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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 June 2020 (11.06.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/115466 A1

(51) International Patent Classification:
G06F 3/01 (2006.01) *B63B 49/00* (2006.01)
G02B 27/01 (2006.01)

(21) International Application Number:
PCT/GB2019/053411

(22) International Filing Date:
03 December 2019 (03.12.2019)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1819896.0 06 December 2018 (06.12.2018) GB
19150823.3 08 January 2019 (08.01.2019) EP

(71) Applicant: **BAE SYSTEMS PLC** [GB/GB]; 6 Carlton Gardens, London SW1Y 5AD (GB).

(72) Inventors: **MOORE, David**; BAE SYSTEMS, Airport Works, Marconi Way, Rochester Kent ME1 2XX (GB). **NICHOLS, Mark**; BAE SYSTEMS, Airport Works, Marconi Way, Rochester Kent ME1 2XX (GB).

(74) Agent: **BAE SYSTEMS PLC, GROUP IP DEPT**; 87 Farnborough Aerospace Centre, Farnborough Hampshire GU14 6YU (GB).

(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, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, 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,

(54) Title: TRACKING SYSTEM

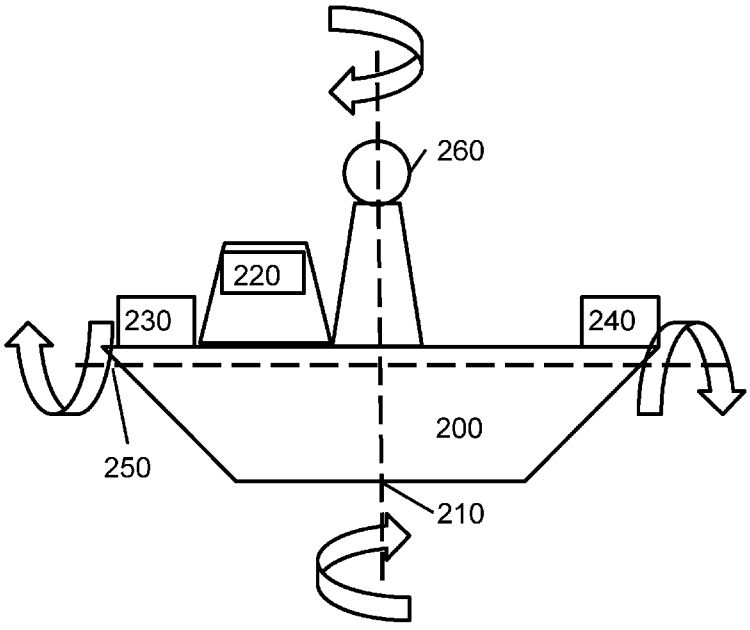

Figure 2

(57) Abstract: A tracking system for use with a head mounted display on a watercraft is disclosed. The tracking system comprises: optical tracking circuitry to determine first tracking information of the head mounted display using optical tracking means; non-optical circuitry to determine second tracking information of the head mounted display using non-optical tracking means; and correction circuitry to determine an updated tracking information of the head mounted display based on the first tracking information and the second tracking information. The selection of at least the optical tracking means or non-optical tracking means to use to determine the first tracking information and the second tracking information is based on a location of the head mounted display.

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[Continued on next page]

GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, 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, 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))*

Published:

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

TRACKING SYSTEM

BACKGROUND

Head mounted displays are a type of display that allow a user to view a scene whilst viewing information over the scene, and at the same time having freedom of movement to move their head position. Head mounted displays may comprise a tracking system. However, tracking systems are typically designed to function in a closed environment, such as an aircraft cockpit, where the freedom of movement of the user is constrained to a relatively small volume. Therefore the tracking systems are not typically capable to track movement accurately over large volumes or large movements.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a tracking system in accordance with some examples.

Figure 2 illustrates a watercraft in accordance with some examples.

Figure 3 illustrates a size-variable optical mark in use.

Figure 4 further illustrates a size-variable optical mark in use.

Figure 5 illustrates a method for use with a tracking system in accordance with some examples.

DETAILED DESCRIPTION

It may be desirable for user on a watercraft to be provided with information regarding their surroundings and watercraft visually. This may be provided with a head mounted display. The information should be overlaid with objects in the field of view of the user, and therefore a tracker system is desirable for the head mounted display. However, it is also may be desirable for the user to be able to move freely about the watercraft, and to be able to view the information at a wide range of viewing angles and positons. Therefore, the tracking system should allow the user to be able to move substantially freely over a large volume whilst still being provided with information aligned with objects in their field of view. Traditionally head tracker systems have been used in applications where the user is constrained in position, for example a pilot in a cockpit.

