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(54) **IMAGE PROCESSING METHOD OF GENERATING AN IMAGE BASED ON A USER VIEWPOINT AND IMAGE PROCESSING DEVICE**

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(57) **ABSTRACT**

Provided are an image processing method and an image processing device. The image processing method includes generating an image based on viewpoint information of a user; rendering the image based on information about what is in front of the user; and outputting the rendered image using an optical element.

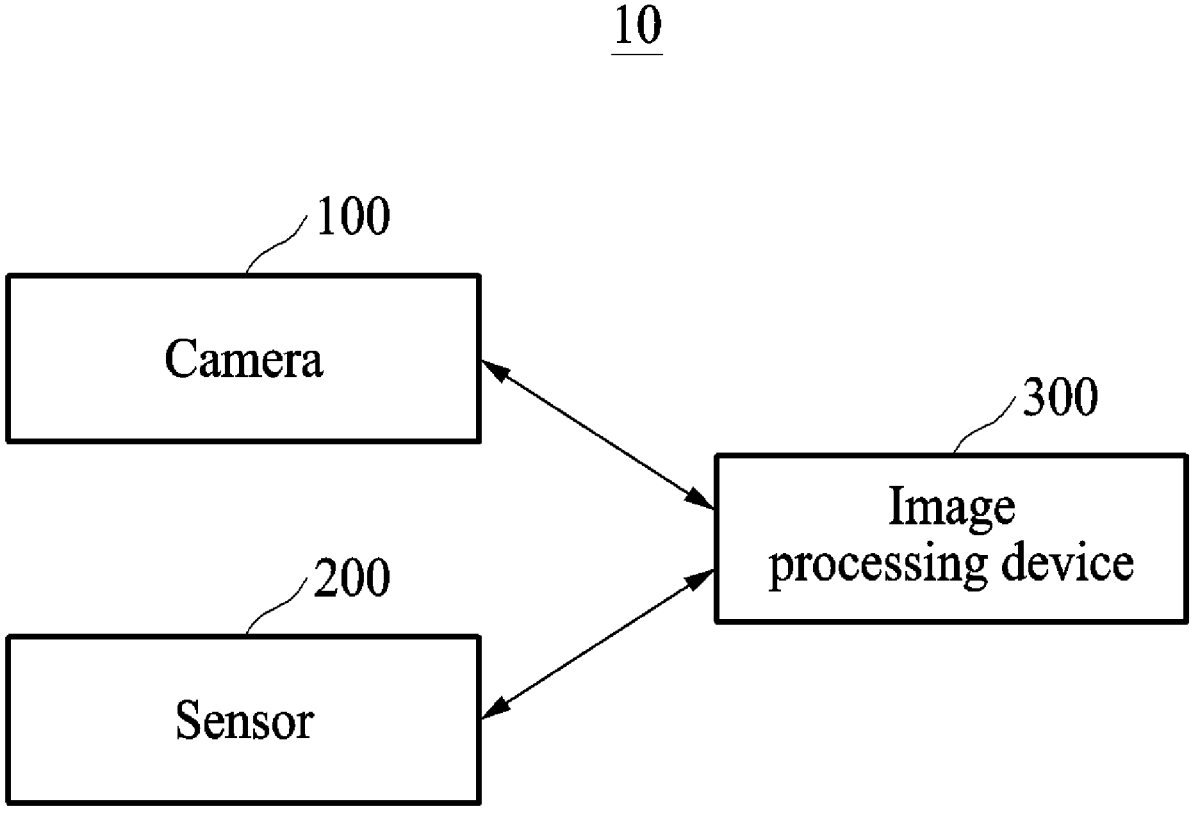

FIG. 1

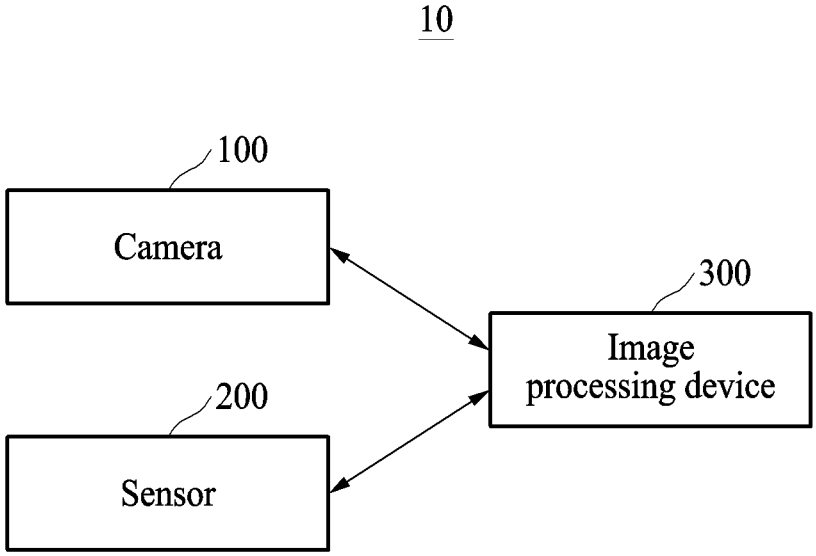

FIG. 2

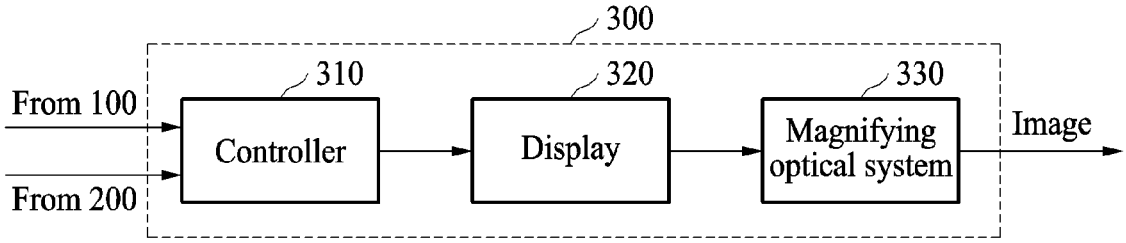

FIG. 3

320

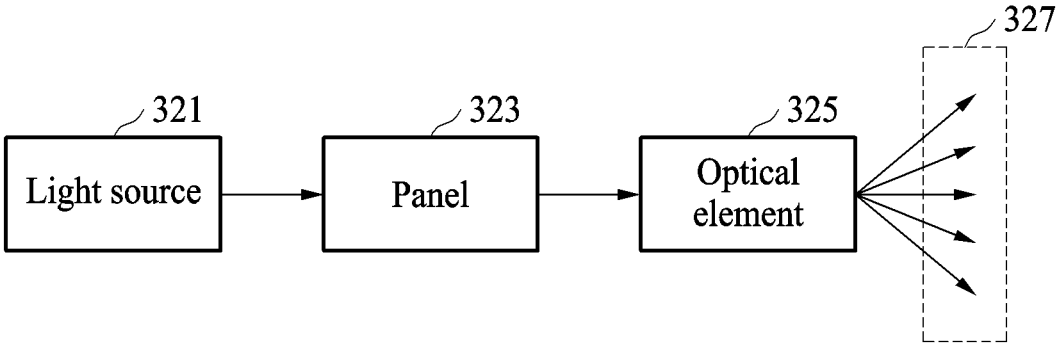

FIG. 4

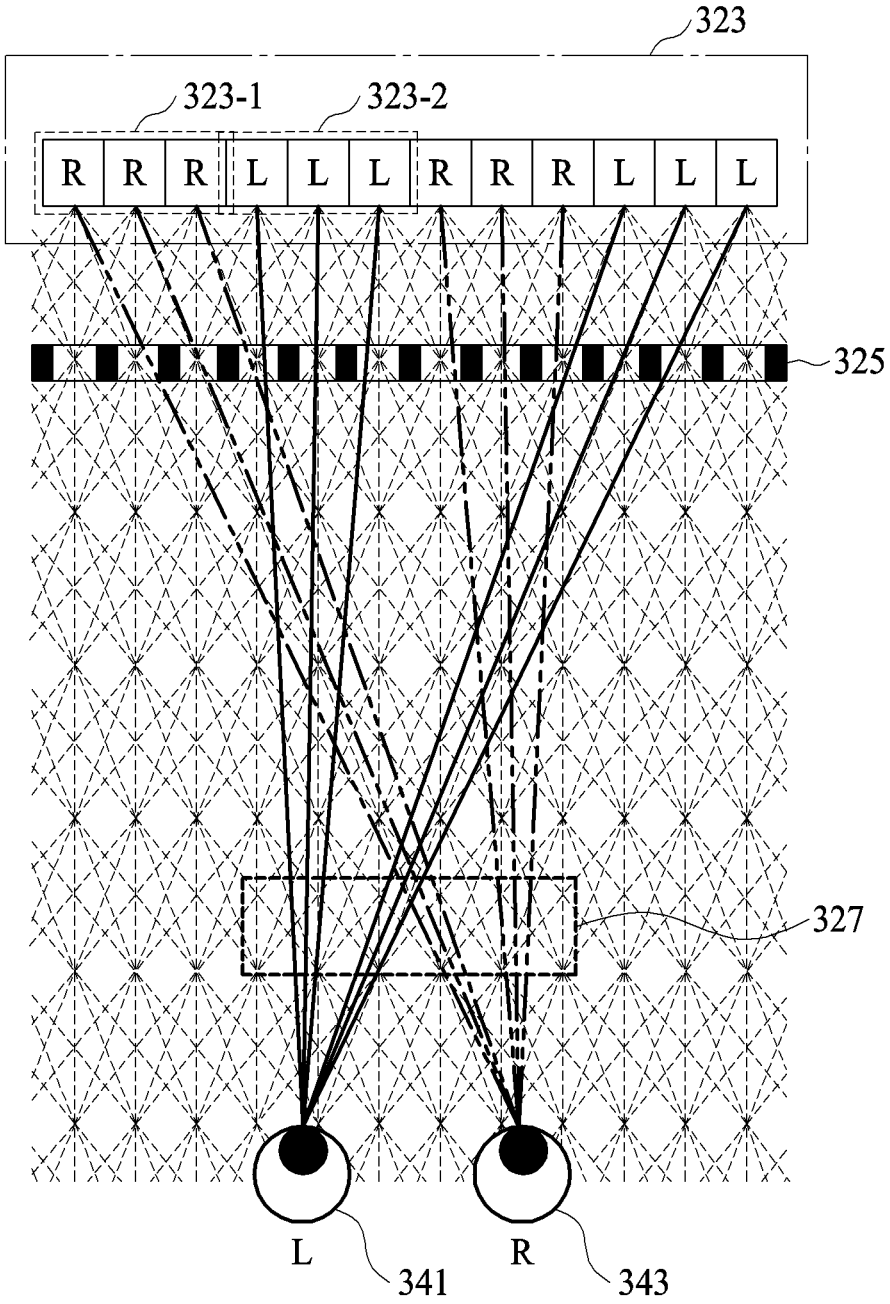

FIG. 5

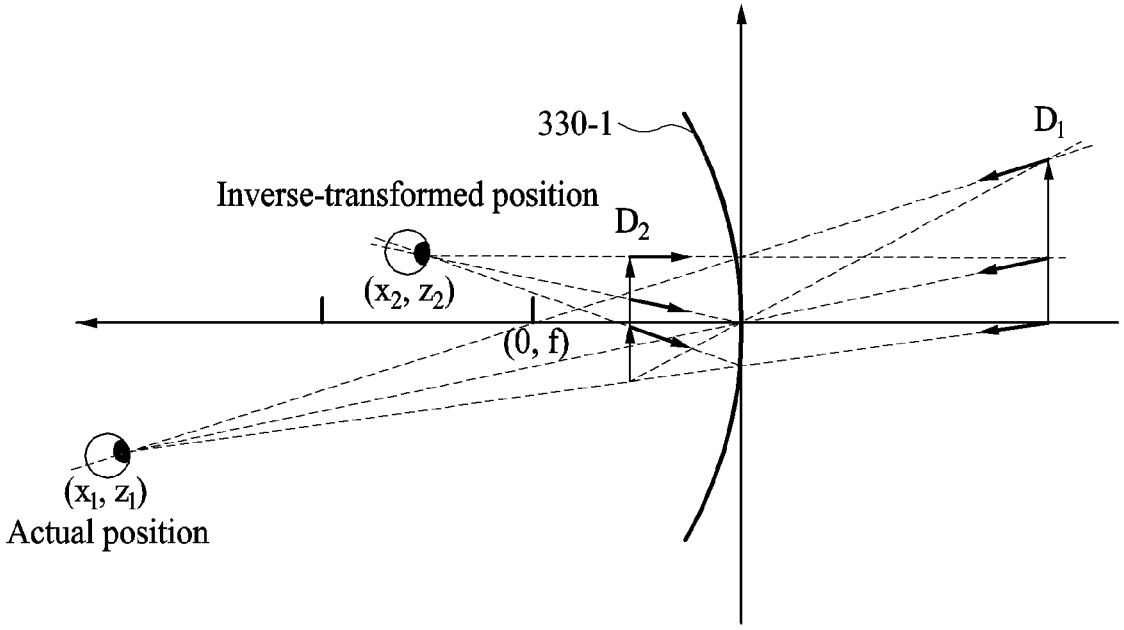

FIG. 6

320

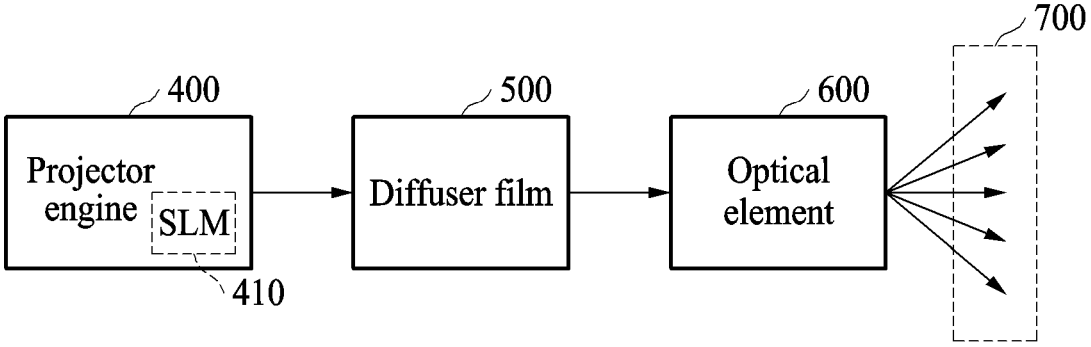

FIG. 7A

