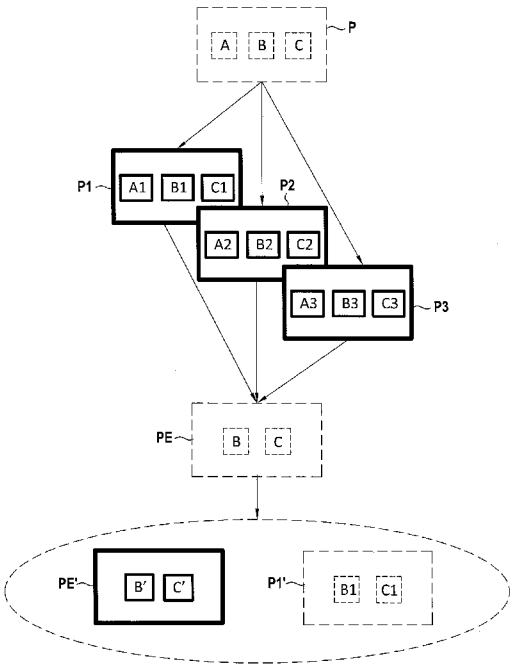

FIG.3

(57) Abstract: A method is described in which sets of corresponding colorimetric values are obtained. In a set, a colorimetric value is associated with a device color. A number of device colors are selected according to the color differences between colorimetric values associated with the same device color. A color calibration pattern is elaborated for a printer to be calibrated using the selected device colors and calibration is performed using the sets of colorimetric values.

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Printer calibration with selected colors

BACKGROUND

Some printers can be color-calibrated to obtain more consistent colors which maintain the stability of a printer's color output. Calibration may comprise printing a pattern of colors. This pattern of colors may be compared to a reference and adjustments may be applied to the printer's parameters. Some printers also use arrays of printing devices that may apply printing fluid simultaneously on a page, and each printing device has to be calibrated.

BRIEF DESCRIPTION OF THE DRAWINGS

The following detailed description references the drawings, wherein:

FIG. 1 is a simplified schematic of an example printer;

FIG. 2 is flowchart of an example of a method for calibrating a printer; and

FIG. 3 is an illustration of examples of calibration patterns.

DETAILED DESCRIPTION

The following detailed description refers to the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the following description to refer to the same or similar parts. While several examples are described in this document, modifications, adaptations, and other implementations are possible. Accordingly, the following detailed description does not limit the disclosed examples. Instead, the proper scope of the disclosed examples may be defined by the appended claims.

In a printer, color calibration may have a variety of requirements and constraints depending on the requested duration and the requested accuracy.

In some page-wide array printers, which have a plurality of print heads arranged in an array or a single print head and a plurality of nozzles arranged in an array, a technical challenge arises due to the number of elements to be calibrated which may be large

and therefore the calibration may be long and complex. Improved calibration may be achieved according to the present disclosure because calibration can be performed on the basis of a controlled number of colors to be printed and measured during calibration. This controlled number of colors may be chosen depending on the application with great flexibility.

Also, the present disclosure may improve various methods for calibration.

On FIG. 1, an example color printer 1 is shown. A color printer 1 may be any appropriate printing device that performs an imaging operation with printing fluid with color. A printing fluid may be dye-based inks, pigment based inks, water-based latex inks, gloss enhancer, etc. The printer 1 is a page-wide array printer comprising a plurality of print heads able to deposit printing fluids (such as colored inks) on media (such as paper).

The printer 1 is able to print color calibration patterns such as arrays of colored rectangles which may be analyzed during calibration (patterns may also comprise other shapes such as hexagons). To this end, the printer 1 comprises a processor 2 and a storage 3. The storage 3 may include any electronic, magnetic, optical, or other physical storage device that stores executable instructions and data. Thus, storage 3 may be, for example, Random Access Memory (RAM), Electrically-Erasable Programmable Read-Only Memory (EEPROM), a storage drive, an optical disc, and the like.

The storage 3 comprises in the present example a plurality 4 of sets of colorimetric values and executable instructions 5.

The plurality of sets of colorimetric values may be received by the printer using a computer controlling the printer 1, or the plurality of sets of device color and colorimetric values may be stored before delivering the printer 1 to its end user.

