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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 June 2014 (19.06.2014)

(10) International Publication Number
WO 2014/092547 A1

(51) International Patent Classification:
H04N 7/18 (2006.01) *G08B 13/196* (2006.01)

(21) International Application Number:
PCT/MY2013/000253

(22) International Filing Date:
12 December 2013 (12.12.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
PI 2012701176 14 December 2012 (14.12.2012) MY

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(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, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

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(54) Title: A SURVEILLANCE SYSTEM AND METHOD FOR RANKING AND DISPLAYING MULTIPLE CAMERA VIEWS

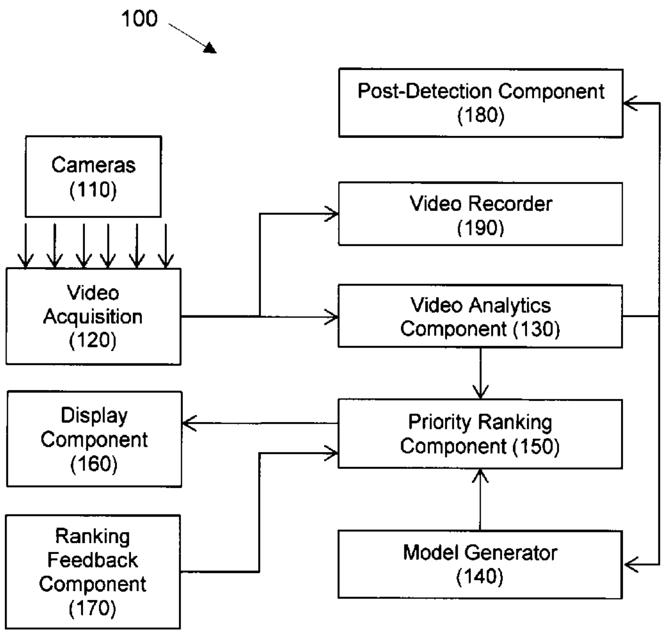

FIG. 1

(57) Abstract: The present invention relates to a surveillance system and method for ranking and displaying multiple camera views. The surveillance system (100) is able to display multiple camera views by ranking the camera views based on a probability of event frequency and camera topology. The probability of event frequency is determined from multi-dimensional time-space models generated by the surveillance system (100). The surveillance system (100) comprises of a plurality of cameras (110), a video acquisition component (120), a video analytics component (130), a model generator (140), a priority ranking component (150), a display component (160), a ranking feedback component (170), a post-detection component (180), and a video recorder (190).

WO 2014/092547 A1

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *of inventorship (Rule 4.17(iv))*

Published:

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

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

A SURVEILLANCE SYSTEM AND METHOD FOR RANKING AND DISPLAYING MULTIPLE CAMERA VIEWS

FIELD OF INVENTION

The present invention relates to a system and method for ranking and displaying multiple camera views and more particularly to a system and method for ranking and displaying multiple camera views based on probability of event frequency and camera topology.

BACKGROUND OF THE INVENTION

In a surveillance system, multiple cameras are placed at various different locations to monitor and detect suspicious events. The camera feeds are streamed and displayed at a central monitoring station. Typically, the camera feeds are displayed by tiling the camera feeds across a single display screen of the central monitoring station. Thus, an operator needs to review every single camera feeds simultaneously to detect and identify a suspicious event. This may not be effective as the operator may fail to identify a suspicious event occurring in one camera while reviewing another camera. Furthermore, if more than one camera detects suspicious events, the operator may not be able to determine which camera needs immediate attention. This may cause the least critical event to be attended first while the most critical event attended last.

Thus, various efforts have been taken to overcome the aforementioned problems of the surveillance system. As an example, PCT Publication No. WO 2011/109935 A1 discloses a surveillance system and method. The surveillance system displays and ranks multiple camera views based on priority rating values, wherein the priority rating value is assigned to each camera views by comparing one or more characteristics identified in each camera views. Such characteristics include an indication of the number of people, animals, and/or objects identified within a surveillance zone at any given time, the location of a person, animal and/or object within a surveillance zone, the relative proximity of a person, animal or object within a surveillance zone, the attributes of persons, animals and/or objects identified within a surveillance zone, and/or the time a person, animal, and/or object enters, leaves or remains within a surveillance zone. However, such system only analyses current characteristics of the camera views to rank and display the camera views. The system does not rank the camera views based on the likelihood of a suspicious event to occur at a period of time. Moreover, the system does not rank based on camera topology to conveniently track an event occurring in one camera view and then, into another camera view.

In another example, US Patent Publication No. 2002/0186300 A1 discloses a security system, wherein the security system displays multiple camera views in a predetermined hierarchy of views, wherein each level of the hierarchy comprises one or more sets of views. The camera views are arrangement of the hierarchy views is based on camera topology of the cameras. However, such system does not dynamically change the arrangement when an event has been detected. Thus, the operator still has to browse through the camera views based on the camera location in order to detect a suspicious event. The occurrence of more than one event in different camera views may further complicate the task of browsing and viewing each camera view to detect the suspicious events.

Therefore, there is still a need to provide a surveillance system and method for displaying and ranking multiple camera views that addresses the aforementioned problems.

SUMMARY OF INVENTION

The present invention provides a surveillance system (**100**). The surveillance system (**100**) comprises a plurality of cameras (**110**), a video acquisition component (**120**), a video analytics component (**130**), a display component (**160**), a post-detection component (**180**), and a video recorder (**190**). Moreover, the surveillance system further includes a model generator (**140**) and a priority ranking component (**150**). The model generator (**140**) is used to generate a multi-dimensional time-space model based on probabilities of event frequency and it is connected to the video analytics component (**130**). The priority ranking component (**150**) is used to determine ranking of each camera view based on a probability of event frequency and camera topology and it is connected to the video analytics component (**130**), the model generator (**140**), and the display component (**160**).

