(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
8 May 2014 (08.05.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/070062 A1

(51) International Patent Classification:
H04N 5/33 (2006.01) *H04N 5/365* (2011.01)
G01J 5/00 (2006.01)

(21) International Application Number:
PCT/SE2013/000166

(22) International Filing Date:
30 October 2013 (30.10.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1230112-3 1 November 2012 (01.11.2012) SE

(71) Applicant: **FLIR SYSTEMS AB** [SE/SE]; P.O. Box 3, S-182 11 Danderyd (SE).

(72) Inventors: **JOHANSSON, Emanuel**; 2/1 Moncrieff Street, Mount Victoria, Wellington 6011 (SE). **LARSON, Odd**; Slånbärsstigen 36, S-125 56 Älvsjö (SE).

(74) Agent: **FORSBERG, Carl-Göran**; Nobeli Business Support AB, Patents and Trademarks, S-691 80 Karlskoga (SE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,

[Continued on next page]

(54) Title: PROCEDURE FOR MAPPING WHEN CAPTURING VIDEO STREAMS BY MEANS OF A CAMERA

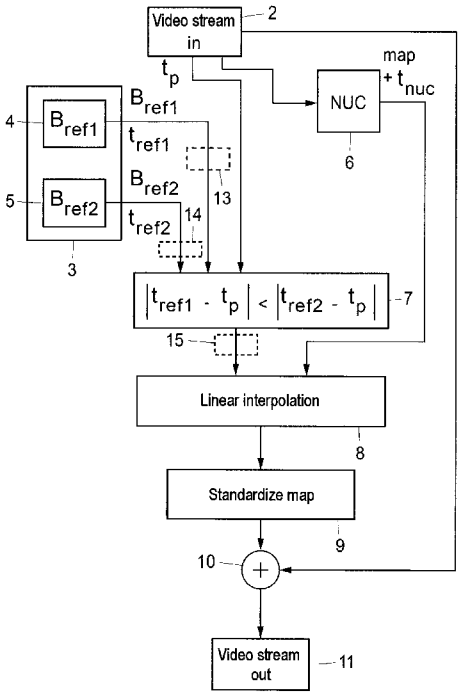

Fig.2

(57) Abstract: The invention relates to a procedure for mapping when capturing video streams by means of a camera, such as an IR camera, as well as to a computer program and a computer program product. According to the procedure the following items are included: a) at least two reference images are recorded in production against a black-body radiator at the same temperature for two or more separate integration times (block 3), b) in conjunction with the updating of an offset map, details of the integration time for which the offset map has been updated are stored (block 6), c) during operation, the actual integration time is compared with the integration time for the most recent updating of the offset map (block 8), d) the recorded reference image which lies closest to the actual integration time is selected as a reference (block 7), and e) a compensation per pixel for the change in the integration time is calculated by linear interpolation between the selected reference image and the most recently updated offset map, resulting in a compensation map (block 8). The integration time can be adapted dynamically by the procedure with access to adequate maps for correction of the offset of constituent pixels.

WO 2014/070062 A1

MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

Procedure for mapping when capturing video streams by means of a camera

Technical Field

The present invention relates to a procedure for mapping when capturing video streams by means of a camera, such as an IR camera, as well as to a computer program and a computer program product.

Background

The output signal from sensor elements in a sensor, such as a focal plane array, IR FPA, contained in a camera can vary quite considerably as a function of the irradiated effect. Sensor elements thus require to be calibrated with one another. The sensor elements contained in a sensor in an IR camera do not behave in the same way, for example, but exhibit variations in gain and offset. In order to manage these variations, so-called gain maps and offset maps are recorded and stored in production. With the help of the gain map, corrections are made during operation for variations in gain in the individual sensor elements in a sensor. The offset map is used correspondingly to shift the sensor signals of the constituent sensor elements in parallel during operation, so that the gain curves of the detectors substantially coincide. To further illustrate the principles behind gain and offset mapping, reference is made to our published US Patent Application US 2011/0164139 A1.

