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(54) **PARAMETER DETERMINATION SYSTEM AND PARAMETER DETERMINATION METHOD THEREOF**

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(57) **ABSTRACT**

A parameter determination system includes an optical panel including a plurality of variable lenses. A display panel is positioned to overlap with the optical panel and is spaced apart from the display panel by a lens-panel gap. The display panel includes a plurality of sub-pixels. A panel viewing distance controller adjusts a viewing distance between the optical panel and an imaging device capturing the optical panel. A controller outputs a signal for adjusting at least one of a size of a lens width of the plurality of variable lenses and a distance of the lens-panel gap, based on images of the display panel captured by the imaging device at different viewing distances.

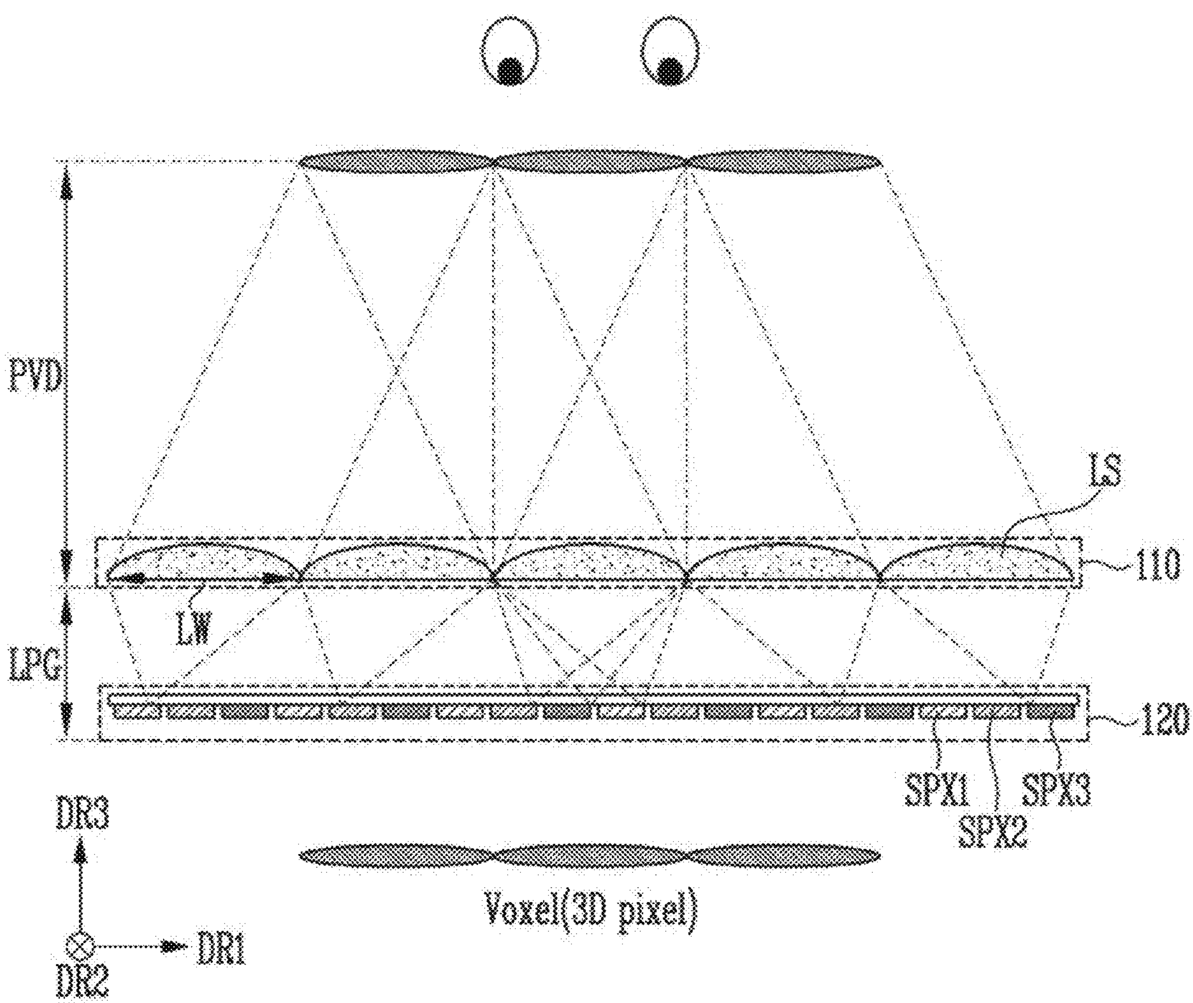


FIG. 1

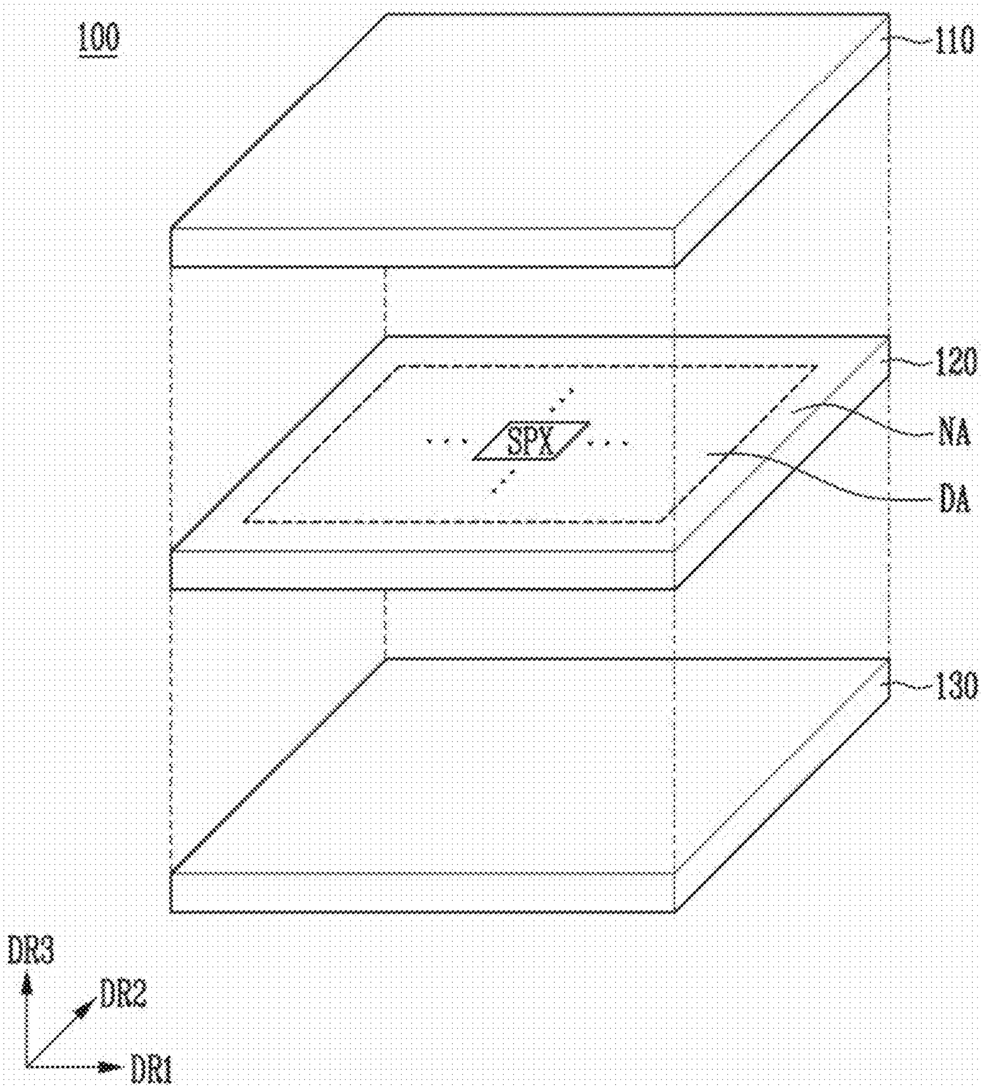


FIG. 2

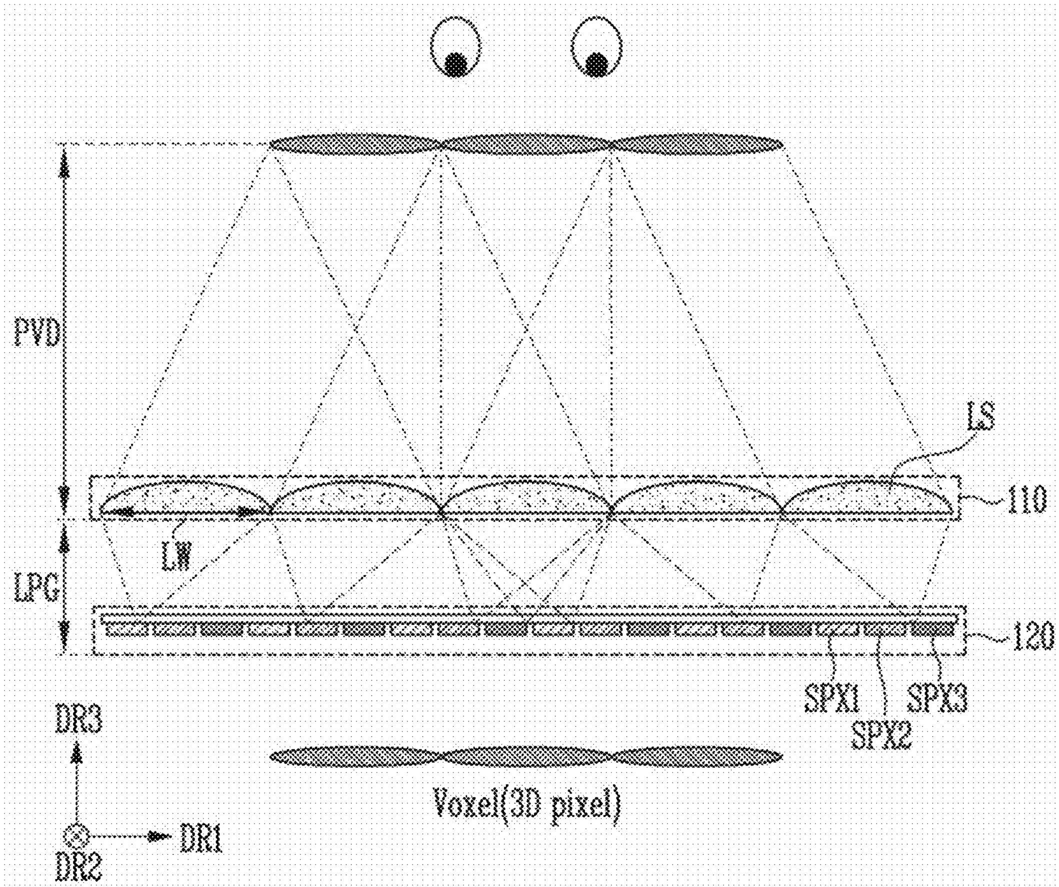


FIG. 3

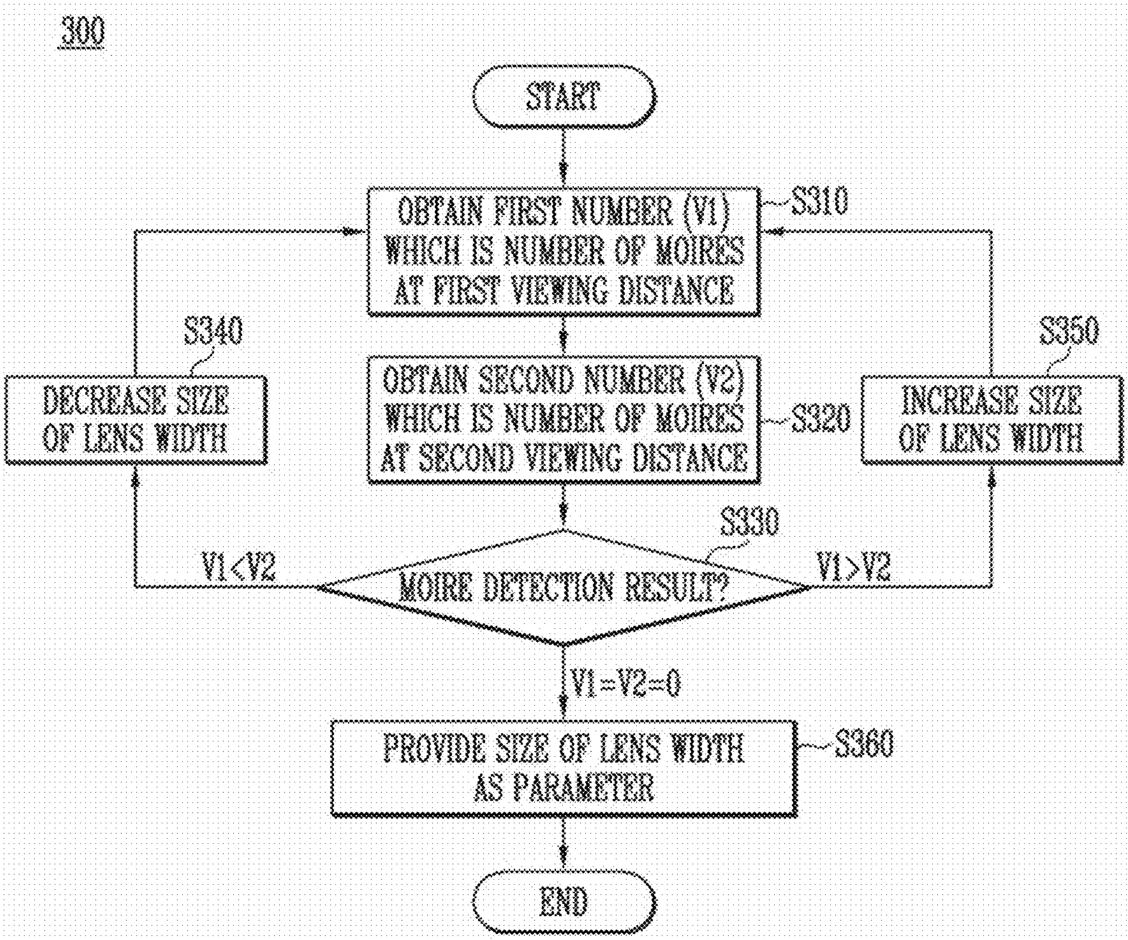

300
START
OBTAIN FIRST NUMBER (V1) WHICH IS NUMBER OF MOIRES AT FIRST VIEWING DISTANCE
S310
OBTAIN SECOND NUMBER (V2) WHICH IS NUMBER OF MOIRES AT SECOND VIEWING DISTANCE
S320
S340
DECREASE SIZE OF LENS WIDTH
S350
INCREASE SIZE OF LENS WIDTH
S330
MOIRE DETECTION RESULT?
V1<V2
V1>V2
V1=V2=0
PROVIDE SIZE OF LENS WIDTH AS PARAMETER
S360
END

