



(51) International Patent Classification:
G02B 27/01 (2006.01)

(21) International Application Number:
PCT/IB2014/000391

(22) International Filing Date:
20 March 2014 (20.03.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2013-078783 4 April 2013 (04.04.2013) JP

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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,
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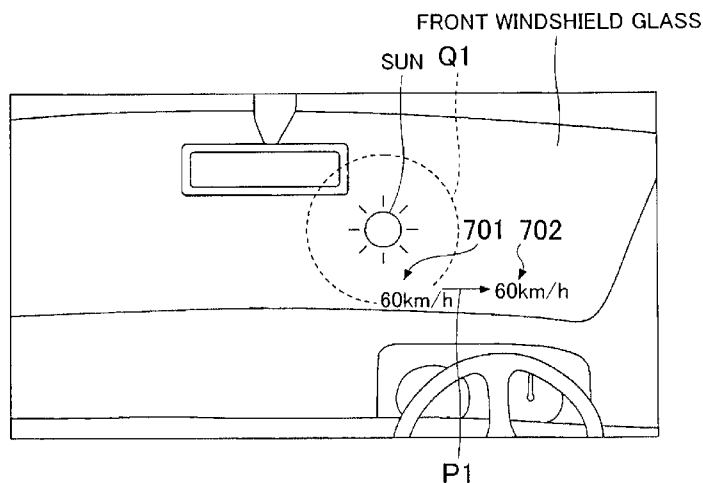
(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Published:

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM, — with international search report (Art. 21(3))

(54) Title: HEAD-UP DISPLAY APPARATUS AND CONTROL METHOD OF HEAD-UP DISPLAY APPARATUS

FIG. 4



(57) Abstract: A head-up display apparatus changes a display position of an image output from the HUD so as to be spaced from a straight line that connects the sun and a viewpoint of a driver, based on position information, of the sun, position information of a movable body, orientation information of the movable body, and viewpoint information on the viewpoint of the driver in the movable body.

HEAD-UP DISPLAY APPARATUS AND CONTROL METHOD OF HEAD-UP DISPLAY APPARATUS

BACKGROUND OF THE INVENTION

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1. Field of the Invention

[0001] The present invention relates to a head-up display apparatus and a control method of a head-up display apparatus.

10 2. Description of Related Art

[0002] For example, Japanese Patent Application Publication No. 2008-285105 A (JP2008-285105A) discloses an information display apparatus in which luminance information of a background passing through a windshield based on luminance of an image captured by a camera and viewpoint information based on a movement of eyes of an occupant are formed, and an information display section is moved, based on the luminance information and the viewpoint information, to that place on the windshield which is close to a position of a viewpoint of the occupant and on a screen that does not have a high luminance.

[0003] Further, such a technique has been known that a traveling direction of a movable body and a radiation direction of sunlight are detected, and a light transmission amount of a window glass of the movable body directed toward the radiation direction of sunlight is adjusted (see, for example, Japanese Patent Application Publication No. 01-168520 (JP01-168520A)).

[0004] However, in a configuration described in JP2008-285105A, a camera for taking vehicle-outside images is required to form the luminance information of the background passing through the windshield.

SUMMARY OF THE INVENTION

[0005] The present invention provides a head-up display apparatus that outputs an

image at a position where influence of dazzling of the sun is reduced, without the need for a camera that takes vehicle-outside images, and a control method of the head-up display apparatus.

[0006] A head-up display apparatus according to a first aspect of the present invention includes a controller that performs control to change a display position of an image output from the head-up display so as to be spaced from a straight line that connects the sun and a viewpoint of a driver, based on position information of the sun, position information of a movable body, orientation information of the movable body, and viewpoint information on the viewpoint of the driver in the movable body.

[0007] A head-up display apparatus according to a second aspect of the present invention includes: a GPS receiver that measures and computes a position of an own vehicle; an illuminance sensor that detects an amount of sunlight; a gyro sensor that outputs a signal according to an angular velocity caused around a center axis of the own vehicle; an inclination sensor that detects an inclination of the own vehicle; a seat position sensor that detects information on a seat position of a driver seat; a head-up display unit that displays various images; and a controller. The controller configured to specify a position of the sun based on own-vehicle position information acquired from the GPS receiver and date-and-time information, to determine whether or not direct sunlight hits the own vehicle based on that amount of sunlight which is acquired from the illuminance sensor, to acquire information on the inclination and a direction of the own vehicle based on inputs from the gyro sensor and the inclination sensor, to specify a viewpoint of a driver based on the information of the seat position sensor, and to perform control to change a display position of the image output from the head-up display so as to be spaced from a straight line that connects the sun and the viewpoint of the driver, based on position information of the sun, position information of the own vehicle, orientation information of the own vehicle, and viewpoint information on the viewpoint of the driver in the own vehicle.

