ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 3, Issue 8, August 2015

Implementation of Ghosting Effects in 3D Dual-View Projection System

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Abstract: In the proposed scheme various technical options to implement 3D dual-view systems, from four frames generated by two triggered or non-triggered 3D projectors. Such a technique offers 3D free-viewpoint capabilities for two viewers. We compare two different technical implementations based on transmissive video projection and reflective silver screen, combining two different 3D encoding techniques: polarization and time multiplexing. The main objective is to analyze and mitigate the ghosting effects, as a function of the technical, modal and frame pairing choices with respect, first to the image optical quality and second to prevent visual fatigue. DUAL-VIEW is an intrinsic capability of TVs or video projectors displaying 3D contents. Dual-View TVs basically play two full HD image streams that can be tuned by the viewers wearing compatible glasses. It means that two users watching the same TV can watch different channels in full HD. In other words, the stereo pair is used to separate the streams for two different viewers. Consequently, watching 3D view requires at least four independent frames projection or display. The benefit is that 3D Dual-View enables two viewers to watch simultaneously two different 3D contents, as well as the possibility for these viewers to watch the same 3D content, but with different viewpoints, according to their location with respect to the screen. This provides the advantage of free viewpoint projection, which is not possible with conventional 3D contents.

Keywords: Active glasses, dual-view, image ghosting, passive glasses, stereoscopic vision.

I.INTRODUCTION

Dual-view is an intrinsic capability of TVs or video projectors displaying 3Dcontents [1]. Dual-View TVs basically play two full HD image streams that can be tuned by the viewers wearing compatible glasses. It means that two users watching the same

TV can watch different channels in full HD. In other words, the stereo pair is used to separate the streams for two different viewers. Consequently, watching 3D view requires at least four independent frames projection or display. The benefit is that 3D Dual-View enables two viewers to watch simultaneously two different 3D contents, as well as the possibility for these viewers to watch the same 3D content, but with different viewpoints, according to their location with respect to the screen. This provides the advantage of free viewpoint projection [2], which is not possible with conventional 3D contents. This technique is interesting because allowing the viewers to share a vision of the same scene, but from their own perspectives. This opens the field for a large number of applications. For instance, in the defense domain, two operators can plan a better strategy of defense or attack, since both 3D and 2D information can be sorted out according to their respective role and physical perspective on the content.

Similarly, in telemedicine, physicians would be able to focus on the lot of accordant advice set after getting absents by the added one's accompanying data. Even if 3D Dual-View address is able and has a huge ambit of applications, some drawbacks can affect its development a part of which the ghosting after-effect produced if an angel not advised for an eye or a user is about perceived. This should be mitigated to abstain interferences amid the two 3D streams, consistent in a confounding of the scene, or assorted physiological drawbacks. In this paper, we call assorted solutions to affectation four absolute video streams, accumulation the absolute stereoscopic encoding technologies: spectral, time or animosity multiplexing. Then, we call two accessible affectation solutions application transmissive or cogitating screens and we explain how to admeasurements their corresponding ghosting steaming with account to physical or physiological parameters. Finally, we suggest some solutions to mitigate these effects.

II. 3D DUAL-VIEW SOLUTIONS

3D Dual-View techniques abide in announcement two altered 3D video capacity on the aforementioned screen. In our case, we affectation a 3D scene, to be apparent by two admirers from altered viewpoints. A 3D stereoscopic account is fabricated up of two 2D images grabbed or actinic from two hardly altered angles [3], one angel getting displayed to the appropriate eye and the added angel to the larboard eye. Therefore, bulging a 3D agreeable implies the use of a 2D video pair. Consequently, the 3D Dual-View address will betoken announcement four 2D video frames. Then, it is appropriate to encode and break four frames, so that anniversary angel is apparent by the eye and user it is advised to be. Three techniques are commonly relied on for stereoscopic visualization: coding by blush (spectral multiplexing), animosity (polar multiplexing) and time (temporal multiplexing) [4] It results that, for 3D Dual-

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View, we could combine two of these three techniques to independently encode the four frames.

