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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 August 2020 (27.08.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/169088 A1

(51) International Patent Classification:
G02B 27/28 (2006.01) *G02B 27/01* (2006.01)

(21) International Application Number:
PCT/CN2020/076262

(22) International Filing Date:
21 February 2020 (21.02.2020)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/808,408 21 February 2019 (21.02.2019) US

(71) Applicants: **UNIVERSITY OF CENTRAL FLORIDA RESEARCH FOUNDATION, INC.** [US/US]; University of Central Florida, 4000 Central Florida Blvd, Orlando, FL 32816 (US). **GOERTEK INC.** [CN/CN]; No. 268 Dongfang Road, Hi-Tech Industry District, Weifang, Shandong 261031 (CN).

(72) Inventors: **ZHAN, Tao**; College of Optics and Photonics, UCF, Orlando, FL 32816 (US). **XIONG, Jianghao**; College of Optics and Photonics, UCF, Orlando, FL 32816 (US). **TAN, Guanjun**; College of Optics and Photonics, UCF, Orlando, FL 32816 (US). **LEE, Yun-Han**; College of Optics and Photonics, UCF, Orlando, FL 32816 (US). **WU, Shin-Tson**; College of Optics and Photonics, UCF, Orlando, FL 32816 (US). **LIU, Sheng**; 5451 Great America Parkway, Suite 301, Santa Clara, CA 95054 (US). **YANG, Jilin**; 5451 Great America Parkway, Suite 301, Santa Clara, CA 95054 (US).

(74) Agent: **BEYOND TALENT PATENT AGENT FIRM**; Room 1201, Kuntai Building, #10 Chaoyangmenwai Str. Chaoyang District, Beijing 100020 (CN).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,

(54) Title: DISPLAY DEVICE AND ELECTRONIC APPARATUS

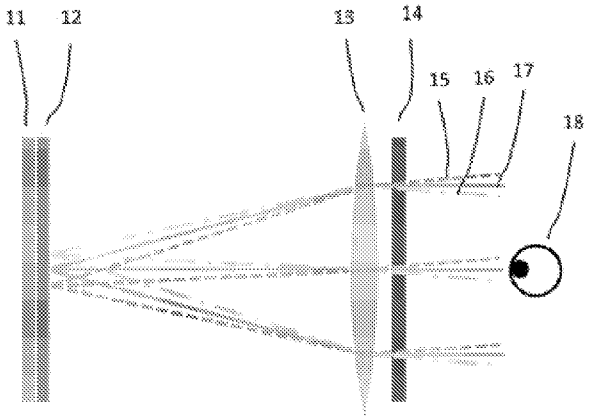


FIG. 1

(57) Abstract: An electronic apparatus (50) comprises a display device (51). The display device (51) comprises an image-display component (11, 12) and a polarization dependent image offset component (14). The image-display component (11, 12) generates an image light output, wherein at least one pixel light of the image light output has light polarization components of at least two polarization states or has a polarization light component of a polarization state and a non-polarization light component. The polarization dependent image offset component (14) receives the image light output coming from the image-display component (11, 12) and deflects the polarization light components based on the polarization states to separate each of the at least one pixel light into at least two pixel lights, or deflects the polarization light component from the non-polarization light component to separate each of the at least one pixel light into at least two pixel lights.

WO 2020/169088 A1

[Continued on next page]

EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

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

DISPLAY DEVICE AND ELECTRONIC APPARATUS

FIELD OF THE INVENTION

The present disclosure pertains to the technical area of a display device, and more specifically, to a display device and an electronic apparatus..

BACKGROUND OF THE INVENTION

Virtual reality is an emerging head-mounted display technology providing immersive 3D experience for users. The current angular resolution of the screens for these types of display devices is about 5 arcmins, whichis far below human-eye acuity. The human-eye acuity is about 1 arcmin. This will cause severe screen-door effects.

One approach is to use panels with higher pixel density, which can maintain the field of view. However, display panels with ultra-high pixel density are very difficult to fabricate, especially for mass production. Moreover, the optical efficiency will be compromised because of the usually reduced aperture ratio.