Figure 1 illustrates a tracking system 100 according to some examples. Head tracking system 100 is for use with a head mounted display to track the head and/or the eyes of a user of the head mounted display on a watercraft. The tracking system 100 comprises optical tracking circuitry 110, non-optical tracking circuitry 120 and correction circuitry 130.

The optical tracking circuitry 110 determines first tracking information of the head mounted display using optical tracking means. The optical tracking means may comprise at least one optical source, such as a laser or light emitting diode, and at least one optical detector. The at least one optical source may be located on the head mounted display, or alternatively the optical detectors may be located on the head mounted display.

Non-optical tracking circuity comprises a set of non-optical means to provide second tracking information. The set of non-optical tracking means may comprise at least one inertial sensor. The head mounted display may comprise at least one inertial sensor attached to or associated with the head mounted display, and also the watercraft may also comprise at least one inertial sensor attached to or associated with the watercraft.

Correction circuitry 130 uses the first and second tracking information to provide updated tracking information.

In some examples the tracking system 1000 may further comprise a prediction circuitry. The prediction circuitry may incorporate additional data from sources such as sensors, accelerometers and gyroscopes to improve the perceived latency and conformal accuracy of the head mounted display and use such data to predict the position of gaze, a number of frames ahead of real-time. In some examples the sensors, accelerometers and gyroscopes may be associated and/or mounted to the head mounted display. In some examples the sensors, accelerometers and gyroscopes may be associated and/or mounted to the watercraft. The prediction circuitry may preferably predict the position and gaze no more than 100 ms in advance.

In some examples the prediction circuitry may use a combination of information received from data sources associated with the watercraft and data

sources associated with head mounted display. The data sources associated with the watercraft may comprise sensors, accelerometers and gyroscopes mounted to the watercraft. The data sources associated with the head mounted display may comprise sensors, accelerometers and gyroscopes mounted to the head mounted display. This combination may improve the perceived latency and accuracy of symbol conformity to objects.

For example, the watercraft may have a predictable motion due to roll caused by the motion of the sea and this information combined with information regarding the movement of the head of the user of the head mounted display further reducing the perceived latency.

The particular non-optical tracking means from the set of non-optical tracking means are selected by the tracking system 100 based on the location of the head mounted display. The tracking system 100 may select one or more than one non-optical tracking means. Selecting the non-optical tracking means based on the location of the head mounted display may allow the tracking system 100 to track the head mounted display over a large area.

In some examples the tracking system 100 selects a non-optical tracking means based on the location of the head mounted display. This is further illustrated by Figure 2.

Figure 2 illustrates a tracked watercraft 200 according to some examples. The tracked watercraft 200 comprises a first axis 210 and a second axis 250 about which the tracked watercraft 200 may be deformed, for example a flex, rotation, or a compression. The tracked watercraft 200 may comprise other axes not shown in Figure 2 that it is also deformed about. Tracked watercraft 200 also comprises a first tracking location 220, second tracking location 230, and third tracking location 240. The tracked watercraft may also comprise a reference area 260. The first tracking location 220, second tracking location 230, and third tracking location 240 are each areas of the tracked watercraft that the user may be tracked.

Non-optical tracking means may be provided at least at the reference area 260. Reference area 260 may be chosen as a positon or area on the tracked

watercraft 200 that is known to have the least deformation. In some examples, knowing conditions regarding the tracked watercraft may allow for calculation to be made regarding the relative movement of the first tracking location 220, second tracking location 230, and third tracking location 240, and therefore a correction may be made to the second tracking information based on the location of the user.

In some examples, at least one of the first tracking location 220, second tracking location 230, and third tracking location 240 may comprise non-optical tracking means, this may be in addition to the non-optical tracking means in the reference area 260. The selection of the non-optical tracking means may be based on the location of the head mounted display, such that the tracker system 100 uses non-optical tracking means associated with the first tracking location 220 when nearest the first tracking location, uses non-optical tracking means associated with the second tracking location 230 when nearest the second tracking location, and uses non-optical tracking means associated with the third tracking location 230 when nearest the third tracking location.

The selection of the appropriate non-optical tracking means may not be based purely on distance. For example, the tracked watercraft 200 may be known to have more flex at a certain location, and therefore the distance may be a weighted distance based on the predicted deformation of the tracked watercraft.