Preferably, the surveillance system further includes a ranking feedback component (**170**) to allow an operator modify ranking of the camera views as being displayed by the display component (**160**). The ranking feedback component (**170**) is connected to the priority ranking component (**150**).

The present invention also provides a method to generate a multi-dimensional time-space model by using the surveillance system (**100**). The method is characterised by the steps of generating the multi-dimensional time space model by a model generator (**140**); determining whether an event is detected by a video analytics component (**130**); determining time and date of the detected event and the corresponding multidimensional time-space model by the model generator (**140**) if an event is detected; incrementing the event frequency for the time of the detected event by an incremental value; determining a probability value in a main probability of event frequency and a probability value in a secondary probability of event frequency based on the incremented event frequency; and predicting a probability value in the secondary probability of event frequency for the next period of time following the period of time of the detected event.

Preferably, an event frequency in the secondary probability of event frequency is initialized to zero if the event is detected on a beginning of a day.

The present invention also provides a method for ranking and displaying multiple camera views by using the surveillance system (**100**). The method is characterised by steps of: (a) determining the probability value from a main probability of event frequency and a secondary probability of event frequency stored in a model generator (**140**) based on time and date of a detected event; (b) determining a ranking for each camera view in a priority list, wherein the ranking is based on the probability value from the main probability of event frequency of each camera view at the time of the detected event, and wherein the ranking is based on the probability value from the secondary probability of event frequency if there is a similar probability value from the main probability of event frequency; (c) displaying a first ranked camera view in a new row of a display component (**160**) and removing the first ranked camera view from the priority list; (d) determining whether any other camera views are located within the same camera topology as the camera view that is being displayed, wherein displaying the camera views side by side with the displayed camera view based on the priority list if the camera views are in the same camera topology as the camera view being displayed; (e) removing the camera views that have been displayed from the priority list; and (f) repeating steps (c) to (e) for the rest of camera views in the priority list.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

FIG. 1 shows a block diagram of a surveillance system (**100**) according to an embodiment of the present invention.

FIG. 2 shows a flowchart of a method for generating and updating a multi-dimensional time-space model according to an embodiment of the present invention.

FIG. 3 shows a flowchart of a method for ranking and displaying multiple camera views according to an embodiment of the present invention.

FIGS. 4(a-g) show exemplary multi-dimensional time-space models generated by a model generator (**140**) of the surveillance system (**100**) of **FIG. 1**.

FIG. 5 shows an exemplary display of multiple camera views based on the method of **FIG. 3**.

DESCRIPTION OF THE PREFFERED EMBODIMENT

A preferred embodiment of the present invention will be described herein below with reference to the accompanying drawings. In the following description, well known functions or constructions are not described in detail since they would obscure the description with unnecessary detail.

Referring to **FIG. 1**, there is shown a surveillance system (**100**) according to an embodiment of the present invention. The surveillance system (**100**) is able to display multiple camera views by ranking the camera views based on probability of event frequency and camera topology. The surveillance system (**100**) comprises of a plurality of cameras (**110**), a video acquisition component (**120**), a video analytics component (**130**), a model generator(**140**), a priority ranking component (**150**), a display component (**160**), a ranking feedback component (**170**), a post-detection component (**180**), and a video recorder (**190**).

The plurality of cameras (**110**) is dispersedly installed within a monitored area and thus, each camera (**110**) is capturing a zone within the monitored area. The cameras (**110**) are connected to the video acquisition component (**120**) via wireless or wired connection to transmit real-time video feeds of the camera views.

The video acquisition component (**120**) is used to acquire the video feeds from the cameras (**110**) and thereon, converts the video feeds into video frames for video analytics processing by the video analytics component (**130**).

The video analytics component (**130**) is used to detect events in the video frames. Such event refers to suspicious event that may pose a security threat in the monitored areas. Examples of events detected by the video analytics component (**130**) include but not limited to intrusion, unattended object, object removal, suspicious path, and slip and fall. The event is detected based on location and behaviour of an interest object in the video frames from the video acquisition component (**120**). The interest object is determined by extracting characteristic properties of motion data which include shape, colour, texture, orientation, speed, path and etc. The values of these properties are matched with specific rules to indicate the suspicious level of the interest object. The video analytics component (**130**) is connected to the video acquisition component (**120**), the model generator (**140**), and the priority ranking component (**150**).

The model generator (**140**) is used to generate a multi-dimensional time-space model based on probabilities of event frequency. The multi-dimensional time-space model provides probabilities of event frequency based on time and camera location, wherein the probabilities of event include a main probability of event frequency and a secondary probability of event frequency. The main probability of event frequency provides the probability values of event frequency over a period of time, while the secondary probability of event frequency provides the probability values of event frequency per day. The number of model to be generated is dependent on number of days in a week that the surveillance system (**100**) is operating. As an example, seven models are generated if the surveillance system

(**100**) is operating on a seven-day week, wherein one model is generated for each day. As another example, five models are generated if the surveillance system (**100**) is operating on a five-day week, wherein one model is generated for each day. **FIGS. 4(a-g)** show exemplary multi-dimensional time-space models generated for a seven-day week operation of the surveillance system (**100**). In particular, **FIG. 4a** shows the multi-dimensional time-space model generated for Monday, **FIG. 4b** shows the multi-dimensional time-space model generated for Tuesday, **FIG. 4c** shows the multi-dimensional time-space model generated for Wednesday, **FIG. 4d** shows the multi-dimensional time-space model generated for Thursday, **FIG. 4e** shows the multi-dimensional time-space model generated for Friday, **FIG. 4f** shows the multi-dimensional time-space model generated for Saturday, and **FIG. 4g** shows the multi-dimensional time-space model generated for Sunday. The model is generated by counting the event detected by a camera at a specific time and thereon, computing the main probability of event frequency and the secondary probability of event frequency for each camera view. The main probability of event frequency is computed by dividing the event frequency detected by a camera with the total event frequency detected from all camera views. The secondary probability of event frequency is computed by dividing the daily event frequency detected by a camera with the event frequency detected from all camera views. The probability of event frequency at a specific time is transmitted to the priority ranking component (**150**) to rank the camera views accordingly.