There are several possible approaches to increasing pixel density without altering the display panel, most of which are realized through combining two offset display pixel matrices in the time domain. The offset could be achieved by birefringent crystal plates (US Patent 5,369,266 and 6,243,055 B1), rotation prism-array (US Patent 5,689,283 and 2004/0041784 A1) for projection system, and optical gratings (Yun-Han Lee, Tao Zhan, and Shin-Tson Wu, "Enhancing the resolution of a near-eye display with a Pancharatnam–Berry phase deflector," Opt. Lett. 42, 4732-4735 (2017)) for near-eye displays.

Through time-multiplexing (i.e., an original frame is divided into two or more sub-frames and assigned low-resolution images are displayed in each sub-frame with according offset), a display system with increased pixel density can be obtained. A common issue of time-multiplexing method is the sacrificed frame rate, which in turn could lead to image blurs especially for fast moving objects.

Moreover, there are other pixel-offset methods utilizing spatial multiplexing, such as a super-resolution display enabled by stacking LCD panels with offset pixels (F. Heide, D. Lanman,

D. Reddy, J. Kautz, K. Pulli, D. Luebke, "Cascaded Displays: Spatiotemporal Superresolution using Offset Pixel Layers," ACM Transactions on Graphics, Vol. 33, No. 4, Article 60, (2014)). Although the device is able to work at the original frame rate, significant light loss is inevitable due to the low transmittance of LCD panels and the screen-door effect is more severe with the decreased aperture ratio.

SUMMARY OF THE INVENTION

One object of this invention is to provide a new technical solution fora display device.

According to a first aspect of the present invention, there is provided a display device, comprising: an image-display component, which generates an image light output, wherein at least one pixel light of the image light output has light polarization components of at least two polarization states or has a polarization light component of a polarization state and a non-polarization light component; and a polarization dependent image offset component, which receives the image light output coming from the image-generating component and deflects the polarization light components based on the polarization states to separate each of the at least one pixel light into at least two pixel lights, or deflects the polarization light component from the non-polarization light component to separate each of the at least one pixel light into at least two pixel lights.

According to a second aspect of the present invention, there is providedan electronic apparatus, comprising a display device according to this disclosure.

According to an embodiment of this invention,a display resolution can be increased without altering a display panel of a display device.

Further features of the present invention and advantages thereof will become apparent from the following detailed description of exemplary embodiments according to the present invention with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a top schematic plane view of an optical display system according to an exemplary embodiment of the invention.

FIG. 2 is a sketch for one possible shifting direction of pixels.

FIG. 3 is a sketch for one possible shifting direction of pixels.

FIG. 4 is a preliminary experimental result of device exploiting resolution enhancement technique disclosed in this patent.

FIG. 5 is a schematic diagram of an electronic apparatus according to various embodiments.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Various exemplary embodiments of the present invention will now be described in detail with reference to the drawings. It should be noted that the relative arrangement of the components and steps, the numerical expressions, and numerical values set forth in these embodiments do not limit the scope of the present invention unless it is specifically stated otherwise.

The following description of at least one exemplary embodiment is merely illustrative in nature and is in no way intended to limit the invention, its application, or uses.

Techniques, methods anddevice as known by one of ordinary skill in the relevant art may not be discussed in detail but are intended to be part of the specification where appropriate.

In all of the examples illustrated and discussed herein, any specific values should be interpreted to be illustrative only and non-limiting. Thus, other examples of the exemplary embodiments could have different values.

Notice that similar reference numerals and letters refer to similar items in the following figures, and thus once an item is defined in one figure, it is possible that it need not be further discussed for following figures.

In this disclosure, it is proposed to uselight polarization components to increase the resolution of a display device.

In one embodiment, a display device comprises: an image-display component, which generates an image light output, wherein at least one pixel light of the image light output has light polarization components of at least two polarization states; and a polarization dependent image offset component, which receives the image light output coming from the image-generating component and deflects the polarization light components based on the polarization states to separate each of the at least one pixel light into at least two pixel lights.

In this manner, one pixel of the image-display component such as a display panel can produce at least two pixels for display to a viewer. This effect can be achieved through optical devices, without the digital image processing, which will save the computing resources and lower the processing and image generating requirements.

In an example,the at least one pixel light further has a non-polarization light component, and the polarization dependent image offset component deflects the polarization light components and the non-polarization light component to separate each of the at least one pixel light into at least three pixel lights. In such a manner, the resolution can further be increased.