FIG. 4A

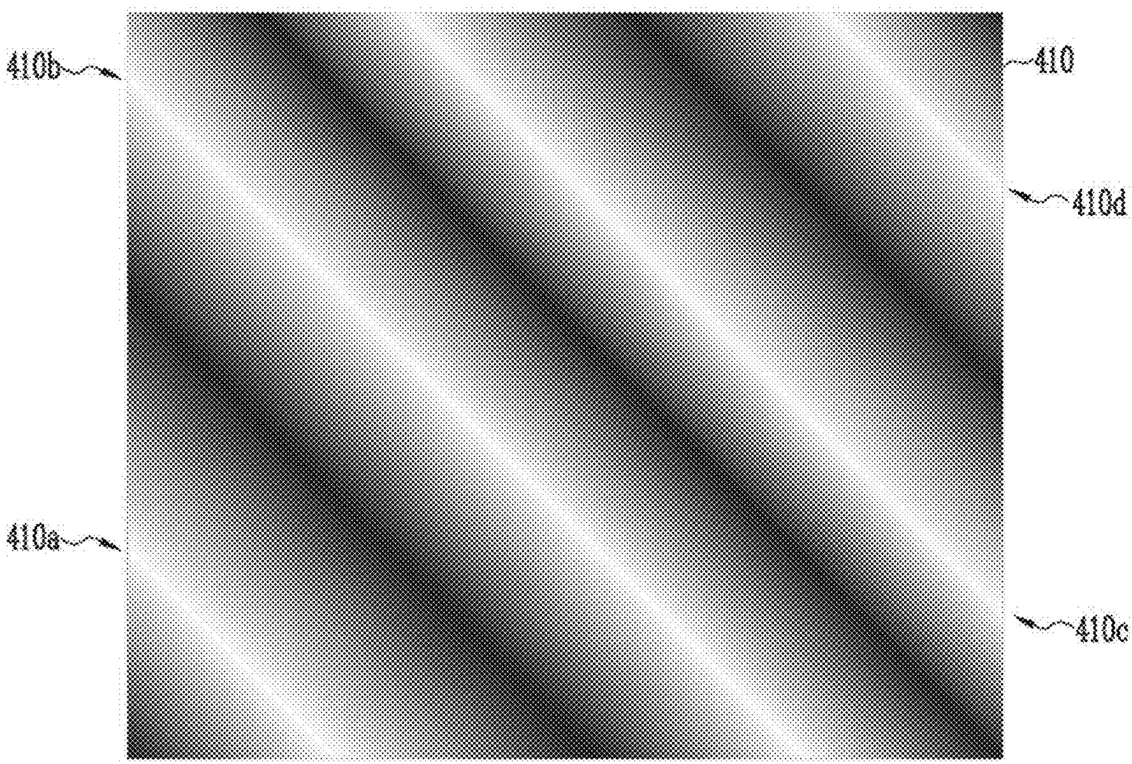


FIG. 4B

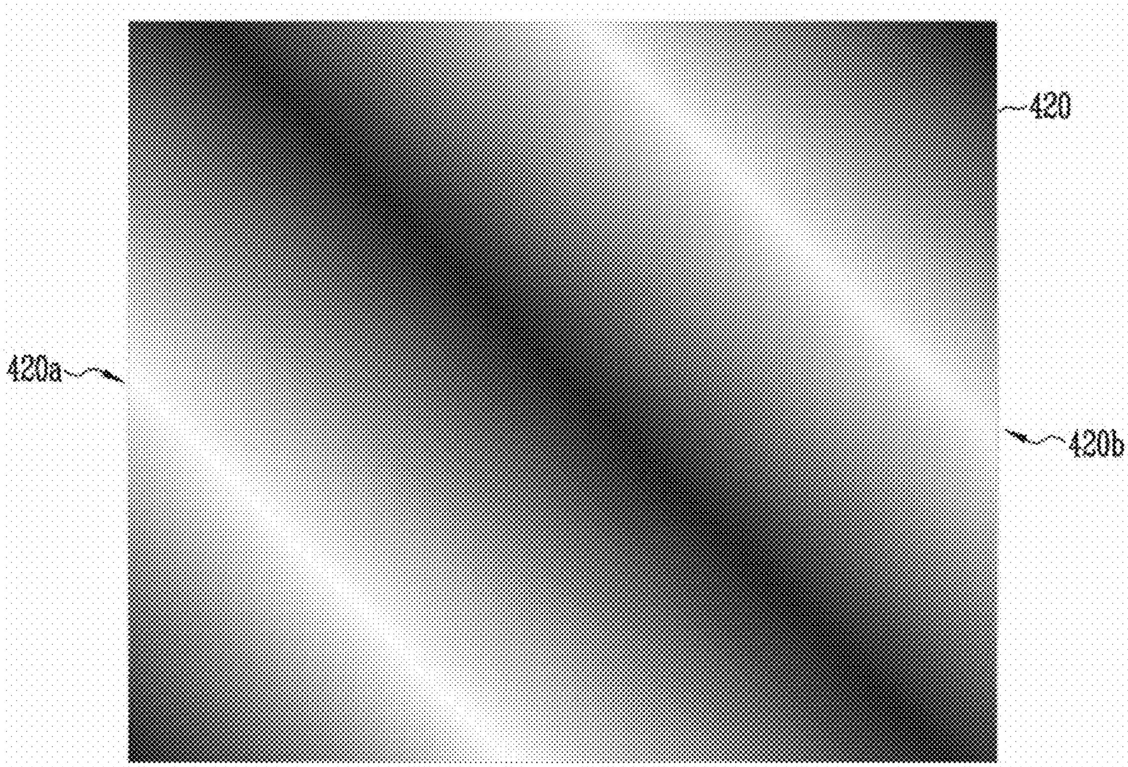


FIG. 5

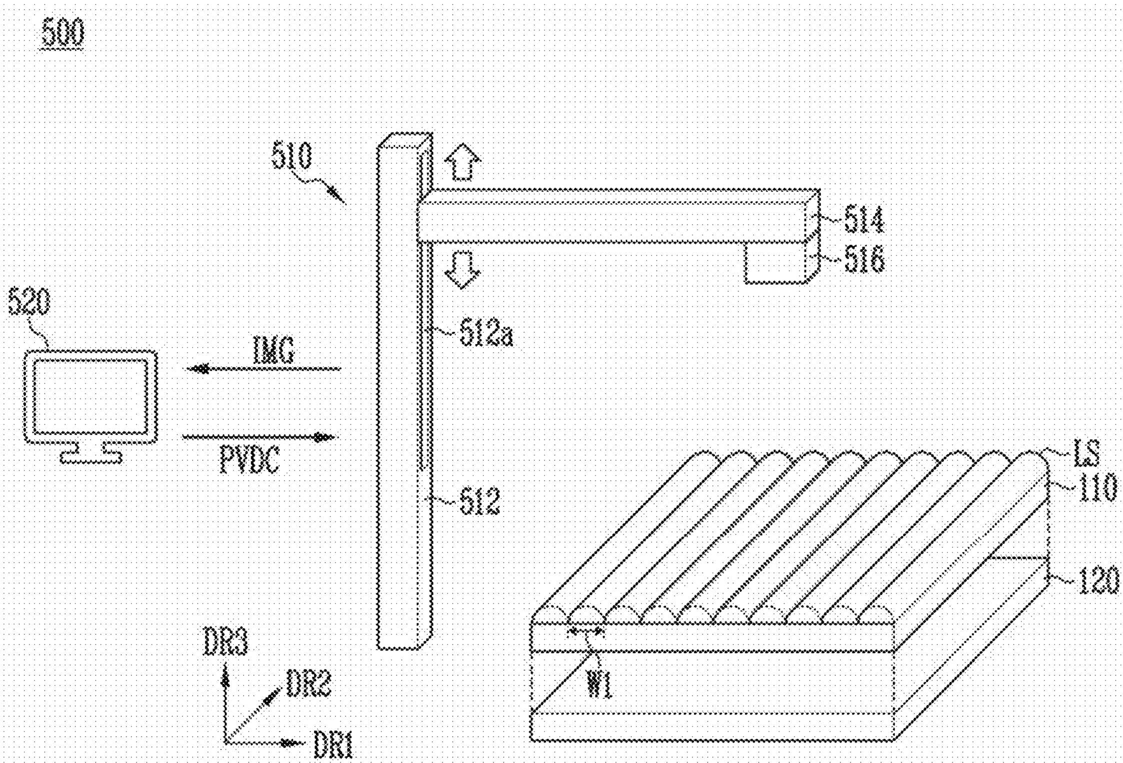


FIG. 6

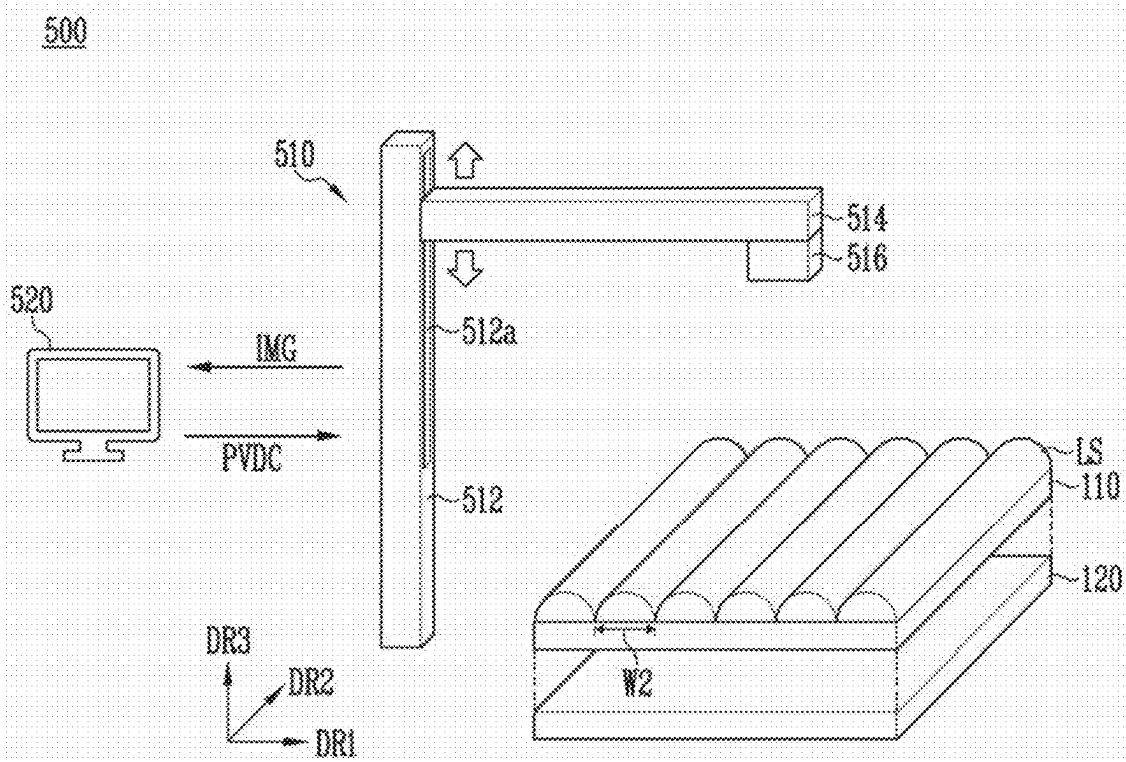


FIG. 7A

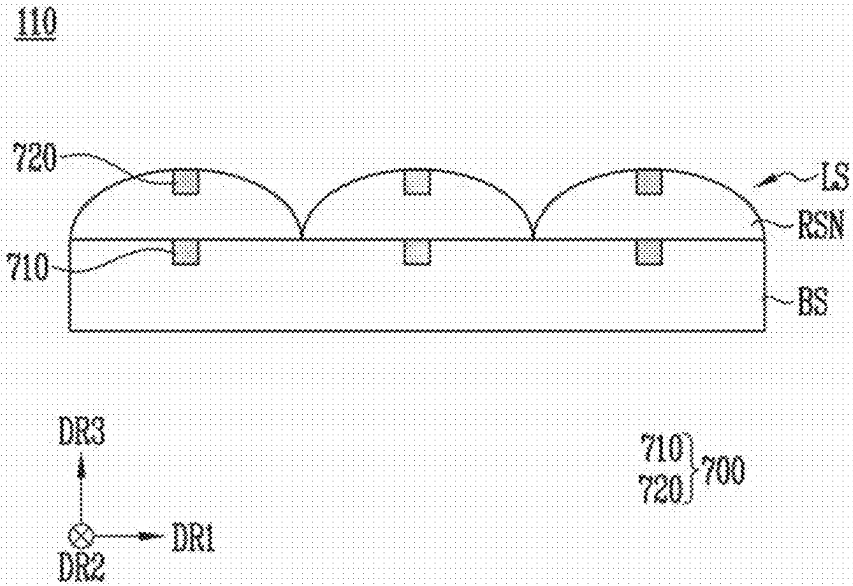

110
720
LS
RSN
710
BS
DR3
DR1
DR2
710
720
700

FIG. 7B

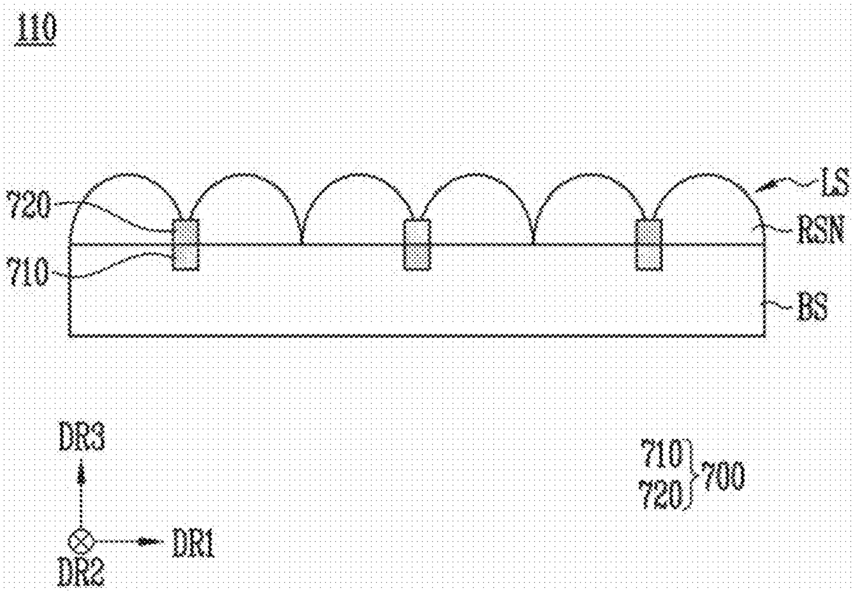

110
LS
720
RSN
710
BS
DR3
DR1
DR2
710
720
700

FIG. 8

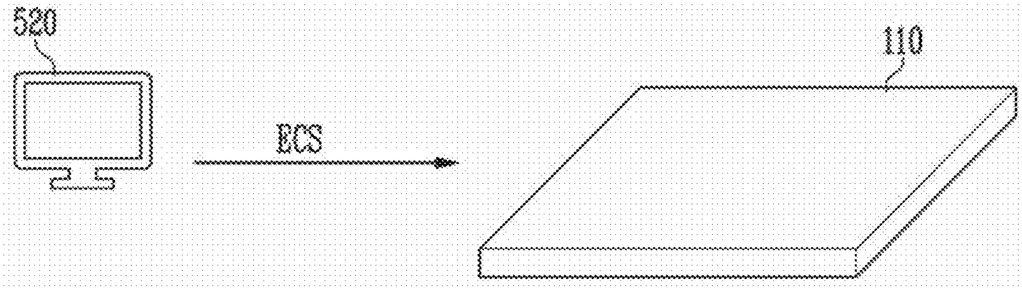