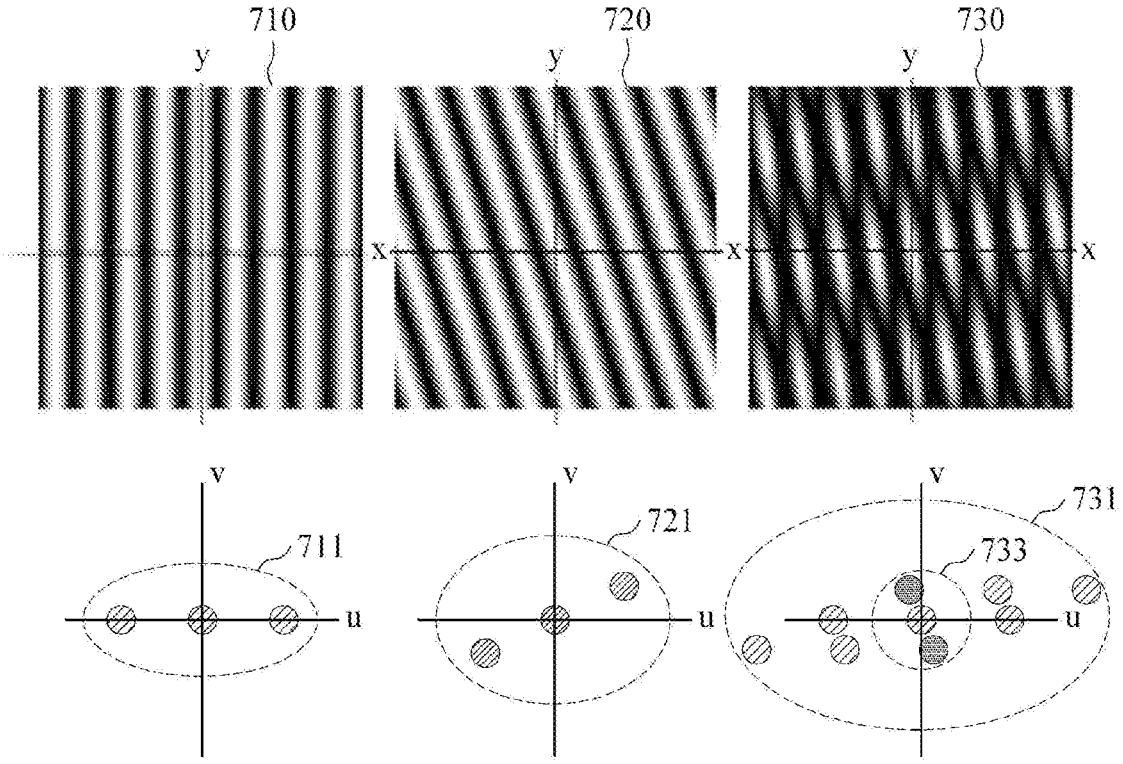

FIG. 7B

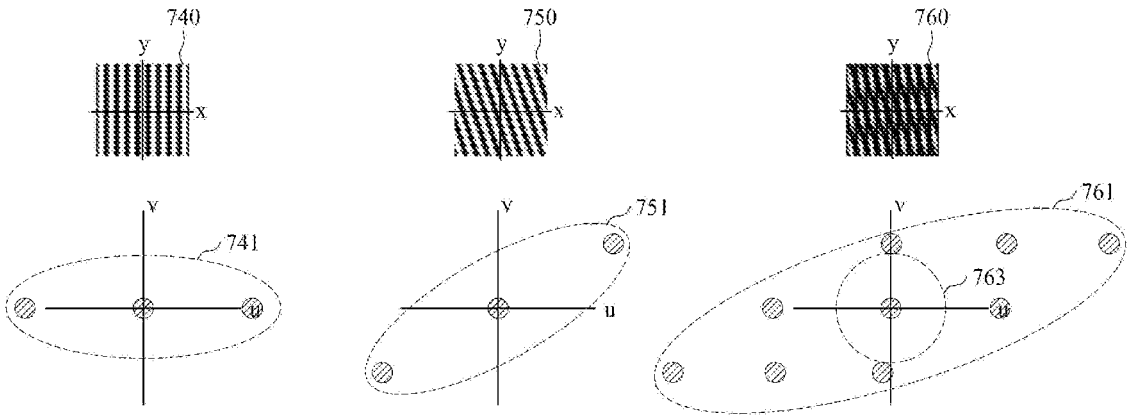

FIG. 8

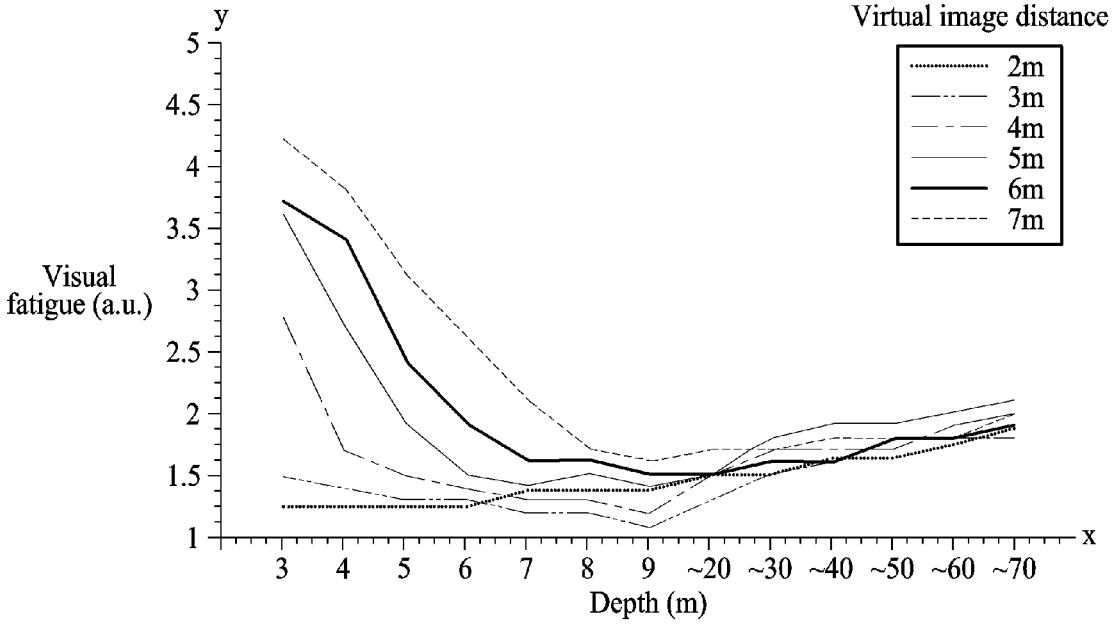
y
Virtual image distance
2m
3m
4m
5m
6m
7m
Visual fatigue (a.u.)
5
4.5
4
3.5
3
2.5
2
1.5
1
x
3
4
5
6
7
8
9
~20
~30
~40
~50
~60
~70
Depth (m)

FIG. 9

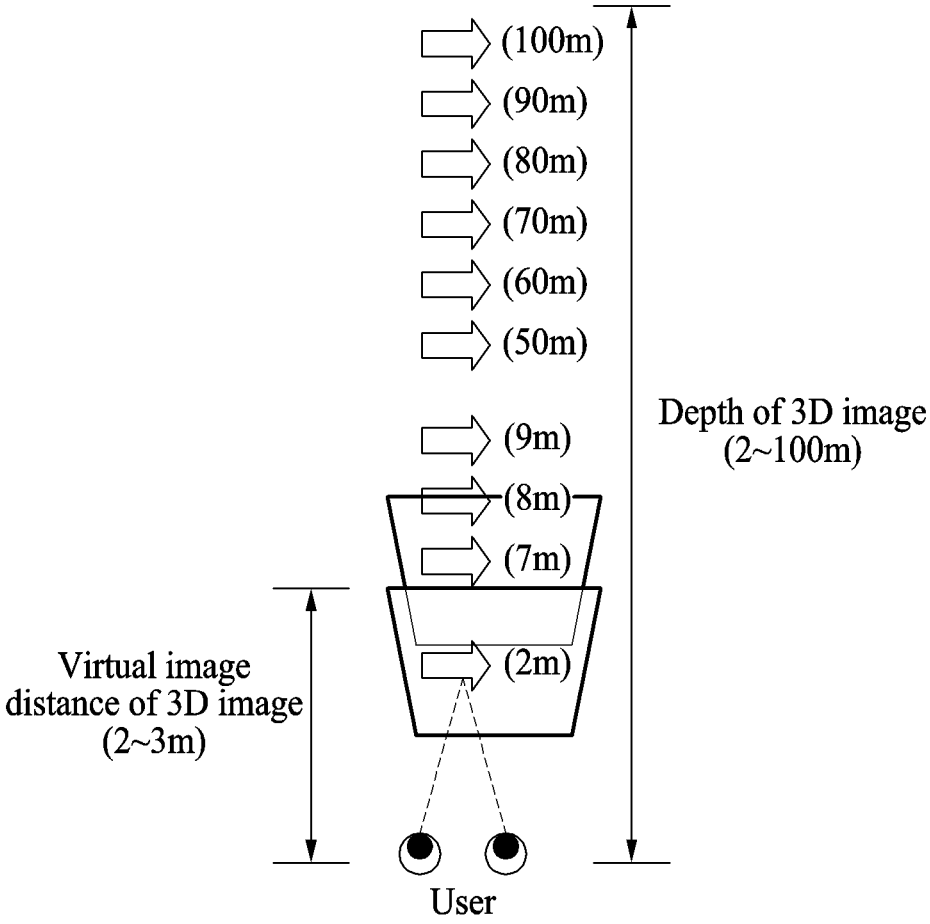
(100m)
(90m)
(80m)
(70m)
(60m)
(50m)
(9m)
(8m)
(7m)
(2m)
Depth of 3D image
(2~100m)
Virtual image
distance of 3D image
(2~3m)
User

