Optics and Laser Technology 101 (2018) 25–29

Contents lists available at ScienceDirect

Optics and Laser Technology

journal homepage: www.elsevier.com/locate/optlastec

Full length article

Augmented reality in laser laboratories

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ARTICLE INFO

Article history:
Received 2 August 2017
Received in revised form 4 October 2017
Accepted 30 October 2017

Keywords:
Laser safety and eye protection
Displays
Infrared imaging
Smartphones

ABSTRACT

Laser safety glasses block visibility of the laser light. This is a big nuisance when a clear view of the beam path is required. A headset made up of a smartphone and a viewer can overcome this problem. The user looks at the image of the real world on the cellphone display, captured by its rear camera. An unimpeded and safe sight of the laser beam is then achieved.

If the infrared blocking filter of the smartphone camera is removed, the spectral sensitivity of the CMOS image sensor extends in the near infrared region up to 1100 nm. This substantial improvement widens the usability of the device to many laser systems for industrial and medical applications, which are located in this spectral region.

The paper describes this modification of a phone camera to extend its sensitivity beyond the visible and make a true augmented reality laser viewer.

1. Introduction

Laser eye injuries in optics laboratories are a real concern [1,2]. Government regulations define mandatory safety measures and standards for the exposition to laser light and eye protection [3–7].

To comply the safety rules, an optical system with lasers of class IIIb and IV, if not suitably shielded to prevent a direct access to the beam [8], should be operated wearing safety glasses to block visibility of the laser light.

When beam alignment is required, a complex and awkward procedure to accomplish this task is needed. Neither the appropriate EN 208 compliant safety eyewear for adjustment work [7] nor a whole lot of auxiliary alignment tools (laser viewing cards, fluorescing alignment disks, etc.) simplify this work much. The simplicity and effectiveness of direct eye view operation are not attainable by any other procedure. Not to speak of the potential risk caused by an unseen stray laser beam wandering around.

In a recent paper [9], a new eye-safety device was proposed to achieve a clear view of the laser light and complies the safety standards (Fig. 1). It is a Google cardboard type viewer [10] in conjunction with a smartphone (Fig. 1a). The user looks, through the viewer, at the image of the real world captured by the rear camera of the phone and visualized on its display. To be precise, the smartphone display shows two identical copies of the image, side to side, for the right and left eye respectively (Fig. 1b). Many suitable application programs (app), easily found on the internet, can accomplish this task. SuperVision for cardboard is a freely downloadable app used in the present work [11]. A handheld Bluetooth controller allows an ease selection of the popup menu items (Fig. 1b and c).

This paper describes how a modified smartphone camera can extend its spectral sensitivity, from the UV to the near infrared up to around 1100 nm.

The NIR portion of the spectrum is particularly interesting because many laser systems for industrial and medical applications are located in this spectral region.

2. A modified camera module

Though a backside illuminated (BSI) CMOS sensor has a spectral sensitivity from about 300 to 1100 nm, the RGB Bayer filter, the Infrared Cut Filter (ICF) and the objective lens, limit the spectral response between 400 and 700 nm, which is ideal for color imaging characteristics.

Some company offer different types of modified cameras to widen the spectral range back to its full extension. A typical camera conversion service involve taking the camera apart and removing the Infrared Cut Filter. A detailed procedure to remove this component from a smartphone camera module was recently proposed [12].

In this paper, a different approach is followed (Fig. 2). The objective lens is unscrewed and removed, leaving the Infrared Cut Filter easily accessible. To get rid of the filter, it must be broken. This is a delicate procedure, the risk of damaging the CMOS sensor is high (Fig. 2c). Notwithstanding, a higher success rate was achieved following this procedure than the one proposed in Ref. [12].