520
ECS
110

FIG. 9

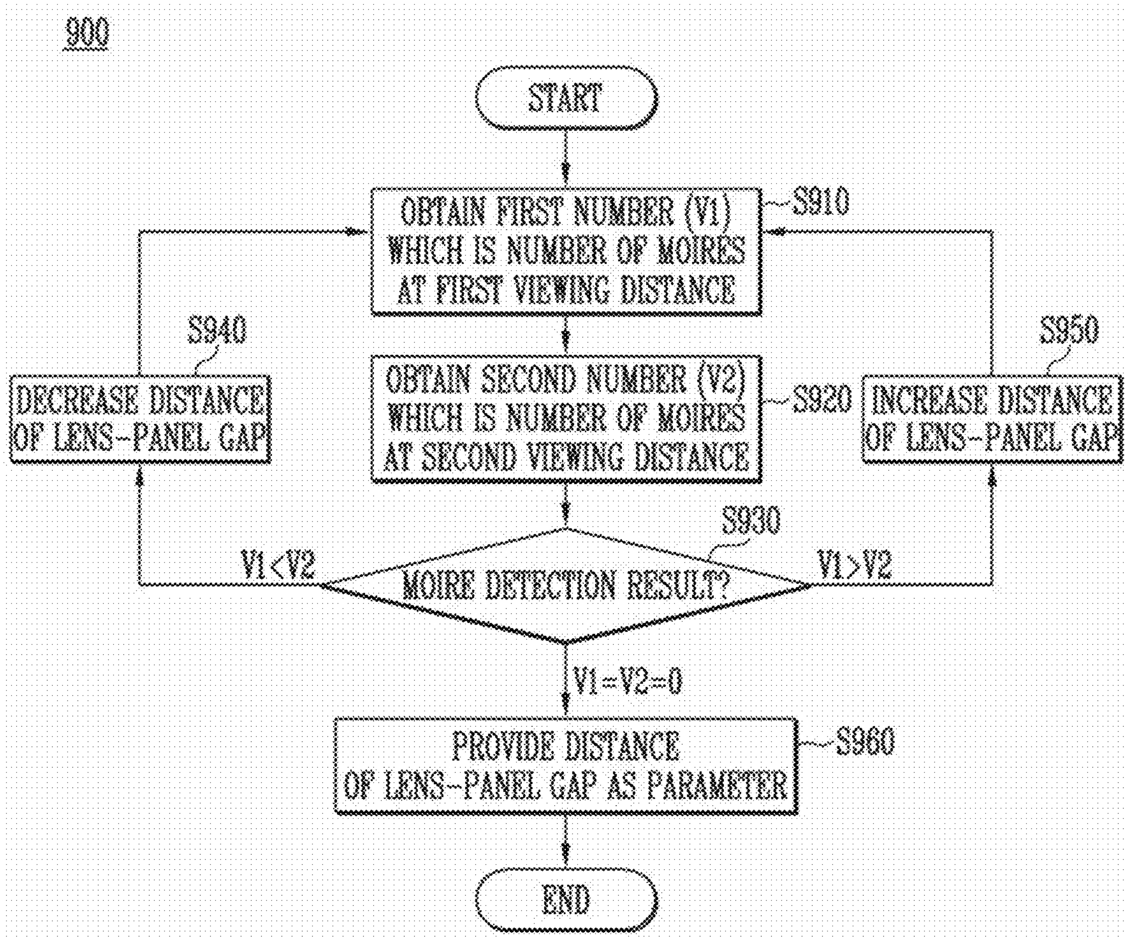

900
START
OBTAIN FIRST NUMBER (V1) WHICH IS NUMBER OF MOIRES AT FIRST VIEWING DISTANCE
S910
OBTAIN SECOND NUMBER (V2) WHICH IS NUMBER OF MOIRES AT SECOND VIEWING DISTANCE
S920
S940
DECREASE DISTANCE OF LENS-PANEL GAP
S950
INCREASE DISTANCE OF LENS-PANEL GAP
S930
MOIRE DETECTION RESULT?
V1<V2
V1>V2
V1=V2=0
PROVIDE DISTANCE OF LENS-PANEL GAP AS PARAMETER
S960
END