[0008] A control method of a head-up display apparatus, according to a third aspect of the present invention includes: acquiring GPS information from a GPS receiver;

acquiring date-and-time information; specifying a position of the sun based on the GPS information and the date-and-time information; and determining whether or not direct sunlight hits an own vehicle based on that amount of sunlight which is acquired from an illuminance sensor. Further, acquiring information on an inclination and a direction of the own vehicle based on inputs from a gyro sensor and an inclination sensor, in a case where the direct sunlight hits the own vehicle; specifying a viewpoint of a driver based on information of a seat position sensor; and changing a display position of an image output from a head-up display so as to be spaced from a straight line that connects the sun and the viewpoint of the driver, based on position information of the sun, position information of the own vehicle, orientation information of the own vehicle, and viewpoint information on the viewpoint of the driver in the own vehicle.

[0009] According to the above aspect, it is possible to output an image at a position where influence of dazzling of the sun is reduced, without the need for a camera that takes outside-vehicle images.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is a system configuration diagram of an example of a head-up display apparatus of the invention;

FIG. 2 is a sectional view schematically illustrating an example of an HUD unit of the invention;

FIG. 3 is a flow chart illustrating an example of a process executed by an ECU of the invention; and

FIG. 4 is a view schematically illustrating a modified example of a display position of a HUD image of the invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0011] The following describes each embodiment in detail with reference to the attached drawings.

[0012] FIG. 1 is a system configuration diagram of one example of a head-up display apparatus 10. The head-up display apparatus 10 includes an electronic control unit 12 (hereinafter referred to as the "ECU 12"). An operation of the head-up display apparatus 10 is controlled by the ECU 12. The ECU 12 is configured as a microcomputer including a CPU, an ROM, an RAM, etc., which are connected to each other via buses (not shown). Further, the ECU 12 may have a clock inside. The ROM stores therein various programs executed by the CPU. Note that various functions (including functions described below) of the ECU 12 may be implemented by given hardware, software, firm-ware, or a combination thereof. For example, a given part of or all of the functions of the ECU 12 may be implemented by an application-specific integrated circuit (ASIC) and a Field Programmable Gate Array (FPGA) for specific use. Further, the ECU 12 may be realized by a plurality of ECUs. The ECU 12 functions as a controller of the present invention.

[0013] A Global Positioning System (GPS) receiver 20, an illuminance sensor 22, a gyro sensor 24, an inclination sensor 26, a seat position sensor 28, and so on may be connected to the ECU 12. Note that a connection form of this is not necessarily a direct connection, and may be an indirect connection. For example, the GPS receiver 20 may be connected to the ECU 12 via a navigation ECU, and in this case, the ECU 12 may acquire own-vehicle position information from the navigation ECU.

[0014] The GPS receiver 20 measures and computes an own-vehicle position based on a GPS signal received from a GPS satellite via a GPS antenna. A positioning method may be any methods such as single point positioning or differential positioning (including interferometric positioning). At this time, the own-vehicle position may be corrected based on outputs from various sensors such as a vehicle speed sensor and the gyro sensor 24, and various information received via a beacon receiver and an FM multiplex receiver.

[0015] The illuminance sensor 22 detects an amount of sunlight. The gyro

sensor 24 detects an angular velocity (yawing rate) caused on the vehicle. The gyro sensor 24 outputs a signal according to an angular velocity caused around a center axis of the vehicle. The inclination sensor 26 detects an inclination of the vehicle. The inclination sensor 26 may be a three-axis acceleration sensor. Further, the inclination sensor 26 may be formed integrally with the gyro sensor 24. For example, the inclination sensor 26 and the gyro sensor 24 may be manufactured by a micromachine technology using a Silicon on Insulator (SOI) wafer. In this case, the inclination sensor 26 and the gyro sensor 24 are provided in a vicinal area of a centroid (a floor tunnel or the like) of the vehicle, and detect a yawing rate and an acceleration speed caused at their mounting position. The yawing rate and the acceleration speed thus detected may be used, for example, for a vehicle running control to prevent skid and the like and to stabilize a behavior of the vehicle. The seat position sensor 28 detects a seat position of a driver seat.