The priority ranking component (**150**) is used to determine ranking of each camera view. The ranking of the camera views is based on a probability of event frequency and camera topology. The priority ranking component (**150**) ranks the camera views in a priority list which is used for displaying the video frames of each camera views according to the determined rank.

The display component (**160**) is used for displaying the video frames of the camera views. The display component (**160**) includes a display device such as a monitor to display multiple camera views. The display component (**160**) is connected to the priority ranking component (**150**).

The ranking feedback component (**170**) is used to allow an operator to interact with the surveillance system (**100**) regarding the ranking of the camera views as being displayed by the display component (**160**). In particular, the ranking feedback component (**170**) allows the operator to manually modify the rank of any camera views. Thus, when the operator selects a camera view by using the ranking feedback component (**170**), the ranking feedback component (**170**) triggers the priority ranking component (**150**) to rank the camera view as first. The ranking feedback component (**170**) includes an input device for receiving an input from the operator. The ranking feedback component (**170**) is connected to the priority ranking component (**150**).

The post detection component (**180**) is used for triggering an alarm once it receives an event detection alert from the video analytics component (**130**). Such alarm may include displaying an alert text on the camera view displaying on the display component (**160**), sound notification, email notification and etc.

The video recorder (**190**) is used to record the video frames of all camera views and store the recordings in a storage of the surveillance system (**100**). The video recording component (**190**) is connected to the video acquisition component (**120**).

The surveillance system (**100**) operates by sending video feeds to the video acquisition component (**120**) from each cameras (**110**), converting the video feeds into video frames by the video acquisition component (**120**), analysing the video frames to detect unusual event by using the video analytics component (**130**), ranking the camera views in a priority list by using the priority ranking component (**150**), displaying the camera views on the display component (**160**) based on the priority list and triggering an alarm by the post-detection component (**180**) if an event is detected. The ranking of camera views is based on a probability of event frequency and camera topology. The probability of event frequency is determined by using the multi-dimensional time-space model which is generated and updated by the model generator (**140**).

Referring now to **FIG. 2**, there is shown a flowchart of a method for generating and updating a multi-dimensional time-space model by using the model generator (**140**) of the surveillance system (**100**). The multi-dimensional time-space model is constantly updated whenever an event is detected by the video analytics component (**130**).

In step **201**, the multi-dimensional time space model is generated. The number of model to be generated is dependent on number of days in a week that the surveillance system (**100**) is operating. **FIGS. 4(a-g)** show exemplary multi-dimensional time-space models generated for a seven-day week operation of the surveillance system (**100**). The model is generated by counting the event detected in a camera view and thereon, computing the main probability of event frequency and the secondary probability of event frequency.

In decision **202**, the model generator (**140**) determines whether an event is detected by the video analytics component (**130**). If there is no event detected, the model is stored in the model generator (**140**) as in step **203**.

However, if an event is detected, the model generator (**140**) determines time and date of the detected event and the corresponding multidimensional time-space model as in step **204**.

If the event is detected on a beginning of a day, the daily event frequency is initialized to zero as in decision **205** and step **206**. Otherwise, the method proceeds to step **207** with the existing daily event frequency.

Thereon, as in step **207**, the total event frequency and daily event frequency are incremented by an incremental value based on the time and camera view that the event is detected. For instance, if the event is detected by a first camera at 1.00am on Friday, the daily event frequency of the first camera at the time of 1.00am on Friday is incremented by one and the total event frequency of the first camera on Friday is also incremented by one. The incremental value can either be a predetermined value or a value determined automatically in real time. The incremental value determined automatically in real time is based on scene information of a particular camera view. For example, the amount of motion information or any metadata represent the scene information can be used to indicate the value of the incremental value.

Based on the change of the event frequency, the main probability of event frequency and the secondary probability of event frequency in the corresponding multidimensional time-space model are computed based on the new total and daily event frequencies as in step **208**.

In step **209**, the model generator (**140**) computes a prediction for the secondary probability of event frequency, wherein the model generator (**140**) predicts the probability of event frequency for the following time period after the time period that the event was detected. For instance, if an event is detected in a first camera view at 1.00am on Friday, the model generator (**140**) predicts the probability value at 2.00am based on the probability value at 1.00am. The prediction of the probability of daily event frequency is computed by using Kalman filter, mean-shift filter, particle filter or any other prediction technique. Thereon, the model generator (**140**) predicts the probability value for the following hour based on the predicted probability value.

Thereon, the model generator (**140**) stores the updated multidimensional time-space model as in step **203**.

Referring now to **FIG. 3**, there is shown a flowchart of a method for ranking and displaying multiple camera views by using the priority ranking component (**150**) of the surveillance system (**100**) as shown in **FIG. 1**. The ranking of the camera views is based on the multidimensional time-space model generated by the model generator (**140**).

The method is initiated whenever an event is detected by the video analytics component (**130**). In step **301**, the priority ranking component (**150**) determines the probability values from the main probability of event frequency and the secondary probability of event frequency stored in the model generator (**140**) based on time and date of the event detected.

Thereon, the priority ranking component (**150**) determines the ranking for each camera view in a priority list as in step **302**. The ranking is based on the probability value from the main probability of event frequency of the camera views at the time of the detected event, wherein the camera view with a lowest probability value is ranked first in the priority list and the camera view with a highest probability value is ranked last in the priority list.