FIG. 10A

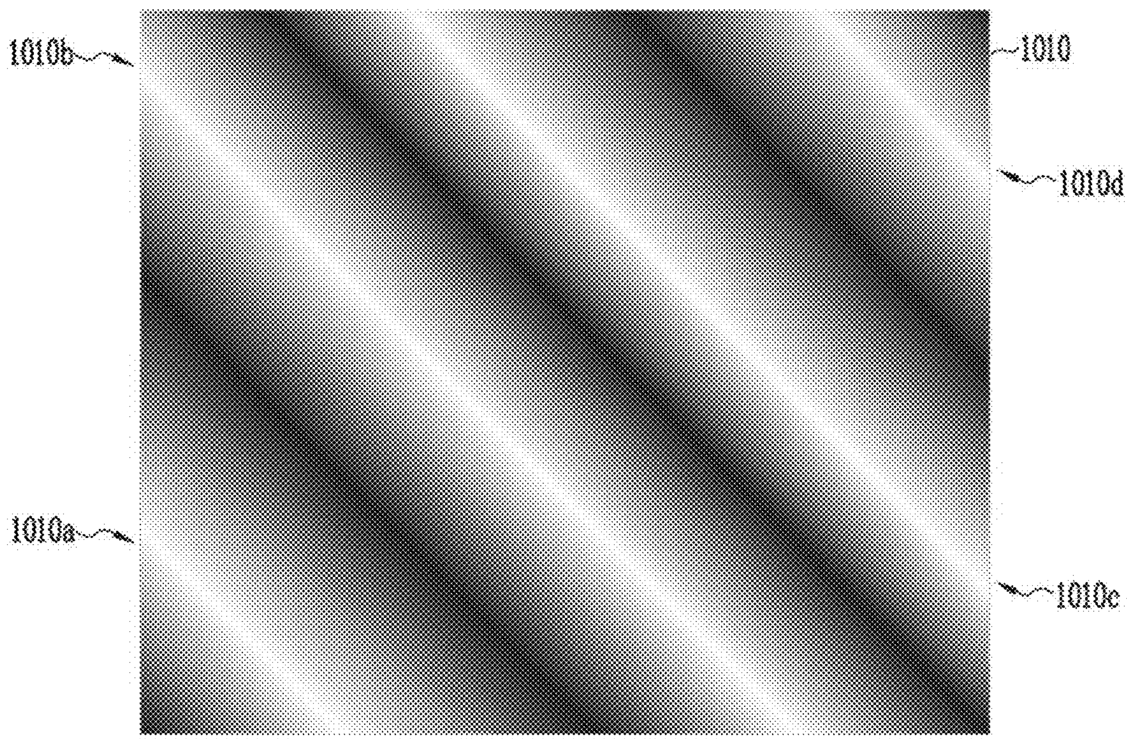


FIG. 10B

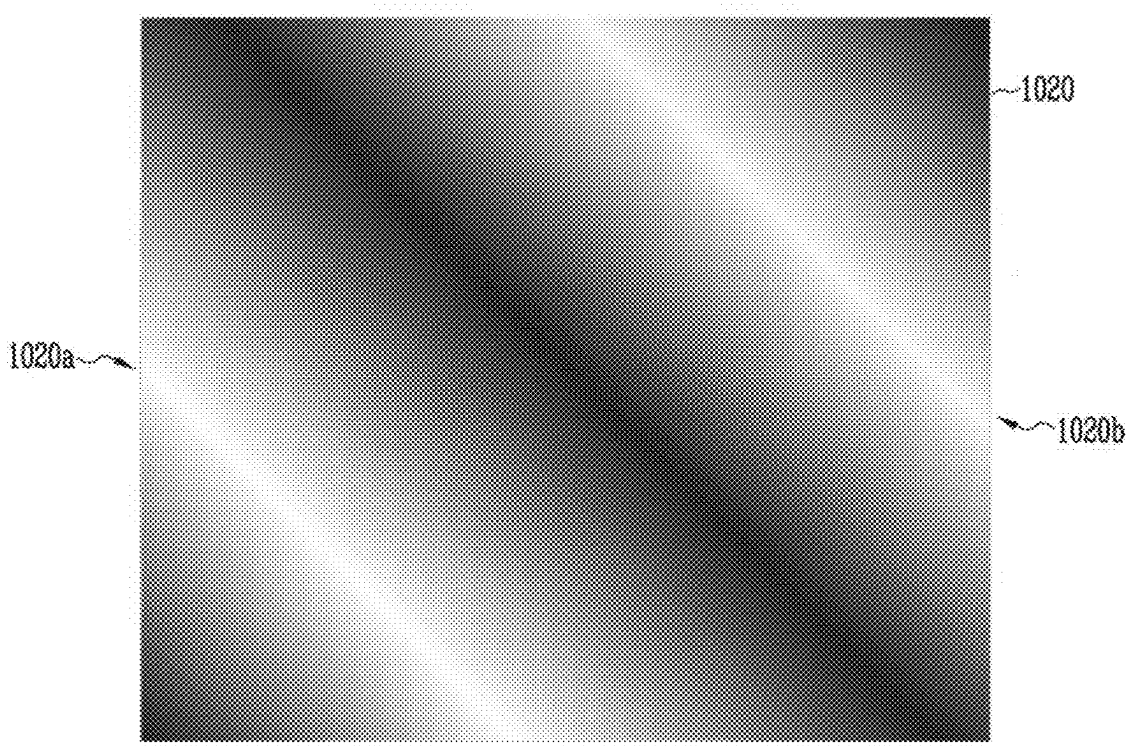


FIG. 11

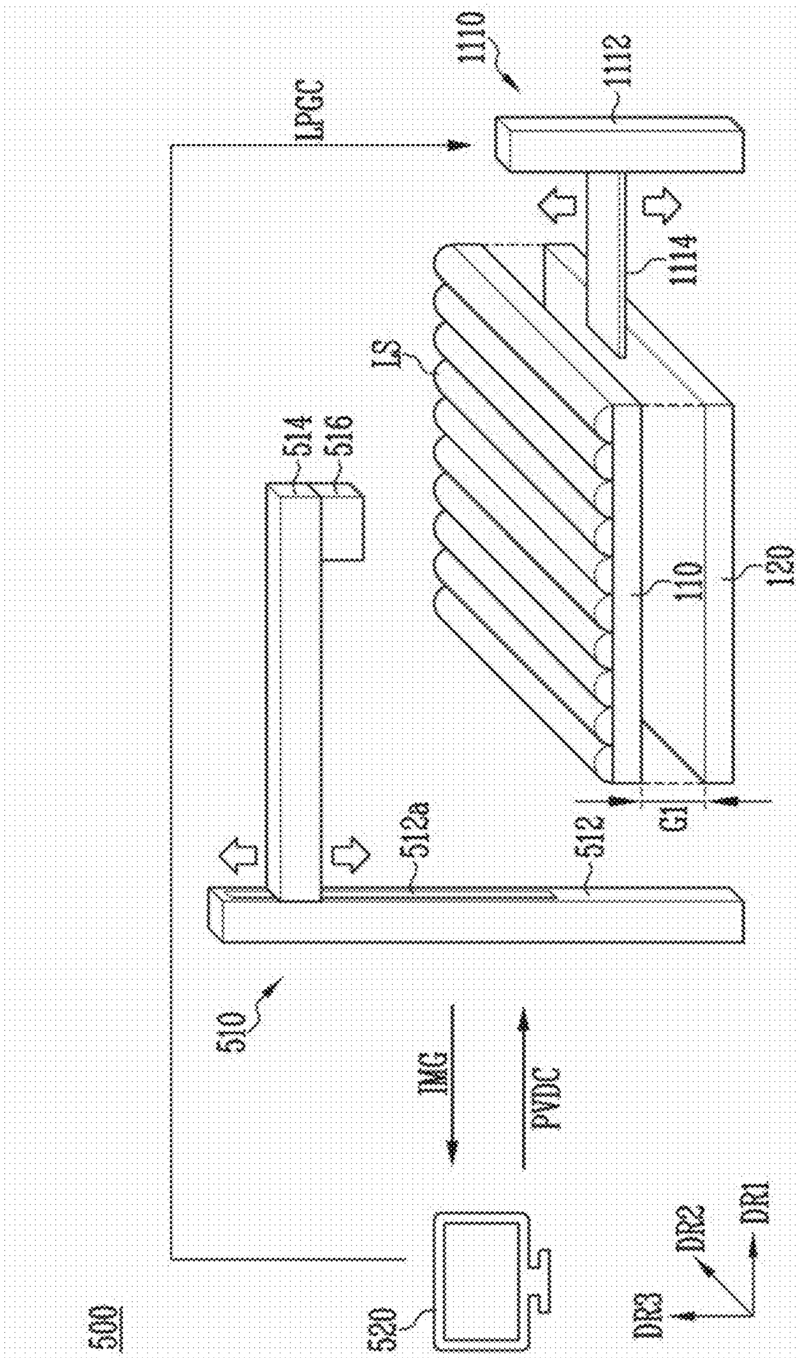

500
510
512
512a
514
516
520
IMG
PVDC
LPGC
LS
110
120
G1
1110
1112
1114
DR1
DR2
DR3

FIG. 12

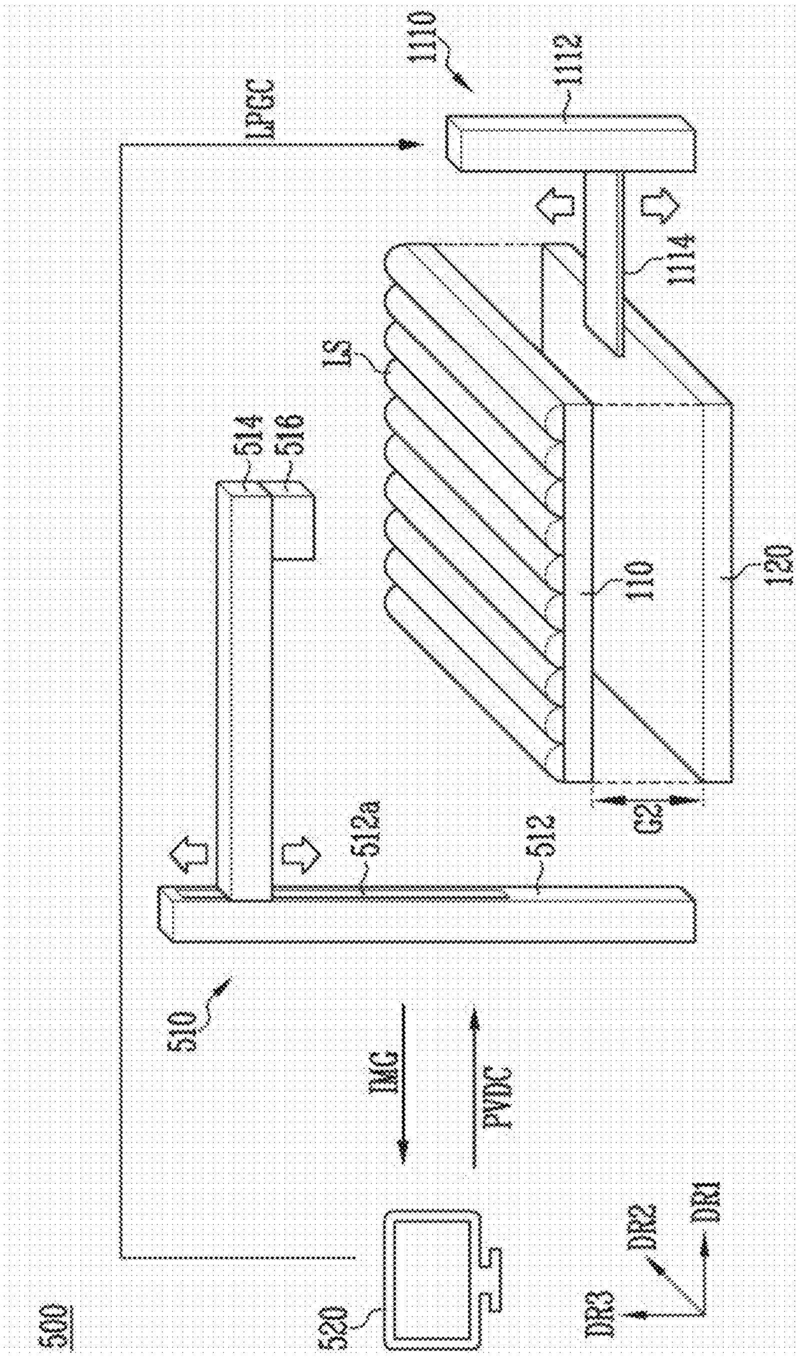

500
520
DR3
DR2
DR1
IMG
PVDC
510
512
512a
514
516
LPGC
1110
1112
1114
LS
110
120
G2

FIG. 13

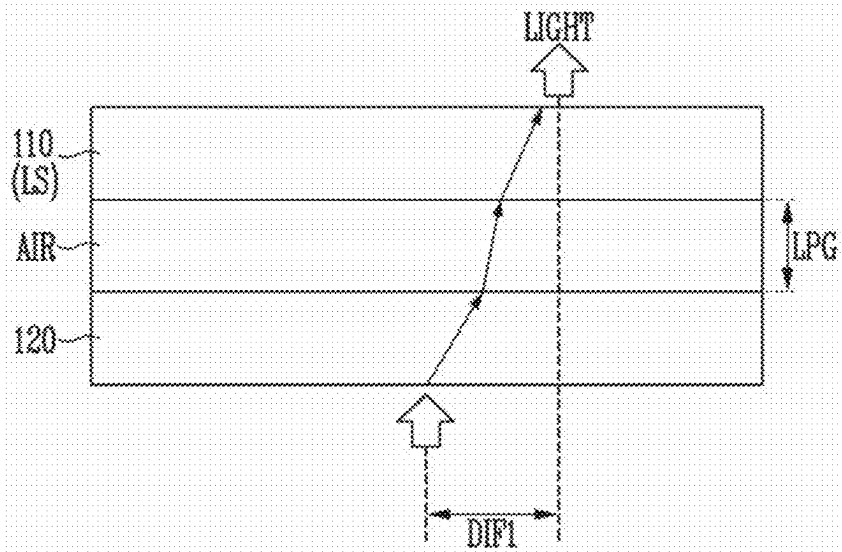


FIG. 14

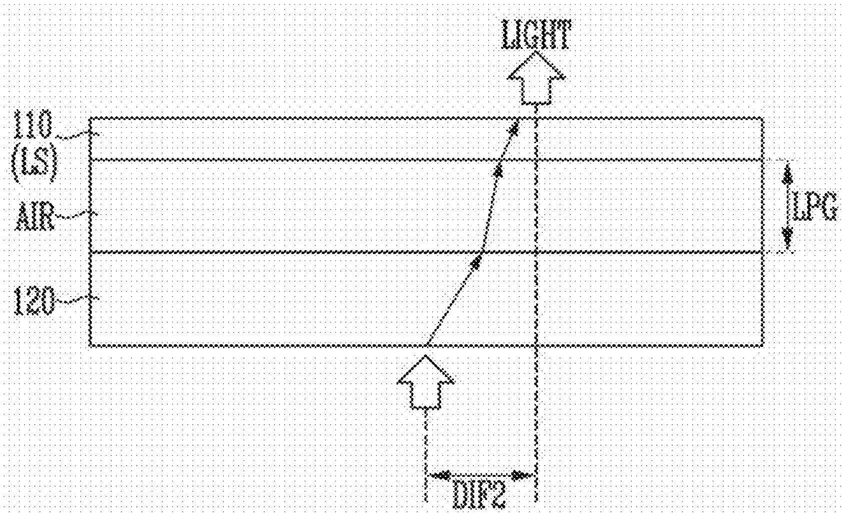
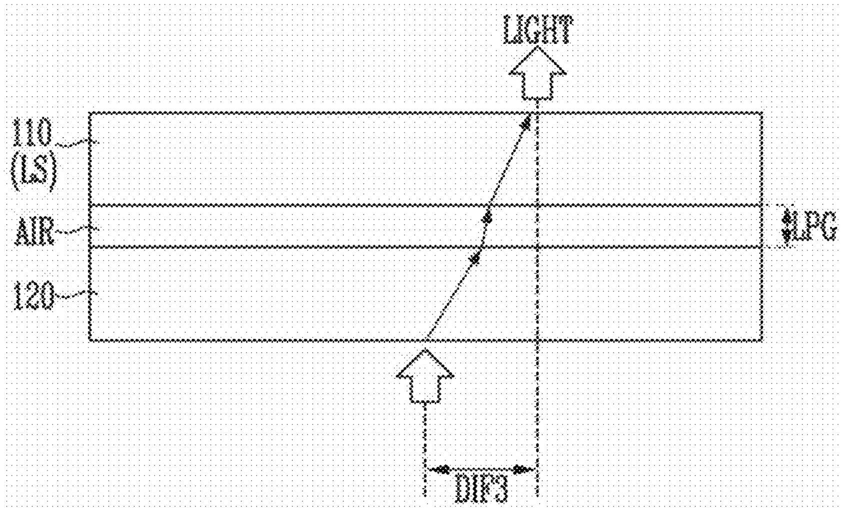


FIG. 15



PARAMETER DETERMINATION SYSTEM AND PARAMETER DETERMINATION METHOD THEREOF

[0001] This application claims priority under 35 U.S.C. § 119 to Korean Patent Application No. 10-2024-0020591, filed on Feb. 13, 2024 in the Korean Intellectual Property Office, the present disclosure of which is incorporated by reference in its entirety herein.

1. TECHNICAL FIELD

[0002] Embodiments of the present disclosure relate to a parameter determination system and a parameter determination method thereof.

2. DISCUSSION OF RELATED ART

[0003] A display device is an electronic device that serves as a connection medium providing images to a user. The importance of display devices has increased along with the development of information technology. For example, the usage of display devices such as a liquid crystal display device (LCD) and an organic light emitting display device is increasing.

[0004] The display device may provide a stereoscopic effect to the user by stimulating a viewer's visual sense identically, or similarly, to an actual object. An image that may provide the stereoscopic effect to the user may be referred to as a stereoscopic image (e.g., a 3D image).

[0005] The display device may provide a physical factor so that an image output from a flat display device is recognized as a stereoscopic image by the user. For example, the display device may provide different images to a left eye and a right eye of the user of the display device. The user may feel the stereoscopic effect of the image due to a binocular parallax between the left eye and the right eye.

[0006] Recently, research is being conducted with respect to a method in which the user may watch the stereoscopic image without wearing stereoscopic glasses (e.g., a glasses-free method). The glasses-free method includes a lenticular method in which images of a left eye and a right eye are separated using a cylindrical lens array, and a barrier method in which images of a left eye and a right eye are separated using a barrier.

SUMMARY

[0007] A technical object to be solved is to provide a parameter determination system and a parameter determination method thereof that may reduce or prevent recognition of moire.

[0008] According to an embodiment of the present disclosure, a parameter determination system includes an optical panel including a plurality of variable lenses. A display panel is positioned to overlap with the optical panel and is spaced apart from the optical panel by a lens-panel gap. The display panel includes a plurality of sub-pixels. A panel viewing distance controller adjusts a viewing distance between the optical panel and an imaging device capturing the optical panel. A controller outputs a signal for adjusting at least one of a size of a lens width of the plurality of variable lenses and a distance of the lens-panel gap, based on images of the optical panel captured by the imaging device at different viewing distances.

[0009] In an embodiment, the controller may output the signal so that a number of moires detected in the images is decreased.

[0010] In an embodiment, the optical panel may further include a base substrate supporting the plurality of variable lenses, a first magnet unit positioned inside the plurality of variable lenses, and a second magnet unit positioned on the base substrate.

[0011] In an embodiment, at least one of the first magnet unit and the second magnet unit may be an electromagnet, and the controller may output an electromagnet control signal for imparting magnetism to the at least one of the first magnet unit and the second magnet unit or removing magnetism from the at least one of the first magnet unit and the second magnet unit.

[0012] In an embodiment, a width of each of the plurality of variable lenses may be controlled based on the electromagnet control signal.

[0013] In an embodiment, the panel viewing distance controller may the imaging device comprising a camera, a first vertical support extending in a vertical direction from a ground, and a first horizontal support extending from the first vertical support in a horizontal direction on the optical panel, the camera is mounted on the first horizontal support. The first horizontal support may move in the vertical direction along the first vertical support.

[0014] In an embodiment, the first vertical support may further include a first rail guiding a movement of the first horizontal support in the vertical direction.

[0015] In an embodiment, the parameter determination system may further include a lens-panel gap controller controlling a distance of the lens-panel gap between the optical panel and the display panel.

[0016] In an embodiment, the lens-panel gap controller may include a second vertical support extending in a vertical direction from a ground, and a second horizontal support extending from the second vertical support in a horizontal direction. The display panel is attached to the second horizontal support. The second horizontal support may move in the vertical direction along the second vertical support.