[0016] A head-up display (HUD) unit 40 is connected to the ECU12. The HUD unit 40 outputs various images (hereinafter the image generated and output from the HUD will be referred to as "HUD image") under control by the ECU 12.

[0017] FIG. 2 is a sectional view schematically illustrating an example of the HUD unit 40. The HUD unit 40 is provided in an instrument panel, for example, as illustrated in FIG. 2.

[0018] The HUD unit 40 includes a display device (a projector) 42. The display device 42 generates visible light (display light) to transmit information to a driver. The display light is generated according to an image signal supplied from the ECU 12. Note that the display device 42 may have any configuration, but, for example, may be a dot Vacuum Fluorescent Display (VFD).

[0019] A type of the HUD image generated by the display device 42 may be any image. For example, the display device 42 may project display light to transmit meter information (e.g., a vehicle speed or the like) from a meter ECU. Further, the display device 42 may project display light including information (that is, front environmental information) included in a video signal received from an infrared camera (not shown) that

takes a vehicle front scenery. Furthermore, the display device 42 may project display light to transmit navigation information from a navigation device. Further, the display device 42 may project display light to transmit a state of an air-conditioning device, audio equipment, or the like.

5 **[0020]** The display light projected from the display device 42 reaches an image projection plane of a front windshield glass. The display light is diffracted in a direction of an observer P (mainly, the driver) by the image projection plane of the front windshield glass, thereby generating a HUD image (virtual image) before the observer P. Note that a projection range (an optical path) of the display light based on the observer P (precisely, a position P of his/her eyes) is illustrated by a dotted line in FIG. 2. Note that, in the example illustrated in FIG. 2, the HUD unit 40 includes a concave mirror 44, and the display light projected from the display device 42 is reflected by the concave mirror 44 and then reaches the image projection plane of the front windshield glass. The display light may be an enlarged image by the concave mirror 44 in conformity with a curvature of the front windshield glass.

15 **[0021]** Note that the image projection plane of the front windshield glass may be provided with a combiner. The combiner may be any type of combiner, for example, a combiner formed of a half mirror or a holographic combiner using a hologram. In a case of the holographic combiner, the hologram may be enclosed between layers of the front windshield glass. Further, the combiner may be constituted by a reflection coating deposited onto a mating surface side of multiple layers of glasses constituting the front windshield glass. Alternatively, the image projection plane of the front windshield glass may not be provided with a combiner. In this case, the front windshield glass may include an interlayer (an interlayer enclosed between the multiple layers of glasses) having a different thickness so as to prevent a double image (an image that appears doubly due to reflection by each of a front face and a rear face of the front windshield glass). For example, the interlayer may be a layer (with a wedge-shaped section) of which a thickness is gradually reduced as it goes from an upper side to a lower side of the front windshield glass.

[0022] FIG. 3 is a flow chart illustrating an example of a process executed by the ECU 12. A processing routine illustrated in FIG. 3 may be performed repeatedly every predetermined period while the head-up display apparatus 10 is turned on.

[0023] In step S300, GPS information is acquired from the GPS receiver 20.
5 The GPS information may include own-vehicle position information and so on.

[0024] In step S302, date-and-time information is acquired. The date-and-time information may be acquired by any information source. For example, the date-and-time information may be acquired from the clock in the ECU 12. Alternatively, the date-and-time information may be acquired by receiving an outside radio wave (a standard
10 radio wave received by an atomic radio clock).

[0025] In step S304, a day-night determination is performed to determine whether it is day or night at the present moment, based on the pieces of information acquired in step S300 and step S302. Note that the reason why the own-vehicle position information is considered is to take a local difference into consideration, but the day-night determination
15 may be performed only based on the date-and-time information. In a case where it is day at the present moment, the process advances to step S306, and in a case where it is night, since it is not necessary to change (a process of step S318) a display position of the HUD image (described later), the process is just finished.

[0026] In step S306, a position of the sun is specified. The position of the sun
20 may be, for example, specified as a position of the sun relative to the own vehicle based on the pieces of information acquired in step S300 and step S302. The position of the sun may be held as a map (table) in terms of a relation between the own-vehicle position (latitude, longitude) and the date and time. The position of the sun may be specified based on that information on the position of the sun per time which is prepared for summer
25 solstice, vernal equinox, autumnal equinox, and winter solstice.

[0027] In step S308, an input from the illuminance sensor 22 is received. That is, illuminance information of the own vehicle is acquired via the illuminance sensor 22.