Cameras of the IR type have traditionally made use of a plurality of fixed integration times to cover the camera's dynamic range. Every such fixed position has been provided with its own maps. The disadvantage of fixed integration times is that deviations in the image quality are necessary in order to be able to cover a particular dynamic range, since the image quality is optimized only at a single scene temperature. Several fixed integration time positions have been introduced in order to increase the image quality, which improves the image quality at the expense of higher complexity but still does not fully cover optimal integration time positions.

An alternative to fixed integration times is to change the integration time dynamically. One disadvantage associated with this is that it involves making a shift away from the integration time which was relevant at the time when the maps were made. This shift away from the integration time at the time when the maps were made gives rise to a low-frequency unevenness of the image. An extra spatial fixed-pattern noise is generated and is visible in low-contrast scenes. A previously known solution to this has been to permit the integration time to be changed only in conjunction with the offset map being updated by a so-called NUC, non uniformity correction. In order for it to function adequately, the solution requires an NUC to be performed as soon as the scene has changed significantly, for example when panning.

For an example of the prior art where the integration time is changed, reference can be made to WO 2008/107117 A1, which describes a procedure for changing the integration time depending on the temperature of an IR sensor.

Summary of the invention

The object of the present invention is to make available a procedure which adapts the integration time dynamically on the basis of the scene content in order to achieve maximum quality in every scene without the need for constant updates of maps by NUC processing and without having to store maps for a large number of fixed integration times.

The object of the invention is accomplished by a procedure that is characterized:

a) in that at least two reference images are recorded in production against a black-body radiator at the same temperature for two or more separate integration times,

b) in that, in conjunction with the updating of an offset map, details of the integration time for which the offset map has been updated are stored,

c) in that, during operation, the actual integration time is compared with the integration time for the most recent updating of the offset map,

d) in that the recorded reference image which lies closest to the actual integration time is selected as a reference,

e) in that a compensation per pixel for the change in the integration time is calculated by linear interpolation between the selected reference image and the most recently updated offset map, resulting in a compensation map, and

f) in that the compensation map is added to an incoming video image.

The use of reference images, the most recent updating of the offset map and its integration time, as well as linear interpolation, permits a compensation map to be created which corresponds closely to the actual integration time. The procedure permits the integration time to be changed continuously and entirely automatically without needing to undergo a further NUC process.

The compensation map is advantageously standardized before addition by deducting the mean value of the compensation map from all the pixels for centring of the compensation map around zero.

Alternatively, the reference images can be standardized before the interpolation takes place by deducting the mean value of the reference image from all the pixels for centring of the reference image around zero.

According to an advantageous procedure, specifically two reference images are recorded in production against a black-body radiator at the same temperature for two separate integration times. By restricting the number of reference images to two, the mapping process can be kept relatively simple from the point of view of storage and calculation.

According to the proposed procedure, the reference images can suitably be taken for integration times within the millisecond range and with a difference in the integration time in the order of 10 milliseconds.

The invention also relates to a computer program comprising program code, which, when the said program code is executed in a computer, causes the said computer to carry out the procedure as described above in order to accomplish the object of the invention, as well as to a computer program product comprising a computer-readable

medium and a computer program as described above, the said computer program being included in the said computer-readable medium.

Brief Description of the Drawings

The invention is described below in more detail by way of example with reference to the accompanying drawings, in which:

Figure 1 depicts schematically an example of a curve which shows the scene temperature as a function of the integration time for optimized image quality.

Figure 2 depicts schematically an example in the form of a block diagram of the principles for mapping according to the procedure of the invention.

Figure 3 depicts schematically an example of a curve which shows the signal per pixel as a function of the integration time for a pixel which has undergone the mapping according to the procedure of the invention.

