Design and Implementation of a low-cost projected virtual reality system to support Learning Processes

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Abstract. Virtual Reality technologies have been successfully incorporated into the learning processes and potential new applications in education are explored continuously. We found that one of the difficulties to popularize its use in the educational context, in countries with emerging and developing economies, is the cost of hardware required to generate satisfactory immersive experience. In this work we considered virtual reality from the perspective of human-computer interaction to support learning processes. The characteristics of low-cost projected virtual reality system (PVR) proposed, combines study and integration of available technology solutions, the development of an image synchronization routine that enables the use of a single video projector and the design of a printable pattern that preserve the state of polarization on the projection screen.

Keywords: Virtual Reality, projection surface, polarization.

1 Introduction

The Virtual Reality (VR) is a strong tool for the learning support process, including tangible and abstract concepts, increase critical performance in activities such as surgical procedures and technical transfer skills [1,2]. Immersion in the VR experience is determined as a key element in the cognitive variables associated with the processes of learning [3].

The technology used in VR is the main limitation for immersive experience. The computer graphics is the spearhead for generation of three-dimensional digital worlds and so far is limited by the processing power, not by lack of algorithms [4]. Something alike occurs with visualization hardware, even though today we have massive HD stereoscopic screens, the first 3D optical perception still requires the use of passive and active goggles. The autosteroscopic display are still far away from popularized as a tool for daily technology VR that support learning processes [5].

In the case of most emerging & developing countries, the costs associated with IT equipment for virtual reality, and their rapid obsolescence, have made quite difficult the incorporation of VR as a tool to support the learning processes [6]. Notwithstanding the foregoing, the software development and 3D digital content have been identified as a potential factor to increase the economic competitiveness of emerging economies, where there was a latent need for hardware related to VR technology [7,8].

This paper considers the critical points for the implementation of a virtual reality system design that includes: a single video projector, a polarize rotary disk filter like a beam shutter type, a printable pattern that preserves the state of polarization on the projection screen.

2. Related Work

The PVR system was treated as a set of devices and software which combined allow stereo viewing digital content and the interaction with them [9]. We identified three critical subsystems for the operation of a PVR system Fig.1(a), the display, data transmission and interaction subsystem.

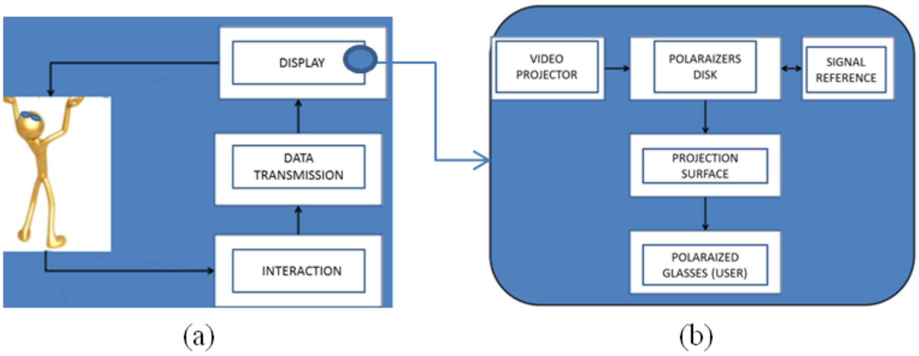


Fig. 1. PVR system scheme based on three subsystems (a). Schematic display subsystem (b).

2.1 PVR Subsystems

Display subsystem, Responsible for viewing digital content and devices for the whole image makers (video projector),image filtering (polarizers), alignment, and optical image formation (projection surface).

As shown in Fig. 1(b), unlike traditional configurations, requiring the use of two video projectors [10] required for generating the stereoscopic selective filtering of each image perspective to the user corresponding eye. Other works [11] have shown how the selective control of each image at a frequency of 30 Hz for each eye has been sufficient to generate an acceptable stereoscopic. Guided by [11] and considering new technologies for the selection of images [12] PVR system was designed with a single video installation projector and a rotary disk-shaped polarizer.

In order to obtain the perspective perception in the passive PVR, conventionally projected two images with different points view simultaneously [10], so the display surface (Projection screen), must retain the polarization of each image. Projection surfaces are called "Silver" screen, in the commercial use, and have higher associated costs against the standard projection surfaces. Other studies have put forward proposals alternatives to preserve the polarization with good results performance [13].

Send data subsystem, includes hardware and software necessary to receive and send information subsystems according to the characteristics and requirements thereof. At this time, the stereoscopic driver that have better performance uses GPU data processing [14]. It supports the majority of branded graphics cards, and is designed to work with most 3D hardware solutions.

