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Improved Eye Tracking with Hardware-generated Multi-Polarized Images

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ABSTRACT

Eye tracking is performed in augmented reality, virtual reality, or extended reality (AR/VR/XR) applications to determine the gaze direction of the user. However, eye tracking based on a captured image of the eye can be inaccurate when the image contains saturated pixels due to high reflection from the user's eye. This disclosure describes techniques to generate multi-polarized images (images with different polarization angles) simultaneously. A metalens is provided in the imaging apparatus to generate multiple images with different polarization. The images are partitioned on the same sensor. The image that is relatively free of saturation can be used to perform eye tracking, thus improving eye tracking accuracy.

KEYWORDS

- Eye tracking
- Gaze direction
- Polarized image
- Metalens
- Near infra-red camera
- Near infra-red illumination
- Augmented Reality (AR)
- Virtual Reality (VR)
- Extended reality

BACKGROUND

Eye tracking is performed in augmented reality, virtual reality, or extended reality (AR/VR/XR) applications to determine the gaze direction of the user. Gaze direction is an important input to determine user-intended operation, e.g., zoom, button selection, etc., and makes the experience immersive and interactive by reducing the need for the user to operate input devices.

Eye tracking modules in AR/VR/XR hardware typically include a near infra-red (NIR) illuminator and a NIR camera. NIR light emitted from the illuminator is reflected from the eye of the wearer of the device. The NIR camera captures the reflected light, and the gaze direction is determined from the captured image. However, captured images may contain saturated pixels due to interference such as lighting conditions, blinking or natural eye movement, use of contact lenses, etc. The calculation of gaze direction based on such images may be inaccurate and may affect the user experience.

DESCRIPTION

This disclosure describes techniques to generate multi-polarized images (images with different polarization angles) simultaneously. A metalens is provided in the imaging apparatus to generate multiple images with different polarization. The images are partitioned on the same sensor. The image that is relatively free of saturation can be used to perform eye tracking, thus improving eye tracking accuracy.