Detailed Description of the Embodiment

The curve 1 depicted in Figure 1 depicts an example of the scene temperature T as a function of the integration time t for optimized image quality. Two fixed integration times t_1 and t_2 are plotted in the Figure. According to the known method, an individual map is connected to each integration time. In the event that another suitable integration time is used, a shift will take place from the integration times for which the maps were produced, and low-frequency unevennesses of the image will occur as a result. According to the proposed procedure for mapping, which is described in more detail with reference to Figure 2, compensation maps are generated which offer relevant mapping along the scene temperature curve between fixed references.

The principles for mapping according to the procedure of the invention are now described with reference to Figure 2.

An incoming video stream is available through a block 2. The stream can be supplied from the sensor part of an IR camera, the said sensor part comprising, for example, one or a plurality of focal plane arrays. The actual integration time for the video stream is designated with t_p.

A block 3 marks the availability of two reference images taken in production. The images have been taken on a black-body radiator at the same temperature for two different integration times. The first reference image is designated here as B_{ref1} and was taken with an integration time t_{ref1}, which in one example here can amount to 3 ms. The other reference image is designated as B_{ref2} and was taken with an integration time t_{ref2}, which in the example here can amount to 14 ms. The reference image B_{ref1} is marked as being stored in block 4, while reference image B_{ref2} is marked as being stored in block 5.

During the operation of an IR camera, calibrations of the camera are performed during a known process known as NUC, non uniformity correction. A block 6 indicates this NUC process. In this NUC process, the integration time, t_{nuc}, with which the NUC process was carried out is saved in addition to the most recent map. The block 6 thus provides both the most recent map and the most recent integration time t_{nuc}.

A block 7 manages the choice of the next reference image. If

$$|t_{ref1} - t_p| < | t_{ref2} - t_p |,$$

reference image B_{ref1} is selected because it lies closest to the new actual integration time t_p. Otherwise, reference image B_{ref2} is selected because it is then considered to lie closest to the new actual integration time t_p.

If the integration time is to be changed, the actual integration time t_p is compared with the integration time t_{nuc} from the most recent NUC, and the reference which lies closest to the new actual integration time t_p is selected as a reference image and is provided by the block 7.

In the block 8, a compensation per pixel is calculated by linear interpolation between the selected reference image, either reference image B_{ref1} or B_{ref2}, and the map from the most recent NUC. The result of the calculation is a map that is referred to in this description as a compensation map. A block 9 undertakes standardization of the correction map before it is added via an adder 10 to the incoming video stream from the block 2 in order to deliver a video stream through a block 11. The output video stream can be connected, for example, to a display for presentation or to a memory medium for storage. A display and a memory medium are not shown in the Figure.

Alternatively, standardization of the reference image can be undertaken before interpolation, and two possible positions of a block for the standardization of reference image B_{ref1} are indicated with dashed blocks 13 and 15 in Figure 2. Two dashed blocks 14 and 15 likewise indicate two possible positions of a block for the standardization of reference image B_{ref2}.

The result of linear interpolation per pixel is illustrated schematically in Figure 3. The signal S per pixel is shown on the curve 12 as a function of the integration time t. The integration times t_{ref1} and t_{ref2} for the reference images B_{ref1} and B_{ref2} are plotted along the time axis t together with the integration time t_{nuc} for the most recent NUC. The actual integration time t_p is plotted in addition. In the illustrated example, reference image B_{ref1} is closer to the actual integration time t_p than reference image B_{ref2}. In line with what has been described with reference to the block 8 in Figure 2, a linear interpolation is made between the reference image B_{ref1} with an integration time t_{ref1} and the map from the most recent NUC with an integration time t_{nuc}.

The invention is described above with reference to a schematic block structure depicted in Figure 2. This description must be regarded only as an explanation of the fundamental structure. The execution of the described functions can be performed in many ways within the framework of the invention, and attention is brought particularly to the use of a computer program for the implementation of the functions.

The invention is not restricted to the procedures described above as examples, but may be subjected to modifications within the scope of the following patent claims.