TABLE I All the Possible Configurations to Separate the Images of Each Viewer Eye and Isolate the Viewers

		Viewers Separation Technique		
		Time	**Polarization**	**Colour**
Eyes Separation Technique	**Time**	Case 1	Case 2.1	Case 3.1
	Polarization	Case 2.2	–	Case 4.1
	Color	Case 3.2	Case 4.2	Case 5

Table I shows possible combinations of encoding techniques to separate the images of each eye and each viewer. The simplest solution is the full time multiplexing (Case 1): 240 Hz TVs exist. They are able to display 60 images/s for each eye and viewer. However, time multiplexing results in a strong attenuation of the light power, which rapidly becomes unacceptable. Besides, even if such 3DTVs exist, it is not yet the case for video-projector solutions that are not available on the market. Therefore we discarded this solution, as well as the full colour encoding: it requires expensive narrow band filters [5] to prevent the ghosting, increasing the whole system cost. Using two orthogonal polarized lights to implement 3D projection requires a single pair of orthogonal polarizing filters. Linear polarizer's can be used but the circular ones are recommended when the viewers can move. Obviously, it is not possible to code more than 2 frames by polar multiplexing only. This is why it is better to combine several encoding techniques. We combine polarization and time multiplexing (active case) or polarization and spectral multiplexing (passive case). The first one is the easiest to implement, because it can rely on widespread hardware. Therefore, we will focus our discussion in Cases 2.2 and 2.1. The main drawback of the polar multiplexing is that a special screen has to be substituted for the regular screen in order to maintain the polarization states for the viewers' goggles. In reflective projection this could be a silver screen. The circular polarization of the light changes when reflected by this kind of screen: a Left Circular Polarizer (LCP) should be used to decode the video stream coded with a Right Circular Polarizer (RCP) and vice versa. To simplify, in the following section, we will consider only the case of a transmissive screen.

III. TIME AND/OR POLARIZATION MULTIPLEXING

Two 3Dprojectors are necessary to implement both solutions. We relied on 3D DLP-Link projectors. Such projectors provide temporally two 2D video streams, displaying 3D contents on a regular screen to viewers wearing active goggles. A circular polarizer is placed in front of each projector. Consequently, these projectors can be used to combine both 3D encoding techniques, provided that silver screen and active goggles, mixing polarization and time multiplexing are used. Let us analyse now these two complementary solutions.

Case 2.1—Independent Projection:

The first way is to separate the two viewers using polarizer's. Therefore, we use two 3D projectors with a RCP in front of one and a LCP in front of the other. To decode only one stream and watch the video from one projector, the viewer should wear special active goggles. These active goggles are regular active goggles used with 3D DLP Link projector, using circular front polarizer's. Goggles synchronization is obtained in two different ways. Suitable polarizer's can be set on each goggle photo-sensor and each projector synchronizes its goggle. We can also synchronize the two projectors; in this case a single synchronization signal (DLP Link) is sent to the screen for all. As shown in Fig. 2, the projector P1 projects alternately the images IMG-R1 and IMG-L1 for the right and left eyes of Viewer1 [5]

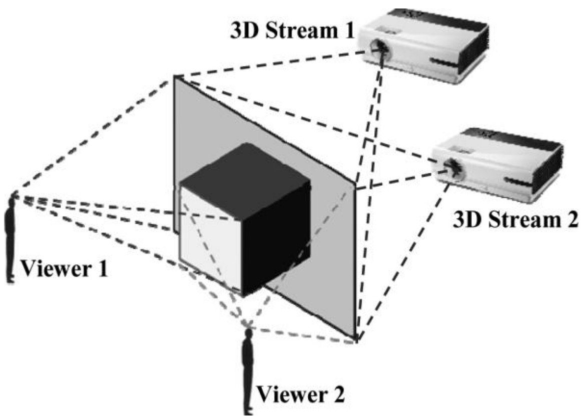

Fig.1.3D Dual-View projection principle with two projectors and for two viewers.

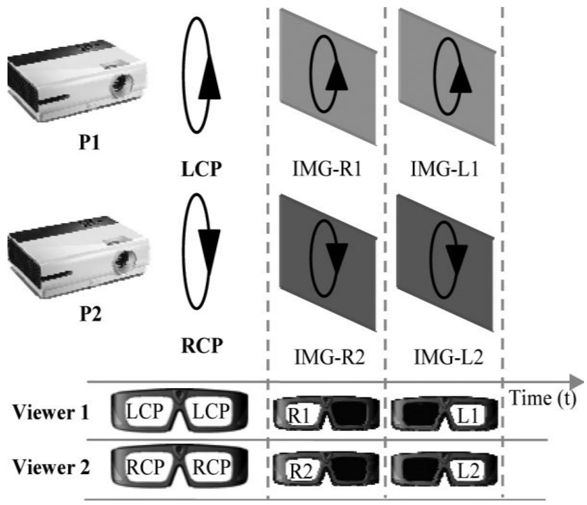

Fig. 2. Case 2.1 illustration, showing the two projectors separated by polarization and the goggles configuration.