FIG. 10

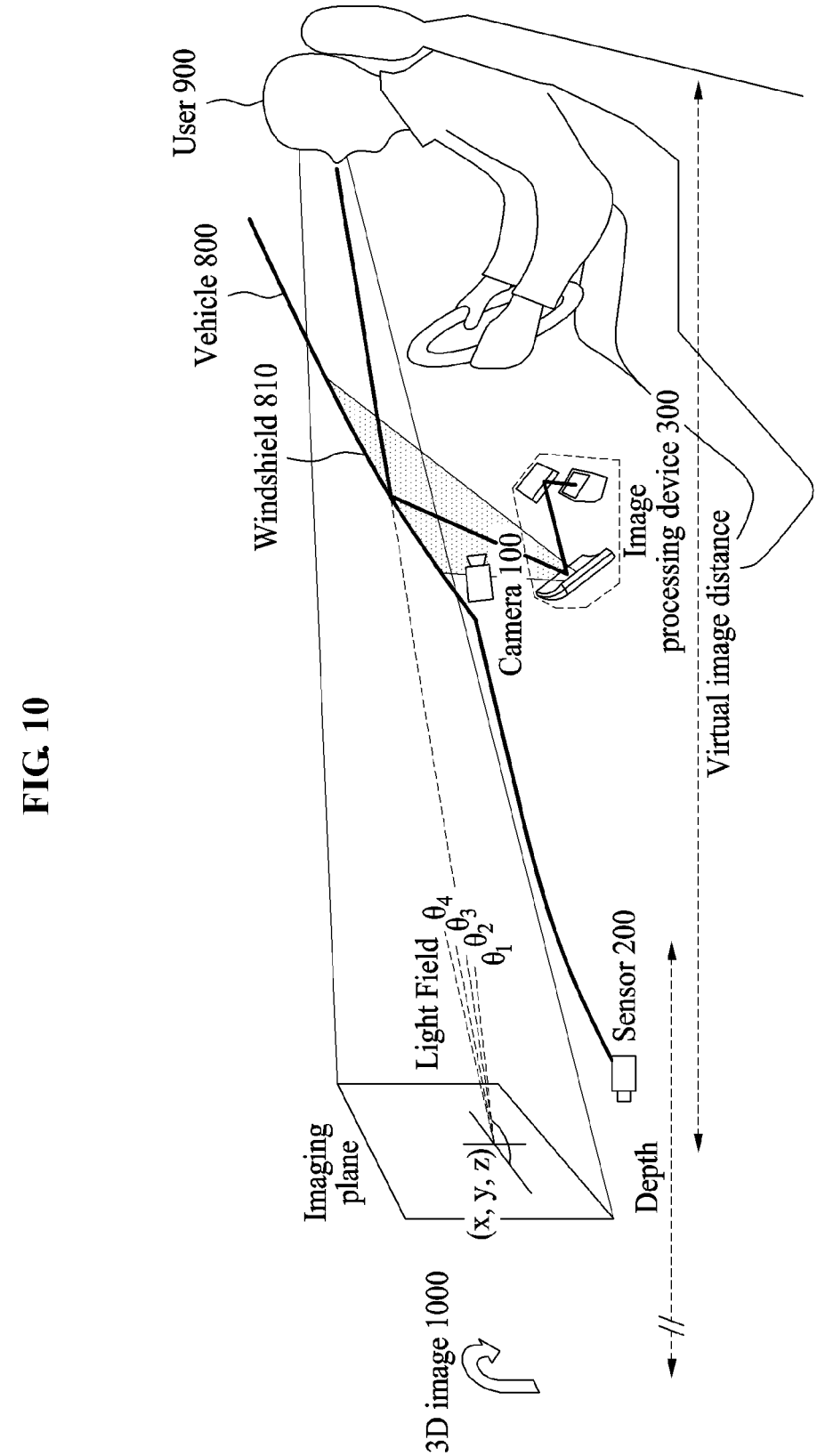
User 900
Vehicle 800
Windshield 810
Camera 100
Image processing device 300
Virtual image distance
Light Field
θ_4
θ_3
θ_2
θ_1
Sensor 200
Imaging plane
(x, y, z)
Depth
3D image 1000

FIG. 11

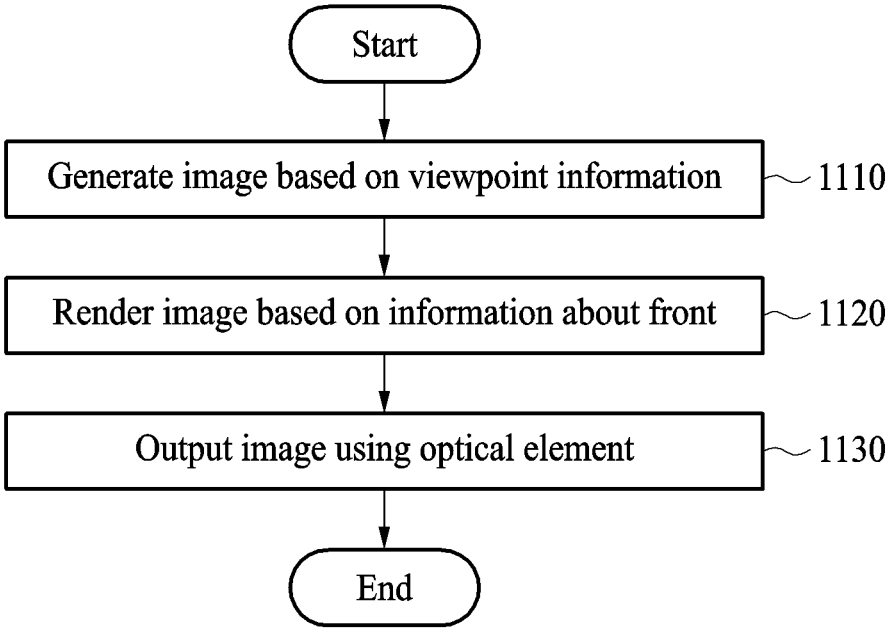
Start
Generate image based on viewpoint information
1110
Render image based on information about front
1120
Output image using optical element
1130
End

IMAGE PROCESSING METHOD OF GENERATING AN IMAGE BASED ON A USER VIEWPOINT AND IMAGE PROCESSING DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation of U.S. application Ser. No. 15/840,382 filed on Dec. 13, 2017, which claims priority from Korean Patent Application No. 10-2017-0095912, filed on Jul. 28, 2017 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND

1. Field

[0002] Methods and apparatuses consistent with exemplary embodiments relate to an image processing method and an image processing device.

2. Description of the Related Art

[0003] A driver driving a transportation device, for example, an automobile, a motorcycle, a smart mobility vehicle, a boat or ship, or an airplane, may acquire information associated with an operation of the transportation device through navigation. A navigation device may be embedded in a control panel portion of a center console of the vehicle or may be attached to a front windshield.

[0004] A driver must pay attention to obstacles present at the front, rear, and sides, of the vehicle while driving. However, if the navigation device is outside of a typical viewing angle or outside of the line of sight of the driver, the driver may either ignore the navigation device or may engage in unsafe driving. In particular, the risk of accidents may increase for inexperienced drivers.

[0005] A driver may use a head-up display (HUD) device that assists in driving. The HUD device may project information, for example, instrument panel information and navigation information, associated with an operation of the vehicle onto the windshield. That is, the driver may view information associated with the operation of the vehicle without changing his gaze or line of sight during driving and thus, may safely drive the vehicle.

[0006] In addition to displaying display panel information, for example, vehicle speed, oil level, and revolutions per minute (RPMs); and navigation information, certain device may also display lane information, information about a dangerous situation ahead, for example, construction, a traffic accident, or a warning about an object, etc., using the HUD device in an augmented reality (AR) form.

SUMMARY

[0007] One or more exemplary embodiments may address at least the above problems and/or disadvantages and other disadvantages not described above. Also, the exemplary embodiments are not required to overcome the disadvantages described above, and an exemplary embodiment may not overcome any of the problems described above.

[0008] According to an aspect of an exemplary embodiment, there is provided an image processing method including generating an image based on viewpoint information of a user; rendering the image based on information about what is in front of the user, including at least one of surroundings and an object present in front of the user; and outputting the rendered image using an optical element.

[0009] The rendering of the image may include acquiring one of a shape, a position, and a depth of an object present in front of the user using a sensor.

[0010] The generating of the image may include acquiring the viewpoint information using an image camera or an infrared camera.

[0011] The acquiring may include acquiring the viewpoint information by directly detecting an eye of the user using the image camera or the infrared camera or by detecting the eye of the user reflected on a windshield of a vehicle.

[0012] The generating of the image may include determining a position of an eye of the user based on the viewpoint information; and allocating an image to a plurality of sub-pixels corresponding to the position of the eye.

[0013] The allocating of the image may include allocating an image to be input to a left eye of the user to a plurality of sub-pixels corresponding to a position of the left eye of the user; and allocating an image to be input to a right eye of the user to a plurality of sub-pixels corresponding to a position of the right eye of the user.

[0014] The generating of the image may include generating the image based on the viewpoint information and on an optical transform.

[0015] The optical element may be a lenticular lens or a parallax barrier.

[0016] The outputting of the rendered image may include enlarging the rendered image using a magnifying optical system.

[0017] The magnifying optical system may include one of an aspherical mirror and a plane mirror.

[0018] The rendering of the image may include rendering the image so that a depth of the image is greater than a virtual image distance.

[0019] According to an aspect of another exemplary embodiment, there is provided an image processing device including a controller configured to generate an image based on viewpoint information of a user, and to render the image based on information about what is in front of the user including at least one of surroundings and an object present in front of the user; and an optical element configured to output the rendered image.