The plurality of sets of colorimetric values forms a database which may be used to elaborate a calibration pattern. It may also be used during calibration. In each set, colorimetric values of device colors are stored. In each set, at least the colorimetric

values for the device colors are stored, although more sets of values may be stored. The device colors may also be stored in correspondence to the colorimetric values.

It should be noted that by device color, what is meant is data interpretable by a printer, for example RGB (Red, Green, Blue) values interpretable by a printer (sometimes called device RGBs), or CMYK (Cyan, Magenta, Yellow, Black) interpretable by a printer (sometimes called device CMYKs), or also ink vectors (i.e., vectors with as many members as there are printing fluids in a printer, where the value of each member expresses an amount of the corresponding printing fluid).

Each colorimetric value may be obtained through a measurement which results in values in a color space, for example CIELAB. In a set of colorimetric values, all the values may have been obtained by a measurement performed on a printed calibration pattern under printing conditions which depend on the printer used for printing this pattern. It should be noted that the printers used for obtaining the plurality of sets of colorimetric values may not include the printer 1 to be calibrated, but they also may include this printer which will then be used to provide the database.

Also, for example, the number of sets of colorimetric values may be such that it covers a variety of states of a printer, including variations in the drop weights and ages of its print heads, different environmental conditions in terms of temperature and relative humidity, etc. E.g., for a printer with four inks or printing fluids (CMYK) and a certain range of drop weight variation across which calibration is expected to work, an example number of sets of colorimetric values would be 3^4 – i.e., all the combinations of each of the inks or printing fluids being at lowest, nominal and highest drop weight.

The executable instructions 5 are executable by the processor and they include an instruction 6 to select a number S of device colors, S being a number which a user may set. This number S may be low to provide a fast calibration, or higher to provide a more accurate calibration. The S device colors are selected according to the color differences between corresponding colorimetric values of the plurality of sets, an instruction 7 to elaborate a color calibration pattern for a printer using the S

device colors, an instruction 8 to print, using the printer, the color calibration pattern elaborated using the selected S device colors selected, an instruction 9 to elaborate a set of colorimetric values from the plurality of sets of colorimetric values and adjusted to the printed color calibration pattern, and an instruction 10 to calibrate the printer using the printed color calibration pattern elaborated using the selected S device colors and the elaborated set of colorimetric values.

The instruction 6 to select S device colors according to the color differences between corresponding colorimetric values of the plurality of sets, when executed, may select S device colors which provide the largest color differences among the plurality of sets of colorimetric values.

For example, selecting S device colors comprises calculating a statistical parameter for each device color according to the color differences between corresponding colorimetric values of the plurality of sets, ranking the device colors according to their statistical parameter, selecting the S device colors according to their rank.

The statistical parameter may be the standard deviation which will be computed, for each device color, between all the colorimetric values which correspond to this device color. The device colors having the largest standard deviation may then be ranked higher and selecting the S device colors according to their rank may comprise selecting the S device colors with the highest ranks.

Calculating the statistical parameter may also comprise computing the color difference between each colorimetric value of each set of colorimetric values with the corresponding colorimetric values of all the other sets of colorimetric values and for example using the 95^{th} percentile of the resulting distribution of color differences.

It can be noted that in the present disclosure, color difference may be computed using different methods, for example CIEDE2000 or CIEDE1976.

It can also be noted that the number S may be entered by a user of a computer controlling the printer 1, or directly on the printer 1, or it may be stored in the storage 3.

The instruction 7 to elaborate a color calibration pattern for a printer using the S device colors may be used to elaborate a calibration pattern to be used to perform a one-dimensional look-up table method, an N-dimensional look-up table method or an adjustment of Neugebauer Primary area coverages (in a HANS printer imaging pipeline), for example using the plurality 4 of sets of colorimetric values.

The elaborated color calibration pattern may be printed to obtain a pattern comprising elements associated with each device color of the selected S device colors.

Because the S selected device colors were selected according to the differences between the colorimetric values, the elaborated pattern is designed using a limited number of device colors (at least S colors) which will still provide good calibration results if a reference used for calibration is chosen using the plurality of sets of colorimetric values because the device colors are the ones which have the largest variations in the plurality of sets and because the reference used for calibration will match the conditions of the printer.