Due to the RCP placed on the shutters of their goggles, Viewer2 see only the images IMG-R2 and IMG-L2 sent by the projector P2. The idea is simple as it is, however, to build this configuration it is not an easy task and the system becomes complex, as it will be seen later on.

Case 2.2—Dependent Projection:

Basically the configuration set-up for the Case 2.2 is close to the Case 2.1. In this case projector P1 projects the left

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INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
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images (IMG-L1 and IMG-L2) for both viewers and projector P2 projects the right images (IMG-R1 and IMG-R2). The two projectors should be synchronized: P1 projects IMG-L1 while P2 projects IMG-R1 for the Viewer1 and one frame after, P1 projects IMG-L2 while P2 projects IMG-R2 for Viewer2. The viewers are separated by time and the viewers' eyes separated by polarization. It means that the goggle shutters open and close simultaneously, a RCP should be placed on the right shutter of the active goggle and a LCP on the left shutter of the active goggles in order to separate the viewer's eyes.

The most interesting point, which differs from the previous case, is how the goggles work. The shutters work simultaneously. Basically the configuration setup for the Case 2.2 is close to the Case 2.1. In this case projector P1 projects the left images (IMG-L1 and IMG-L2) for both viewers and projector P2 projects the right images (IMG-R1 and IMG-R2). The two projectors should be synchronized: P1 projects IMG-L1 while

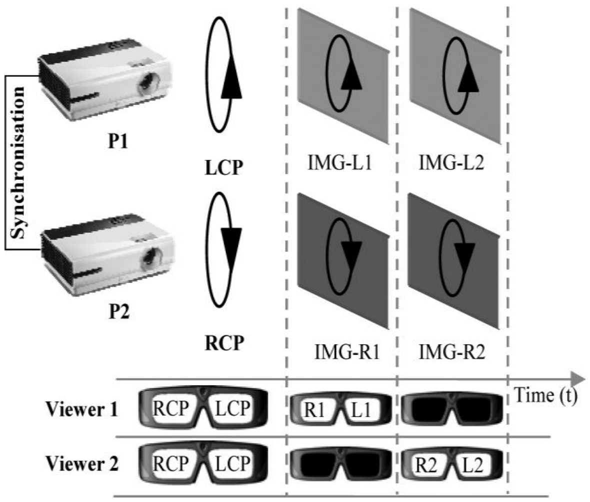

Fig.3.Case 2.2 illustration, showing the two triggered projectors and the goggles opening and closing simultaneously.

P2 projects IMG-R1 for the Viewer1 and one frame after, P1 projects IMG-L2 while P2 projects IMG-R2 for Viewer2. The viewers are separated by time and the viewers' eyes separated by polarization. It means that the goggle shutters open and close simultaneously, a RCP should be placed on the right shutter of the active goggle and a LCP on the left shutter of the active goggles in order to separate the viewer's eyes. The most interesting point, which differs from the previous case, is how the goggles work. The shutters work simultaneously.

IV. 3D DUAL-VIEW SET-UP

As we just described, there are two accordant modes to apparatus 3D Dual-View techniques, depending on whether the awning is cogitating or transmissive. We congenital two commutual prototypes to formally analyse the two altered methods. The cogitating approach (RM) consists in two DLP Link projectors (e.g., actuality Optoma HD67), beeline polarizer (Thorlabs LPVISE200), division wave-plate films, a argent awning (Screen-Tech), a claimed computer (Intel Core i7 3.5Ghz) with a clear lath NVidia Quadro 4000 and a software developed by our team, to administer the two 3D video streams. The division wave-plates (QWP) and the beeline polarizer (LP) are acclimated to accomplish the annular polarizers and the argent awning to activity the images after alteration the animosity states. The 3D glasses are synchronized by the DLP Link projectors.