[0028] In step S310, it is determined whether or not direct sunlight hits the own vehicle, based on the illuminance information acquired in step S308. For example, in a

case where an output value from the illuminance sensor 22 is a predetermined threshold or more, it may be determined that the direct sunlight hits the own vehicle. In a case where the direct sunlight hits the own vehicle, the process advances to step S312, and otherwise, since it is not necessary to change (the process of step S318) the display position of the HUD image (described later), the process is just finished.

[0029] In step S312, inputs from the inclination sensor 26 and the gyro sensor 24 are received. That is, information (hereinafter referred to as three-dimensional orientation information) on an inclination and a direction (orientation in three dimensions) of the vehicle is acquired via the inclination sensor 26 and the gyro sensor 24.

[0030] In step S314, a viewpoint of the driver is specified. The viewpoint of the driver may be specified by any method. For example, as an easy method, the viewpoint of the driver may be specified based on a seat position (information from the seat position sensor 28) of the driver seat. Since the viewpoint of the driver changes according to a difference in height of drivers, the viewpoint of the driver may be specified by assuming an average height of the drivers. Alternatively, the viewpoint of the driver may be specified in such a manner that height information in driver information (e.g., information that is input at the time of a default setting) is used if it exists, and the height is taken into consideration. Further, the viewpoint of the driver may be specified based on a detection result (detected by a sensor, for example) of an orientation of an inner mirror or an orientation of a side mirror. This is because there is a correlation between the viewpoint of the driver and the orientation of the inner mirror, and there is also a correlation between the viewpoint of the driver and the orientation of the side mirror. Alternatively, the viewpoint of the driver may be detected by a camera in the vehicle.

[0031] In step S316, it is determined whether the HUD image overlaps with the sun based on that position of the sun which is specified in step S306, that three-dimensional orientation information of the vehicle which is acquired in step S312, and that viewpoint of the driver which is specified in step S314. More specifically, it is determined whether or not the HUD image exists on a straight line that connects that position of the sun which is specified in step S306 and the viewpoint of the driver

(hereinafter referred to as a "sun-viewpoint straight line"), or in its vicinal area. For example, a local coordinate system may be assumed in which the viewpoint of the driver is taken as an origin and a traveling direction of the vehicle based on the three-dimensional orientation of the vehicle is taken as a Y-axis, so as to determine whether or not an angle
5 formed between a position vector of the HUD image in the local coordinate system and a position vector of the sun in the local coordinate system is a predetermined angle or less. The predetermined angle may correspond to that upper limit of an angular range at which the HUD image is hard to see due to the presence of the sun, or may be adjusted by a test or the like. The predetermined angle may be zero, but practically, even in a case where
10 the HUD image exists around the sun-viewpoint straight line, the driver feels dazzled. In view of this, the predetermined angle may be a value larger than zero. When the HUD image overlaps with the sun, the process advances to step S318. Otherwise, since it is not necessary to change (the process of step S318) the display position of the HUD image (described later), the process is just finished.

15 **[0032]** In step S318, the display position of the HUD image is changed. More specifically, the display position of the HUD image is changed in a direction apart from the sun-viewpoint straight line. For example, in a case where the aforementioned local coordinate system is assumed, the display position of the HUD image may be changed so that the angle formed between the position vector of the HUD image in the local
20 coordinate system and the position vector of the sun in the local coordinate system is larger than the predetermined angle. A changing direction of the display position of the HUD image may be a right-and-left direction, an up-and-down direction, or a combination thereof. The change of the display position of the HUD image in the right-and-left direction may be realized by changing an output pixel position (a pixel position where the
25 display light for the HUD image is generated) of the display device 42 in the right-and-left direction. For this purpose, the display device 42 may be configured to have a size (a display light output range) sufficient in the right-and-left direction. Alternatively, the movement may be realized mechanically by moving a position of the display device 42 in the right-and-left direction. Further, the change of the display position of the HUD image

in the up-and-down direction may be realized by changing the output pixel position (the pixel position where the display light for the HUD image is generated) of the display device 42 in the up-and-down direction. For this purpose, the display device 42 may be configured to have a size (a display light output range) sufficient in the up-and-down direction. Alternatively, the movement may be realized mechanically by moving the position of the display device 42 in the up-and-down direction. In either case, a moving range of the display position of the HUD image is determined by the size and the like of the display device 42. Accordingly, the display position of the HUD image may be changed (moved) in a direction furthest from the sun-viewpoint straight line within the moving range.