The instruction 9 to elaborate a set of colorimetric values from the plurality of sets of colorimetric values and adjusted to the printed color calibration pattern may comprise identifying the set of colorimetric values which is the closest to the printed one (or more precisely to the colorimetric values measured from the printed one), or also calculating a new set of colorimetric values to obtain a set of colorimetric values close to the printed one. This results in calibration being performed with a limited set of colors with a reference which is adjusted to the printing conditions of the printer and leads to good accuracy.

FIG. 2 is a flowchart of an example of a method for performing calibration of a printer such as the one described in reference to FIG. 1.

Firstly, color calibration patterns are printed under different printing conditions (reference S1). These color calibration patterns each comprise elements that are each associated with device colors. In a color calibration pattern, all the device colors have an associated element, but the color calibration pattern may not be all identical because some color calibration pattern may also comprise additional information.

The different printing conditions may result from using different printers of the same model or not, different sizes of ink (or printing fluid) drop if ink jet printers are used, printing under different environmental conditions.

Then, the colorimetric values of each element of each printed pattern is measured S2 to obtain the plurality of sets of corresponding colorimetric values such as the one described in reference to FIG. 1.

This plurality of sets of colorimetric values is then obtained S3, for example by storing the plurality of sets of colorimetric values in a storage of a printer to be calibrated.

Then, S device colors are selected (reference S4), for example in the same manner as when instruction 6 described in reference to FIG. 1 is executed.

A color calibration pattern can then be elaborated and printed (reference S5) by the printer to be calibrated. The printed pattern comprises a number of elements which

may be low depending on the number S. A low number S leads to performing calibration on a low number of device colors which are highly relevant. A higher number S leads to performing calibration on a greater number of device colors in order to obtain a better color accuracy. A good level of flexibility is obtained.

It should be noted that the printed color calibration pattern is associated with a calibration method (for example a one-dimensional look-up table method or an N-dimensional look-up table method).

The colorimetric values of each printed element associated with one of the device colors from the selected S device colors are then measured (reference S6). A user may perform this measurement using various types of sensors and a computing system controlling the printer.

Calibration is performed by comparing measured colorimetric values with other values. In this example, the other values are elaborated using the plurality of sets of colorimetric values. This leads to using colorimetric values which match the printing conditions of the printer to be calibrated, which allow calibration using a small number of colors because the remaining colors are likely to match the ones of the elaborated set.

For example, an elaborated set of colorimetric values may be identified among the plurality of sets of colorimetric values, the elaborated set of colorimetric values being the set having colorimetric values associated with the S device colors which are the closest to the measured colorimetric value of each element of the printed color calibration pattern elaborated using the S device colors. A statistical parameter may be used to identify the elaborated set. Also, identifying the elaborated set may comprise selecting the set of colorimetric values having the smallest 95% percentile of difference with respect to the measured colorimetric values

Also for example, the elaboration of the elaborated set may comprise:

identifying T sets of colorimetric values among the plurality of sets of colorimetric values, the T sets of colorimetric values being the sets having colorimetric values associated with the selected S device colors which are the closest to the measured colorimetric value of each element of the printed color calibration pattern elaborated using the selected S device colors,

calculating colorimetric values of the elaborated set using a statistical calculation and the T sets of colorimetric values. For example, the statistical calculation may comprise, for each device color, calculating the convex weight derived from the color differences of the T sets, and using this convex weight to obtain an elaborated colorimetric value for the elaborated set.

Finally, the calibration is performed using the printed color calibration pattern and the elaborated set of colorimetric values which has been elaborated from the plurality of sets of colorimetric values and is adjusted to the printed color calibration pattern.

FIG. 3 shows examples of the various color calibration patterns used when performing a method as described in reference to FIG. 2. The color calibration patterns shown on FIG. 3 may be printed on paper, which is represented by the use of a thick line contour. A color calibration pattern interpretable by a printer before being printed is shown using dotted lines.

An initial color calibration pattern P is shown having three elements each associated with a device color A, B, or C. This initial pattern P may be the pattern which will be printed under different printing conditions as disclosed in reference to FIG. 2.

Three color calibration patterns P1, P2, and P3 are then obtained by printing under different printing conditions the color calibration pattern P.