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https://doi.org/10.1016/j.optlastec.2017.10.033
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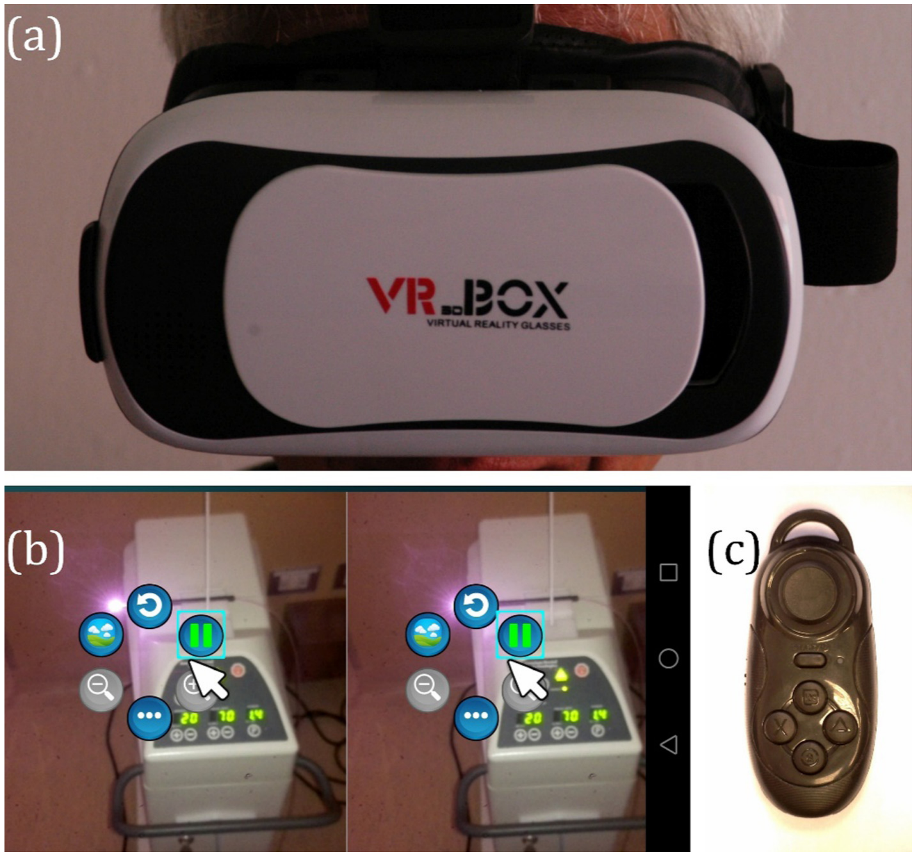

Fig. 1. Augmented Reality device. (a) VR BOX II virtual reality glasses; (b) screenshot of the smartphone display with the image captured by the rear camera and the superposed popup menu of the SuperVision app, and (c) the handheld Bluetooth controller.

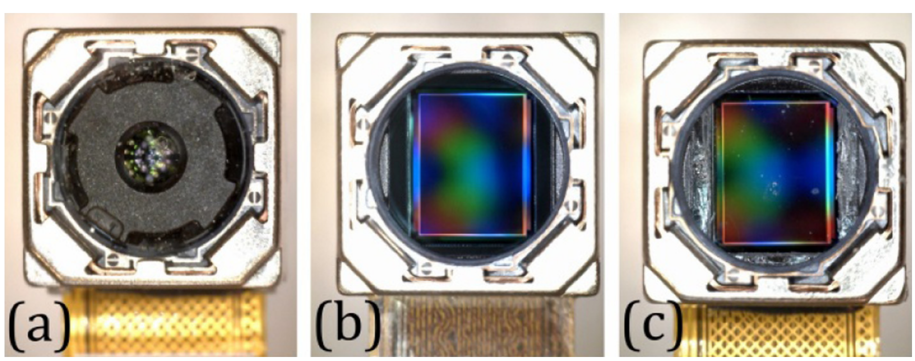

Fig. 2. The Sunny P13N05B rear camera module (a) with the objective lens in place, (b) the objective was unscrewed, the Infrared Cut Filter and, beyond, the CMOS image sensor, are visible and, (c) the IR filter was removed. Some damaged areas of the sensor are visible.

Moreover, this method seems to be generally applicable to all camera modules.

Once the filter has been removed, the objective is put again in place, and the camera module is positioned back into the cellphone. Finally, a focusing adjusting procedure, as described in [12], must be performed.

3. Exprimental setup and results

The viewer is a VR BOX II, (Shenzhen AZhuo Digital Technology Limited, Shenzhen, China) (Fig.1a) [9]. The market sector of virtual and augmented reality is living a great ferment, and new products come out every day. The choice was dictated by the low price, while ensuring sufficient performance in terms of safety and comfort.

Regarding safety issues, a robust structure guarantees durability and reliability and, a foam seal around the border assures protection from the laser stray light. Comfort is ensured by an optical system adjustable both sideways for pupillary distance and longitudinally for focusing distance.

The smartphone is a Huawei Ascend P7-L10. Its rear camera module is a Sunny P13N05B with a Sony IMX214, 4208 $\times$ 3120 back-illuminated CMOS image sensor [13]. The smartphone display is a full HD LCD, with 1080 $\times$ 1920 pixels.

SuperVision for cardboard is a freely downloadable app, suitable for this application [11]. Zoom control up to 6X; flashlight on/off switch; and, fast focus switching between far and near sight according to the vertical orientation of the head are among the useful features of this app. They are selectable from a popup menu