In some examples the deformation behaviour of the watercraft may be known, for example by modelling or physical measurements. This may enable the calculation of the second tracking information to be adapted based on the current location of the user of the head tracking system. This may counteract the fact that when the user is a distance from an inertial sensor located on the vehicle the motion of the user may different from the motion of the inertial sensor in a predictable manner due to deformation of the vehicle.

The tracker system may also take into account the motion of at least two of the first tracking location 220, second tracking location 230, third tracking location 240, and reference area 260 to such that for a known positon on the

watercraft 200 a movement relative to the reference movement can be determined based on known properties of the tracked watercraft 200.

The number of tracking areas is illustrative, and the tracked watercraft 200 may comprise any number of tracked areas. In some examples the tracked areas may be discrete, such that they have defined boundaries. In some examples the tracked areas may be continuous, such that there is not a well-defined boundary. In some examples none or at least one of the tracked areas may overlap. In some examples at least one of the tracking locations may comprise a bridge of the watercraft.

In some examples the non-optical tracking means may comprise at least one inertial sensor. The non-optical tracking means may comprise a set of inertial sensors to measure movement of the helmet relative to the watercraft, and a plurality of sets of inertial sensors to measure the movement of the watercraft relative to the surroundings. The tracking system may select one of the plurality of sets of inertial sensors based on the location of the head mounted display. The plurality of sets of inertial sensors may be disjoint sets, such that each set does not share any sensor with any other set of inertial sensors.

In some examples, the optical tracking means may comprise a size-variable optical tracking mark. The physical size of the size-variable optical tracking mark may be configured to change based on the location of the head mounted display. The physical size may be based on the distance from the size-variable optical tracking mark, or from a defined position in the watercraft or tracking area. The distance may also be a weighted distance. In some examples the size of the size-variable optical tracking mark may vary such that the apparent size from the location of the head mounted display appears to be the substantially same irrespective of the distance from the size-variable optical tracking mark.

Figure 3 illustrates the size-variable optical tracking mark in use. A head mounted display 300 is located at a first distance 310a from the size-variable optical tracking mark 320. This results in the size-variable optical tracking mark 320 having a first size 330a. When the head mounted display 300 is located at a

second distance 310b from the size-variable optical tracking mark 320 the size-variable optical tracking mark 320 has a second size 330b.

The size-variable optical tracking mark may vary size mechanically, such as by expanding, contracting or a rotation.

The optical tracking marks may comprise an active device, such as a light source, or a passive device such as a reflector or a detector.

Figure 4 illustrates a cross-shaped size-variable optical tracking mark 400 according to some examples. The shape is illustrative, and it is understood that the size-variable optical tracking mark may have any shape. Furthermore, the size-variable optical tracking mark may be configured to increase size in all angles, rather than vertically and horizontally.

If the head mounted display is located at a first distance from the cross-shaped size-variable optical tracking mark 400, then a single optical tracking mark 410a may be used by the tracker system and six optical tracking marks not used 420a. If the head mounted display is located at a second distance from the cross-shaped size-variable optical tracking mark 400 then a further four optical tracking marks may be used 410b, and four optical tracking marks not used 420b, wherein the first distance is less than the second distance. If the head mounted display is located at a third distance from the cross-shaped size-variable optical tracking mark 400 then a further four optical tracking marks may be used 410c, and no optical tracking marks not used, wherein the third distance is more than the second and first distances.

The tracking system may also comprise a plurality of size-variable optical tracking marks and a plurality of constant-size optical tracking marks which do not change size. For example, the walls of the tracked area may comprise size-variable optical tracking marks as the user may move towards and away from the walls, but the ceiling may comprise constant-size optical tracking marks as the user may not significantly change the distance from the ceiling to the head mounted display, at least in the vertical direction.

The size-variable optical tracking marks are illustrated as increasing size from the centre, however they are not limited to increasing in this manner. The

number of size-variable marks is not required to increase with distance of the user form the marks. In some examples the number of size-variable tracking marks may stay constant, such that the spacing of the marks increase with increasing distance of the user from the marks.

In some examples the intensity of the marks may depend on the distance of the user from the mark. In some examples the intensity of the mark may be relatively constant with distance.

Figure 5 illustrates a method 500 according to some examples. The method comprises determining first tracking information 510, determining second tracking information 520, and determining updated tracking information 530.