[0020] The controller may be configured to acquire one of a shape, a position, and a depth of an object present in front of the user using a sensor.

[0021] The controller may be configured to acquire the viewpoint information using an image camera or an infrared camera.

[0022] The image camera or the infrared camera may be configured to acquire the viewpoint information based on an eye of the user directly detected or the eye of the user reflected on a windshield of a vehicle.

[0023] The controller may be configured to determine a position of an eye of the user based on the viewpoint information and to allocate an image to a plurality of sub-pixels corresponding to the position of the eye.

[0024] The controller may be configured to allocate an image to be input to a left eye of the user to a plurality of sub-pixels corresponding to a position of the left eye of the user, and to allocate an image to be input to a right eye of the user to a plurality of sub-pixels corresponding to a position of the right eye of the user.

[0025] The controller may be configured to generate the image based on the viewpoint information and on an optical transform.

[0026] The optical element may be a lenticular lens or a parallax barrier.

[0027] The image processing device may further include a magnifying optical system configured to enlarge the image output from the optical element.

[0028] The magnifying optical system may include one of an aspherical mirror and a plane mirror.

[0029] The controller may be configured to render the image so that a depth of the image is greater than a virtual image distance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The above and/or other exemplary aspects will be more apparent by describing certain exemplary embodiments with reference to the accompanying drawings, in which:

[0031] FIG. **1** is a diagram illustrating an image processing system according to an exemplary embodiment;

[0032] FIG. **2** is a diagram illustrating an example of an image processing device of FIG. **1** according to an exemplary embodiment;

[0033] FIG. **3** is a diagram illustrating an example of a display of FIG. **2** according to an exemplary embodiment;

[0034] FIG. **4** illustrates an operation of an optical element of FIG. **3** according to an exemplary embodiment;

[0035] FIG. **5** illustrates an operation of a controller of FIG. **2** according to an exemplary embodiment;

[0036] FIG. **6** illustrates another example of the display of FIG. **2** according to an exemplary embodiment;

[0037] FIG. **7**A illustrates an example of describing a moire phenomenon of the display of FIG. **2** according to an exemplary embodiment;

[0038] FIG. **7**B illustrates another example of describing a moire phenomenon of the display of FIG. **2** according to an exemplary embodiment;

[0039] FIG. **8** is an example of a graph showing a visual fatigue of a driver according to an exemplary embodiment;

[0040] FIG. **9** illustrates an example of an operation of an image processing device based on the visual fatigue of FIG. **8** according to an exemplary embodiment;

[0041] FIG. **10** illustrates an example of the image processing system of FIG. **1** configured in a vehicle according to an exemplary embodiment; and

[0042] FIG. **11** is a flowchart illustrating an image processing method according to an exemplary embodiment.

DETAILED DESCRIPTION

[0043] Reference will now be made in detail to exemplary embodiments which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. Exemplary embodiments are described below in order to explain the present disclosure by referring to the figures.

[0044] The following structural or functional descriptions are exemplary to merely describe the exemplary embodiments, and the scope of the exemplary embodiments is not limited to the descriptions provided in the present specification. Various changes and modifications can be made thereto by those of ordinary skill in the art.

[0045] Although terms of "first" or "second" are used to explain various components, the components are not limited to the terms. These terms should be used only to distinguish one component from another component. For example, a "first" component may be referred to as a "second" component, or similarly, and the "second" component may be referred to as the "first" component within the scope of the right according to the concept of the present disclosure.

[0046] It will be understood that when a component is referred to as being "connected to" another component, the component can be directly connected or coupled to the other component or intervening components may be present.

[0047] As used herein, the singular forms are intended to include the plural forms as well, unless the context clearly indicates otherwise. It should be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, components or a combination thereof, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0048] Unless otherwise defined herein, all terms used herein including technical or scientific terms have the same meanings as those generally understood by one of ordinary skill in the art. Terms defined in dictionaries generally used should be construed to have meanings matching with contextual meanings in the related art and are not to be construed as an ideal or excessively formal meaning unless otherwise defined herein.

[0049] Hereinafter, the exemplary embodiments are described with reference to the accompanying drawings. However, the scope of the exemplary embodiments are not limited thereto or restricted thereby. Here, like reference numerals illustrated in each drawing refer to like elements throughout.

[0050] FIG. **1** is a diagram illustrating an image processing system according to an exemplary embodiment.

[0051] Referring to FIG. **1**, an image processing system **10** includes a camera **100**, a sensor **200**, and an image processing device **300**.

[0052] The image processing system **10** may provide information associated with an operation to a user. Herein, the user may be a driver that drives a transportation device. For example, the image processing system **10** may provide the user with instrument panel information, navigation information, lane information, information about a dangerous situation ahead, and the like. The instrument panel information may include a speed, an oil level, an RPM, etc., of the transportation device. Information about the dangerous situation ahead may include information about construction or a traffic accident, or a warning for an object, such as an animal, a human being, a bicycle, a vehicle, or the like.

[0053] The image processing system **10** may output information associated with the operation in an AR form. The image processing system **10** may output an image in front of a driver, that is, a user using a windshield. For example, the image processing system **10** may output an optical image or a virtual image.

[0054] The image processing system **10** outputting the optical image or the virtual image may include adjusting a position and a depth of the optical image or the virtual image. That is, the image processing system **10** may adjust a distance and a depth at which the image is represented. An operation of the image processing system **10** adjusting the

distance and depth, by the image processing system **10** is described with reference to FIGS. **7**A and **7**B, and FIGS. **8** and **9**. The user may perform safe driving by referring to the optical image or the virtual image reflected on the windshield.

[0055] The image processing system **10** may be configured in the transportation device. For example, the image processing system **10** may be configured in an automobile, a motorcycle or an auto bicycle, a smart mobility vehicle, a boat or ship, or an airplane. Hereinafter, a description is made based on an example in which the image processing system **10** is configured in a vehicle. However, this is merely exemplary.

[0056] The camera **100** may track viewpoint information of the user. The viewpoint information may include a position and/or a viewpoint of an eye of the user. For example, the camera **100** may acquire information about a position of a left eye and a position of a right eye of the user. Also, the camera **100** may acquire information about a direction in which the user is gazing. The camera **100** may acquire ray information corresponding to each of the left eye and the right eye.

[0057] The camera **100** may be provided in front of the user. The camera **100** may be provided at an upper portion or a lower portion of the windshield and may track a position and/or a viewpoint of an eye of the user in front of the user. Also, the camera **100** may be configured within the image processing device **300**.

[0058] For example, when the camera **100** is provided at an upper portion of the windshield, the camera **100** may be configured within a rear view mirror. When the camera **100** is provided at a lower portion of the windshield, the camera **100** may be configured within a dashboard.

[0059] The camera **100** may face the user or face the windshield. When the camera **100** faces the windshield, the camera **100** may track a position and/or a viewpoint of an eye of the user as reflected on the windshield.

[0060] The camera **100** may track the position and/or the viewpoint of the user's eye in real time. For example, when the user, that is, the driver gazes ahead from a position in the driver's seat and then gazes ahead from a position of the passenger's seat, by tilting his body, the camera **100** may acquire information indicating that the position of the eye of the user has moved from the position of the driver seat to the position of the passenger seat. Also, when the user gazes toward the front and then gazes toward right, in order to turn right, the camera **100** may acquire information indicating that the viewpoint of the user has moved from the front to the right.

[0061] The camera **100** may be an image camera and/or an infrared camera. For example, if light, for example, the intensity of light is sufficient or it is during the daytime, the image camera may track a viewpoint of the user. If light, for example, the intensity of light, is insufficient or it is during the nighttime, the infrared camera may track the viewpoint of the user.

[0062] The camera **100** may include a clock to measure time. For example, the duration of a preset time may be determined to be a time during which light, for example, the intensity of light, is sufficient or during which it is considered to be the daytime, and the image camera may operate. If the preset time has elapsed, it may be determined to be a time during which light, for example, the intensity of light, is insufficient or during which it is considered to be the nighttime, and the infrared camera may operate.

[0063] Also, the camera **100** may include an optical sensor or a photodetector configured to measure, for example, the intensity of light. If the intensity of light measured at the optical sensor is greater than or equal to a reference value, the image camera may operate. If the intensity of light measured at the optical sensor is less than the reference value, the infrared camera may operate. The optical sensor may be configured as a separate sensor **200** instead of being included in the camera **100**.

[0064] The camera **100** may output information about the tracked position and/or viewpoint of the user's eye to the image processing device **300**.