In another embodiment, a display devicecomprises: an image-display component, which generates an image light output, wherein at least one pixel light of the image light output has a polarization light component of a polarization state and a non-polarization light component; anda polarization-dependent image offset component, which receives the image light output coming from the image-generating component and deflects the polarization light component from the non-polarization light component to separate each of the at least one pixel light into at least two pixel lights.

In this embodiment, the original light path will be kept and only one polarization light component is required. As such, the requirement of generating a polarization light component is lowered.

The image-generating component may further comprises:an image-generating component, which generates a raw image light output; anda polarization modulation component, which modulates at least one pixel light of the raw image light output to have the at least two

polarization states. For example, the image-generating component is anLCD display panel, an OLED display panel, a mini-LED enabled LCD display panel, a LCoS display panel, a micro-LED display, a fiber scanning display panel, or a QLED display panel. For example, the LCD display panel isa twisted nematicLCD display panel, an in-plane-switchingLCD display panel or a vertical alignmentLCD display panel.

In an example, thepolarization modulation componentis a polarization modulation layer attached to a light emitting plane or image plane of the image-generating component.

Thepolarization modulation componentmay be pixelated. Thepolarization modulation componentcan have the same pixel density as the image-generating component.

Thepolarization modulation component may beprogrammably activated based on the pixels of the image light output. For example, areas on thepolarization modulation component corresponding to black pixels of the image light output may beinactivated.

The polarization modulation componentmay be an active-driving polarization modulation device that can change the polarization state of light incoming from the image-generating component. For example, the polarization modulation component is a liquid crystal device. For example,the polarization modulation component is a twist-nematic LC panel.

In an example,the polarization modulation component independently modulates the polarization states of red, blue and green sub-pixels of the raw image light output.

The display device in various embodiments can further comprises a lens unit, which is disposed after the image-display component and adjusts the image light output. For example, thelens unitincludes at least one of a plano-convex lens, a biconvex lens, an aspheric lens,and a Fresnel lens. The lens unit may be disposed between the image-display component and the polarization dependent image offset component, or is disposed optically behind the polarization dependent image offset component. The impact of the lens unit on the polarization states of the image light output is predetermined.

The image-display component may beanLCD display panel, an OLED display panel, a mini-LED enabled LCD display panel, an LCoS display panel, a micro-LED display, a fiber scanning display panel, or a QLED display panel. The LCD display panelmay bea twisted

nematicLCD display panel, an in-plane-switchingLCD display panel or a vertical alignmentLCD display panel.

The polarization dependent image offset component isadiffractive polarization grating, for example, aliquid crystal diffractive polarization grating or acrystal diffractive polarization grating.

The polarization dependent image offset componentmay have a mono-layer structure with spatial-varying anisotropy or a multi-layer structure with spatial-varying anisotropy.

The polarization dependent image offset componentmay have a periodicity determined by the pixel pattern to be displayed.

The polarization dependent image offset componentcan deflect each of the at least onepixel light into light beams propagating along 2 or 3 directions, simultaneously.

The polarization dependent image offset component assigns desired intensities to the deflected light beams. The desired intensitiesof the deflectedlight beams are different. In some situations, this approach with give a viewer a feeling that the display is bright.

In another example, the light intensitiesin the polarization light components and/or the non-polarization light component of each of the at least one pixel light are equal.

The polarization light components of at least two polarization states include right-handed circularly polarized light component and left-handed circularly polarized light component,and the polarization dependent image offset component deflects the right-handed circularly polarized light component and the left-handed circularly polarized light component into opposite directions.

The display device according to various embodiments may comprises a supporting framework for supporting components in the display device.

The image light output generated by the image-display componentis linearly polarized light.

The display deviceaccording to various embodiments may comprises a processing component.The processing componentchanges an original image data with higher resolution to a display image data with lower resolution and sends the display image data to the image-display component for generating the image light output. As such, the processing requirements of the

image-display component may be lowered. This could lower the cost and power consumption of the image-display component, while keeping similar display resolution.

the processing component may include a processor and a memory, the memory stores instructions and the instructions control the processor to changes the original image data to the display image data.

The processing component may be a digital signal processing device.