Patent Claims

1. Procedure for mapping when capturing video streams by means of a camera, such as an IR camera, **characterized**

a) in that at least two reference images are recorded in production against a black-body radiator at the same temperature for two or more separate integration times,

b) in that, in conjunction with the updating of an offset map, details of the integration time for which the offset map has been updated are stored,

c) in that, during operation, the actual integration time is compared with the integration time for the most recent updating of the offset map,

d) in that the recorded reference image which lies closest to the actual integration time is selected as a reference,

e) in that a compensation per pixel for the change in the integration time is calculated by linear interpolation between the selected reference image and the most recently updated offset map, resulting in a compensation map, and

f) in that the compensation map is added to an incoming video image.

2. Procedure according to Patent Claim 1, **characterized in that** the compensation map is standardized before addition by deducting the mean value of the compensation map from all the pixels for centring of the compensation map around zero.

3. Procedure according to Patent Claim 1, **characterized in that** the reference images are standardized before the interpolation takes place by deducting the mean value of the reference images from all the pixels for centring of the reference image around zero.

4. Procedure according to one of the preceding patent claims, **characterized in that** two reference images are recorded in production against a black-body radiator at the same temperature for two different integration times.

5. Procedure according to one of the preceding patent claims, **characterized in that** the reference images are taken for integration times within the millisecond range and with a difference in the integration time in the order of 10 milliseconds.

6. Computer program comprising program code, which, when the said program code is executed in a computer, causes the said computer to carry out the procedure according to one of Patent Claims 1-4.

7. Computer program product comprising a computer-readable medium and a computer program according to Patent Claim 6, the said computer program being included in the said computer-readable medium.