[0065] The sensor **200** may acquire information about what is in front of the vehicle. For example, the sensor **200** may acquire information about the vehicle surroundings and/or an object present ahead of the vehicle. The sensor **200** may be a radar device, a light detection and ranging (LIDAR) apparatus, an ultrasound sensor, an infrared sensor, a thermal sensor, an optical sensor, a global positioning system (GPS) module, or the like.

[0066] Information about the vehicle surroundings may include, for example, road information, lane information, speed bump information, traffic light information, and speed camera information.

[0067] Information about the object may include, for example, shape information, position information, and depth information of the object.

[0068] The sensor **200** may output information about what is in front of the vehicle to the image processing device **300**.

[0069] The image processing device **300** may acquire information about the tracked position and/or viewpoint of the user's eye from the camera **100** and may acquire information about what is in front of the vehicle from the sensor **200**.

[0070] The image processing device **300** may generate an image based on information about the tracked position and/or viewpoint of the user's eye. The image processing device **300** may determine the position of the user's eye of the user based on information about the tracked position and/or viewpoint of the user's eye and may allocate the image to pixels corresponding to the position of the eye. That is, the image processing device **300** may include a display.

[0071] A single pixel may include a plurality of sub-pixels. The image processing device **300** may output the image by allocating, to sub-pixels, sub-pixel values corresponding to the image to be output.

[0072] For example, the image processing device **300** may allocate an image to be input to the user's left eye to a plurality of sub-pixels corresponding to a position of the user's left eye and may allocate an image to be input to the user's right eye to a plurality of sub-pixels corresponding to a position of the user's right eye.

[0073] The image processing device **300** may acquire information about what is in front of the vehicle from the sensor **200**. The image processing device **300** may render the generated image based on information about what is in front of the vehicle. The image processing device **300** may output the rendered image to the user.

[0074] The image processing device **300** may be provided at a lower portion of the dashboard of the vehicle and may output a plurality of rays to the windshield. The user may

view the plurality of rays reflected through the windshield. The image processing device **300** may be a HUD device.

[0075] The image processing device **300** may include a glasses-free (glassesless) three-dimensional (3D) display or an autostereoscopic 3D screen. For example, the image processing device **300** may uniformly output a plurality of rays associated with the rendered image. That is, the image processing device **300** may output the rendered image in an AR form. Accordingly, the user may view a 3D image without wearing 3D glasses, stereoscopic glasses, or smart glasses. The user may further safely drive the vehicle by referring to the 3D image that matches information associated with the operation.

[0076] FIG. **2** is a diagram illustrating an example of an image processing device of FIG. **1** according to an exemplary embodiment; FIG. **3** is a diagram illustrating an example of a display of FIG. **2** according to an exemplary embodiment; and FIG. **4** illustrates an operation of an optical element of FIG. **3** according to an exemplary embodiment.

[0077] Referring to FIGS. **2** through **4**, the image processing device **300** includes a controller **310**, a display **320**, and a magnifying optical system **330**.

[0078] The controller **310** may acquire information about a tracked position and/or a viewpoint of an eye of a user from the camera **100**, and may acquire information about what is in front of a vehicle from the sensor **200**.

[0079] The controller **310** may perform a 3D image rendering operation based on information about the position and/or the viewpoint of the eye of the user acquired from the camera **100**. The 3D image rendering operation may refer to performing a rendering operation on the image so that the user may view a 3D image. The controller **310** may perform a light field rendering operation on the left eye and the right eye of the user.

[0080] The controller **310** may allocate pixel values, corresponding to an image to be output, to a plurality of pixels of the display **320** based on information about the position and the viewpoint of the user. A single pixel may include a plurality of sub-pixels. For example, the controller **310** may allocate sub-pixel values corresponding to an image to be output to a plurality of sub-pixels.

[0081] In detail, the controller **310** may allocate a pixel value (sub-pixel values) corresponding to a first viewpoint to a first pixel (first sub-pixels) and may allocate a pixel value (sub-pixel values) corresponding to a second viewpoint to a second pixel (second sub-pixels). Here, the first viewpoint and the second viewpoint used to allocate a pixel value may be referred to as candidate viewpoints. The candidate viewpoints may include a left viewpoint and a right viewpoint for a single user or may include a predetermined number of viewpoints for a multi-view. For example, the first viewpoint may be a viewpoint for the right eye of the user and the second viewpoint may be a viewpoint for the left eye of the user.

[0082] The controller **310** may perform a 3D image rendering operation in real time. For example, in response to a change in a position or a viewpoint of the user, the controller **310** may acquire information about the changed position and/or viewpoint of the eye of the user from the camera **100** and may perform the 3D image rendering operation in real time based on the changed information. The user may view an image representing a sense of reality similar to an actual environment and the user's visual fatigue may be reduced. Also, the controller **310** may perform the 3D image rendering operation in real time, which may be advantageous in displaying a large screen, a high depth, and a continuous parallax.

[0083] The controller **310** may perform an optical transform or an optical inverse-transform on the tracked position and/or viewpoint of the eye of the user. To configure a precise 3D image, a plurality of rays output from the image processing device **300** may need to be accurately and uniformly incident onto the right eye and the left eye of the user. Thus, the controller **310** may perform the 3D image rendering operation through the optical transform or the optical inverse-transform. The optical transform or optical inverse-transform operation of the controller **310** is described with reference to FIG. **5**.

[0084] Also, the controller **310** may perform an AR object rendering operation based on information about what is in front of the vehicle acquired from the sensor **200**. The AR object rendering operation may indicate a rendering operation for configuring an environment similar to reality with respect to an object included in the image to be output.

[0085] For example, the controller **310** may generate an AR object of an image to be output based on information about the surroundings of the vehicle and an object present in front of the vehicle, and may perform a rendering operation on the AR object. The AR object may indicate AR content.

[0086] The controller **310** may apply depth information to an image to be output. For example, the controller **310** may adjust a depth of an AR object included in the image to be output. The controller **310** may adjust the depth of the AR object within the range of 0 to 100 m.

[0087] The controller **310** may perform the AR object rendering operation using navigation, map information, a geographic information system (GIS), and the like. For example, the controller **310** may output an accurate position of the user, operation information, and the like on a map using navigation, map information, a GIS, and the like.

[0088] The controller **310** may perform the AR object rendering operation based on information about the position and/or the viewpoint of the eye of the user. For example, the controller **310** may control a plurality of rays output from the display **320** to adaptively output an image corresponding to a change in a position or a viewpoint of the user. Accordingly, a sense of difference occurring due to a depth difference between an actual object and an AR object of an image may be reduced and the user may view an image representing a sense of reality similar to an actual environment and a visual fatigue of the user may be reduced.

[0089] The display **320** may be configured as a 3D display using a light field scheme. For example, the display **320** may be a light field display.

[0090] Referring to FIG. **3**, the display **320** includes a light source **321**, a panel **323**, and an optical element **325**. The display **320** may output a plurality of rays **327**.

[0091] The light source **321** may be configured as a backlight unit at the rear of the display, or may be configured as a directional backlight unit that is an example of an optical layer. The directional backlight unit may provide a plurality of rays having a limited direction to the panel **323**.

[0092] The light source **321** may include a white light emitting diode (LED), a red, green, and blue (RGB) LED, or an RGB laser. The light source **321** may output, that is emit, a plurality of rays used to generate an image.

[0093] The plurality of rays output from the light source **321** may pass through at least one of the panel **323** and the optical element **325**.

[0094] The panel **323** may be configured as a liquid crystal display (LCD) panel including a plurality of pixels. The panel **323** may output an image based on pixel values, for example, sub-pixel values, allocated by the controller **310**. That is, the plurality of rays output from the light source **321** may pass through the plurality of pixels (plurality of sub-pixels) of the panel **323** and an image corresponding to a pixel value (sub-pixel values) of each of the plurality of pixels may be viewed by the user.

[0095] For example, the panel **323** may provide a ray of a first viewpoint direction to a pixel to which a pixel value corresponding to a first viewpoint is allocated, and may provide a ray of a second viewpoint direction to a pixel to which a pixel value corresponding to a second viewpoint is allocated. The user may view an image corresponding to the first viewpoint at the first viewpoint and may view an image corresponding to the second viewpoint at the second viewpoint. The user may observe a 3D effect by viewing different images with the right eye and the left eye. That is, the user may acquire information associated with the operation by viewing the 3D image.

[0096] The optical element **325** may be a lenticular lens or a parallax barrier. In detail, the parallax barrier may output the plurality of rays **327** in a limited direction through slits or apertures disposed at predetermined intervals. The lenticular lens may output the plurality of rays **327** in the limited direction through a lens curve. The optical element **325** may uniformly output the plurality of rays toward a position of an eye of the user.