If there is a similar probability value between two or more camera views, those camera views are then ranked based on the probability value from the secondary probability of event frequency at the time of the detected event as in decision **303** and step **304**, wherein the camera view with a lowest probability value is ranked first among the camera views with similar probability value from the main probability of event frequency and the camera view with a highest probability value is ranked last among the camera views with similar probability value from the main probability of event frequency. Otherwise, the method proceeds to step **305**.

In step **305**, the priority ranking component (**150**) displays the first ranked camera view in a new row of the display component (**160**). The camera view is removed from the priority list once it has been displayed on the display component (**160**).

Thereon, in step **306**, the priority ranking component (**150**) determines whether any other camera views are located within the same camera topology as the camera view that is being displayed. The camera topology is determined by using any estimation techniques based on distance of the cameras (**110**) and division of the physical structure that hold the cameras (**110**). An example of the estimation technique used for determining camera topology is nearest neighbour technique.

If any of the camera views is in the same camera topology as the camera view being displayed, that camera views are displayed side by side with the displayed camera views based on the priority list as in decision **307** and step **308**. Those camera views that have been displayed on the display component (**160**) are removed from the priority list.

However, if none of the camera views fall in the same topology as the camera view being displayed, the priority ranking component (**150**) determines whether any other camera views is still in the priority list as in decision **309**.

If there is none in the priority list meaning that all of the camera views have been displayed, the display component (**160**) displays the camera views as arranged by the priority ranking component (**150**). **FIG. 5** shows an exemplary display of multiple camera views as arranged by the priority ranking component (**150**).

Otherwise, steps **305** to **307** are repeated for the camera views in the priority list which is displayed on the following row of the display component.

While embodiments of the invention have been illustrated and described, it is not intended that these embodiments illustrate and describe all possible forms of the invention. Rather, the words used in the specifications are words of description rather than limitation and various changes may be made without departing from the scope of the invention.

CLAIMS

1. A surveillance system (**100**) comprising:
   a) a plurality of cameras (**110**),
   b) a video acquisition component (**120**),
   c) a video analytics component (**130**),
   d) a display component (**160**),
   e) a post-detection component (**180**), and
   f) a video recorder (**190**);

   wherein said surveillance system (**100**) is characterised in that it further includes:
   a) a model generator (**140**), wherein said model generator (**140**) is used to generate a multi-dimensional time-space model based on probabilities of event frequency, and wherein said model generator (**140**) is connected to said video analytics component (**130**); and
   b) a priority ranking component (**150**), wherein said priority ranking component (**150**) is used to determine ranking of each camera view based on a probability of event frequency and camera topology, and wherein said priority ranking component (**150**) is connected to said video analytics component (**130**), said model generator (**140**), and said display component (**160**).

2. The surveillance system (**100**) as claimed in claim **1**, wherein said surveillance system (**100**) further includes a ranking feedback component (**170**) to allow an operator modify ranking of the camera views as being displayed by the display component (**160**), and wherein said ranking feedback component (**170**) is connected to said priority ranking component (**150**).

3. A method to generate a multi-dimensional time-space model by using a surveillance system (**100**) as claimed in claim **1** is characterised by the steps of:
   a) generating the multi-dimensional time space model by a model generator (**140**);
   b) determining whether an event is detected by a video analytics component (**130**);

c) determining time and date of the detected event and the corresponding multidimensional time-space model by the model generator (**140**) if an event is detected;

d) incrementing the event frequency for the time of the detected event by an incremental value;

e) determining a probability value in a main probability of event frequency and a probability value in a secondary probability of event frequency based on the incremented event frequency; and

f) predicting a probability value in the secondary probability of event frequency for the next period of time following the period of time of the detected event.

4. The method as claimed in claim **3**, wherein initializing an event frequency in the secondary probability of event frequency to zero if the event is detected on a beginning of a day

5. A method for ranking and displaying multiple camera views by using a surveillance system (**100**) as claimed in claim **1** is characterised by steps of:

a) determining the probability values from a main probability of event frequency and a secondary probability of event frequency stored in a model generator (**140**) based on time and date of a detected event;

b) determining a ranking for each camera view in a priority list, wherein the ranking is based on the probability value from the main probability of event frequency of each camera view at the time of the detected event, and wherein the ranking is based on the probability value from the secondary probability of event frequency if there is a similar probability value from the main probability of event frequency;

c) displaying a first ranked camera view in a new row of a display component (**160**) and removing the first ranked camera view from the priority list;

d) determining whether any other camera views are located within the same camera topology as the camera view that is being displayed, wherein displaying the camera views side by side with the displayed camera view based on the priority list if the camera views are in the same camera topology as the camera view being displayed;

e) removing the camera views that have been displayed from the priority list; and

f) repeating steps (c) to (e) for the rest of camera views in the priority list.