The processing componentmay generate the display image data by factorizing the original image data. The processing componentmay factorize the original image data by the linear least square algorithm for displays with large open aperture ratio.

The processing componentfactorizes the original image data by direct sampling algorithm for displays with small open aperture ratio.

The displayed image coming from the polarization dependent image offset component has a resolution higher than that of the display image data and is displayed simultaneously.

The displayed image coming from the polarization dependent image offset component works at the original frame rate of the original image data.

The display image data are encoded in the retardation of pixels in the polarization modulation component.

In this disclosure, an electronic apparatus is also provided, which comprises a display device according to various embodiments. The electronic apparatus may be a head-mounted electronics apparatus. The electronics apparatus may be avirtual, augmented, or mixed reality electronics apparatus.

In this disclosure, the display device includes an image-display component, which may include an information display (image-generating) component and a polarization modulation layer. The display device further comprises a polarization dependent image offset optical element and a lens unit. By controlling the polarization state of each pixel through a polarizationmodulation layer, each display pixel can be separated into two pixels by a certain portion with a desired angular distance.Thus, the apparent pixel density is increased,and the screen-door effect as observed by the users can be greatly reduced.

In the display device, the display pixel grid can be optically duplicated and offset by a portion of a pixel width, such that the pixel density is increased.

The display device can be an optical image display/view system in an electronic apparatus, such as a phone, a head-mounted electronics apparatus and so on. In an exemplary, the electronic apparatus may includea support structure that can be wearable by a viewer. The image-generating component of the image-display component of the display device is adapted to generate an image output. The polarization modulation component of the image-display component is imposed to accept the polarized image output and adapted to control the polarization of each pixel electrically. A lens unit may be disposed to magnify and collimate the image-generating component. The polarization dependent image offset component is disposed to accept the collimated image output.

Theimage output may bepolarization-modulated in the pixel level.The image offset component is a polarization grating.

Fig. 1 schematically illustrates a display device. The display devicecomprises animage-generating component 11 that is attached with a polarization modulation layer 12 and is optically followed by a lens 13. Then, the lens 13 is followed by an image offset component 14. The displayed image then enters eyes 18 of a viewer.

The image-generating component11 can be an OLED display, mini-LED enabled LCD display, a LCoS display, a micro-LED display, a fiber scanning display, or another display components as known in the art. For example, the image-generating component 11 outputs or is adapted to output a polarized light (virtual) image. Typically, display components such as LCD and LCoS displays produce polarized outputs. If the display output is not inherently polarized, as produced by, e.g., a micro-LED display, an OLED display, or a fiber scanning display, a polarizer, a reflective polarizer will advantageously be disposed on the output side of the image-generating component 11 as known in the art to effect a desired polarization state image output.

The polarization modulation component 12 can be easily adapted from a twist-nematic LC panel or other active-driving polarization modulation devices that could change the polarization state of incoming light from each pixel independently in component 11.

The lens 13 can be a plano-convex lens, a biconvex lens, an aspheric lens, a Fresnel lens or a hybrid kind of above. This lens 13 serves to magnify and project the display image to a proper viewable distance. For example, in the situation of a head-mounted viewing device,the distance is preferably in the range from 0 to 3 diopters.

The polarization dependent image offset component 14 is preferably a liquid crystal diffractive polarization grating, which may be similar to that disclosed in [Svetlana Serak, Nelson Tabiryan, and Boris Zeldovich, "High-efficiency 1.5 μm thick optical axis grating and its use for laser beam combining," Opt. Lett. 32, 169-171 (2007)]. It can serve to generate the pixels offset 15, 16, 17. The light rays from a pixel on the image-generating component 11 are directly collimated by lens 13. With polarization dependent image offset component 14, the light rays from a single pixel will be separated by a small angle in opposite directions (15, 16), and thus generating two apparent pixel matrix for the viewer 18. In some situation, a light ray in direction 17 will be also left to generate further pixels for the viewer 18.

