41.3: Zero Barrier, Zero Crosstalk Autosteresoscopic 3D Display System for Cinema & Home Theater Multi-user Settings

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Abstract

Using a 4-viewer Autostereoscopic 3D Home Theater display system, a radically designed projection screen film system coupled with a conventional projection display is herein presented and shown to produce a superior 3D effect than most current autostereoscopic and non-autostereo 3D Display systems. The proposed design's goals were specifically aimed at tackling the, until now, mutually exclusive properties of most parallax based autostereoscopic 3D Displays i.e. staggeringly high Display Optical Efficiency and drastically low levels of image Crosstalk. By uniquely patterning a film stack onto a projection screen so that the projected left and right images are reflected to their respective viewers locations without the need for barrier or lenticular lens, we were able to achieve a 0% Image Crosstalk at ~90% Optical Efficiency in a 4 concurrent autostereosocopic 3D viewers Home Theater Display System.

Keywords - 3D, Cinema, 0% Crosstalk, Optical Efficiency

1. Objective and Background

The present market trends in 3D displays shows a meandering but steadily growing trend in adoption. There are however technological limitations which are holding the technology back and thus limiting the trend from becoming a torrent to instead a trickle. Among the notable of these technical drawbacks in autostereoscopic systems being the ever present crosstalk and its inversely linked and related optical efficiency, particularly in parallax barrier type autostereoscopic systems. However encouraging news as recently as of November 25, 2008 regarding an article that stated that the NFL experimented with 3D live broadcast should, among other things, be an incentive to tackle the above stumbling blocks once and for all and thus open the market flood gates. The herein presented approach is intended to do just that. We termed the resulting system The Zero Barrier Zero Crosstalk [ZBZX] 3D Display because for the first time we have managed to produce the elusive high number of concurrent multi-users autostereoscopic 3D display system with zero barrier and yet zero crosstalk.

Thus, the specific objective for the herein presented display is to provide a radically different 3D Display system that simultaneously lowers crosstalk to unprecedented levels as low as 0% while keeping optical efficiency higher than 90%. The method formulated herein takes advantage of mature technologies in Projection Displays and marrying them with a passive patterned projection screen design. The patterned projection screen's pattern then reflects the projected left and right images to multiple viewers' eyes within specific range locations. The proposed patterned film was constructed in ASAP and simulation experiments carried out to check the validity of the hypothesis.

The illustrative simple system set up showing the first row of concurrent 3D viewers is show in Fig. 1 below.

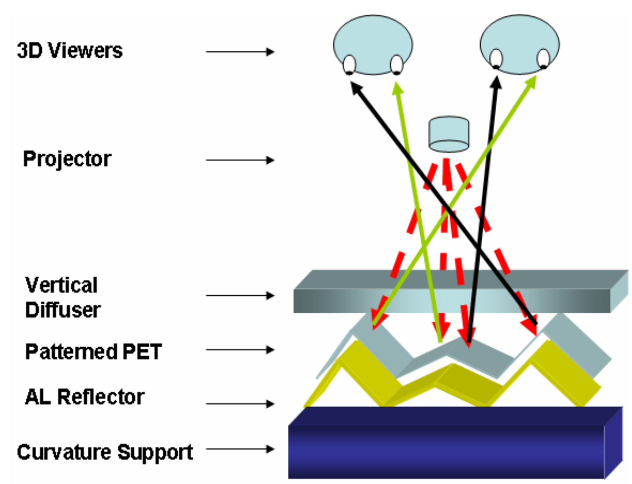


Fig. 1 Illustration of the system concept

The second set of viewers is then placed behind the first set of viewers in a cinema style seating.

In this paper we demonstrate a 4 concurrent 3D viewers display system. The parameters used in this system and whose results will be simulated are as shown in Fig 2, below:

