Learning Optics with a DIY Polarization-based 3D display

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Abstract: Common devices for digital imaging can be used as reliable instruments to design and perform light polarization experiments. In particular, a simple modification of the front polarizer of a LCD monitor provides an exciting opportunity for students to get hands-on experience into stereoscopy and 3D perception, polarization and complementary colors.

1. Introduction

While theoretical knowledge teaches the basic principles behind reasoning practical knowledge is gained by means of hands-on. In this regard, the modification of existing technologies can be an efficient tool in the Optics classroom. In particular, commercially available LCD displays, are by themselves an interesting teaching tool to explain how image formation relies on polarization optics and can also be easily modified [1, 2] in order to be turned into 3D displays with the aid of a pair of polarization glasses. The visualization of 3D information is also a great source of teaching resources by engaging students into the understanding of how parallax [3, 4] and convergence allow a 3D perception.

2. Stereoscopic visualization

3D visualization in projection-type displays [5] can be achieved as depicted in Fig. 1. A stereo pair (*L* and *R* images of a given object, obtained either in a single shot with a commercially available stereo camera as in the present work or by means of horizontally displacing a single camera) is displayed on a screen and while the light from each image of the pair arrives to its corresponding eye without cross-talk with the other eye, observer perceives as if the light comes from a center-crossing object. Among different methods to eliminate the cross-talk effect and allow for 3D visualization, the use of stereo-pairs with a defined (linear) cross polarization in each image and a pair of cross-polarized glasses is a cost-effective alternative with can be achieved with off the shelf components.

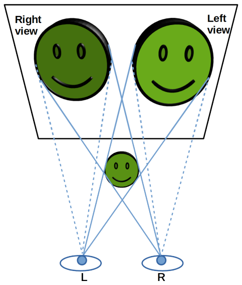

Fig. 1. Principle of stereoscopy. In solid line the (correct) crossing light paths to each eye while in dashed line the direct light paths that need to be blocked for each eye in order to allow for 3D visualization.

3. Polarized-based 3D display

The image that is currently viewed in standard LCD monitors is obtained by placing an analyzer in front of the liquid crystal, in cross configuration to the polarizer in the back of the display. The signal passed on to the display,

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which encodes the intensity of each color channel (R,G,B), relies on the use of an standard configuration for what we might call the ”positive” image. In particular, if we rotate the analyzer by 90 degrees, instead of obtaining the usual image we obtain one that is its complementary in color or ”negative” image. In the same sense, if we display a negative image with the analyzer rotated by 90 degrees, the positive image is obtained.

We propose then a simple modification of a commercially available display (in this case an old LCD monitor) where the frontal analyzer is removed and replaced by a dual analyzer, that is the original analyzer -with its axis at 45 degrees to the horizontal- is cut in two equal pieces and one of them -say the left part- is horizontally or vertically flipped so that now the left side analyzer is cross-polarized to the right side as shown in Fig. 2 (a-2). Then the stereo pair (Right image on the left side) is passed on to the display with its Right image in negative while the Left image is in positive (Fig. 2 (a-1)) so that after passing through the dual analyzer an stereo pair where each image has a definite polarization is obtained (Fig. 2 (a-3)). By observing at the screen with a proper pair of glasses with cross-polarized sides (Fig. 2 (a-4)), 3D visualization is obtained.

In Fig. 2 (b-1) the actual setup with the stereoscopic pair displayed is shown. Note that the cross-polarized glasses (Fig. 2 (b-2)) eliminate cross-talk between eyes since the image not corresponding to the eye is blocked by the polarizer film in front (Figs. 2 (b-3,4)).

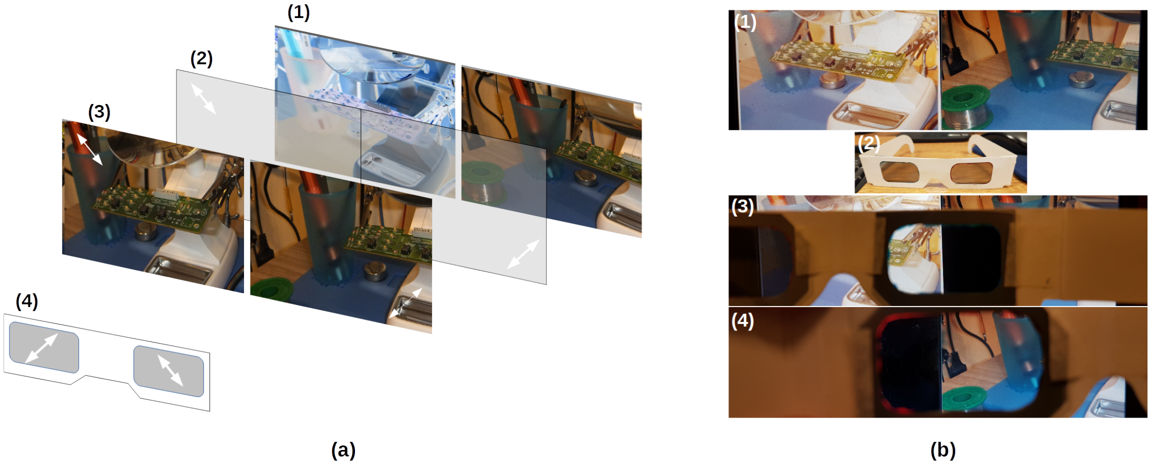

Fig. 2. (a) Image formation and 3D display scheme: (1) input stereo pair Right (in negative) and Left images, (2) dual analyzer, (3) exit stereo pair with a defined polarization for each image, (4) polarization glasses for 3D visualization. (b) Details of the actual display: (1) R-L stereo pair with defined polarization; (2) cross-polarized glasses; screen of 3D display observed through the Right (3) and Left (4) side of the polarized glasses (no cross-talk)

4. Conclusions

A modification over a commercially available LCD, which can in turn be achieved in a teaching lab or classroom or even at home, allowed us to obtain a 3D visualization display. Stereo pairs can be displayed on the system and visualized with the aid of polarization glasses which can in turn be obtained with off the shelf components. The concepts of 3D perception through stereoscopic-pairs in displays, polarized light and complementary colors are then experienced on a simple experimental setup.

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