[0017] In an embodiment, the second vertical support may further include a second rail guiding a movement of the second horizontal support in the vertical direction.

[0018] In an embodiment, the controller may compare a first number comprising a number of moires detected in an image captured at a first viewing distance with a second number comprising a number of moires detected in an image captured at a second viewing distance farther than the first viewing distance, and the controller outputs a signal for adjusting at least one of a size of the lens width and a distance of the lens-panel gap based on a comparison result of the first number with the second number.

[0019] In an embodiment, the controller may detect the number of moires in the image captured at the first viewing distance, and detect the number of moires in the image captured at the second viewing distance farther than the first viewing distance.

[0020] In an embodiment, when the first number is less than the second number, the controller may decrease the size of the lens width, and when the first number is greater than the second number, the controller may increase the size of the lens width.

[0021] In an embodiment, when the first number is less than the second number, the controller may decrease the distance of the lens-panel gap, and when the first number is greater than the second number, the controller may increase the distance of the lens-panel gap.

[0022] In an embodiment, the controller may provide at least one of a size of the lens width and a size of the lens-panel gap as a parameter when both of the first number and the second number are 0.

[0023] According to an embodiment of the present disclosure, a parameter determination method includes capturing an optical panel that includes a plurality of variable lenses at a first viewing distance by a camera of a panel viewing distance controller. The optical panel is spaced apart from a display panel by a lens-panel gap of a predetermined distance. A first number is obtained that is a number of moires in an image of the optical panel captured by the camera at the first viewing distance. The optical panel is captured by the camera at a second viewing distance that is less than the first viewing distance. A second number is obtained that is a number of moires in an image of the optical panel captured by the camera at the second viewing distance. A signal is output for adjusting at least one of a size of a lens width of the plurality of variable lenses and a distance of the lens-panel gap so that a number of moires is decreased based on a result of comparing the first number and the second number by a controller.

[0024] In an embodiment, when the first number is less than the second number, the controller may decrease the size of the lens width, and when the first number is greater than the second number, the controller may increase the size of the lens width.

[0025] In an embodiment, the controller may provide the size of the lens width as a parameter when both of the first number and the second number are 0.

[0026] In an embodiment, when the first number is less than the second number, the controller may decrease the distance of the lens-panel gap, and when the first number is greater than the second number, the controller may increase the distance of the lens-panel gap.

[0027] In an embodiment, the controller may provide the distance of the lens-panel gap as a parameter when both of the first number and the second number are 0.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] The above and other features of the present disclosure will become more apparent by describing in further detail non-limiting embodiments thereof with reference to the accompanying drawings, in which:

[0029] FIG. **1** is a conceptual diagram of a display device according to an embodiment of the present disclosure;

[0030] FIG. **2** is a diagram illustrating display of a stereoscopic image from a viewpoint by the display device of FIG. **1** according to an embodiment of the present disclosure;

[0031] FIG. **3** is a flowchart of a parameter determination method according to an embodiment of the present disclosure;

[0032] FIG. **4**A is an example of an image in which more moire is detected;

[0033] FIG. **4**B is an example of an image in which less moire is detected;

[0034] FIGS. **5** and **6** are parameter determination systems according to embodiments of the present disclosure;

[0035] FIGS. **7**A and **7**B are diagrams illustrating embodiments in which a width of a plurality of variable lenses are adjusted in an optical panel;

[0036] FIG. **8** is a diagram illustrating a controller transmitting an electromagnet control signal to the optical panel;

[0037] FIG. **9** is a flowchart of a parameter determination method according to an embodiment of the present disclosure;

[0038] FIG. **10**A is an example of an image in which more moire is detected;

[0039] FIG. **10**B is an example of an image in which less moire is detected;

[0040] FIGS. **11** and **12** are parameter determination systems according to embodiments of the present disclosure; and

[0041] FIGS. **13** to **15** are diagrams conceptually illustrating that an area from which light is emitted varies according to a lens-panel gap and a thickness of a lens according to embodiments of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0042] Hereinafter, various embodiments of the present disclosure will be described in detail with reference to the accompanying drawings so that those skilled in the art may easily carry out the present disclosure. Embodiments of the present disclosure may be implemented in various different forms and is not limited to embodiments described herein.