[0033] FIG. 4 is an explanatory view of FIG. 3, and is a view schematically illustrating a modified example of the display position of the HUD image. Note that FIG. 4 schematically illustrates a display state of the HUD image from the viewpoint of the driver. In FIG. 4, a scenery (a real image) seen from the driver includes the sun. An area Q1 circled by a dotted line is neither a real image nor an image, but a circle for description, and an arrow P1 is not an image but an arrow for description. In the example illustrated in FIG. 4, the HUD image is an image to transmit vehicle speed information, and is "60km/h" here.

[0034] In FIG. 4, a display position 701 indicates the display position of the HUD image before change, and a display position 702 indicates the display position of the HUD image after change. In the example illustrated in FIG. 4, in the display position 701 before change, the HUD image is placed within a predetermined range Q1 around the sun-viewpoint straight line. Because of this, an affirmative determination is made in step S316 of FIG. 3, and the process of step S318 is performed. As a result, the HUD image is output at the display position 702. That is, the HUD image is moved from the display position 701 to the display position 702, as illustrated by the arrow P1. As such, in the process illustrated in FIG. 3, the display position of the HUD image is moved to a position where influence of the sun is reduced.

[0035] According to the head-up display apparatus 10 of the present embodiment

described above, the following excellent effects are yielded in particular.

[0036] As mentioned above, since the display position of the HUD image is changed according to the relationship between the viewpoint of the driver and the position of the sun, it is possible to reduce dazzling felt by the driver when the driver sees the HUD image, thereby improving visibility of the HUD image. That is, by moving the display position of the HUD image at a position where influence of the sun is reduced, it is possible to reduce the influence of the sun and to improve the visibility of the HUD image in comparison with a configuration where the HUD image is displayed always at the same display position.

[0037] Further, in the present embodiment, since a camera that takes outside-vehicle images is not used as information acquisition means to change the display position of the HUD image, it is possible to realize a simple configuration. Note that the vehicle in which the head-up display apparatus 10 is provided may be provided with a camera for capturing outside-vehicle images for other purposes (e.g., recognition of white lines or recognition of obstructions).

[0038] Each embodiment has been described above, but the present invention is not limited to any specific embodiment, and various modifications and alternations can be made within a scope of Claims. Further, all or some of constituents in the above embodiments can be combined.

[0039] For example, the process illustrated in FIG. 3 can be modified variously. For example, either or both of the determination in step S304 and the determination in step S310 may be omitted. In a case where the determination in step S310 is omitted, the process of step S308 may be omitted along with that. Further, position information of the sun may be acquired from outside via wireless communication (e.g., a center server). In this case, the process of step S302 may be omitted.

[0040] Further, in the above embodiment, the head-up display apparatus 10 is for vehicles, but can be provided in other movable bodies. For example, the head-up display apparatus 10 may be provided not only in vehicles other than automobiles (railroads, construction equipment), but also in aircrafts, vessels, and the like.

CLAIMS:

1. A head-up display apparatus comprising:

a controller that performs control to change a display position of an image output from the head-up display so as to be spaced from a straight line that connects the sun and a viewpoint of a driver, based on position information of the sun, position information of a movable body, orientation information of the movable body, and viewpoint information on the viewpoint of the driver in the movable body.

2. The head-up display apparatus according to claim 1, wherein:

the controller changes the display position when the display position is close to the straight line that connects the sun and the viewpoint of the driver, by a predetermined reference or more.

3. The head-up display apparatus according to claim 1 or 2, wherein:

the movable body is a vehicle, and the viewpoint information is acquired based on information on at least one of a seat position of a driver seat, an orientation of an inner mirror, and an orientation of a side mirror.

4. A head-up display apparatus comprising:

a GPS receiver that measures and computes a position of an own vehicle;

an illuminance sensor that detects an amount of sunlight;

a gyro sensor that outputs a signal according to an angular velocity caused around a center axis of the own vehicle;

an inclination sensor that detects an inclination of the own vehicle;

a seat position sensor that detects information on a seat position of a driver seat;

a head-up display unit that displays various images; and

a controller that configured to specify a position of the sun based on own-vehicle position information acquired from the GPS receiver and date-and-time information,

configured to determine whether or not direct sunlight hits the own vehicle based on that amount of sunlight which is acquired from the illuminance sensor, configured to acquire information on the inclination and a direction of the own vehicle based on inputs from the gyro sensor and the inclination sensor, configured to specify a viewpoint of a driver based on the information of the seat position sensor, and configured to perform control to change a display position of the image output from the head-up display so as to be spaced from a straight line that connects the sun and the viewpoint of the driver, based on position information of the sun, position information of the own vehicle, orientation information of the own vehicle, and viewpoint information on the viewpoint of the driver in the own vehicle.