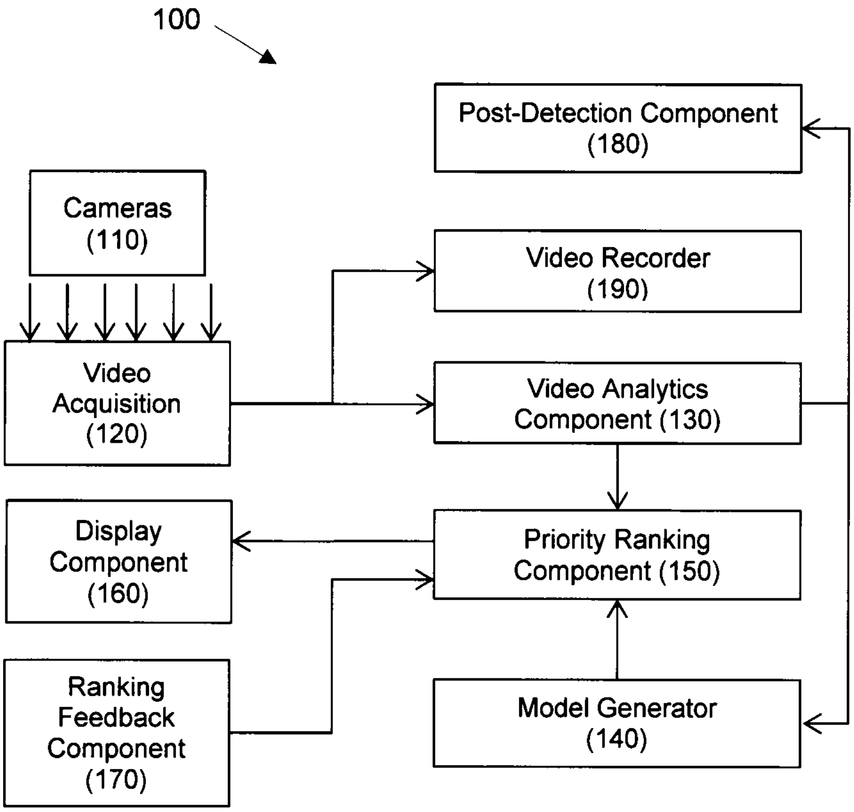
100
Post-Detection Component (180)
Cameras (110)
Video Recorder (190)
Video Acquisition (120)
Video Analytics Component (130)
Display Component (160)
Priority Ranking Component (150)
Ranking Feedback Component (170)
Model Generator (140)

FIG. 1

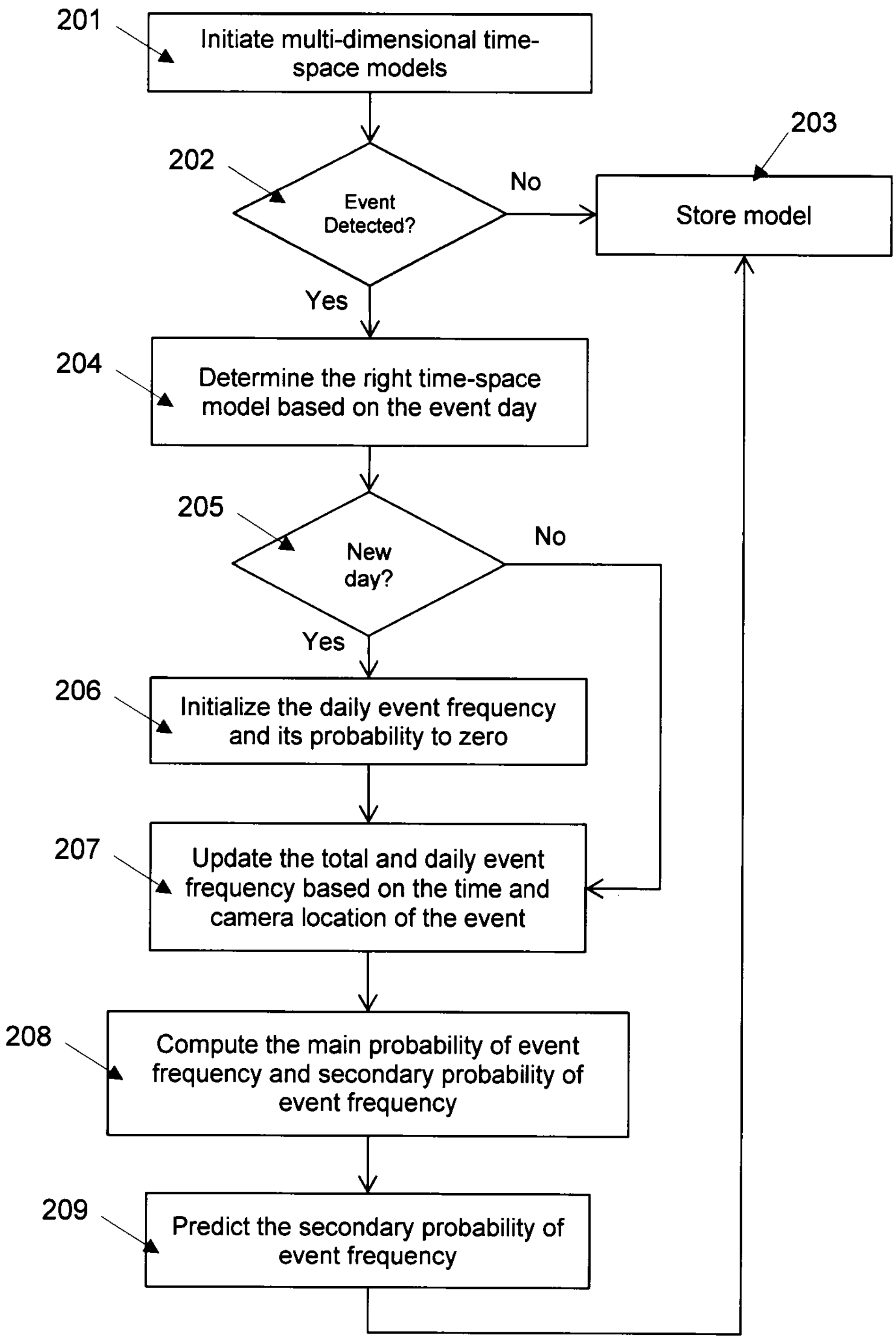
201
Initiate multi-dimensional time-space models
202
Event Detected?
No
203
Store model
Yes
204
Determine the right time-space model based on the event day
205
New day?
No
Yes
206
Initialize the daily event frequency and its probability to zero
207
Update the total and daily event frequency based on the time and camera location of the event
208
Compute the main probability of event frequency and secondary probability of event frequency
209
Predict the secondary probability of event frequency