If the display device has an original angular pixel size $d\theta$, this shift can be set so that pixels all move vertically or horizontally by half angular size (move $d\theta/2$), such as the case shown in FIG. 2. FIG. 2only shows the case of shifting in horizontal direction, but the same applies to vertical shifting. By changing the polarization state through polarization modulation layer 12, a single pixel could be optically separated into 2 pixels (21, 22) with a desired separation ratio subject to the modification from the polarization modulation layer 12. This shift can also be set to move pixels diagonally (45° with respect to the unit pixel) by approximated by $\sqrt{2} \times d\theta/2$ as shown in Fig. 3. By changing the polarization state through the polarization modulation layer 12, a single pixel could be optically separated into 2 pixels (31, 32) with the desired separation ratio insubject to the modification from the polarization modulation layer 12. Through the modulation of the polarization, spatial separation and shifting of the pixels with desired brightness can be realized. Equivalently, there are two virtual panels, with opposite spatial shift, being displayed to the viewer simultaneously. By dividing one high-resolutionimages into two low-resolution images and assign these two images to the two virtual panels accordingly, a high-resolution image could be displayed for the observer 18.

FIG. 4 is a preliminary experimental result of a display device according to an embodiment. Fig. 4(a) shows the display image without pixel density enhancement and Fig. 4(b) shows the display image with pixel density enhancement. The detailed texture is visible in Fig. 4(b) after pixel density enhancement.

FIG. 5 is a schematic diagram of an electronic apparatus according to various embodiments.The electronic apparatus 50 includes a display device 51as described above. The electronic apparatus 50 may be a projector, a television, a computer, a wearable display devicesuch as a virtual reality device, an augmented reality device or a mixed reality device.

Although some specific embodiments of the present invention have been demonstrated in detail with examples, it should be understood bya personskilled in the art that the above examples are only intended to be illustrative but not to limit the scope of the present invention.

CLAIMS

1. A display device, comprising:

an image-display component, which generates an image light output, wherein at least one pixel light of the image light output has light polarization components of at least two polarization states or has a polarization light component of a polarization state and a non-polarization light component; and

a polarization dependent image offset component, which receives the image light output coming from the image-generating component and deflects the polarization light components based on the polarization states to separate each of the at least one pixel light into at least two pixel lights, or deflects the polarization light component from the non-polarization light component to separate each of the at least one pixel light into at least two pixel lights.

2. The display device according to claim 1, whereinthe at least one pixel light has light polarization components of at least two polarization states and a non-polarization light component, and the polarization dependent image offset component deflects the polarization light components and the non-polarization light component to separate each of the at least one pixel light into at least three pixel lights.

3. The display device according to claim 1 or 2, wherein the image-generating component further comprises:

an image-generating component, which generates a raw image light output; and

a polarization modulation component, which modulates at least one pixel light of the raw image light output to have the at least two polarization states.

4. The display device according to any of claims 1-3, wherein thepolarization modulation component is programmably activated based on the pixels of the image light output.

5. The display device according to any of claims 1-4, wherein areas on thepolarization modulation component corresponding to black pixels of the image light output is inactivated.

6. The display device according to any of claims1-5, whereinthe polarization modulation component is an active-driving polarization modulation device that can change the polarization state of light incoming from the image-generating component.

7.The display device according to any of claims 1-6, whereinthe polarization dependent image offset component deflects each of the at least one pixel light into light beams propagating along 2 or 3 directions, simultaneously, and the polarization dependent image offset component assigns desired intensities to the deflected light beams and the desired intensitiesof the deflectedlight beams are different.

8. The display device according to any of claims 1-7, whereinthe displayed image coming from the polarization dependent image offset component works at the original frame rate of the original image data.

9. The display device according to any of claims 1-8, further comprising: a processing component, wherein the processing componentchanges an original image data with higher resolution to a display image data with lower resolution and sends the display image data to the image-display component for generating the image light output.