5. A control method of a head-up display apparatus, comprising:

acquiring GPS information from a GPS receiver;

acquiring date-and-time information;

specifying a position of the sun based on the GPS information and the date-and-time information;

determining whether or not direct sunlight hits an own vehicle based on that amount of sunlight which is acquired from an illuminance sensor;

acquiring information on an inclination and a direction of the own vehicle based on inputs from a gyro sensor and an inclination sensor, in a case where the direct sunlight hits the own vehicle;

specifying a viewpoint of a driver based on information of a seat position sensor; and

changing a display position of an image output from a head-up display so as to be spaced from a straight line that connects the sun and the viewpoint of the driver, based on position information of the sun, position information of the own vehicle, orientation information of the own vehicle, and viewpoint information on the viewpoint of the driver in the own vehicle.

FIG. 1

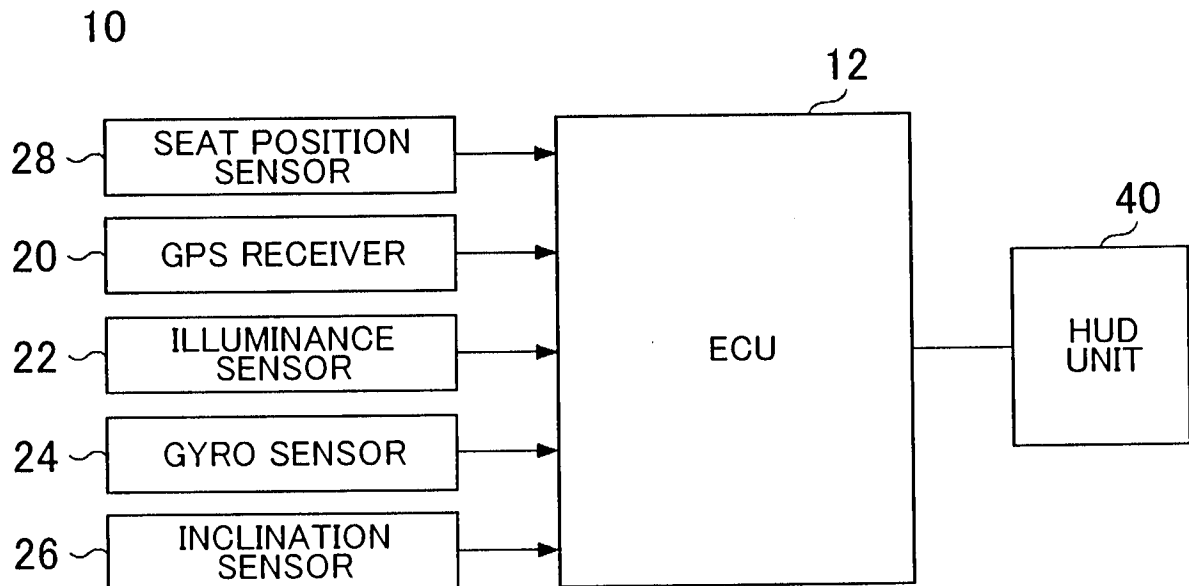


FIG. 2

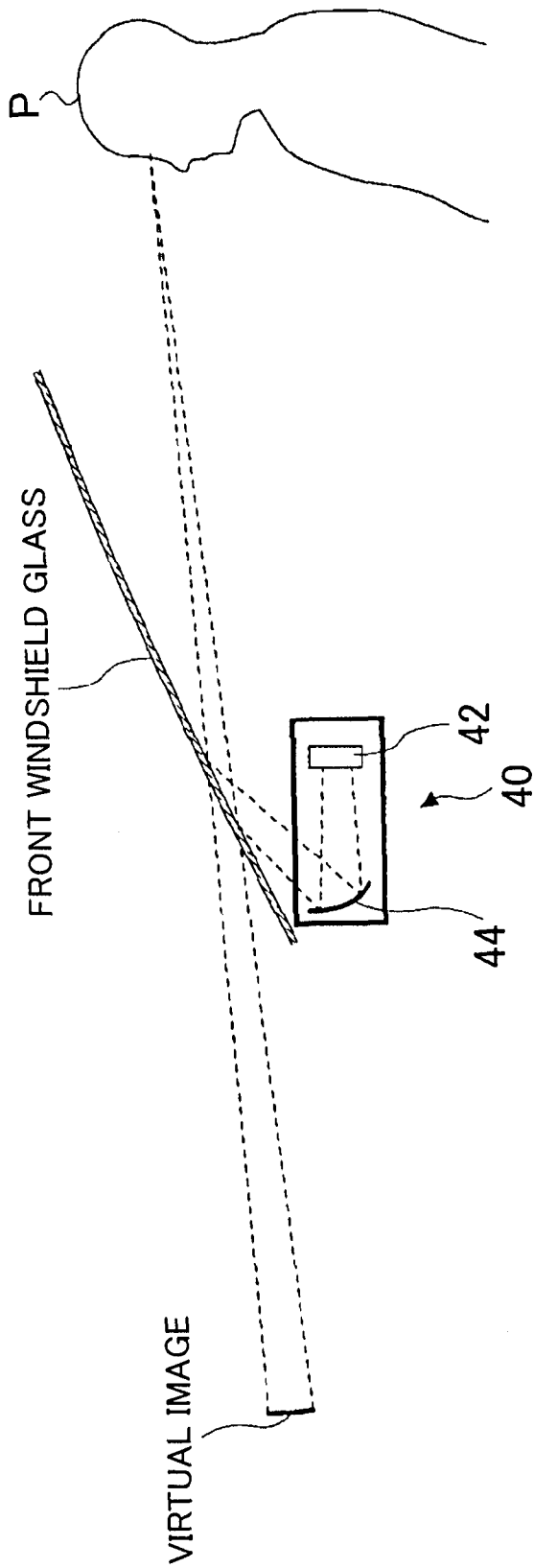


FIG. 3

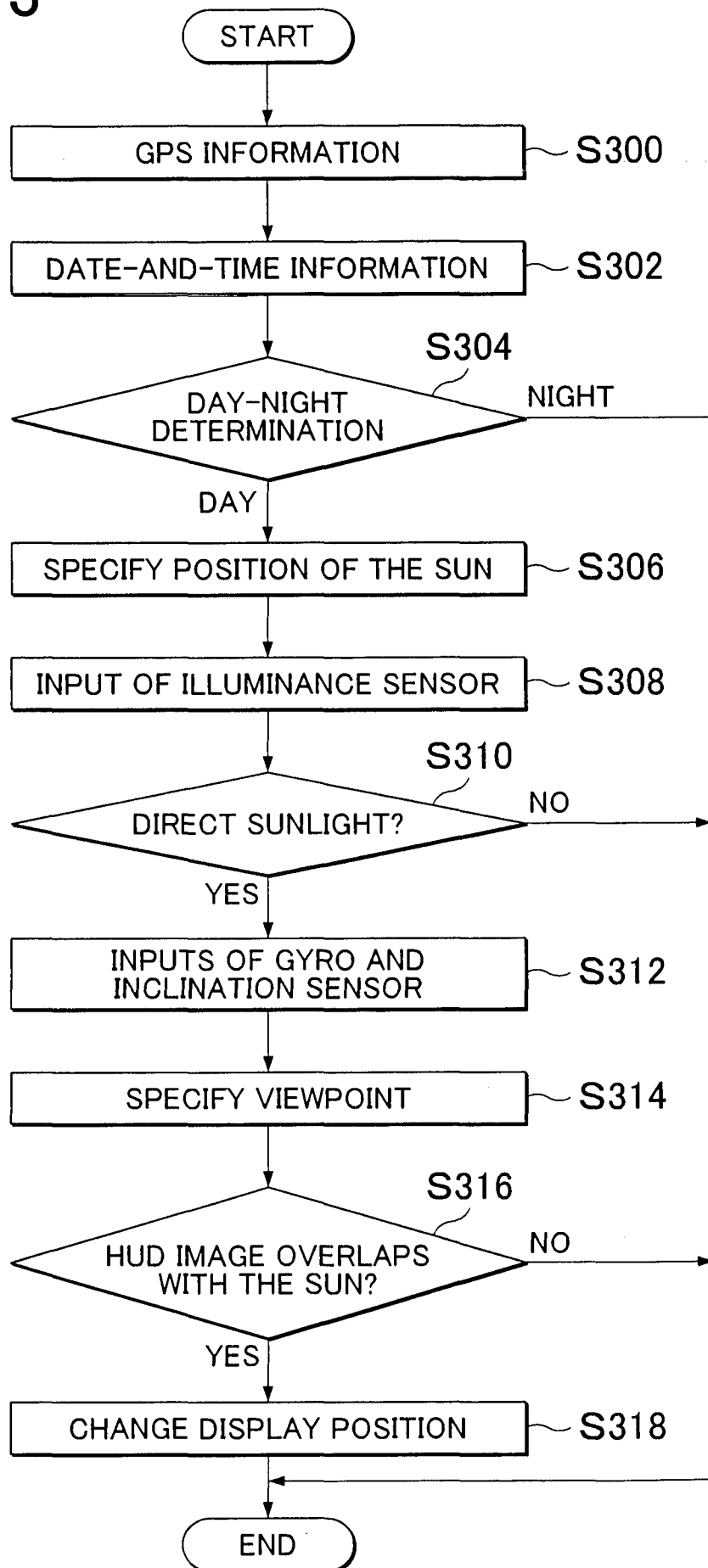
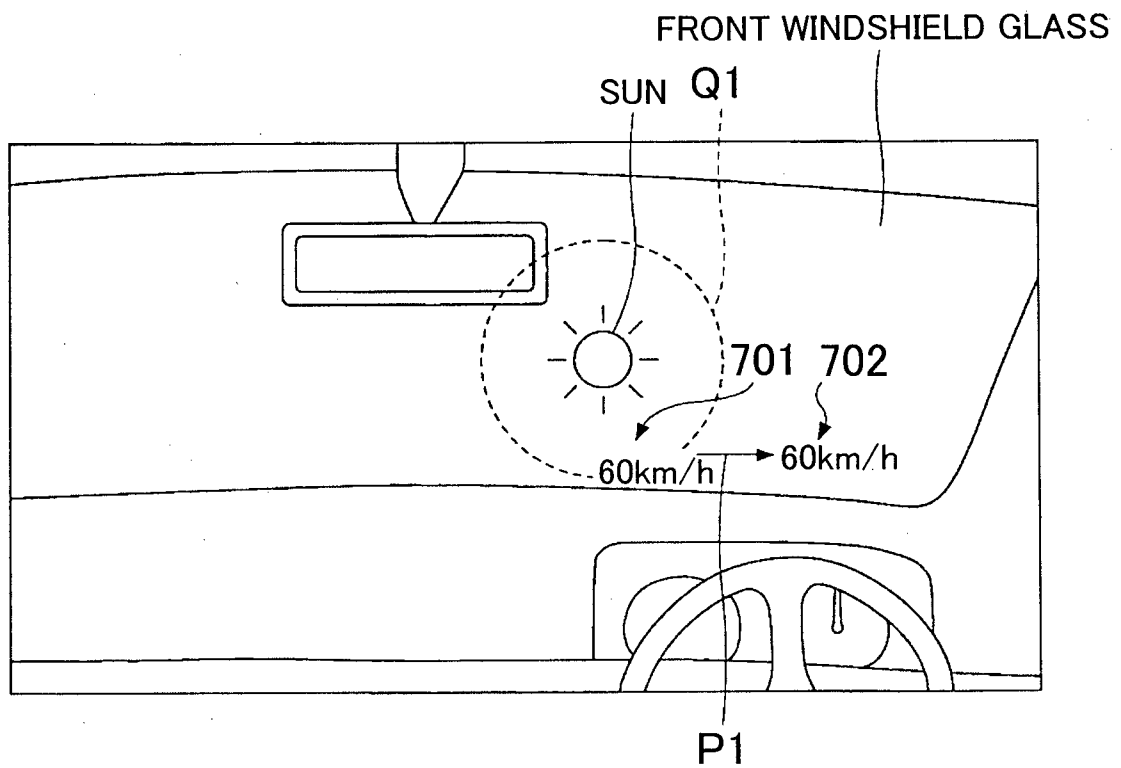


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/000391

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B27/01
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)
G02B

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)

EP0-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 2008/046151 A1 (ZIEHR LAWRENCE P [US]) 21 February 2008 (2008-02-21) Paragraphs [0002]-[0003], [0006]-[0008], [0029]-[0037]; claims 1,8; figures 2,3,4,5 -----	1-5
X	JP 2007 276766 A (OMRON TATEISI ELECTRONICS CO) 25 October 2007 (2007-10-25) Paragraphs [0035], [0056]-[0057], [0139], [0168]-[0169]; figure 16 -----	1-3
A	JP 2008 285105 A (TOKAI RIKI CO LTD) 27 November 2008 (2008-11-27) cited in the application Paragraphs [0002]-[0003], [0012], [0015], [0019], [0020] ----- -/--	1-5



Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search

12 June 2014

Date of mailing of the international search report

20/06/2014

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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/000391

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