FIG. 2

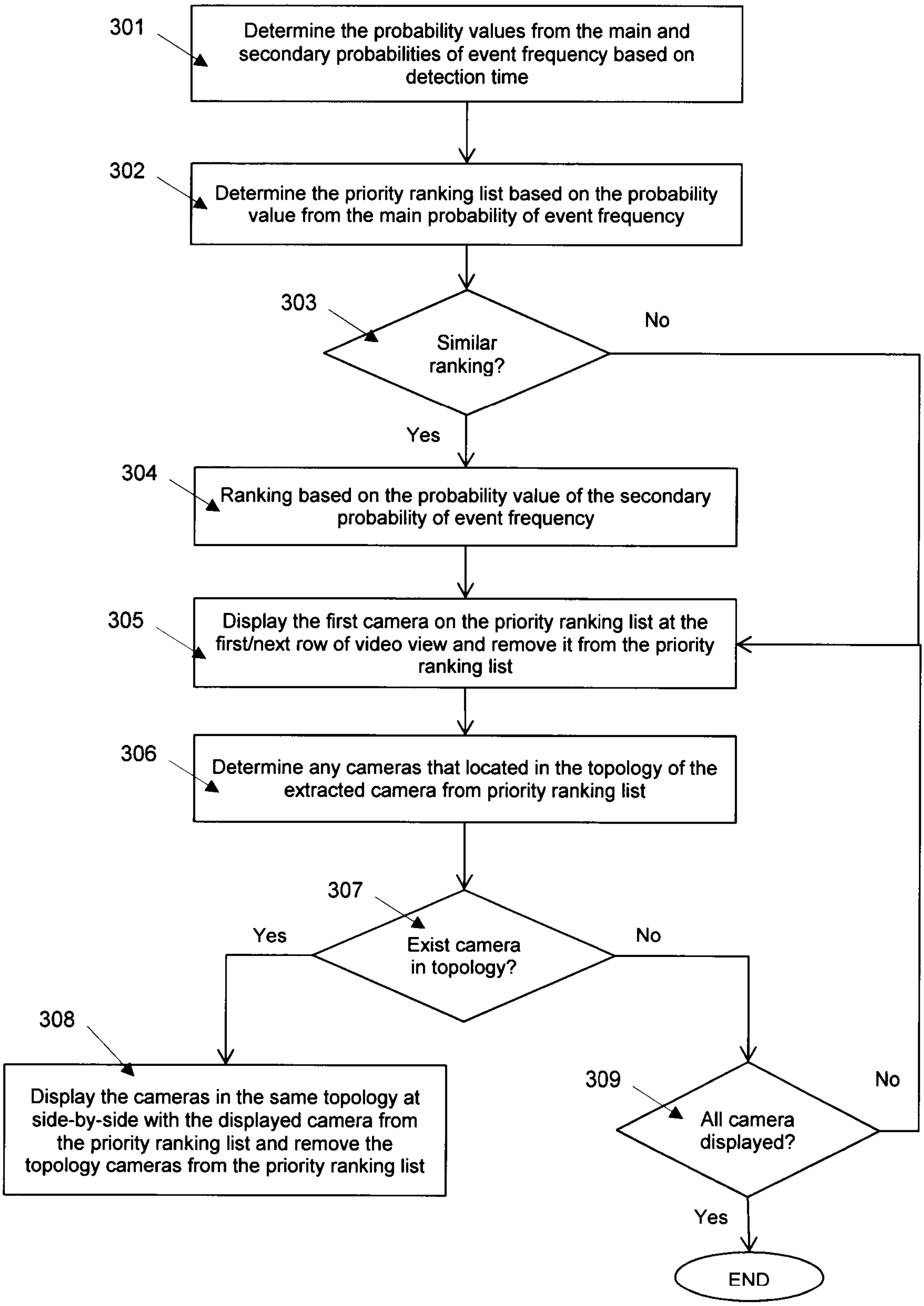
301
Determine the probability values from the main and secondary probabilities of event frequency based on detection time
302
Determine the priority ranking list based on the probability value from the main probability of event frequency
303
Similar ranking?
No
Yes
304
Ranking based on the probability value of the secondary probability of event frequency
305
Display the first camera on the priority ranking list at the first/next row of video view and remove it from the priority ranking list
306
Determine any cameras that located in the topology of the extracted camera from priority ranking list
307
Exist camera in topology?
Yes
No
308
Display the cameras in the same topology at side-by-side with the displayed camera from the priority ranking list and remove the topology cameras from the priority ranking list
309
All camera displayed?
No
Yes
END