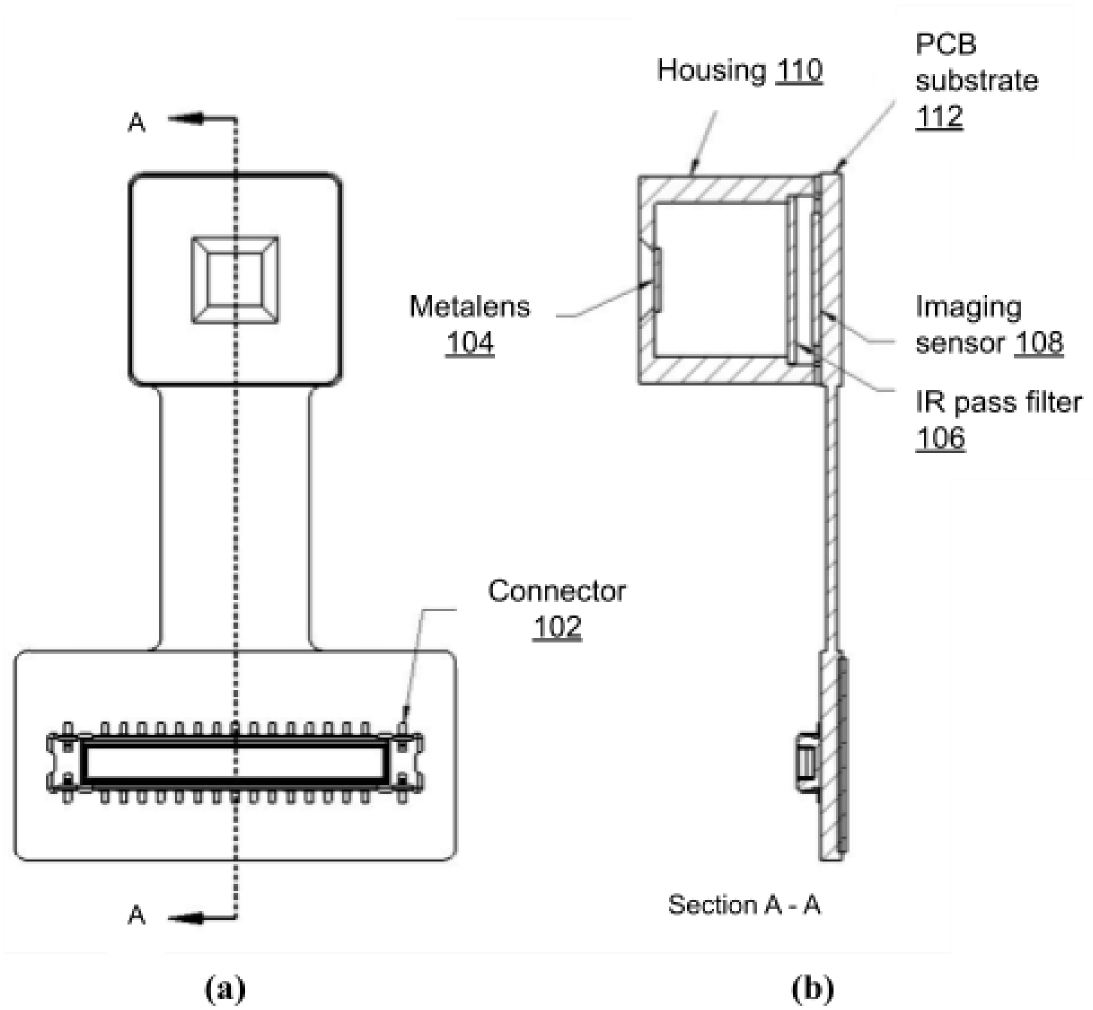

Fig. 1: Imaging apparatus with metalens to capture polarized images

Fig. 1 shows an illustration of the mechanical structure of the imaging apparatus which includes a connector (102), metalens (104), an infrared pass filter (106), an imaging sensor (108), housing (110) and substrates (112) such as FR4 PCB, ceramic, etc. Fig. 1(a) shows a front view of the apparatus. Fig. 1(b) shows a sectional view of the section A-A of Fig.1 (a).

The connector provides necessary power supply to the apparatus and establishes communication between a host computer or processor and the apparatus. Metalens is an optical component that enables capture of multi-polarized images. Metalens includes multiple nano-scale meta-structures to facilitate image capture through diffraction optics. The structures can be designed with beam steering and beam polarization simultaneously to form multiple images onto the imaging sensor.

Steered beams passed through the infrared pass filter (106) before reaching the imaging sensor, where optical energy is converted to electrical signals to obtain the image in digital format. Metalens and imaging sensor are positioned with precision within the housing to obtain sharp focus. The apparatus substrate facilitates electrical connections and physical placement of multiple components within the apparatus.

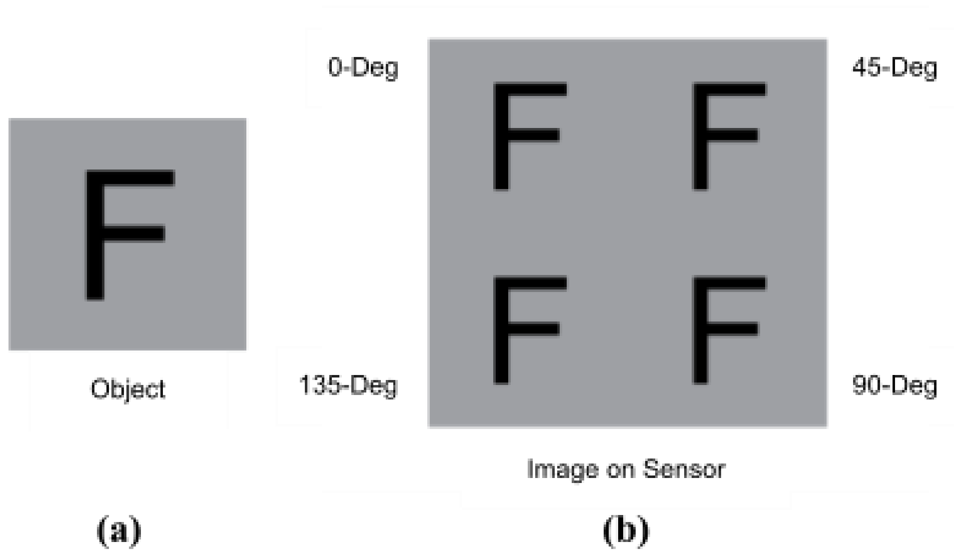

Fig. 2: Illustration of multi-polarized images captured on single sensor

Fig. 2 illustrates an example multi-polarized image captured on a single sensor using the apparatus illustrated in Fig. 1. Light reflected from the object shown in Fig. 2(a) is captured through metalens to form multiple images on the sensor. As shown in Fig. 2(b), four polarized images with a respective polarization angle are simultaneously obtained for the single object.

The images are equally partitioned on the sensor. The polarization of images is indicated with polarization angles such as 0-Deg, 45-Deg, 90-Deg, 135-Deg, etc. The polarization angles and placement of images in sections can be varied as per requirements. Further, the orientation of the images may also be varied. For example, the images may be flipped on the long edge or on the short edge.

With the use of beam steering and polarization features of metalens, multiple images are formed simultaneously, each with a respective polarization. Among the multiple images, at least one image is free from (or has less) saturated pixels (high reflection) and can be used for determining the gaze direction. Eye tracking accuracy is thus improved.

The described techniques can be used in the eye tracking sensing subsystem of any AR/VR/XR hardware device. Algorithms can be implemented to use images free from saturated pixels when determining gaze direction.

CONCLUSION

This disclosure describes techniques to generate multi-polarized images (images with different polarization angles) simultaneously. A metalens is provided in the imaging apparatus to generate multiple images with different polarization. The images are partitioned on the same sensor. The image that is relatively free of saturation can be used to perform eye tracking, thus improving eye tracking accuracy.

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