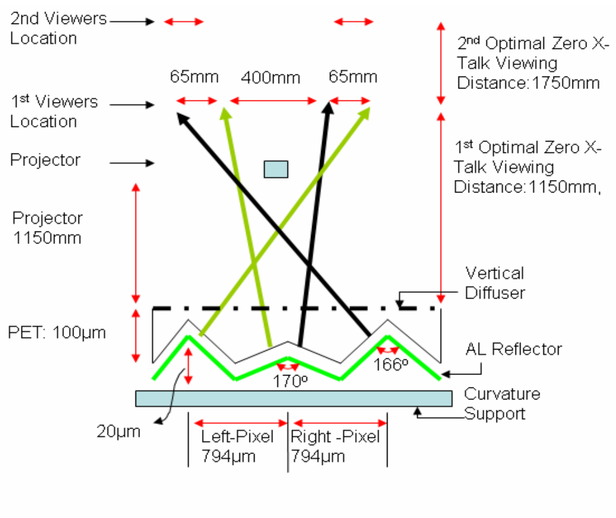


Fig. 2 Figure shows the computed and utilized parameters in our prototype 4 Viewers 3D system

In order to evaluate the effectiveness of the design industry conventions for computing 3D display performances were used. In particular computations for Crosstalk and Optical Efficiency were carried out based on the usual conventions as seen in Fig. 3 below.

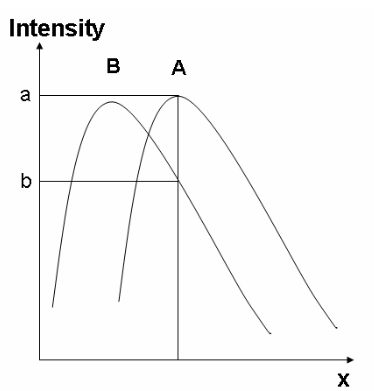


Fig. 3 Shows the diagram of Intensity vs. Left [A] and Right[B] eye locations in a conventional parallax based 3D Display system

Cross Talk = b/a……………………………………(1)
Optical Efficiency =(Barrier Slit Size)/(Pixel Pitch)….(2)

With the standard conventions ,and equations (1) and (2), of judging the quality and performance of the design now in place we proceeded to building the system and then simulating it in Breault Research Organization - ASAP Optical Engineering Software.

Results

The 3D overview of the system built in ASAP is as shown in Fig 4. below clearly showing the distribution of reflected light from the screen in parallel columns as it is observed by the detector sheet placed on 1st Viewers location.

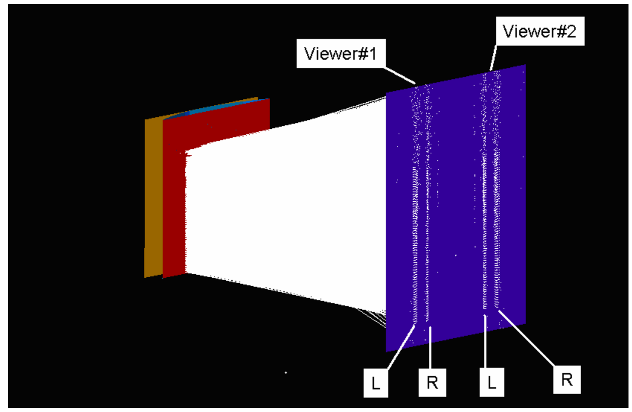


Fig. 4. A 3D Perspective of the 166°-170° Prism, Vertical Diffuser , 100% Optical Efficiency, 0% X-Talk, 1150mm Viewing Distance

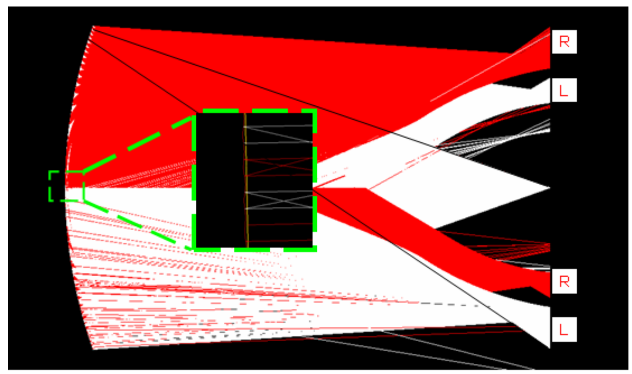


Fig. 5. Aerial Perspective for the: 166°-170° Prism, Vertical Diffuser , 100% Optical Efficiency, 0% X-Talk,1150mm Viewing Distance