FIG. 3

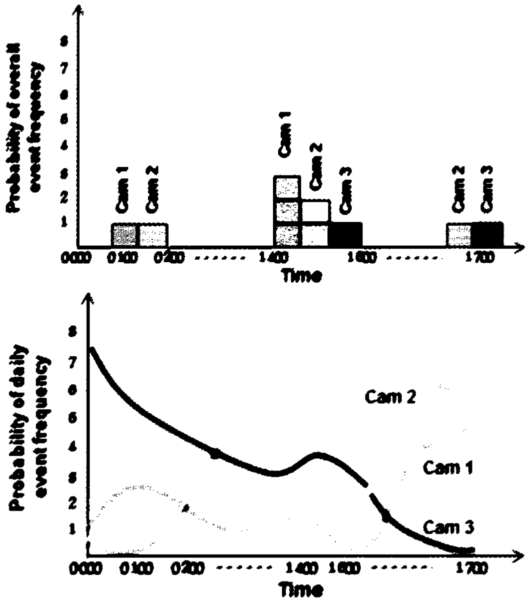

FIG. 4a

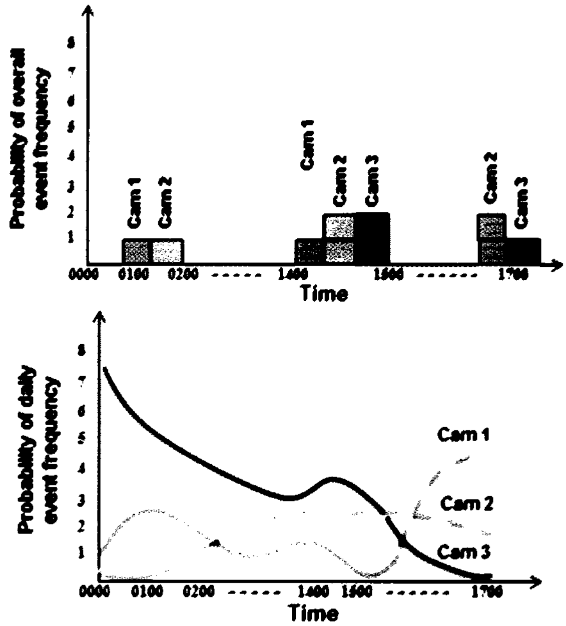

FIG. 4b

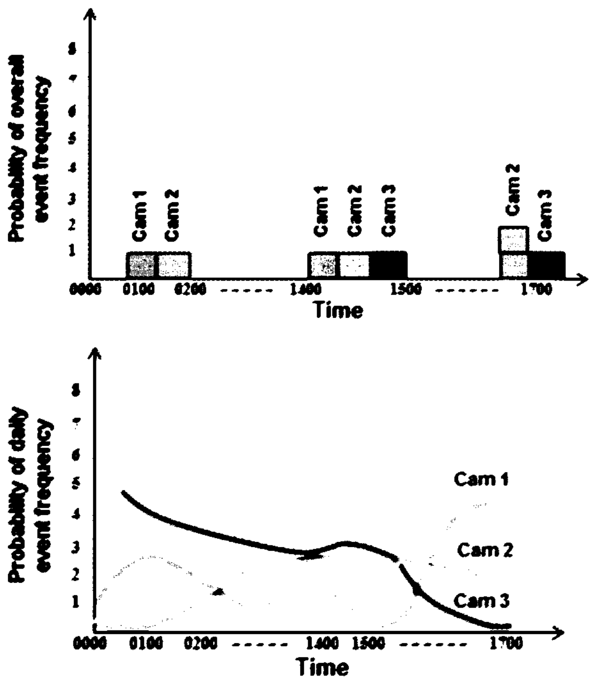

FIG. 4c

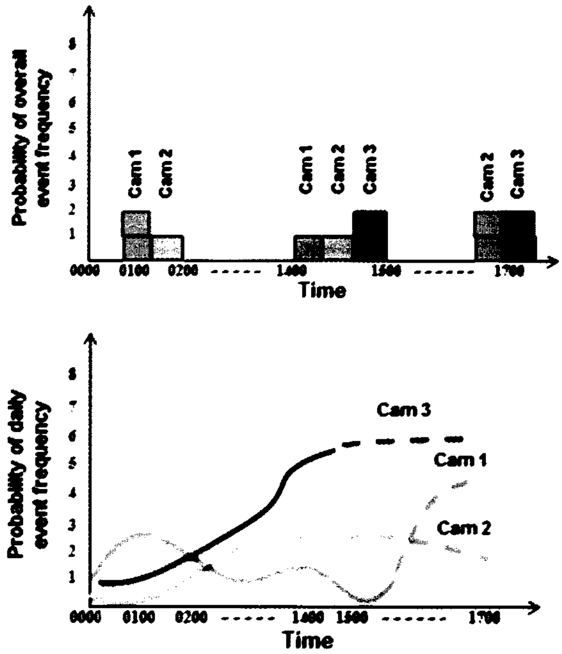

FIG. 4d

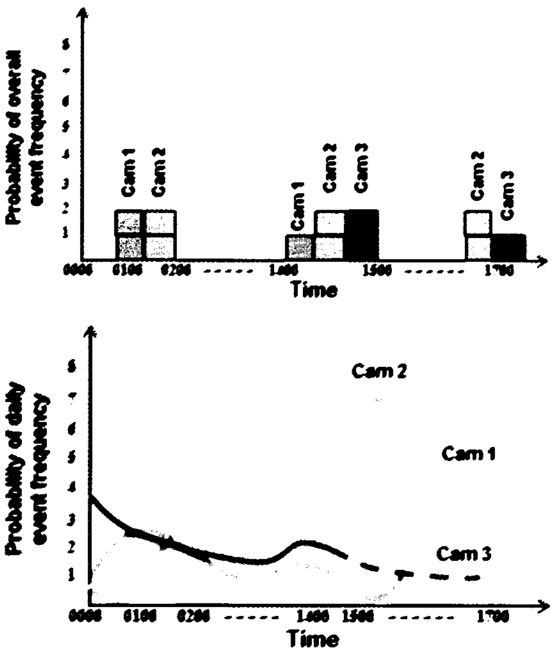

FIG. 4e

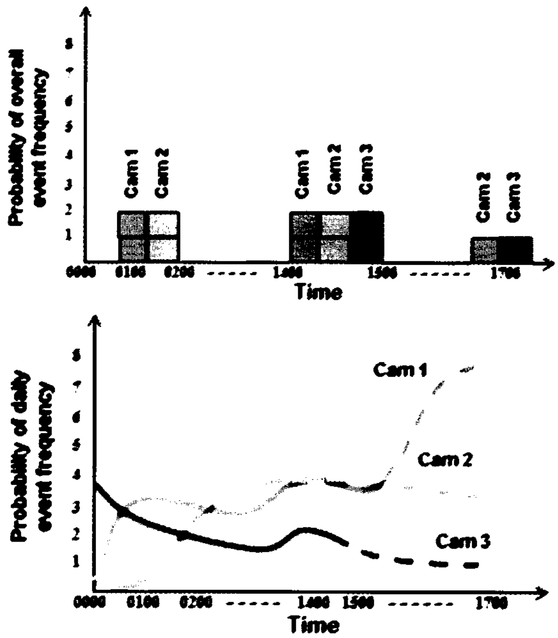

FIG. 4f

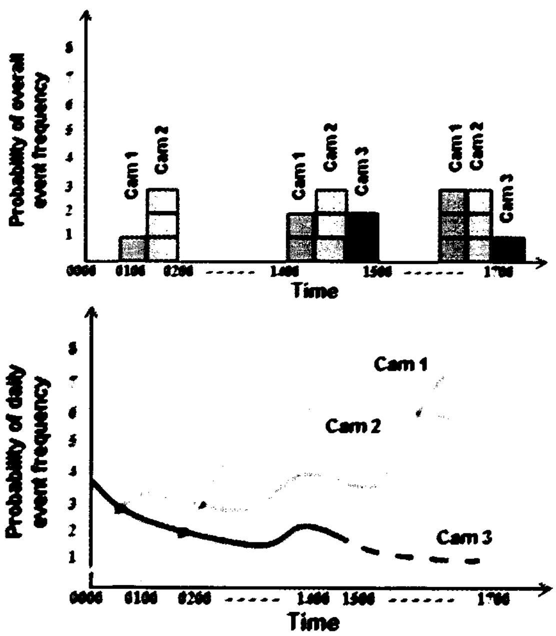

FIG. 4g

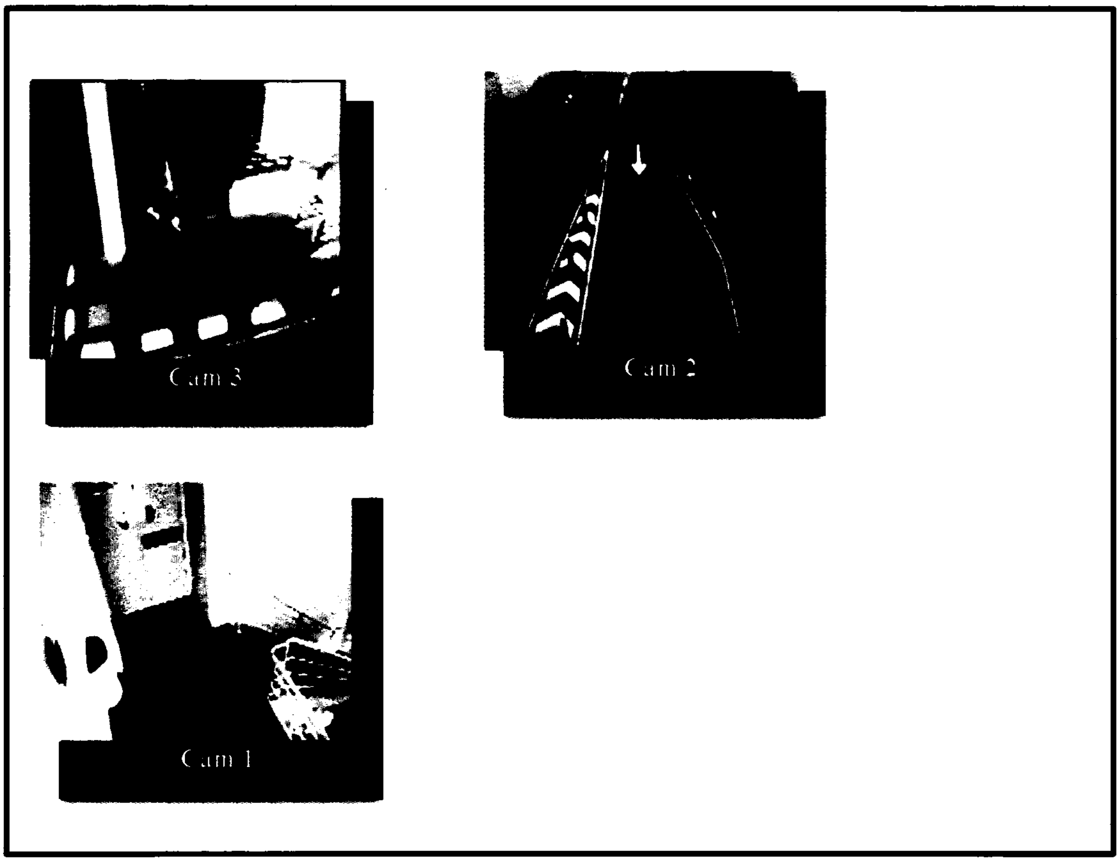

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/MY2013/000253

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04N7/18
ADD. G08B13/196

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 G08B

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.
A	WO 2011/109935 A1 (GLOBAL ADVANCED VISION LTD [CN]; JIN JESSE SHENG [AU]; AU SZE LOK [CN]) 15 September 2011 (2011-09-15) cited in the application paragraph [0039] - paragraph [0054]; figures 1,2 -----	1-5
A	US 2002/186300 A1 (HUDSON JOHN [GB]) 12 December 2002 (2002-12-12) cited in the application the whole document -----	1-5
A	US 2010/097472 A1 (CHATHUKUTTY SILKY [IN] ET AL) 22 April 2010 (2010-04-22) paragraph [0006] paragraph [0027] - paragraph [0033] -----	1-5

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

☒ See patent family annex.

* Special categories of cited documents :

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 May 2014	20/05/2014

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	Beaudoin, Olivier

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/MY2013/000253

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
WO 2011109935	A1	15-09-2011	CN	102860003	A	02-01-2013
			US	2013011014	A1	10-01-2013
			WO	2011109935	A1	15-09-2011
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			US	2002186300	A1	12-12-2002
US 2010097472	A1	22-04-2010	NONE			