[0043] To clearly describe embodiments of the present disclosure, parts that are not related to the description may be omitted, and the same or similar elements are denoted by the same reference numerals throughout the specification. Therefore, the above-described reference numerals may be used in other drawings.

[0044] In addition, sizes and thicknesses of each component shown in the drawings may be arbitrarily shown for convenience of description, and thus embodiments of the present disclosure are not necessarily limited to those shown in the drawings. In the drawings, thicknesses may be exaggerated to clearly express various layers and areas.

[0045] In addition, an expression "is the same" in the description may mean "is substantially the same". Other expressions may also be expressions in which "substantially" is omitted.

[0046] Terms of "first", "second", and the like may be used to describe various components, but the components should not necessarily be limited by the terms. The terms may be used only for the purpose of distinguishing one component from another component. For example, without departing from the scope of embodiments of the present disclosure, a first component may be referred to as a second component, and similarly, a second component may also be referred to as a first component. The singular expressions include plural expressions unless the context clearly indicates otherwise.

[0047] Terms of "under", "below", "on", and "above" are used to describe an association of configurations shown in the drawings. The terms are described based on a direction indicated in the drawings as relative concepts.

[0048] Unless defined otherwise, all terms (including technical terms and scientific terms) used herein have the same meaning as a meaning generally understood by one of ordinary skill in the art to which embodiments of the present disclosure belongs. In addition, terms such as those defined in a generally used dictionary are to be interpreted as having a meaning consistent with a meaning in a context of the related art, unless explicitly defined herein, and should not be interpreted in an overly formal meaning.

[0049] It should be understood that a term of "include", "have", or the like is used to specify that there is a feature, a number, a step, an operation, a component, a part, or a combination thereof described in the specification, but does not exclude a possibility of the presence or addition of one or more other features, numbers, steps, operations, components, parts, or combinations thereof in advance.

[0050] Hereinafter, embodiments of the present disclosure are described in detail with reference to the accompanying drawings.

[0051] FIG. **1** is a conceptual diagram of a display device **100** according to an embodiment of the present disclosure.

[0052] The display device **100** according to an embodiment of the present disclosure may include an optical panel **110**, a display panel **120**, a back cover **130**, and the like.

[0053] The optical panel **110** may be configured to adjust an intensity and a direction of light emitted from the display panel **120**. In an embodiment, the optical panel **110** may include one or more lenses, and a user of the display device **100** may recognize an image emitted from the display panel **120** as a stereoscopic image.

[0054] The display panel **120** may include a display area DA and a non-display area NA positioned around the display area DA (for example, an edge area of the display area DA in the first and/or second directions DR**1**, DR**2**). The display area DA may extend in a first direction DR**1** and a second direction DR**2** that intersects the first direction DR**1**. The display panel **120** may include a plurality of sub-pixels SPX. Each of the plurality of sub-pixels SPX may emit light of a predetermined wavelength band. The plurality of sub-pixels SPX may be arranged in the display area DA. For example, the plurality of sub-pixels SPX arranged along the first direction DR**1** may form a pixel row. For example, the plurality of sub-pixels SPX arranged along the second direction DR**2** may form a pixel column.

[0055] The display panel **120** according to an embodiment of the present disclosure may generate light and include a light emitting layer configured to emit the generated light. For example, in an embodiment the light emitting layer may include an organic light emitting layer, a quantum dot light emitting layer, an inorganic light emitting layer, or the like. According to a type of the light emitting layer included in the display panel **120**, the display device **100** may be implemented as a self-emission display device, such as an organic light emitting display device, a quantum dot display device, or an inorganic light emitting display device.

[0056] The display panel **120** according to an embodiment of the present disclosure may not directly generate light and may be configured to selectively emit light incident from an outside. For example, the display device **100** according to an embodiment of the present disclosure may include a light source (e.g., a backlight unit or the like) external to the display panel **120**. For example, the display panel **120** may include a liquid crystal configured to adjust an amount of light emitted from the display panel **120**. The display panel **120** may adjust the amount of light emitted from the display panel **120** by adjusting a tilting angle or the like of the liquid crystal. In an embodiment in which the display panel **120** does not include a light emitting layer, the display device **100** may be implemented as a light receiving and emitting display device, such as a liquid crystal display.

[0057] Below, for convenience of description, the display panel **120** according to an embodiment of the present disclosure is described as a self-emission display device. However, embodiments of the present disclosure are not necessarily limited thereto.

[0058] The sub-pixel SPX may include a light emitting element and a pixel circuit for driving the light emitting element. For example, in an embodiment, the pixel circuit may include at least two transistors and at least one capacitor.

[0059] In an embodiment, the display panel **120** may include a substrate, a thin film transistor layer on which the pixel circuit is formed, and the light emitting element layer on which a light emitting element is positioned. In an embodiment, the substrate may include a glass substrate, an organic/inorganic composite material substrate, or the like. The substrate may support the thin film transistor layer and the light emitting element layer.

[0060] A panel driving circuit for supplying various signals and/or voltages for driving the sub-pixel SPX may be further connected to the display panel **120**. The panel driving circuit may be connected (e.g., electrically connected) to a pad unit provided in the non-display area of the display panel **120** to supply the signal, the voltage, and the like to the display panel **120**.

[0061] The back cover **130** may be positioned on a back surface of the display panel **120**. In an embodiment, the panel driving circuit connected to the display panel **120** may be received in the back cover **130**. According to an embodiment, at least a portion of the panel driving circuit may be bent to the back surface of the display panel **120** and the panel driving circuit may then be received in the back cover **130**. However, embodiments of the present disclosure are not necessarily limited thereto. For example, in an embodiment, the back cover **130** may be omitted.

[0062] FIG. **2** is a diagram illustrating display of a stereoscopic image from a viewpoint by the display device **100** of FIG. **1** according to an embodiment of the present disclosure.

[0063] In an embodiment, the display panel **120** may include a plurality of sub-pixels SPX**1**, SPX**2**, and SPX**3** that emit light to display an image. In an embodiment, each of the plurality of sub-pixels SPX**1**, SPX**2**, and SPX**3** may output one of light of a first wavelength band (e.g., a red wavelength band), light of a second wavelength band (e.g., a green wavelength band), and light of a third wavelength band (e.g., a blue wavelength band). The red wavelength band may be a wavelength band of approximately 630 nm (nanometer) to 750 nm. The green wavelength band may be a wavelength band of approximately 495 nm to 570 nm. The blue wavelength band may be a wavelength band of approximately 450 nm to 495 nm. However, embodiments of the present disclosure are not necessarily limited thereto and the wavelength bands of light emitted from the plurality of sub-pixels SPX**1**, SPX**2**, and SPX**3** may vary, and light of various colors for full-color implementation may be output. The plurality of sub-pixels SPX**1**, SPX**2**, and SPX**3** that emit light of different wavelength bands may configure one pixel.

[0064] The optical panel **110** may be disposed on the display panel **120** (e.g., in a third direction DR**3**) from the display panel **120**. For example, the display panel **120** may overlap with the optical panel **110** and be spaced apart from the optical panel **110** by a predetermined lens-panel gap LPG (e.g., in the third direction DR**3**). In an embodiment, the optical panel **110** may include a plurality of variable lenses LS configured to refract light incident from the plurality of sub-pixels SPX**1**, SPX**2**, and SPX**3**. The plurality of variable lenses LS may configure a lens array. In an embodiment, the lens array may be implemented as, for example, a lenticular lens array, a micro lens array, or the like. The plurality of variable lenses LS may be disposed to extend in the second direction DR**2** in the optical panel **110**.

[0065] The display device **100** (refer to FIG. **1**) according to an embodiment of the present disclosure may be implemented as a light field display device. The light field display is a three-dimensional (3D) display device implementing a stereoscopic image by forming a light field expressed as a vector distribution (e.g., intensity and direction) of light in a space using a flat display, such as the display panel **120**, and an optical element, such as the lens array of the optical panel **110**. The light field display is a display technology that is expected to be utilized variously through convergence with augmented reality (AR) technology or the like since the light field display allows a depth, a side surface, and the like of an object to be seen and enabling a more natural stereoscopic image.

[0066] A light field may be implemented in various methods. For example, in some embodiments, the light field may be formed in a method of creating the light field in a plurality of directions using a plurality of projectors, a method of controlling a direction of light using a diffraction grating, a method of adjusting a direction and an intensity (e.g., luminance) of light according to a combination of the plurality of sub-pixels SPX**1**, SPX**2**, and SPX**3** using two or more display panels, a method of controlling a direction of light using a pinhole or a barrier, a method of controlling a refraction direction of light through a lens array, or the like.

[0067] In an embodiment, as shown in FIG. **2**, the lens array type of display device **100** (refer to FIG. **1**) may display a stereoscopic image (e.g., a three-dimensional image) by forming the light field.

[0068] One or more sub-pixels SPX may be allocated to the variable lens LS of the optical panel **110**. Light emitted from the sub-pixel SPX may be refracted by the variable lens LS and may proceed in a specific direction, and thus the light field expressed by the intensity and the direction of the light may be formed. When a user of the display device looks at the display device (e.g., the display panel **120**) in the light field formed as described above, the user may feel a stereoscopic effect of the corresponding image.

[0069] Image information according to a viewer's viewpoint in the light field may be defined and processed in a voxel unit. A voxel may be understood as graphic information that defines a predetermined point (e.g., a pixel) in a three-dimensional space. A resolution of a two-dimensional image may be determined by the number (e.g., density) of pixels or sub-pixels SPX for the same area. For example, when the number of pixels or sub-pixels SPX increases with respect to the same area, the resolution may increase. For example, to display a high-resolution image, the display panel **120** with a high pixel density may be required. Similarly, as the number of voxels at the same viewpoint through the optical panel **110** increases, the resolution of the stereoscopic image may increase.

[0070] In the optical panel **110**, the plurality of variable lenses LS may extend in one direction (e.g., the second direction DR**2**). Accordingly, the user of the display device **100** (refer to FIG. **1**) at a viewpoint shown in FIG. **2** may feel the stereoscopic effect of the image.

[0071] In an embodiment, the user may view the optical panel **110** at various distances. Referring to FIG. **2**, a distance between the user and the optical panel **110** may be indicated as a panel viewing distance PVD. Even though the panel viewing distance PVD varies, it is desirable for the user to recognize a natural stereoscopic image. Therefore, it may be advantageous that moire (e.g., one or more moire patterns) is recognized as little as possible (e.g., minimally or not at all).

[0072] The number of moires recognized by the user may vary according to at least the following two parameters. First, the number of moires recognized by the user may be affected by the lens-panel gap LPG, which is a distance between the display panel **120** and the optical panel **110** (e.g., in the third direction DR**3**). Second, the number of moires recognized by the user may be affected by a width LW of the variable lens LS in the optical panel **110**.

[0073] Embodiments of the present disclosure may provide a parameter determination system and a parameter determination method thereof for providing a parameter value in which the recognition of moire is reduced or prevented at various panel viewing distances PVD.

[0074] FIG. **3** is an embodiment of a flowchart of a parameter determination method **300** according to an embodiment of the present disclosure.