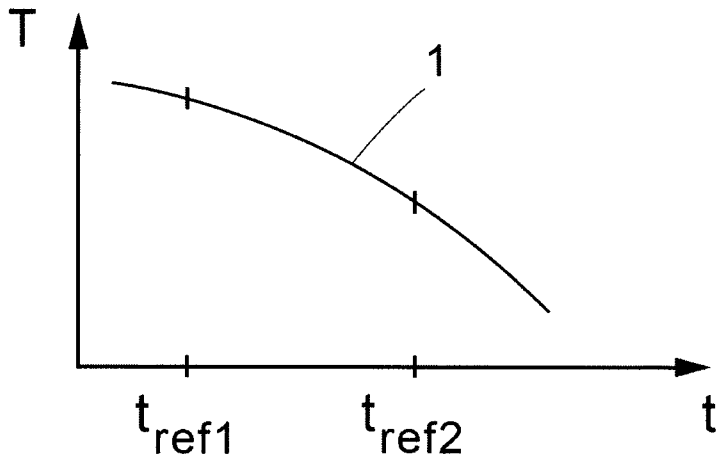

Fig.1

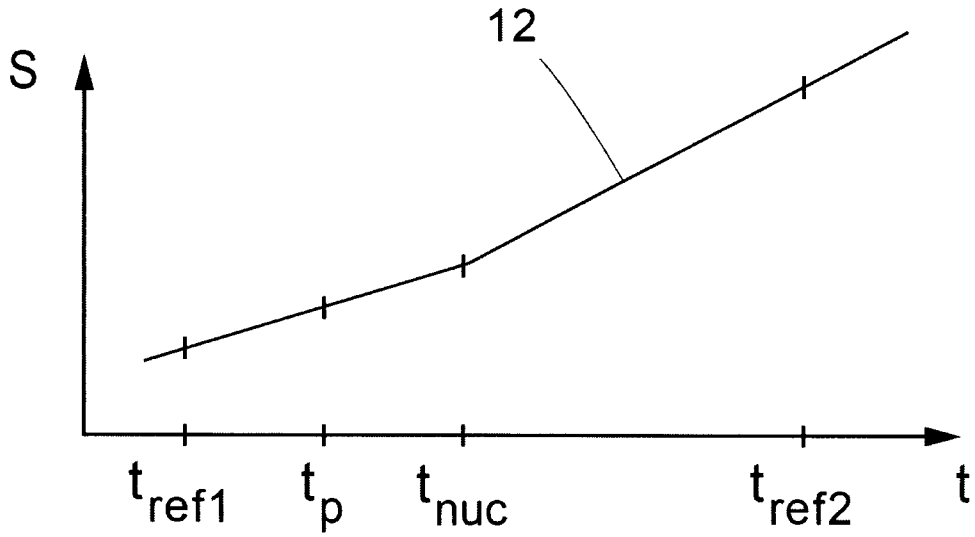

Fig.3

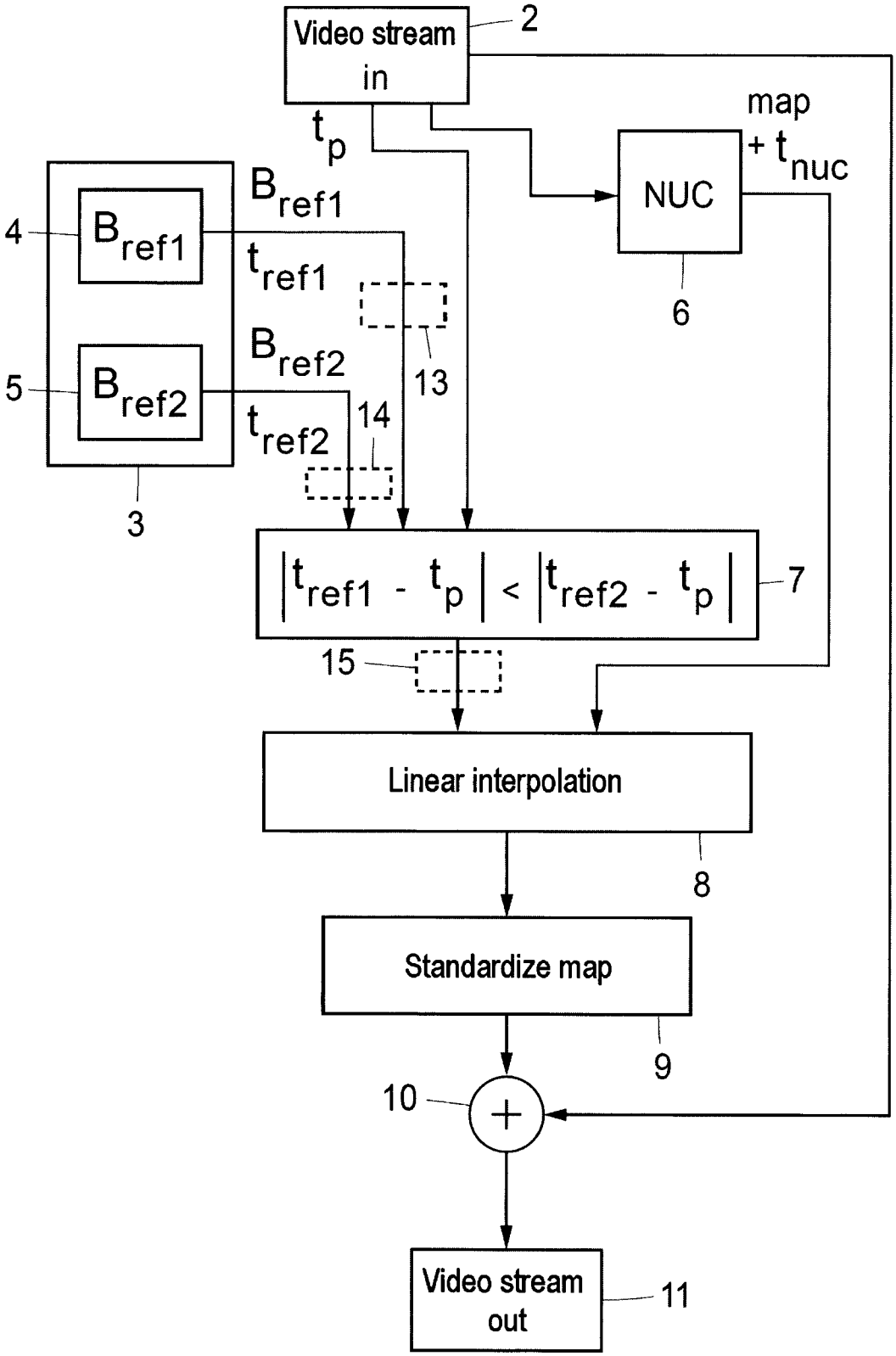
Video stream in
2
t_p
map + t_{nuc}
NUC
6
B_{ref1}
4
B_{ref1}
t_{ref1}
13
B_{ref2}
5
B_{ref2}
14
t_{ref2}
3
$|t_{ref1} - t_p| < |t_{ref2} - t_p|$
7
15
Linear interpolation
8
Standardize map
9
10
Video stream out
11