Determining first tracking information 510 comprises using optical tracking means to determine the first tracking information using optical tracking means. The optical tracking means may comprise at least one optical sensor and at least one optical source. The optical detectors may be located on the head mounted display, or the optical sources may be located on the head mounted display.

Determining second tracking information 520 comprises using non-optical tracking means to determine the second tracking information using non-optical tracking means.

The selection of at least one of the optical tracking means and non-optical tracking means may be based on the location of the head mounted display.

In some examples the method may comprise selecting a non-optical tracking means based on the location of the head mounted display. A watercraft may comprise a plurality of tracked areas, and the selecting the non-optical tracking means may comprise selecting a subset of the non-optical tracking means, the subset of the non-optical tracking means being closest to the head mounted display.

In some examples the method may comprise providing the location of the head mounted display to the optical means, and basing the size of the variable-sized marks on the distance from the variable-sized mark to the head mounted display. The location of the head mounted display may be a rough estimation. In

some examples the tracking system may determine the location by performing a measurement. In some examples the location may be a relative location, such that the location provides information regarding the distance from the size-variable optical tracking mark but does not provide the absolute location of the head mounted display on the watercraft.

Although the above examples are described in relation to watercraft, it should be understood that tracking system 100 may be used with any type of application where a user's head is required to be tracked over a large volume.

CLAIMS

1. A tracking system for use with a head mounted display on a watercraft, the tracking system comprising:

optical tracking circuitry to determine first tracking information of the head mounted display using optical tracking means;

non-optical circuitry to determine second tracking information of the head mounted display using at least one non-optical tracking means of a set of non-optical tracking means;

correction circuitry to determine an updated tracking information of the head mounted display based on the first tracking information and the second tracking information; and wherein

the tracking system is configured to select the at least non-optical tracking means of the set of non-optical tracking means based on a location of the head mounted display.

2. The tracking system according to claim 1, wherein the set of non-optical tracking means comprises a plurality of disjoint sets of inertial sensors located on the watercraft, each individual set comprising at least one inertial sensor, each disjoint set located in separate locations of the watercraft, wherein the tracking system is configured to select one of the plurality of disjoint sets of inertial sensors to use to determine the second tracking information based on the location of the head mounted display.

3. The tracking system according to any preceding claim, wherein the optical tracking means comprises at least one size-variable optical tracking mark, a physical size and configuration of the variable-sized alignment mark is based on the location of the head mounted display.

4. The tracking system according to claim 3, wherein the size-variable optical tracking mark comprises at least one light source.

5. The tracking system according to claim 4, wherein the at least one light source comprises a light emitting diode.

6. The tracking system according to any preceding claim, wherein the non-optical circuity is configured to adapt the determination of the second tracking information based on an estimate of the physical deformation at the location of the head mounted display.

7. The tracking system according to claim 6, wherein the estimate of the physical deformation is based upon non-optical tracking means at at least two separate locations.

8. The tracking system according to any preceding claim, wherein the tracking system further comprises gaze prediction circuitry.

9. A watercraft comprising the tracking system of any of claims 1-8.

10. A method for use with a tracking system according to any of claims 1-8, the method comprising:

determining first tracking information of a head mounted display based on optical tracking means;

determining second tracking information of a head mounted display based on at least one non-optical tracking means of a set of non-optical tracking means;

determining an updated tracking information of the head mounted display based on the first tracking information and the second tracking information; and wherein

selecting the at least one non-optical tracking means to use to determine the second tracking information is based on a location of the head mounted display.

11. The method according to claim 10, wherein the non-optical tracking means comprises a plurality of disjoint sets of inertial sensors located on the watercraft, each individual disjoint set comprising at least one inertial sensor, each disjoint set located in separate locations of the watercraft, and selecting the at least one optical tracking means comprises selecting one of the disjoint sets of inertial sensors based on the location of the head mounted display.

12. The method according to claim 10 or 11, wherein the optical tracking means comprises at least one variable-sized mark, a size and configuration of the variable-sized alignment mark is based on the location of the head mounted display.

13. The method according to any of claims 10-12, wherein determining the second tracking information is based on an estimate of the physical deformation at the location of the head mounted display.

14. The method according to claim 13, wherein the estimate of the physical deformation is based upon non-optical tracking means at at least two separate locations

15. A machine readable medium comprising instructions, that when executed, cause a processing means to perform the method of any of claims 10-14.