[0075] Referring to FIG. **3**, the parameter determination method **300** according to an embodiment of the present disclosure may include obtaining the first number V**1**, which is the number of moires at a first viewing distance in block S**310**, obtaining the second number V**2**, which is the number of moires at a second viewing distance in block S**320**, determining a moire detection result in block S**330**, decreasing a size of a lens width in block S**340**, increasing the size of the lens width in block S**350**, and providing (e.g., outputting) the size of the lens width as a parameter in block S**360**.

[0076] In an embodiment, in obtaining the first number V**1**, which is the number of moires at the first viewing distance in block S**310**, the panel viewing distance PVD (refer to FIG. **2**) may be the first viewing distance. The first number V**1** may be an integer greater than or equal to 0.

[0077] In obtaining the second number V**2**, which is the number of moires at the second viewing distance in block S**320**, the panel viewing distance PVD (refer to FIG. **2**) may be the second viewing distance. In an embodiment, the second viewing distance may be farther than the first viewing distance. The second number V**2** may be an integer greater than or equal to 0.

[0078] In determining the moire detection result in block S**330**, the first number V**1** and the second number V**2** may be compared to each other.

[0079] As a result of the comparison, when the first number V**1** is less than the second number V**2**, decreasing the size of the lens width in block S**340** may be performed. After decreasing the size of the lens width (e.g., decreasing by a predetermined size), obtaining the first number V**1**, which is the number of moires at the first viewing distance in block S**310**, may be performed again.

[0080] As a result of the comparison, when the first number V**1** is greater than the second number V**2**, increasing the size of the lens width in block S**350** may be performed. After increasing the size of lens width (e.g., increasing by a predetermined size), obtaining the first number V**1**, which is the number of moires at the first viewing distance in block **S310**, may be performed again.

[0081] As a result of the comparison, when the first number V**1** and the second number V**2** are the same, providing the size of the lens width as the parameter in block S**360** may be performed. In the above step, both of the first number V**1** and the second number V**2** may be the same as 0.

[0082] According to the parameter determination method **300** according to an embodiment of the present disclosure, a parameter for the size of the lens width may be provided.

[0083] FIG. **4**A is an example of an image **410** in which more moire is detected. FIG. **4**B is an example of an image **420** in which less moire is detected.

[0084] When moire occurs, a wave pattern may be observed in an image. The number of valleys or ridges of the wave pattern appearing in an image may correspond to the number of moires detected in the image.

[0085] Referring to FIG. **4**A, four moires **410***a*, **410***b*, **410***c*, and **410***d* are detected in the image **410**.

[0086] Referring to FIG. **4**B, two moires **420***a* and **420***b* are detected in the image **420**.

[0087] Referring to FIG. **3** described above, when the image **410** of FIG. **4**A corresponds to an image captured at the first viewing distance and the image **420** of FIG. **4**B corresponds to an image captured at the second viewing distance, the first number V**1** is four, and the second number V**2** is two. In the above case, since the first number V**1** is greater than the second number V**2**, increasing the size of the lens width in block S**350** may be performed.

[0088] In contrast, when the image **420** of FIG. **4**B corresponds to an image captured at the first viewing distance and the image **410** of FIG. **4**A corresponds to an image captured at the second viewing distance, the first number V**1** is two, and the second number V**2** is four. In the above case, since the first number V**1** is less than the second number V**2**, decreasing the size of the lens width in block S**340** may be performed.

[0089] FIGS. **5** and **6** are a parameter determination system **500** according to embodiments of the present disclosure.

[0090] Referring to FIGS. **5** and **6**, the parameter determination system **500** according to embodiments of the present disclosure may include an optical panel **110**, a display panel **120**, a panel viewing distance controller **510**, and a controller **520**.

[0091] The optical panel **110** may include a plurality of variable lenses LS. Each of the plurality of variable lenses LS may have a predetermined lens width. Referring to FIG. **5**, a size of the lens width may be a first size W**1**. Referring to FIG. **6**, a size of the lens width may be a second size W**2** which may be greater than the first size W**1**. In embodiments shown in FIGS. **5**-**6**, the plurality of variable lenses LS extend longitudinally in the second direction DR**2**. However, embodiments of the present disclosure are not necessarily limited thereto.

[0092] The display panel **120** may be disposed to be spaced apart from the optical panel **110** in the third direction DR**3**. Light emitted from the display panel **120** may be refracted through the optical panel **110** and emitted to the outside.

[0093] The panel viewing distance controller **510** is configured to capture (e.g., image) the optical panel **110** on the display panel **120**. In an embodiment, the panel viewing distance controller **510** may include a first vertical support **512**, a first horizontal support **514**, and a camera **516** (e.g., an imaging device).

[0094] The first vertical support **512** may be disposed to extend in the third direction DR**3** from a ground. For example, the third direction DR**3** may be a direction perpendicular to the ground. In an embodiment, the first vertical support **512** may be positioned adjacent to the display panel **120** and the optical panel **110** in one direction (e.g., the first direction DR**1**).

[0095] In an embodiment, the first horizontal support **514** may extend longitudinally from the first vertical support **512** in one direction (e.g., a horizontal direction, such as the first direction DR**1**). The first horizontal support **514** may move in a vertical direction (e.g., the third direction DR**3** and a direction opposite thereto) along the first vertical support **512**. In an embodiment, the first vertical support **512** may include a first rail **512***a* configured to guide a movement of the first horizontal support **514** in the vertical direction (e.g., the third direction DR**3**).

[0096] The camera **516** (e.g., an imaging device) may be mounted on the first horizontal support **514**. The camera **516** may capture (e.g., image) the optical panel **110**. For example, the camera **516** may capture the image from the light emitted from the display panel **120** and refracted through the optical panel **110**. An image IMG captured by the camera **516** photographing the optical panel **110** may be transmitted to the controller **520**.

[0097] In an embodiment, the controller **520** may output a panel viewing distance control signal PVDC for controlling a vertical direction movement (e.g., movement in the third direction DR**3**) of the first horizontal support **514**. The first horizontal support **514** may move to a position corresponding to the panel viewing distance control signal PVDC in response to the panel viewing distance control signal PVDC. The controller **520** may receive the image IMG from the camera **516**.

[0098] In an embodiment, the controller **520** may receive at least four images IMG from the camera **516**.

[0099] The controller **520** may receive an image captured by the camera **516** at the first viewing distance when the size of the lens width is a first size W**1**.

[0100] The controller **520** may receive an image captured by the camera **516** at the second viewing distance when the size of the lens width is the first size W**1**.

[0101] The controller **520** may receive an image captured by the camera **516** at the first viewing distance when the size of the lens width is a second size W**2**.

[0102] The controller **520** may receive an image captured by the camera **516** at the second viewing distance when the size of the lens width is the second size W**2**.

[0103] The controller **520** may determine the size of the lens width at which the number of moire is decreased based on comparing the number of moires in the obtained images IMG.

[0104] FIGS. **7**A and **7**B are diagrams illustrating an embodiment in which the width of the plurality of variable lenses LS is adjusted in the optical panel **110**.

[0105] Referring to FIG. **7**A, the optical panel **110** may include the plurality of variable lenses LS and a base substrate BS supporting the plurality of variable lenses LS.

[0106] In an embodiment, the base substrate BS may be a light-transmissive (e.g., a transparent) substrate. The base substrate BS may be a rigid substrate or a flexible substrate.

The base substrate BS may include plastic or glass. However, embodiments of the present disclosure are not necessarily limited thereto.

[0107] In an embodiment, the plurality of variable lenses LS may include a light-transmissive (e.g., transparent) fluid, such as a light-transmissive liquid. For example, the plurality of variable lenses LS may include resin RSN. For example, the resin RSN may be in an uncured liquid state. However, embodiments of the present disclosure are not necessarily limited thereto.

[0108] In an embodiment, the optical panel **110** may further include an electromagnet unit **700**. For example, the electromagnet unit **700** may include a first magnet unit **710** and a second magnet unit **720**. The first magnet unit **710** is positioned on the base substrate BS, and the second magnet unit **720** is positioned inside the plurality of variable lenses LS.

[0109] At least one of the first magnet unit **710** and the second magnet unit **720** may be implemented as an electromagnet.

[0110] In an embodiment, both of the first magnet unit **710** and the second magnet unit **720** may be implemented as electromagnets, and the polarities of the electromagnets may be different from each other. In an embodiment, one of the first magnet unit **710** and the second magnet unit **720** may be implemented as a permanent magnet, and the other may be implemented as an electromagnet. In an embodiment, one of the first magnet unit **710** and the second magnet unit **720** may be implemented as an electromagnet, and the other may be implemented as a metal attached to a magnet. For example, in an embodiment, the metal may be iron (Fe), nickel (Ni), cobalt (Co), or the like. However, embodiments of the present disclosure are not necessarily limited thereto.

[0111] In an embodiment, by electrically controlling the electromagnet unit **700**, the first magnet unit **710** and the second magnet unit **720** may be attached to each other or separated from each other. Accordingly, the width of the variable lens LS may be adaptively controlled.

[0112] Referring to FIG. **7**A, a case where the first magnet unit **710** and the second magnet unit **720** are separated from each other is shown. In the above case, the size of the lens width of the variable lens LS may be relatively large.

[0113] Referring to FIG. **7**B, a case where the first magnet unit **710** and the second magnet unit **720** are attached to each other (e.g., in direct contact with each other) is shown. In the above case, the size of the lens width of the variable lens LS may be relatively small.

[0114] Referring to FIGS. **7**A and **7**B, an embodiment in which one electromagnet unit **700** is disposed in correspondence with each of the plurality of variable lenses LS is shown. However, embodiments of the present disclosure are not necessarily limited thereto. For example, in some embodiments, two or more electromagnet units **700** may be disposed in correspondence with one variable lens LS.

[0115] FIG. **8** is a diagram illustrating the controller **520** transmitting an electromagnet control signal to the optical panel **110**.

[0116] Referring to FIG. **8**, the controller **520** according to an embodiment of the present disclosure may output an electromagnet control signal ECS. The optical panel **110** may provide a voltage to an internal electromagnet based on the electromagnet control signal ECS to impart magnetism or remove magnetism to the internal electromagnet.

[0117] FIG. **9** is a flowchart of a parameter determination method **900** according to an embodiment of the present disclosure.

[0118] Referring to FIG. **9**, the parameter determination method **900** according to an embodiment of the present disclosure may include obtaining the first number V**1**, which is the number of moires at a first viewing distance in block S**910**, obtaining the second number V**2**, which is the number of moires at a second viewing distance in block S**920**, determining a moire detection result in block S**930**, decreasing a distance of the lens-panel gap in block S**940**, increasing the distance of the lens-panel gap in block S**950**, and providing the distance of the lens-panel gap as a parameter in block S**960**.

[0119] In an embodiment, in obtaining the first number V**1**, which is the number of moires at the first viewing distance in block S**910**, the panel viewing distance PVD (refer to FIG. **2**) may be the first viewing distance. The first number V**1** may be an integer greater than or equal to 0.

[0120] In obtaining the second number V**2**, which is the number of moires at the second viewing distance in block S**920**, the panel viewing distance PVD (refer to FIG. **2**) may be the second viewing distance. In an embodiment, the second viewing distance may be greater than the first viewing distance. The second number V**2** may be an integer greater than or equal to 0.

[0121] In determining the moire detection result in block S**930**, the first number V**1** and the second number V**2** may be compared to each other.

[0122] As a result of the comparison, when the first number V**1** is less than the second number V**2**, decreasing the distance of the lens-panel gap in block S**940** may be performed. After decreasing the distance of the lens-panel gap (e.g., decreasing by a predetermined distance), obtaining the first number V**1**, which is the number of moires at the first viewing distance in block S**910**, may be performed again.