Printed color calibration pattern P1 comprises three elements having colorimetric values which can be measured. For device color A, printed color calibration pattern P1 comprises an element having a measured colorimetric value of A1. Similarly, for device color B, the measured colorimetric value is B1, and for device color C, the measured colorimetric value is C1.

For printed color calibration pattern P2, for device color A, the measured colorimetric value is A2, for device color B, the measured colorimetric value is B2, and for device color C, the measured colorimetric value is C2. For printed color calibration pattern P3, for device color A, the measured colorimetric value is A3, for device color B, the measured colorimetric value is B3, and for device color C, the measured colorimetric value is C3. Three sets of colorimetric values are then obtained, the first one comprising A1, B1, and C1, the second one comprising A2, B2, and C2, and the third one comprising A3, B3 and C3.

If a user chooses to select only two colors (S equals 2), then it is possible to select two device colors among A, B, and C according to the color differences between corresponding colorimetric values of the plurality of sets, namely the color differences between A1, A2 and A3, the color differences between B1, B2 and B3, and the color differences between C1, C2 and C3.

If device colors B and C show the largest differences (for example if the standard deviation for B1, B2, and B3, and the standard deviation for C1, C2, and C3 are bigger than the standard deviation for A1, A2 and A3), then they are the selected two device colors.

A color calibration pattern PE can then be elaborated comprising only B and C.

Using the color calibration pattern PE, a printed color calibration pattern PE' can be obtained having elements which have colorimetric values B' and C'. For calibration, an elaborated set of colorimetric values may be identified as being the closest to PE', and in this example, the elaborated set is P1', corresponding to P1 but only showing the relevant colorimetric values which will be used during calibration. This set matches the printing conditions of the printer to be calibrated here.

It can be noted that in the above examples, color calibration is performed using various methods, providing good flexibility. Also, the color calibration is performed on a number of device colors which can be reduced, which results in a fast calibration process. The accuracy of the calibration can be adjusted using the number S. No assumption of color space sampling regularity is used to obtain the S device colors, which provides good flexibility and color accuracy. Also, it can be noted that multiple calibration methods of various types may be used simultaneously on the S device colors.

CLAIMS

1. A method comprising:

obtaining a plurality of sets of corresponding colorimetric values, the corresponding colorimetric values being associated with the same device color,

selecting S device colors according to the color differences between corresponding colorimetric values of the plurality of sets,

elaborating a color calibration pattern for a printer using the S device colors

printing, using the printer, the color calibration pattern elaborated using the selected S device colors selected,

elaborating a set of colorimetric values from the plurality of sets of colorimetric values and adjusted to the printed color calibration pattern,

calibrating the printer using the printed color calibration pattern elaborated using the selected S device colors and the elaborated set of colorimetric values.

2. A method in accordance with claim 1, wherein obtaining the plurality of sets of corresponding colorimetric values comprises printing a plurality of color calibration patterns each printed under different printing conditions and each pattern comprising corresponding elements, the corresponding elements being associated with the same device color, and

measuring the colorimetric value of each element of each printed pattern to obtain the plurality of sets of corresponding colorimetric values.

3. A method in accordance with claim 1, wherein selecting S device colors comprises:

calculating a statistical parameter for each device color according to the color differences between corresponding colorimetric values of the plurality of sets,

ranking the device colors according to their statistical parameter,

selecting the S device colors according to their rank.

4. A method in accordance with claim 3, wherein calculating a statistical parameter comprises computing the color difference between each colorimetric value of each set of colorimetric values with the corresponding colorimetric values of all the other sets of colorimetric values.

5. A method in accordance with claim 3, wherein calculating a statistical parameter comprises calculating, for each device color, the standard deviation between all the corresponding colorimetric values.

6. A method in accordance with claim 1, wherein obtaining a plurality of sets of corresponding colorimetric values comprises storing, in the printer, the plurality of sets of corresponding colorimetric values.

7. A method in accordance with claim 1, wherein the printed color calibration pattern elaborated using the selected S device colors comprises elements each associated with a selected device color, and

calibrating the printer comprises measuring the colorimetric value of each element of the printed color calibration pattern elaborated using the selected S device colors.

8. A method in accordance with claim 7, wherein elaborating the set of colorimetric values from the plurality of sets of colorimetric values and adjusted to the printed color calibration pattern comprises identifying a set of colorimetric values among the plurality of sets of corresponding colorimetric values having colorimetric values associated with the selected S device colors which are the closest to the measured colorimetric value of each element of the printed color calibration pattern elaborated using the selected S device colors.