Fig.2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2013/000166

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: G01J, H04N

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20110164139 A1 (EKDAHL BENGT), 7 July 2011 (2011-07-07); abstract; paragraphs [0004], [0008], [0030]-[0035]; figures 1, 4a-4c --	1-7
A	WO 2008107117 A1 (THERMOSENSORIK GMBH ET AL), 12 September 2008 (2008-09-12); abstract; page 3, line 13 - page 8, line 8; figure 1; claim 1 --	1-7
A	US 20120200714 A1 (MINASSIAN CHRISTOPHE ET AL), 9 August 2012 (2012-08-09); abstract; paragraphs [0022]-[0037], [0051], [0053], [0057] --	1-7

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"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)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"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
"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
"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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17-02-2014	18-02-2014

Name and mailing address of the ISA/SE
Patent- och registreringsverket
Box 5055
S-102 42 STOCKHOLM
Facsimile No. + 46 8 666 02 86

Authorized officer
Heidi Wiik Edlund
Telephone No. + 46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2013/000166

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0601534 A1 (HUGHES AIRCRAFT CO -(B1) RAYTHEON CO [US]), 15 June 1994 (1994-06-15); abstract; column 4, line 38 - line 58 --	1-7
A	US 20030183765 A1 (CHEN HAI-WEN ET AL), 2 October 2003 (2003-10-02); abstract; paragraphs [0004]-[0007], [0032] -- --------	1-7

International application No.
PCT/SE2013/000166

Continuation of: second sheet

International Patent Classification (IPC)

H04N 5/33 (2006.01)
G01J 5/00 (2006.01)
H04N 5/365 (2011.01)

US	20110164139	A1	07/07/2011	EP	2304935	A4 15/05/2013
				SE	532353	C2 22/12/2009
				SE	0801436	L 20/12/2009
				WO	2009154533	A1 23/12/2009
WO	2008107117	A1	12/09/2008	DE	102007010649	B8 22/01/2009
US	20120200714	A1	09/08/2012	CA	2777646	A1 28/04/2011
				CN	102687496	A 19/09/2012
				EP	2491711	A1 29/08/2012
				FR	2951895	A1 29/04/2011
				RU	2012114794	A 27/11/2013
				WO	2011048326	A1 28/04/2011
EP	0601534	A1	15/06/1994	AU	656492	B2 02/02/1995
				AU	5220793	A 16/06/1994
				CA	2110368	A1 08/06/1994
				DE	69323531	D1 25/03/1999
				ES	2127779	T3 01/05/1999
				IL	107828	A 04/09/1996
				JP	2661865	B2 08/10/1997
				JP	6235663	A 23/08/1994
				NO	934422	A 08/06/1994
				TR	28036	A 11/12/1995
				US	5420421	A 30/05/1995
US	20030183765	A1	02/10/2003	US	20060082490	A1 20/04/2006
				US	20030191610	A1 09/10/2003
				US	20030186663	A1 02/10/2003
				US	20030185247	A1 02/10/2003
				US	20030184468	A1 02/10/2003
				US	7576681	B2 18/08/2009
				US	7436884	B2 14/10/2008
				US	7065465	B2 20/06/2006
				US	6944566	B2 13/09/2005
				US	6909997	B2 21/06/2005
				US	6897446	B2 24/05/2005