10. An electronic apparatus, comprising a display device according to any of claims 1-9.

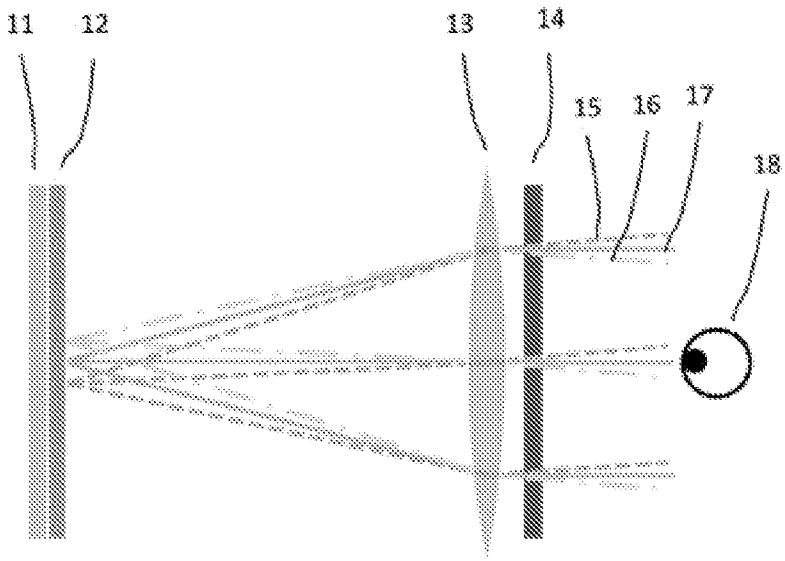


FIG. 1

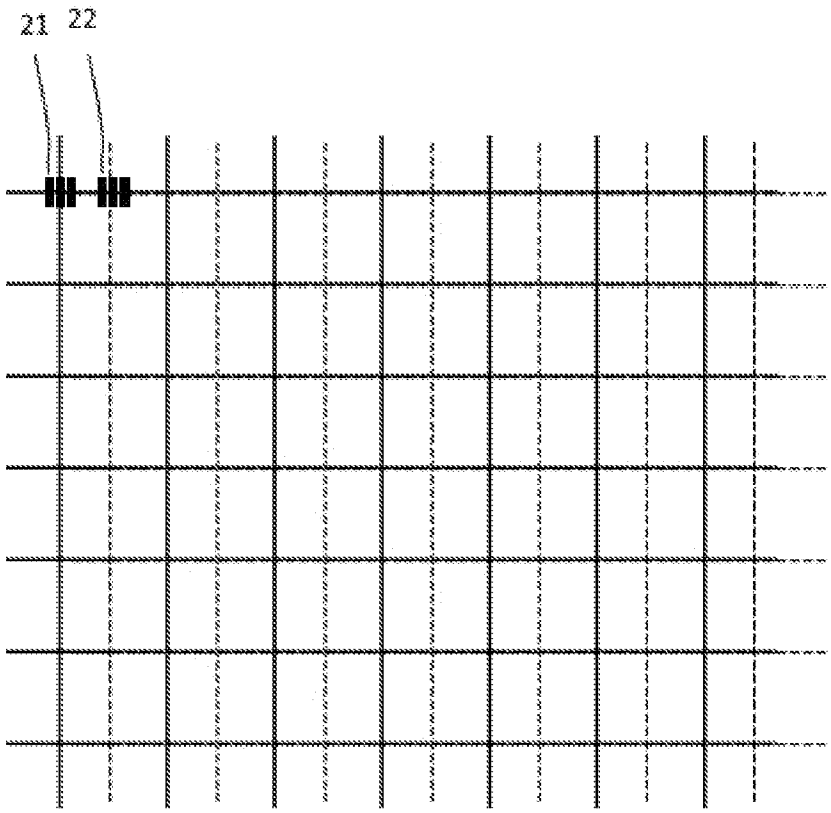


FIG. 2

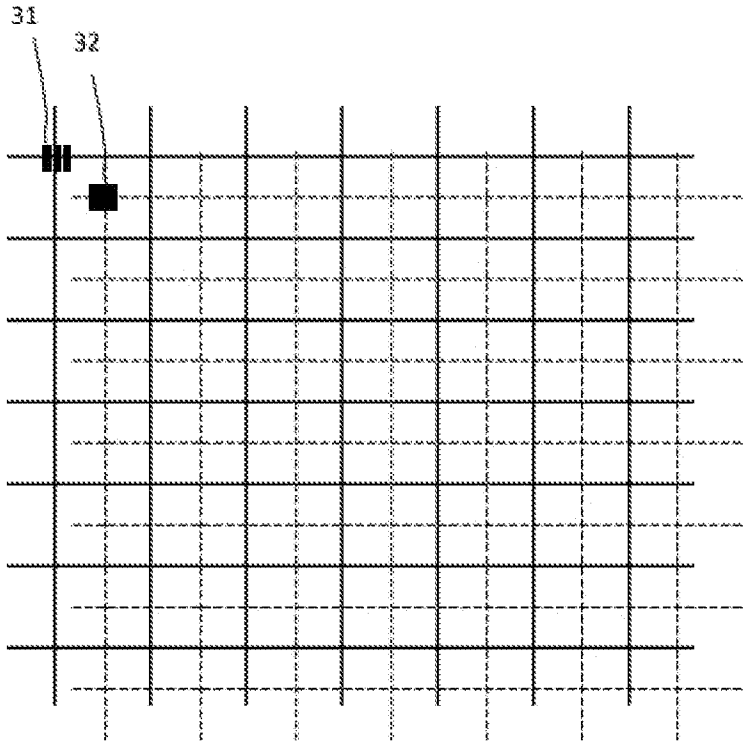


FIG. 3

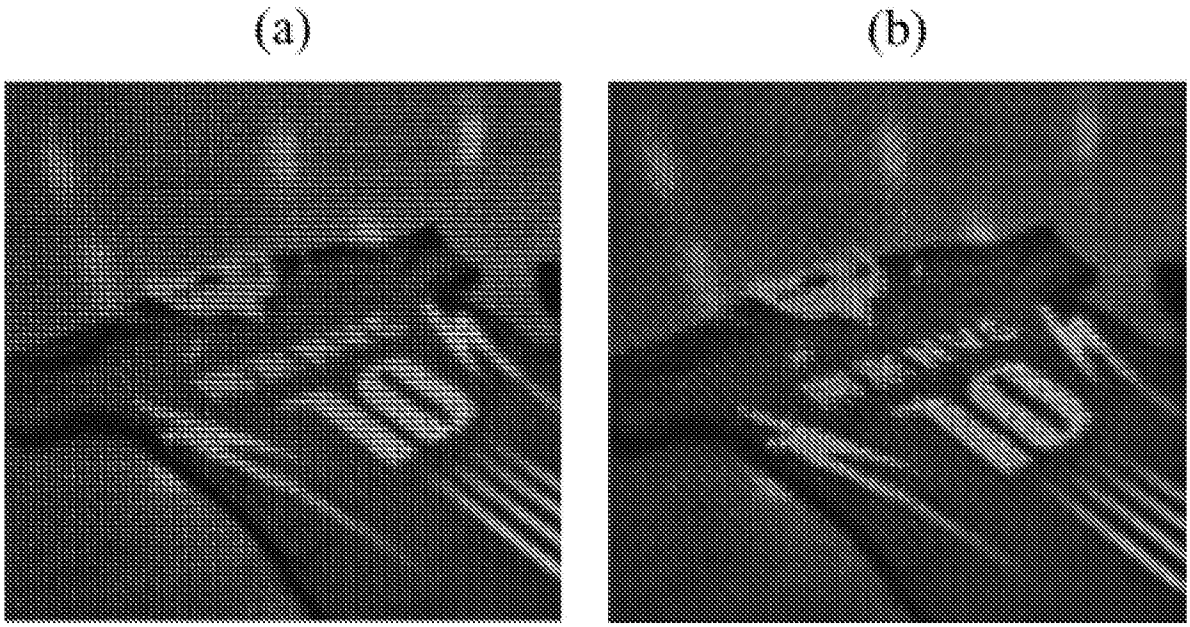


FIG.4

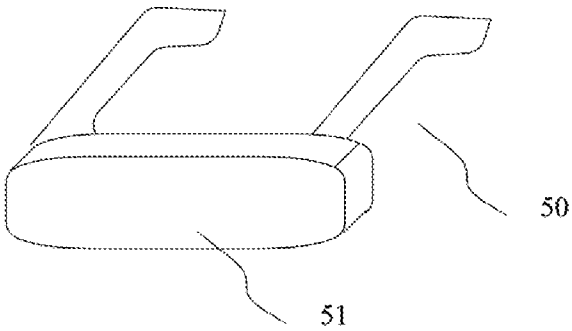


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2020/076262

A. CLASSIFICATION OF SUBJECT MATTER

G02B 27/28(2006.01)i; G02B 27/01(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G02B 27,G09G 3,G02F 1;CPC:G02B 2027/0147,G02B 27/0101,G02B 27/017,G02B 27/0172,G02B 2027/0178,G09G 3/007