9. A method in accordance with claim 7, wherein elaborating the set of colorimetric values from the plurality of sets of colorimetric values and adjusted to the printed color calibration pattern comprises:

identifying T sets of colorimetric values among the plurality of sets of colorimetric values, the T sets of colorimetric values being the sets having colorimetric values associated with the selected S device colors which are the closest to the measured colorimetric value of each element of the printed color calibration pattern elaborated using the selected S device colors,

calculating colorimetric values of the elaborated set using a statistical calculation of convex weights and the T sets of colorimetric values.

10. A method in accordance with claim 1, wherein calibrating the printer is performed using a one-dimensional look-up table method, an N-dimensional look-up table method or an adjustment of Neugebauer Primary area coverages in a HANS printer imaging pipeline.

11. A device comprising a storage and a processor, the storage comprising executable instructions to:

obtain a plurality of sets of colorimetric values, each colorimetric value in a set of colorimetric values corresponding to a device color,

determine S device colors according to the color differences between corresponding colorimetric values of the plurality of sets,

elaborate a color calibration pattern for a printer using the S device colors

print, using the printer, the color calibration pattern elaborated using the selected S device colors selected,

elaborate a set of colorimetric values from the plurality of sets of colorimetric values and adjusted to the printed color calibration pattern,

calibrate the printer using the printed color calibration pattern elaborated using the selected S device colors and the elaborated set of colorimetric values.

12. A printer comprising a storage and a processor,
the storage comprising a plurality of sets of colorimetric values, each colorimetric value in a set of colorimetric values corresponding to a device color, and
executable instructions to:
select S device colors according to the color differences between corresponding colorimetric values of the plurality of sets,
elaborate a color calibration pattern for a printer using the S device colors,
print, using the printer, the color calibration pattern elaborated using the selected S device colors selected,
elaborate a set of colorimetric values from the plurality of sets of colorimetric values and adjusted to the printed color calibration pattern,
calibrate the printer using the printed color calibration pattern elaborated using the selected S device colors and the elaborated set of colorimetric values.

13. A printer in accordance with claim 12, wherein the instructions to elaborate the set of colorimetric values from the plurality of sets of colorimetric values and adjusted to the printed color calibration pattern comprise instructions to identify a set of colorimetric values among the plurality of sets of corresponding colorimetric values having colorimetric values associated with the selected S device colors which are the closest to the measured colorimetric value of each element of the printed color calibration pattern elaborated using the selected S device colors.

14. A printer in accordance with claim 12, wherein the instructions to elaborate the set of colorimetric values from the plurality of sets of colorimetric values and adjusted to the printed color calibration pattern comprise instructions to

identify T sets of colorimetric values among the plurality of sets of colorimetric values, the T sets of colorimetric values being the sets having colorimetric values associated with the selected S device colors which are the closest to the measured

colorimetric value of each element of the printed color calibration pattern elaborated using the selected S device colors,

calculate colorimetric values of the elaborated set using a statistical calculation of convex weights and the T sets of colorimetric values.

15. A printer in accordance with claim 12, wherein the executable instruction further comprises instructions to performs a one-dimensional look-up table method or an N-dimensional look-up table method using the plurality of sets of colorimetric values.

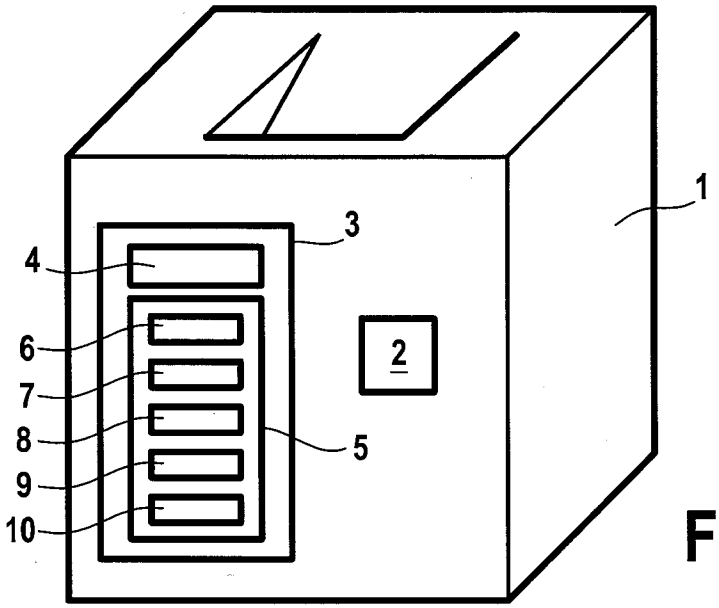
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FIG.1