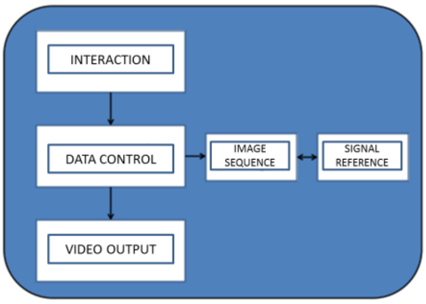
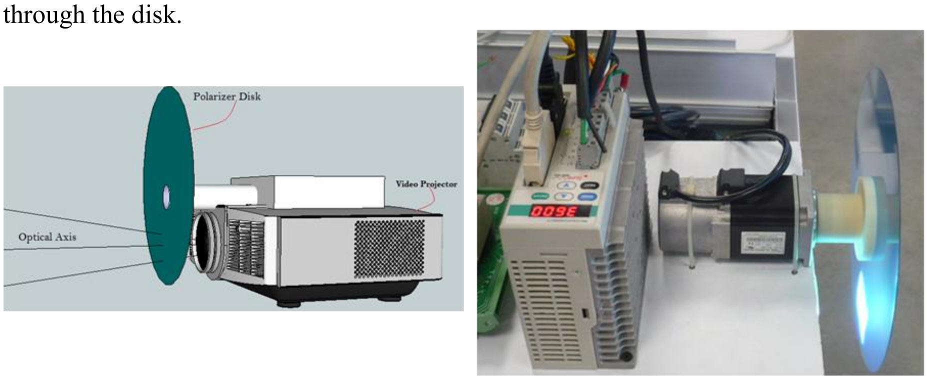


Fig. 2. Schematic send data Subsystem

Subsystem interaction is defined as the set of peripherals which is effected by interaction with the digital scene. In the market offers a wide range of devices that meet this function, standing between haptic and kinetic devices [15]. The Wii controller has been tested as a successful tool human-computer interaction technologies related to VR. A wide range of applications and libraries available in different programming languages under the GNU (General Public Licences); on the other hand, it was considered a low cost hardware (40 USD per unit) [16].

3. Experimental Procedures and results

The display subsystem design was set with reference to the optical axis of projection, the polarized filter was placed into the lens front of the video projector (Figure 4), in order that the light that comes from the video projector, is polarized when goes through the disk.



(a) (b)

Fig. 4. Rotary polarizer for display subsystem: (a) Schematic representation, (b) montage implemented.

For the rotation synchronization of the polarizer with the sequence of projected images, we developed a routine called "digital image synchronization stereoscopic (DSIS)" (figure 5), synchronization sequence image. DSIS routine maintains the cross-polarization between the projected images in sequence and compensates the natural delay generated by the rotation of the motor at a constant revolution 60 Hz.

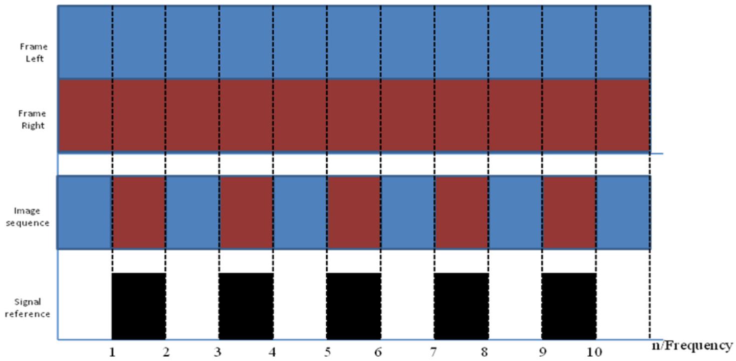


Fig. 5. Timing diagram of the DSIS routine.

In order to maintain the standard of usability in the system application proposed, a mono images output application from BINO software was implemented on the VGA output signal to DSIS input routine, establishing itself as the reference signal for synchronizing video and disk rotation frequency polarizer, thus has an open loop to maintain state sequential polarization between the projected images.

For the projection surface, we designed a printable pattern that successfully retained polarization stage (Figure 6); cost implementation was minimal compared to the Silver screen available on market.

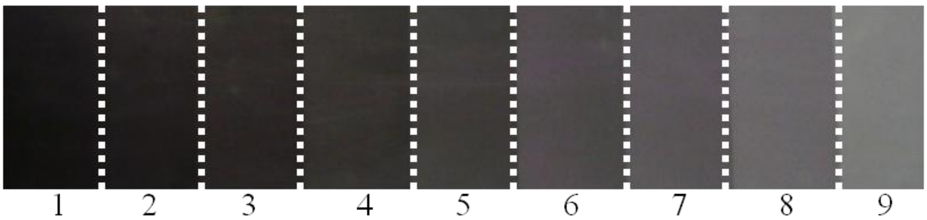


Fig. 6. Gray scale for printables patrons. The projection surface had better perfomace whit printable patron number 6.

4 Conclusions and future work

One of the main differential PVR system designed over conventional systems was the use of a single video beam. Which avoided the need for optical axis alignment of the images, it requires additional study to compare the level of immersion of this design compared to conventional.

The timing sequence of image for the cross polarization, could consider an alternative technique for stereoscopic display and its performance depends on the delta of change in the state of images polarization.

The designed printable patron can be used as a projection surface PVR system with similar benefits to the "silver" screen. However it requires a holographic quality printer resolution in order to optimize its functionality.

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