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS;CNTXT;DWPI;SIPOABS:UYFL,QDGR,display,pixel,density,resolution,definition,polarize,polarise,offset,deflect, separate,divide,shift,move,steer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	WO 2019203873 A1 (FACEBOOK TECHNOLOGIES LLC) 24 October 2019 (2019-10-24) description page 4 line 6 to page 34 line 28; figures 1A-19	1-10
X	US 10115327 B1 (UNIVERSITY OF CENTRAL FLORIDA RESEARCH FOUNDATION INC) 30 October 2018 (2018-10-30) claims 1-6; description column 2 line 1 to column 4 line 64; figures 1-5	1-10
X	WO 2018011285 A1 (SEEREAL TECH S A) 18 January 2018 (2018-01-18) description page 14 lines 14-26 and page 26 line 1 to page 26 line 16; figure 6	1-10
X	US 6243055 B1 (FERGASON J L) 05 June 2001 (2001-06-05) description column 13 line 16 to column 18 line 41 and column 42 line 48 to column 44 line 47; figures 1-5C, 42-43	1-10
X	US 6061103 A (OLYMPUS OPTICAL CO LTD) 09 May 2000 (2000-05-09) description column 19 line 25 to column 22 line 13; figures 29-32	1-10
X	US 5689283 A (SONY CORP) 18 November 1997 (1997-11-18) description column 12 line 66 to column 14 line 31; figures 15-17	1-10
A	WO 2017160367 A1 (GOOGLE INC) 21 September 2017 (2017-09-21) the whole document	1-10

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 May 2020	**09 May 2020**
Name and mailing address of the ISA/CN **National Intellectual Property Administration, PRC** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer **NIE,Zefeng** Telephone No. **86-010-62085596**

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2005105016 A1 (SHARP KK) 19 May 2005 (2005-05-19) the whole document	1-10
A	CN 1423151 A (SHARP KK) 11 June 2003 (2003-06-11) the whole document	1-10
A	CN 108051928 A (UNIV CHENGDU TECHNOLOGICAL) 18 May 2018 (2018-05-18) the whole document	1-10

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2020/076262

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
WO	2019203873	A1	24 October 2019	US	2019318677	A1	17 October 2019
US	10115327	B1	30 October 2018	WO	2018236379	A1	27 December 2018
WO	2018011285	A1	18 January 2018	US	2019227492	A1	25 July 2019
				DE	112017003546	A5	28 March 2019
				CN	109690387	A	26 April 2019
				KR	20190027889	A	15 March 2019
				TW	201802540	A	16 January 2018
US	6243055	B1	05 June 2001	US	2002075202	A1	20 June 2002
US	6061103	A	09 May 2000	JP	3590138	B2	17 November 2004
				JP	H0915548	A	17 January 1997
US	5689283	A	18 November 1997	EP	0606162	A2	13 July 1994
				EP	0606162	A3	02 November 1994
				DE	69414427	T2	29 April 1999
				JP	3547015	B2	28 July 2004
				JP	H06324320	A	25 November 1994
				EP	0606162	B1	11 November 1998
				DE	69414427	D1	17 December 1998
WO	2017160367	A1	21 September 2017	US	2017270637	A1	21 September 2017
				US	9886742	B2	06 February 2018
US	2005105016	A1	19 May 2005	US	7277140	B2	02 October 2007
				TW	200303429	A	01 September 2003
				WO	03046652	A1	05 June 2003
				TW	580592	B	21 March 2004
				JP	2004004301	A	08 January 2004
				JP	2004004424	A	08 January 2004
				JP	2003161962	A	06 June 2003
				JP	3998954	B2	31 October 2007
CN	1423151	A	11 June 2003	CN	1201180	C	11 May 2005
				TW	I231379	B	21 April 2005
				US	2003095092	A1	22 May 2003
				US	7034784	B2	25 April 2006
				KR	20030042426	A	28 May 2003
				KR	100478804	B1	25 March 2005
				TW	200301367	A	01 July 2003
				JP	2003344871	A	03 December 2003
				JP	2003222832	A	08 August 2003
				JP	3973524	B2	12 September 2007
CN	108051928	A	18 May 2018	CN	207799252	U	31 August 2018