[0123] As a result of the comparison, when the first number V**1** is greater than the second number V**2**, increasing the distance of the lens-panel gap in block S**950** may be performed. After increasing the distance of the lens-panel gap (e.g., increasing by a predetermined distance), obtaining the first number V**1**, which is the number of moires at the first viewing distance in block S**910**, may be performed again.

[0124] As a result of the comparison, when the first number V**1** and the second number V**2** are the same, providing the distance of the lens-panel gap as the parameter in block S**960** may be performed. In the above step, both of the first number V**1** and the second number V**2** may be 0.

[0125] In the parameter determination method **900** according to an embodiment of the present disclosure, a parameter for the distance of the lens-panel gap may be provided.

[0126] FIG. **10**A is an example of an image in which more moire is detected. FIG. **10**B is an example of an image in which less moire is detected.

[0127] Referring to FIG. **10**A, four moires **1010***a*, **1010***b*, **1010***c*, and **1010***d* are detected in the image **1010**.

[0128] Referring to FIG. **10**B, two moires **1020***a* and **1020***b* are detected in the image **1020**.

[0129] Referring to FIG. **9** described above, when the image **1010** of FIG. **10**A corresponds to an image captured at the first viewing distance and the image **1020** of FIG. **10**B corresponds to an image captured at the second viewing distance, the first number V**1** is four, and the second number V**2** is two. In the above case, since the first number V**1** is greater than the second number V**2**, increasing the distance of the lens-panel gap in block S**950** may be performed.

[0130] In contrast, when the image **1020** of FIG. **10**B corresponds to an image captured at the first viewing distance and the image **1010** of FIG. **10**A corresponds to an image captured at the second viewing distance, the first number V**1** is two, and the second number V**2** is four. In the above case, since the first number V**1** is less than the second number V**2**, decreasing the distance of the lens-panel gap in block S**940** may be performed.

[0131] FIGS. **11** and **12** are a parameter determination system **500** according to embodiments of the present disclosure.

[0132] Referring to FIGS. **11** and **12**, the parameter determination system **500** according to embodiments of the present disclosure may include an optical panel **110**, a display panel **120**, a panel viewing distance controller **510**, a controller **520**, and a lens-panel gap controller **1110**.

[0133] A description of the optical panel **110**, the display panel **120**, and the panel viewing distance controller **510** are the same as that described above with reference to FIGS. **5** and **6**, and thus a description thereof is omitted for economy of description.

[0134] The lens-panel gap controller **1110** may be configured to adjust the lens-panel gap LPG (refer to FIG. **2**) between the optical panel **110** and the display panel **120**. In an embodiment, the lens-panel gap controller **1110** may include a second vertical support **1112** and a second horizontal support **1114**.

[0135] In an embodiment, the second vertical support **1112** may be positioned adjacent to the optical panel **110** and/or the display panel **120** in one direction (e.g., the first direction DR**1**). However, embodiments of the present disclosure are not necessarily limited thereto. The second vertical support **1112** may extend in one direction (e.g., the third direction DR**3**) from the ground.

[0136] The second horizontal support **1114** may be connected to the second vertical support **1112** and may move in a vertical direction (e.g., the third direction DR**3**). The second horizontal support **1114** may be attached to at least one of the optical panel **110** and the display panel **120** to increase or decrease the lens-panel gap between the optical panel **110** and the display panel **120**. For example, as shown in an embodiment of FIG. **11**, the second horizontal support **1114** may be attached to (e.g., directly attached thereto) the display panel **120** to increase or decrease a distance between the optical panel **110** and the display panel **120**. The second horizontal support **1114** may increase or decrease the distance between the optical panel **110** and the display panel **120** in response to a lens-panel gap control signal LPGC.

[0137] In an embodiment, the second vertical support **1112** may further include a second rail configured to guide a movement of the second horizontal support **1114** in the vertical direction (e.g., in the third direction DR**3**).

[0138] The controller **520** may output the lens-panel gap control signal LPGC for controlling a movement of the second horizontal support **1114** in the vertical direction. The second horizontal support **1114** may move to a position corresponding to the lens-panel gap control signal LPGC in response to the lens-panel gap control signal LPGC. The controller **520** may receive an image IMG from the camera **516**.

[0139] In an embodiment, the controller **520** may receive at least four images IMG from the camera **516**.

[0140] The controller **520** may receive an image captured by the camera **516** at the first viewing distance when the distance of the lens-panel gap is a first distance G**1**.

[0141] The controller **520** may receive an image captured by the camera **516** at the second viewing distance when the lens-panel gap distance is the first distance G**1**.

[0142] The controller **520** may receive an image captured by the camera **516** at the first viewing distance when the lens-panel gap distance is a second distance G**2**. The second distance G**2** may be different from the first distance G**1**. For example, in an embodiment the second distance G**2** may be greater than the first distance G**1**.

[0143] The controller **520** may receive an image captured by the camera **516** at the second viewing distance when the distance of the lens-panel gap is the second distance G**2**.

[0144] The controller **520** may determine the distance of the lens-panel gap at which the number of moire is decreased based on the obtained images IMG.

[0145] FIGS. **13** to **15** are diagrams conceptually describing that an area from which light is emitted varies according to a lens-panel gap and a thickness of a lens in embodiments of the present disclosure.

[0146] Referring to FIGS. **13** to **15**, in an embodiment light may be emitted by passing through the display panel **120**, an air layer AIR, and the optical panel **110**. The display panel **120** may correspond to an area on a light emitting element. The optical panel **110** may correspond to a thickness of the variable lens LS. The air layer AIR may correspond to the distance of the lens-panel gap LPG.

[0147] Referring further to FIGS. **7**A and **7**B described above, a decrease in the thickness of the variable lens LS may correspond to a decrease in the width of the variable lens LS. An increase in the thickness of the variable lens LS may correspond to an increase in the width of the variable lens LS.

[0148] Comparing FIGS. **13** and **14**, when a thickness of the optical panel **110** decreases (e.g., the thickness of the variable lens LS decreases), a difference between an area where light is incident and an area where light is emitted may decrease from a first difference DIF**1** to a second difference DIF**2**.

[0149] Comparing FIGS. **13** and **15**, when the distance of the lens-panel gap LPG decreases (e.g., a thickness of the air layer AIR decreases), the difference between the area where light is incident and the area where light is emitted may decrease from the first difference DIF**1** to a third difference DIF**3**.

[0150] Accordingly, a parameter that may alleviate or eliminate a phenomenon in which moire is recognized to the user may be provided by adaptively varying the difference between the area where light is incident and the area where light is emitted according to a position. The above-described parameter may be the lens width of the variable lens LS. The above-described parameter may be a lens-panel gap LPG corresponding to the distance between the optical panel **110** and the display panel **120**.

[0151] According to the parameter determination system and the parameter determination method of the parameter determination system according to embodiments of the present disclosure, a parameter that may alleviate or prevent moire from being recognized may be provided.

[0152] The drawings referred to so far and the detailed description of non- limiting embodiments of the present disclosure described herein are merely examples of embodiments the present disclosure, are used for merely describing the present disclosure, and are not intended to limit the meaning and the scope of the present disclosure. Therefore, those skilled in the art will understand that various modifications and equivalents are possible from the described embodiments.

What is claimed is:

1. A parameter determination system comprising:

an optical panel including a plurality of variable lenses;

a display panel positioned to overlap with the optical panel and spaced apart from the optical panel by a lens-panel gap, the display panel including a plurality of sub-pixels;

a panel viewing distance controller adjusting a viewing distance between the optical panel and an imaging device capturing the optical panel; and

a controller outputting a signal for adjusting at least one of a size of a lens width of the plurality of variable lenses and a distance of the lens-panel gap, based on images of the optical panel captured by the imaging device at different viewing distances.

2. The parameter determination system according to claim **1**, wherein the controller outputs the signal so that a number of moires detected in the images is decreased.

3. The parameter determination system according to claim **1**, wherein the optical panel further comprises:

a base substrate supporting the plurality of variable lenses;

a first magnet unit positioned inside the plurality of variable lenses; and

a second magnet unit positioned on the base substrate.

4. The parameter determination system according to claim **3**, wherein:

at least one of the first magnet unit and the second magnet unit is an electromagnet; and

the controller outputs an electromagnet control signal for imparting magnetism to the at least one of the first magnet unit and the second magnet unit or removing magnetism from the at least one of the first magnet unit and the second magnet unit.

5. The parameter determination system according to claim **4**, wherein a width of each of the plurality of variable lenses is controlled based on the electromagnet control signal.

6. The parameter determination system according to claim **1**, wherein the panel viewing distance controller comprises:

the imaging device comprising a camera;

a first vertical support extending in a vertical direction from a ground; and

a first horizontal support extending from the first vertical support in a horizontal direction on the optical panel, the camera is mounted on the first horizontal support,

wherein the first horizontal support moves in the vertical direction along the first vertical support.

7. The parameter determination system according to claim **6**, wherein the first vertical support further comprises a first rail guiding movement of the first horizontal support in the vertical direction.

8. The parameter determination system according to claim **1**, further comprising:

a lens-panel gap controller controlling a distance of the lens-panel gap between the optical panel and the display panel.

9. The parameter determination system according to claim **8**, wherein the lens-panel gap controller comprises:

a second vertical support extending in a vertical direction from a ground;

a second horizontal support extending from the second vertical support in a horizontal direction, the display panel is attached to the second horizontal support, and

wherein the second horizontal support moves in the vertical direction along the second vertical support.

10. The parameter determination system according to claim **9**, wherein the second vertical support further comprises a second rail guiding movement of the second horizontal support in the vertical direction.

11. The parameter determination system according to claim **1**, wherein:

the controller compares a first number comprising a number of moires detected in an image captured at a first viewing distance with a second number comprising a number of moires detected in an image captured at a second viewing distance farther than the first viewing distance; and

the controller outputs a signal for adjusting at least one of a size of the lens width and a distance of the lens-panel gap based on a comparison result of the first number with the second number.

12. The parameter determination system according to claim **11**, wherein the controller detects the number of moires in the image captured at the first viewing distance, and detects the number of moires in the image captured at the second viewing distance farther than the first viewing distance.

13. The parameter determination system according to claim **12**, wherein when the first number is less than the second number, the controller decreases the size of the lens width, and when the first number is greater than the second number, the controller increases the size of the lens width.

14. The parameter determination system according to claim **13**, wherein the controller provides at least one of a size of the lens width and a size of the lens-panel gap as a parameter when both the first number and the second number are 0.

15. The parameter determination system according to claim **12**, wherein when the first number is less than the second number, the controller decreases the distance of the lens-panel gap, and when the first number is greater than the second number, the controller increases the distance of the lens-panel gap.

16. A parameter determination method comprising:

capturing an optical panel that includes a plurality of variable lenses at a first viewing distance by a camera of a panel viewing distance controller, wherein the optical panel is spaced apart from a display panel by a lens-panel gap of a predetermined distance;

obtaining a first number that is a number of moires in an image of the optical panel captured by the camera at the first viewing distance;

capturing the optical panel by the camera at a second viewing distance that is less than the first viewing distance;

obtaining a second number that is a number of moires in an image of the optical panel captured by the camera at the second viewing distance; and

outputting a signal for adjusting at least one of a size of a lens width of the plurality of variable lenses and a distance of the lens-panel gap so that a number of moires is decreased based on a result of comparing the first number and the second number by a controller.

17. The parameter determination method according to claim **16**, wherein:

when the first number is less than the second number, the controller decreases the size of the lens width; and

when the first number is greater than the second number, the controller increases the size of the lens width.

18. The parameter determination method according to claim **17**, wherein the controller provides the size of the lens width as a parameter when both the first number and the second number are 0.

19. The parameter determination method according to claim **16**, wherein:

when the first number is less than the second number, the controller decreases the distance of the lens-panel gap; and

when the first number is greater than the second number, the controller increases the distance of the lens-panel gap.

20. The parameter determination method according to claim **19**, wherein the controller provides the distance of the lens-panel gap as a parameter when both of the first number and the second number are 0.

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