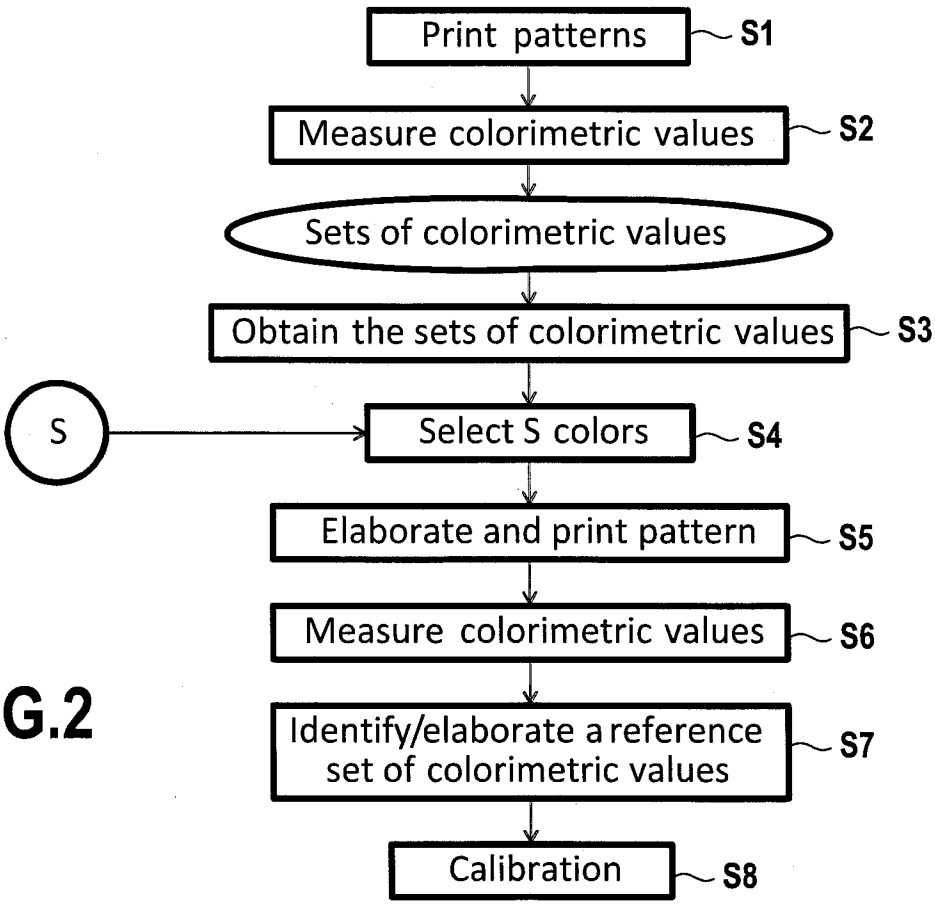
Print patterns
S1
Measure colorimetric values
S2
Sets of colorimetric values
Obtain the sets of colorimetric values
S3
S
Select S colors
S4
Elaborate and print pattern
S5
Measure colorimetric values
S6
Identify/elaborate a reference set of colorimetric values
S7
Calibration
S8