The transmissive mode (TM) uses a projection table built by the company Immersion [6], with two projectors underneath, displaying the 3D image streams for two viewers standing in opposite sides of the table. The projection system consists of two stereoscopic projectors, circular polarizers (right and left handed), a computer (with Intel i7 processor) and the same video adapter NVidia Quadro 4000. Glasses are synchronized by the infrared emitters. Fig. 4 shows an overall schematic of the described experimental set up in both modes.

In the Case 2.1, for each goggle both shutters use the same type of circular front polarizer. Then, the QWP fast axis is stuck on the left and on the right shutter at 45 in one goggle and at 45 in the other goggle. Glasses for the Case 2.2 are made by sticking the QWP on the left shutter with the fast axis at 45 with respect to the front linear polarizer to have an active left handed circular polarizer, and at 45 on right shutter, for an active right handed circular polarizer. Fig. 5 shows the optical configuration of the goggles for the Cases 2.1 and 2.2. In RM, the 3D glasses are synchronized by the DLP Link projector: it sends a light flash to the screen that reflects reaching the goggle photo-sensor and triggers the shutters to open and close at the right time, according to the displayed images. Theoretically, no synchronization is needed between the projectors for Case 2.1. We have set up orthogonally circular polarizers in front of each goggle photo-sensor to trigger them separately.

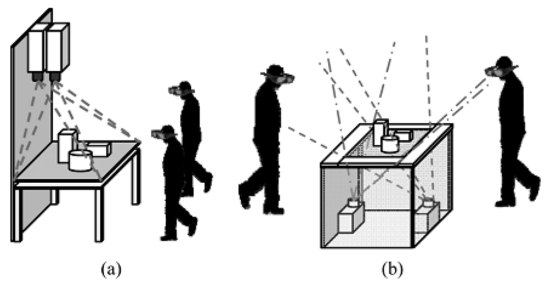

Fig.4.The 3D Dual-View in reflective mode (RM) (a), and transmissive mode (TM) (b).

However, due to the weak screen depolarization, goggles can detect both signals and the shutters could open and shut at the wrong time. Therefore, we decided to synchronize the two projectors. The software controlling the two 3D video streams provides a synchronous projection and consequently the synchronization of the goggles.

 DOI 10.17148/IJIREEICE.2015.3820

ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 3, Issue 8, August 2015

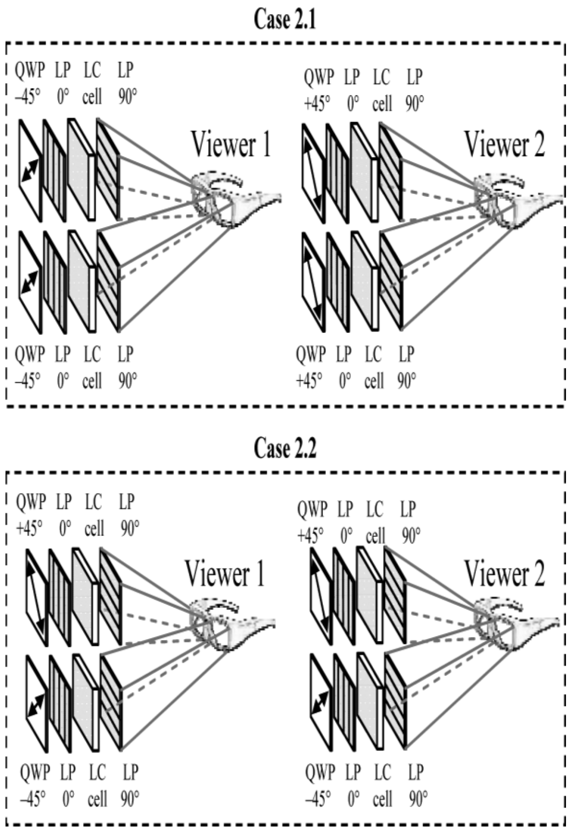

Fig.5. Optical configuration of 3D glasses for the Cases 2.1 and 2.2.

V. GHOSTING MEASUREMENT SETUP

The ghosting due to polarization is angle dependent [7][8], making it critical to be studied. We used a spectrophotometer (Minolta CS-100 chromameter) to measure the angular dependence of the GR. It was mounted on a mechanical arm, allowing the device to measure the colour and the luminance for all viewing directions. As shown on Fig. 06, the polar angle goes from 00 to 900 and the a azimuthally angle from to 1800 .The chromameter holder was fixed on a small metallic surface, mounted on the silver screen for RM and on the transmissive screen for TM. To assess the ghosting, one of the glasses is placed in front of the chromameter to measure the light passing through the shutter SHT-R2. Four measurements are carried out.