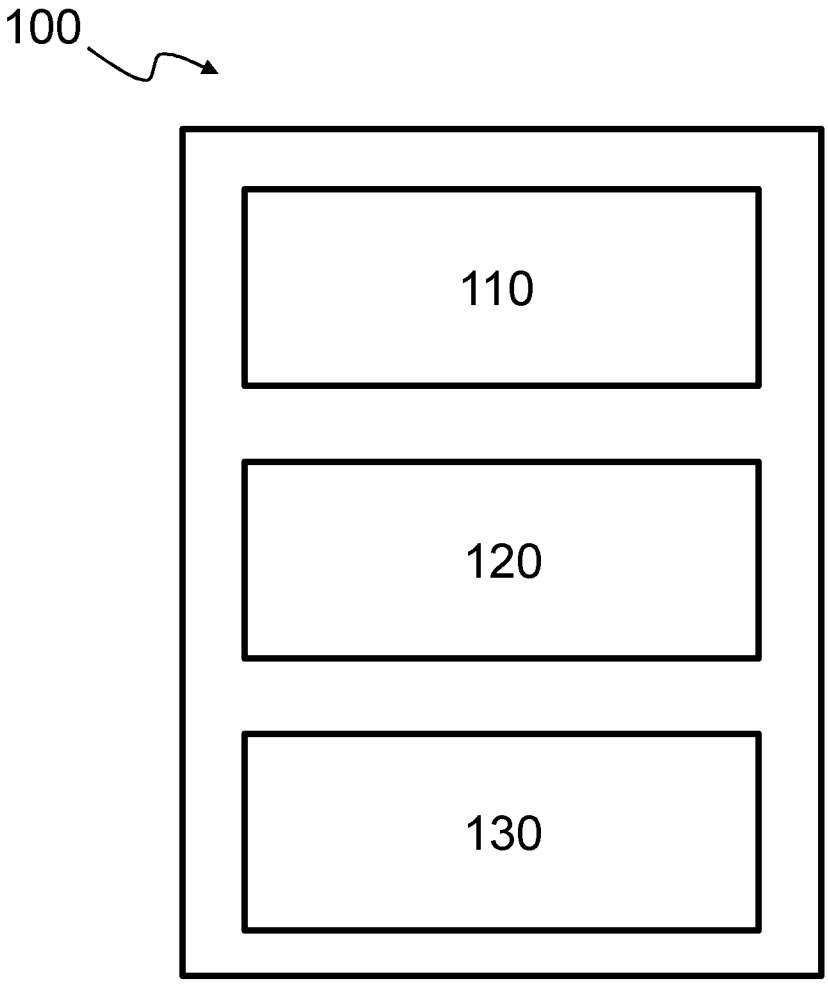

Figure 1

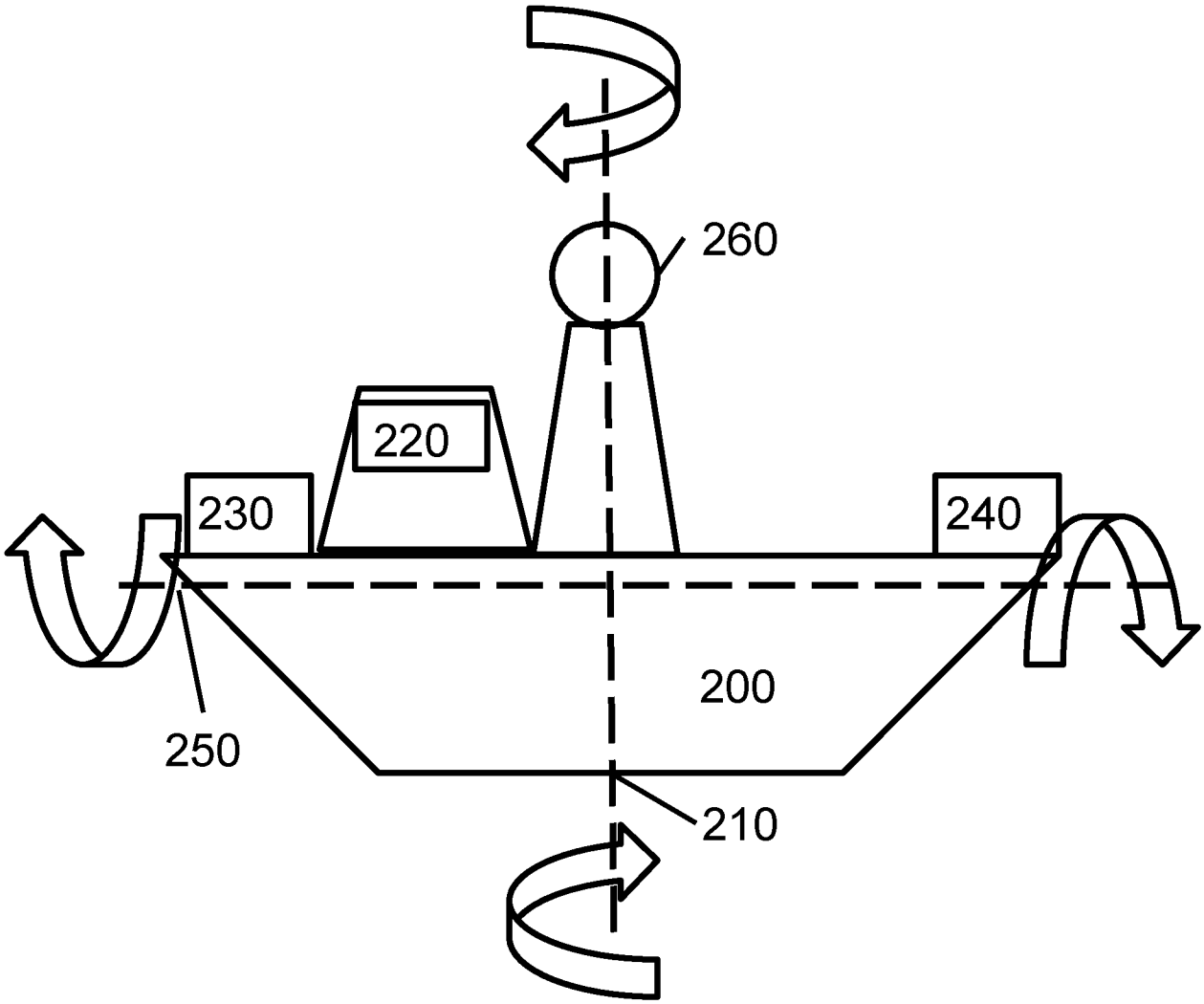

Figure 2

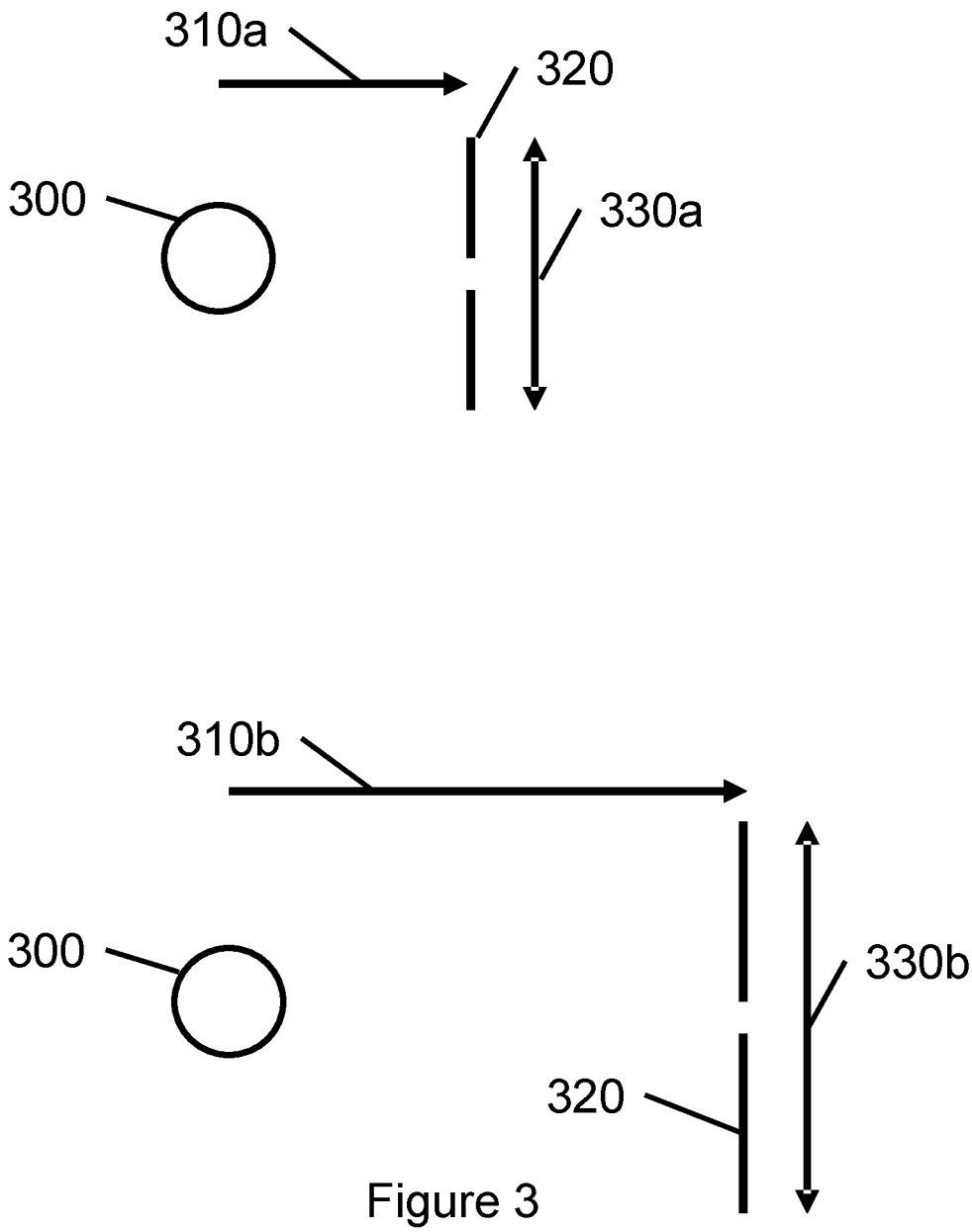

Figure 3

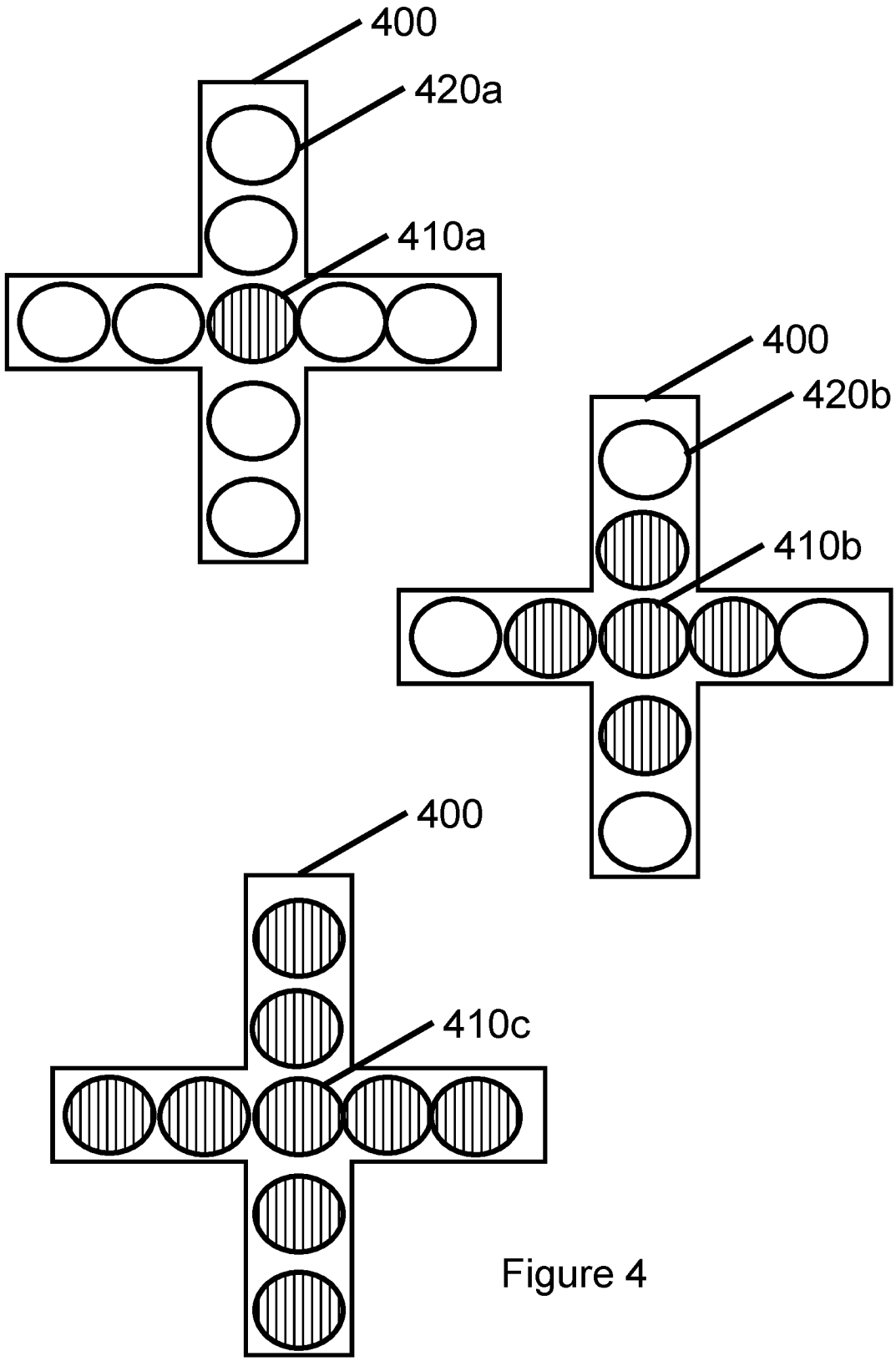

Figure 4

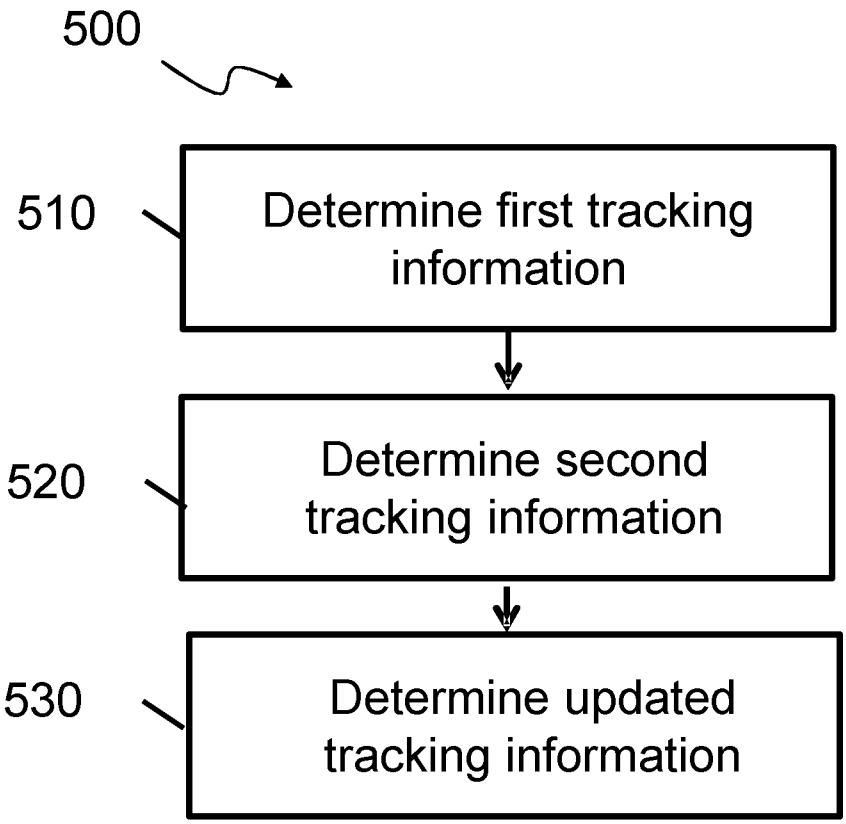
500
510
Determine first tracking information
520
Determine second tracking information
530
Determine updated tracking information

Figure 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2019/053411

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F3/01 G02B27/01 B63B49/00
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)
G06F G02B B63J B63B

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.
Y	WO 2017/042588 A1 (BAE SYSTEMS PLC [GB]) 16 March 2017 (2017-03-16) abstract page 1, line 1 - page 19, line 14 page 29, line 1 - page 30, paragraph 28; figures 1, 3-4	1-15
Y	US 2016/088417 A1 (KIM HONGKOOK [KR] ET AL) 24 March 2016 (2016-03-24) abstract paragraphs [0046], [0080] - [0081]	1-15
Y	EP 3 177 010 A1 (SONY CORP [JP]) 7 June 2017 (2017-06-07) paragraphs [0030], [0052], [0057], [0084] - [0088], [0100] - [0105], [0110]	8

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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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
31 January 2020	11/02/2020

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	González Carballo, N

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2019/053411

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2004/102676 A1 (BRENDLEY KEITH W [US] ET AL) 27 May 2004 (2004-05-27) abstract the whole document -----	1-15

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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