FIG.2

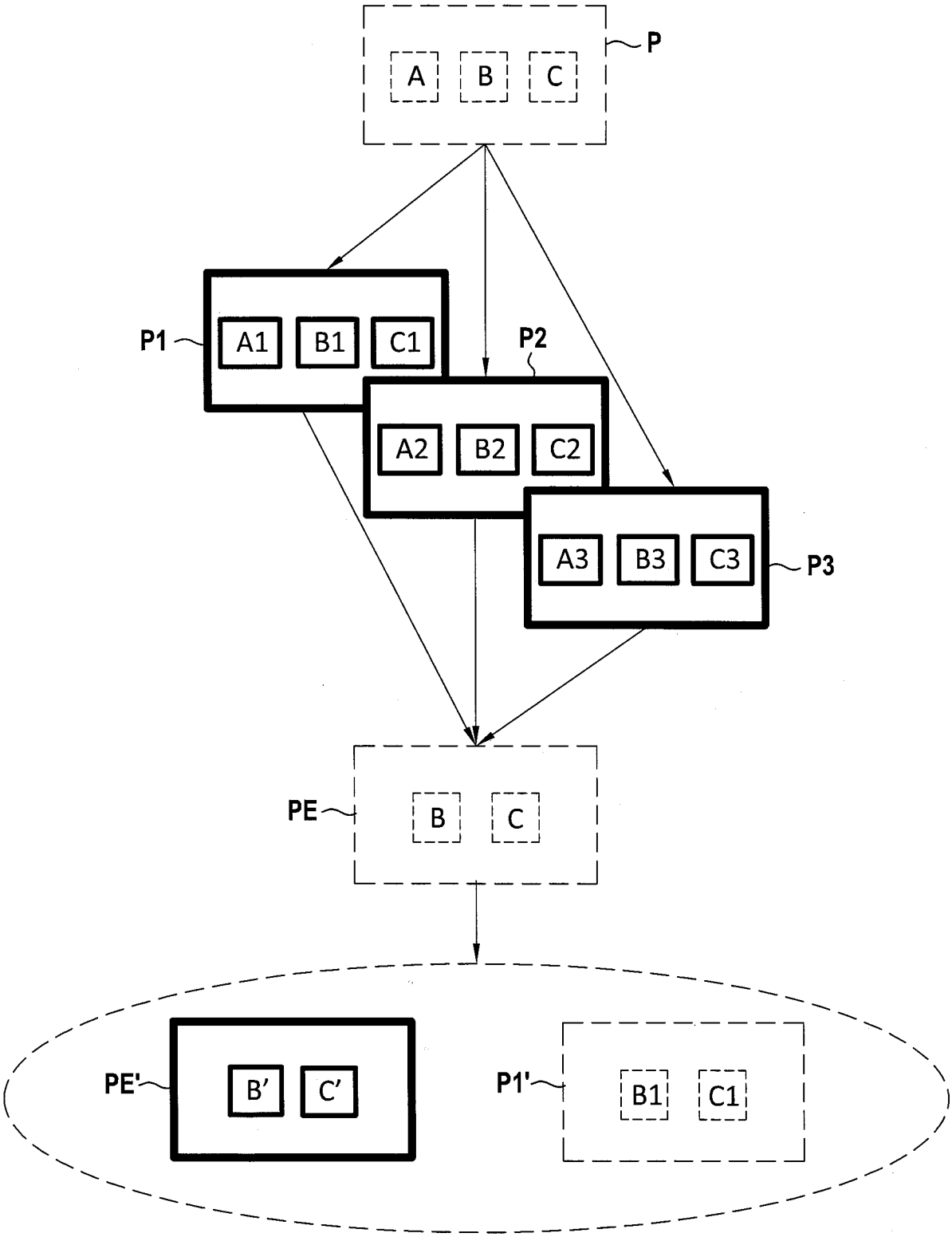

FIG.3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/066679

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04N1/60
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, 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	US 2007/002344 A1 (KLASSEN R V [US]) 4 January 2007 (2007-01-04) paragraph [0098] - paragraph [0103]; figure 4 paragraph [0114] - paragraph [0116] -----	1-15
A	US 2011/286018 A1 (HASHIZUME ASAKO [JP]) 24 November 2011 (2011-11-24) paragraph [0030] - paragraph [0042]; figure 3 paragraph [0053] - paragraph [0057]; figures 7, 8 -----	1-15
A	US 2012/147391 A1 (BALA RAJA [US] ET AL) 14 June 2012 (2012-06-14) paragraph [0021] - paragraph [0038]; figures 1,2 -----	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
28 March 2017	04/04/2017

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

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/066679

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007002344 A1	04-01-2007	NONE	
US 2011286018 A1	24-11-2011	CN 102253619 A	23-11-2011
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US 2012147391 A1	14-06-2012	NONE	