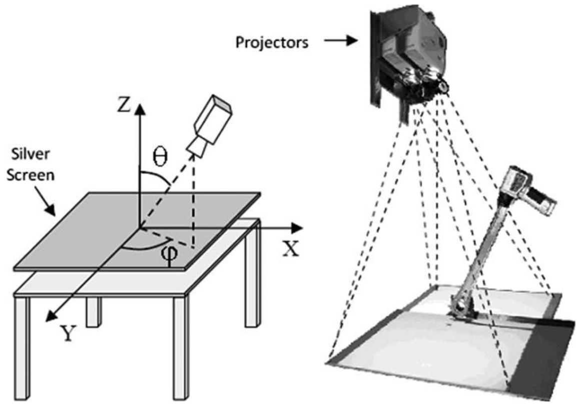

Fig.6. Principle of the ghosting measurement set-up.

We projected IMG-R2, varying the gray level from 0 to 255 and measure the luminance of the useful light. Then, we do the same for the three other video streams IMG-R1, IMG-L2 and IMG-L1. We measure then four Gamma curves and we calculate the three GR values. We distinguish the Polarization ghosting (due to the leakage of the image in the opposite polarization state), the Time ghosting (the image leakage in the same polarization state for the closed shutter) and the Polar-Time ghosting (the image leakage in the opposite polarization when the shutter is closed).

We present the results for only one shutter (SHT-R2). The results for the other shutters are similar. Besides, the GR has been measured for the red, green, blue and white colors for different viewing directions .In parallel, light distributions have been measured to calibrate the analysis.

VI. GHOSTING RATIO RESULTS

Measurements have been done for red, green, blue and white images but only the results for white are presented for the Cases2.1 and 2.2 and for both transmissive and reflective modes Case 2.2 were not implemented in transmissive mode. The light distribution of the transmissive and reflective screens was measured and presented as well as the calculated GR values. This distribution is crucial to understand the angle dependence of the ghosting effect, for all the tested situations.

A Reflective Mode: Cases 2.1 and 2.2

Fig. 7 shows the result in RM. It shows the luminance distribution. Then, the left column gives the results for the Case 2.1 and the right column the results for Case 2.2. The first row corresponds to the polar ghosting, the second row to the time ghosting and the last row to the polar-time ghosting. The polarization ghosting is the most critical; we see a magnitude difference but the behavior remains the same. The GRP is around 0.25 at normal incidence and increases when tilted up to 0.50.

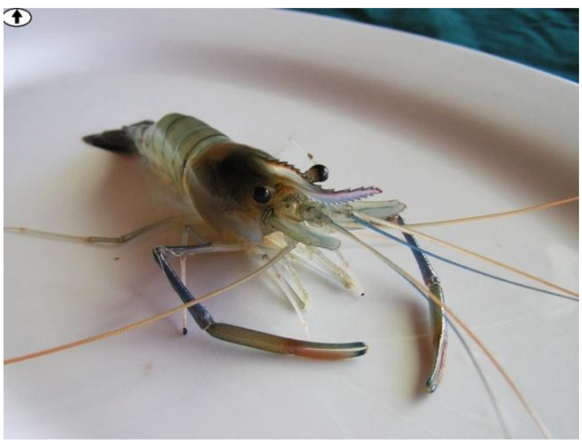

Fig: 7 the left column gives the results for the Case 2.1

The slightly higher values of the GRT in Case 2.2 are due to a different behaviour: both shutters open and close at the same time, the electronic driving is sought more and the shutter switching is slower.

ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

The GRT is uniform and almost independent of the polar and azimuthally angles. The GRPT can be neglected due to the separation made in same time by polarization and good dark states of the 3D shutters [9]

B. Transmissive Mode: Case 2.1Case 2.1

Fig. 8 shows the values of various ghosting ratios in TM for the Case 2.1 only.