[0097] FIG. **4** illustrates an operation of the optical element **325** that outputs the plurality of rays **327** in the limited direction. Referring to FIG. **4**, the controller **310** may allocate a pixel value corresponding to a first viewpoint to a first pixel **323-1** of the panel **323** and may allocate a pixel value corresponding to a second viewpoint to a second pixel **323-2**. A plurality of rays that pass through the panel **323** may be transmitted in a limited direction upon passing the optical element **325**. Accordingly, the different rays **327** may be incident to a left eye **341** and a right eye **343** of the user. The different rays **327** incident to the left eye **341** and the right eye **343** may generate two images between which disparity is present. The user may view the 3D image based on the two images between which the disparity is present.

[0098] The magnifying optical system **330** may generate the 3D image on a front surface of the windshield by enlarging, that is, magnifying in the plurality of rays **327**. For example, the magnifying optical system **330** may adjust a magnification of the 3D image output to the user. That is, the magnifying optical system **330** may enlarge or reduce, that is, zoom in or out the 3D image.

[0099] The magnifying optical system **330** may be a catadioptric system. The magnifying optical system **330** may include a mirror corresponding to a reflecting optical system or a lens corresponding to a refracting optical system. For example, the mirror corresponding to the reflecting optical system may be a concave mirror, an aspherical mirror, or a plane mirror. The lens corresponding to the refracting optical system may be a concave lens or a convex lens.

[0100] The magnifying optical system **330** may include a folding mirror. The folding mirror may reduce an optical path of the magnifying optical system **330**. Accordingly, a space occupied by the magnifying optical system **330** may be reduced and the magnifying optical system **330** may be miniaturized.

[0101] FIG. **5** illustrates an example of an operation of the controller of FIG. **2** according to an exemplary embodiment.

[0102] Referring to FIGS. **2** and **5**, the controller **310** may allocate pixel values to a plurality of pixels. The controller **310** may determine a path of a ray that passes through each of the plurality of pixels. For example, if a ray that passes through a first pixel is provided to a first viewpoint, the controller **310** may allocate a pixel value corresponding to the first viewpoint to the first pixel.

[0103] The controller **310** may allocate a pixel value based on the effect of the magnifying optical system **330** on the plurality of rays. Paths of rays output from the display **320** may be changed by the magnifying optical system **330**. For example, the magnifying optical system **330** may change paths of rays to enlarge or reduce, that is, zoom in or out an image.

[0104] Accordingly, a precise operation is used for the controller **310** to determine a path of a ray that passes each of a plurality of pixels.

[0105] The controller **310** may perform an optical transform or an optical inverse-transform on a tracked position and/or viewpoint of an eye of a user. The controller **310** may perform the optical transform or the optical inverse-transform based on an optical characteristic of a mirror **330-1** including a focus f and a curve. FIG. **5** illustrates a single mirror for clarity of description. However, it is provided as an example only. Various optical systems for generating an optical effect similar to a corresponding mirror may be used instead of using a single mirror.

[0106] The controller **310** may determine an actual position (x_1, z_1) of an eye of the user and a virtual image D_1 formed on an opposite surface of the mirror **330-1** that constitutes the magnifying optical system **330**, and may perform the optical transform or the optical inverse-transform on the actual position (x_1, z_1) and the virtual image D_1. Accordingly, the controller **310** may acquire an inverse-transformed position (x_2, z_2) of the eye of the user and a corresponding virtual image D_2 that is formed on an inner surface of the mirror **330-1**. Here, the corresponding virtual image D_2 corresponds to the virtual image D_1.

[0107] The controller **310** may enhance the accuracy of an operation by performing transform or inverse transform so that the user views the corresponding virtual image D_2 at the position (x_2, Z_2).

[0108] The controller **310** may allocate pixel values to a plurality of pixels based on a positional relationship between the inverse-transformed position (x_2, z_2) of the eye of the user and the corresponding virtual image D_2. For example, the controller **310** may determine an optical image corresponding to each of a viewpoint of the right eye and a viewpoint of the left eye of the user and may allocate pixel values to the plurality of pixels based on a positional relationship between each optical image and the display **320**. The controller **310** may determine the optical image corresponding to the viewpoint of the user based on the optical transform or the optical inverse-transform.

[0109] The controller **310** may allocate a pixel value to a first pixel based on a positional relationship between an optical image corresponding to the first viewpoint and the display **320**. Likewise, the controller **310** may allocate a

pixel value to a second pixel based on a positional relationship between an optical image corresponding to the second viewpoint and the display **320**. Through this, the effect of the magnifying optical system **330** against the plurality of rays may be applied using a relatively small calculation amount.

[0110] FIG. **6** illustrates another example of the display of FIG. **2** according to an exemplary embodiment.

[0111] Referring to FIG. **6**, the display **320** includes a projector engine **400**, a diffuser film (or a scattering film) **500**, and an optical element **600**. The display **320** may output a plurality of rays **700**.

[0112] Configurations and operations of the optical element **600** and the plurality of rays **700** of FIG. **6** may be substantially the same as the optical element **325** and the plurality of rays **327** of FIG. **3**.

[0113] The projector engine **400** may include a spatial light modulator (SLM) **410**. The projector engine **400** may output, that is emit, a plurality of rays corresponding to an image to be output. The plurality of rays output from the projector engine **400** may pass through at least one of the diffuser film **500** and the optical element **600**.

[0114] Here, the diffuser film **500** may be provided at a position on an image formation surface of the image output from the projector engine **400**. That is, the projector engine **400** may output the image to the diffuser film **500**.

[0115] The optical element **600** may be a lenticular lens or a parallax barrier. The optical element **600** may uniformly output the plurality of rays **700** toward a position of an eye of the user.

[0116] FIG. **7**A illustrates an example of describing a moire phenomenon of the display of FIG. **2** according to an exemplary embodiment, FIG. **7**B illustrates another example of describing a moire phenomenon of the display of FIG. **2** according to an exemplary embodiment, FIG. **8** is an example of a graph showing a visual fatigue of a driver according to an exemplary embodiment, and FIG. **9** illustrates an example of an operation of an image processing device based on the visual fatigue of FIG. **8** according to an exemplary embodiment.

[0117] Referring to FIGS. **1** through **9**, the plurality of rays **327** or **700** output from the display **320** may be incident onto the magnifying optical system **330**. The magnifying optical system **330** may generate an enlarged 3D image on the front surface of the windshield by reflecting or refracting the plurality of rays **327** or **700**. When the magnifying optical system **330** generates the 3D image, the magnifying optical system **330** may adjust a virtual image distance of the 3D image by adjusting a magnification of an optical system or by adjusting an interval between mirrors that constitute the magnifying optical system **330**.

[0118] The magnifying optical system **330** may adjust the virtual image distance of the 3D image based on the moire phenomenon. The moire phenomenon may occur due to an interference between layers having a periodic pattern. That is, the moire phenomenon may occur due to interference between periodic patterns of configurations included in the display **320**. For example, a periodic pixel pattern of the panel **323** and a periodic pattern of the optical element **325** may cause the moire phenomenon.

[0119] FIG. **7**A illustrates an example in which the magnifying optical system **330** outputs the 3D image by increasing a magnification ratio of an optical system.

[0120] A moire pattern **730** may be generated based on a linear pattern **710**, of the periodic pixel pattern of the panel **323**, and a linear pattern **720**, of the periodic pattern of the optical element **325**.

[0121] When the linear pattern **710** by the periodic pixel pattern of the panel **323** is transformed into a frequency domain, it may be represented as a frequency included in a domain **711** indicated by dotted lines. When the linear pattern **720** by the periodic pattern of the optical element **325** is transformed to the frequency domain, it may be represented as a frequency included in a domain **721** indicated by dotted lines.

[0122] Here, a frequency included in a domain **731** indicated by dotted lines occurring due to interference or convolution between the frequencies in the domains **711** and **721** may correspond to a moire pattern **730**.

[0123] FIG. **7**B illustrates an example in which the magnifying optical system **330** outputs the 3D image by decreasing a magnification ratio of an optical system.

[0124] A moire pattern **760** may be generated based on a linear pattern **740**, of the periodic pixel pattern of the panel **323**, and a linear pattern **750**, of a periodic pattern of the optical element **325**.

[0125] When the linear pattern **740** of the periodic pixel pattern of the panel **323** is transformed to a frequency domain, it may be represented as a frequency included in a domain **741** indicated by dotted lines. When the linear pattern **750** by the periodic pattern of the optical element **325** is transformed to the frequency domain, it may be represented as a frequency included in a domain **751** indicated by dotted lines.

[0126] A frequency included in a domain **761** indicated by dotted lines occurring due to interference or convolution between the frequencies in the domains **741** and **751** may correspond to a moire pattern **760**.

[0127] The magnifying optical system **330** may adjust a virtual image distance of the 3D image to reduce, or alternatively, minimize the moire phenomenon. That is, to reduce, or alternatively, minimize the moire pattern **730** or **760**, the magnifying optical system **330** may adjust the virtual image distance of the 3D image.

[0128] According to a decrease in a number of frequencies included in a cognitive frequency domain **733** or **763** indicated by dotted lines, the moire pattern **730** or **760** may become less visible. Accordingly, the magnifying optical system **330** may reduce the virtual image distance of the 3D image by decreasing the magnification ratio of the optical system or by adjusting an interval between mirrors that constitute the magnifying optical system **330** to reduce the number of frequencies included in the cognitive frequency domain **733** or **763**.

[0129] The graph of FIG. **8** shows the visual fatigue of a user based on a virtual image distance and a depth of a 3D image output from the image processing device **300**. In the graph of FIG. **8**, an x axis denotes the depth of the 3D image and a y axis denotes the visual fatigue of the user. Each line of a different pattern represents a virtual image distance of the 3D image. Referring to the graph of FIG. **8**, the visual fatigue of the user was measured to be a value from 1 point to 5 points, while changing the depth of the 3D image within the range of 3 to 70 meters (m) at each virtual image distance. Also, the visual fatigue of the user was measured while changing each virtual image distance within the range

of 2 to 7 m based on a unit of 1 m. The visual fatigue of the user may represent a relative value.

[0130] When the virtual image distance of the 3D image output from the image processing device **300** is one of 2 m and 3 m and the image processing device **300** represents a near distance corresponding to a relatively shallow depth, the graph shows that a fatigue level of the user does not increase. When the virtual image distance of the 3D image output from the image processing device **300** is any one of 4 m, 5 m, 6 m, and 7 m, and the image processing device **300** represents the near distance corresponding to the relatively shallow depth, the graph shows that the fatigue level of the user may increase. That is, when the image processing device **300** represents the 3D image as the near distance corresponding to the relatively shallow depth as compared to the virtual image distance, the fatigue level of the user may increase.

[0131] When the virtual image distance of the 3D image output from the image processing device **300** is one of 2 m and 3 m and the image processing device **300** represents a far distance, corresponding to a relatively large depth, the graph shows that the fatigue level of the user does not change significantly. When the virtual image distance of the 3D image output from the image processing device **300** is any one of 4 m, 5 m, 6 m, and 7 m and the image processing device **300** represents the far distance, corresponding to a relatively large depth, the graph shows that the fatigue level of the user does not change greatly. That is, when the image processing device **300** represents the 3D image as the far distance corresponding to the relatively large depth, the virtual image distance of the 3D image may not greatly affect the visual fatigue.

[0132] Accordingly, the image processing device **300** may output the 3D image while not increasing the fatigue level of the user. For example, the image processing device **300** may output the 3D image to have a depth greater than the virtual image distance.

[0133] When the virtual image distance of the 3D image is one of 2 m and 3 m, the image processing device **300** may represent the depth of the 3D image as the near distance or the far distance. That is, the image processing device **300** may represent the near distance or the far distance by adjusting the depth of the 3D image within the range of 2 to 100 m. When the virtual image distance of the 3D image is one of 2 m and 3 m, the image processing device **300** may generate the 3D image in front of the hood of the vehicle.

[0134] When the virtual image distance of the 3D image is any one of 4 m, 5 m, 6 m, and 7 m, the image processing device **300** may represent the depth of the 3D image as the far distance. Here, the image processing device **300** may adjust the depth of the 3D image to be greater than the virtual image distance.

[0135] FIG. **9** illustrates an example in which the image processing device **300** outputs a 3D image for a user by adjusting a virtual image distance and/or a depth of the 3D image.

[0136] FIG. **10** illustrates an example in which the image processing system of FIG. **1** is configured in a vehicle according to an exemplary embodiment.

[0137] Referring to FIG. **10**, the components that constitute the image processing system **10** may be configured in a vehicle **800**.

[0138] The image processing device **300** may acquire information about a tracked position and/or viewpoint of an eye of a user **900**, that is, a driver, from the camera **100** and may acquire information about a front of the vehicle **800** from the sensor **200**. The image processing device **300** may acquire information from the camera **100** and/or the sensor **200** in real time. Accordingly, although the position of the eye of the user **900** or the viewpoint of the user **900** is changed, the user may view an image representing a sense of reality similar to an actual environment.

[0139] The image processing device **300** may generate an image based on one of or any combination of information about the position of the eye of the user **900**, information about the viewpoint of the user **900**, and information about what is in front of the vehicle **800**. For example, the image processing device **300** may output an optical image or a virtual image in front of the user **900** through a windshield **810**.

[0140] The image processing device **300** may output a 3D image **1000**. For example, the image processing device **300** may output the 3D image **1000** by performing a light field rendering operation. The image processing device **300** may minimize a visual fatigue of the user by adjusting one of or a combination of a virtual image distance and a depth of the 3D image **1000**.

[0141] In addition to the vehicle **800**, the image processing system **10** may be configured in a motor cycle, a smart mobility vehicle, a boat or ship, an airplane, or the like.

[0142] FIG. **11** is a flowchart illustrating an image processing method according to an exemplary embodiment.

[0143] Referring to FIGS. **1** and **11**, in operation **1110**, the image processing device **300** may generate an image based on viewpoint information of a user. The image processing device **300** may acquire viewpoint information of the user from the camera **100**. Herein, the user may be a driver that drives a transportation device. The viewpoint information may include a position of an eye and/or a viewpoint of the user.

[0144] The image processing device **300** may acquire viewpoint information of the user in real time. Accordingly, although the position of the eye of the user or the viewpoint of the user varies, the user may continue to view an image representing a sense of reality similar to an actual environment.

[0145] In operation **1120**, the image processing device **300** may render the image based on information about what is in front of the vehicle. The image processing device **300** may acquire information about what is in front of the vehicle from the sensor **200**. Information about what is in front of the vehicle may include information about vehicle surroundings ahead of the vehicle, information about an object ahead of the vehicle, and the like. Information about the surroundings may include, for example, road information, lane information, speed bump information, traffic light information, and speed camera information. Information about the object may include, for example, shape information, position information, and depth information of the object.

[0146] The image processing device **300** may generate an AR object of an image to be output based on information about what is in front of the vehicle. The AR object may indicate AR content. The image processing device **300** may adjust a depth of the AR object included in the image to be output. The image processing device **300** may render the AR object based on navigation, map information, a GIS, and the like.

[0147] In operation **1130**, the image processing device **300** may output the image using an optical element. The optical element may be a lenticular lens or a parallax barrier. That is, the image processing device **300** may uniformly output a plurality of rays having a limited direction to the user. The user may thereby view a 3D image.

[0148] The methods according to the above-described exemplary embodiments may be recorded in non-transitory computer-readable media including program instructions to implement various operations of the above-described exemplary embodiments. The media may also include, alone or in combination with the program instructions, data files, data structures, and the like. The program instructions recorded on the media may be those specially designed and constructed for the purposes of exemplary embodiments, or they may be of the kind well-known and available to those having skill in the computer software arts. Examples of non-transitory computer-readable media include magnetic media such as hard disks, floppy disks, and magnetic tape; optical media such as CD-ROM discs, DVDs, and/or Blue-ray discs; magneto-optical media such as optical discs; and hardware devices that are specially configured to store and perform program instructions, such as read-only memory (ROM), random access memory (RAM), flash memory (e.g., USB flash drives, memory cards, memory sticks, etc.), and the like. Examples of program instructions include both machine code, such as produced by a compiler, and files containing higher level code that may be executed by the computer using an interpreter. The above-described devices may be configured to act as one or more software modules in order to perform the operations of the above-described exemplary embodiments, or vice versa.

[0149] The foregoing exemplary embodiments are examples and are not to be construed as limiting. The present teaching can be readily applied to other types of apparatuses. Also, the description of the exemplary embodiments is intended to be illustrative, and not to limit the scope of the claims, and many alternatives, modifications, and variations will be apparent to those skilled in the art.

What is claimed is:

1. An image processing method comprising:

tracking first information including a first position of a left eye of a user and a second position of a right eye of the user;

generating second information associated with at least one of surroundings and an object present in front of the user;

rendering an image of a display panel so as to provide a first virtual image to be input to the left eye of the user and a second virtual image to be input to the right eye of the user on an imaging plane based on the first information and the second information; and

controlling the display panel to output the rendered image.

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