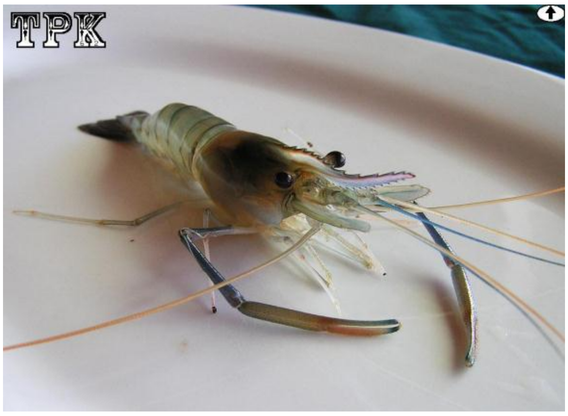

Fig 8: The right column gives the results for the Case 2.1

As expected, the animosity ghosting is the lot of harmful, followed by the time ghosting. The GRT did not change significantly: the affliction abstinent case, in RM is 0.1 and 0.08 in TM. Nevertheless, the GRP administration in the TM is absolutely altered from RM due to the corresponding ablaze administration of the projectors in RM and TM. This can be apparent by comparing Figs.7 and 8. In TM the ablaze is added charge with a best manual at and and decreases acutely if the examination bend changes. In RM there is no such directivity; the ablaze has beyond regions transmitting the aforementioned ablaze bulk with no fast changes while alteration the examination angle.

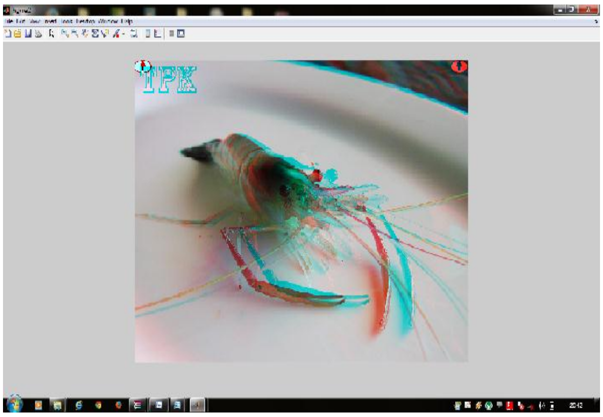

Fig 09: The resulting ghosting 3D-Dual view image

Then, the other projector has more light at, consequently, the ghosting by polarization [Fig.] is higher at because the light of the opposite projector becomes more intense in this region. We recall that the projectors in TM are located one in front of each other [Fig]. The worst measured ghosting for the white colour was 0.51 in RM and 0.33 in TM.

Since the TM setup favours a configuration where both projector and the viewers are one in front of the other, the light from each projector is much more directed towards its respective viewer [Fig. 9]. It is like if two different projectors display on different screens, each viewer being in front of his own screen. In contrast, in RM case, the application could take into account viewers that are side by side, with both ones receiving light from both projectors [Fig.9]

VII CONCLUSION

We have demonstrated how 3D Dual-View can be implemented in various ways by mixing different stereoscopic encoding techniques. The time combined with polarization multiplexing has been chosen due to the easiness to find the associated devices on the market. Two encoding techniques, Cases 2.1 and 2.2, have been tested in the reflective mode and only the Case 2.1 in transmissive one. The difference between these cases relies on the video sequence and the glass shutters functionality. Among possible impairments, the ghosting effect is the most important and has been measured for Cases 2.1 and 2.2 in reflective mode and in Case 2.1 for transmissive one. In TM, the Case 2.2 makes no sense because the projectors are facing each other and the light received by one viewer due to one projector is more intense than the other projector and the left and right image would have unbalanced intensities.
As a capital conclusion, we accept apparent that the ghosting by animosity is the a lot of adverse for 3D Dual-View systems [10] for several reasons. First, division beachcomber plates are amicableness dependent. Secondly, both argent and the transmissive screens clutter the animosity of the admission light. Comparing Case 2.1 for TM and RM is difficult, because the ablaze administration is not the aforementioned and the area of the projectors with account to the awning is different. In the TM the ghosting has a beyond angular dependence; if affective about the table the ghosting changes. In RM the ghosting depends actual little on the examination administration and a ghost-busting can be implemented apart of the eyewitness position. We accept apparent also, that the Cases 2.1 and 2.2 are not agnate if because added appearance such as physiological ambit and, in particular, a accessible eye unbalance.The ghost-busting address should cover this point, if the admirers are affective about the table. Therefore, ghost-busting four images in absolute time, such a agreement is abundant added computer consuming.

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ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

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Vol. 3, Issue 8, August 2015

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