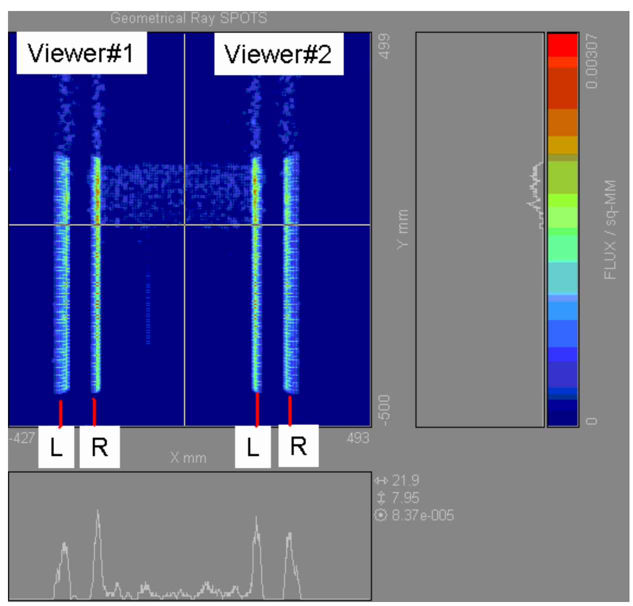


Fig. 6. Intensity Distribution for the: 166°-170° Prism, Vertical Diffuser , 100% Optical Efficiency, 0% X-Talk, 1150mm Viewing Distance

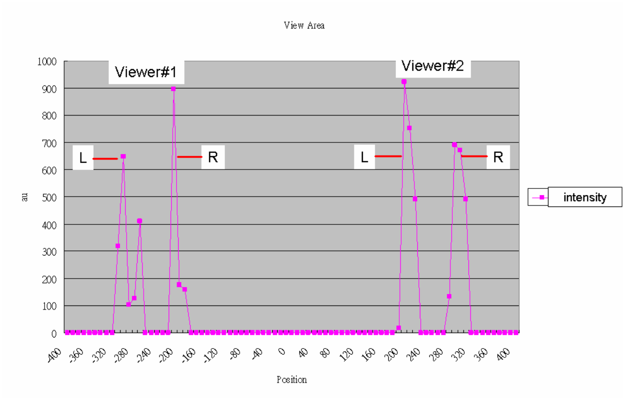


Fig. 7 Intensity Graph for the: 166°-170° Prism, Vertical Diffuser , 100% Optical Efficiency, 0% X-Talk, 1150mm Viewing Distance.

Similarly results for the 2nd Viewing Location were recorded and are as shown below.

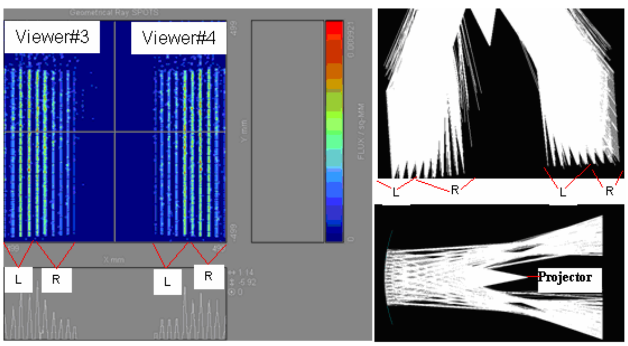
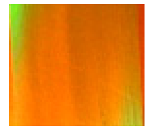
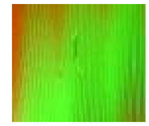
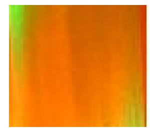
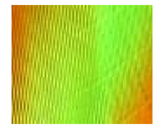


Fig. 8 Intensity Distribution for the: 166°-170° Prism, Vertical Diffuser , 100% Optical Efficiency, 0% X-Talk, 1750mm Viewing Distance.

In this illustrated 4 concurrent multi-user 3D Display system, the distinct intensities for the left and right eye images show no overlapping, 0% crosstalk, unlike in the case of most parallax barrier or lenticular lens 3D autostereoscopic display systems. More importantly the system does not use a barrier at all, thus by the industry conventional definition of optical efficiency the system achieves in excess of 90% Optical Efficiency at the observed 0% Crosstalk. The losses in optical efficiencies are mostly due to the screen scattering effect in the vertical diffuser segment.

Experiment

A large Left pixel in Red and a large Right Pixel in Green were combined using vertical interlacing then projected onto our 3D screen. Same portions of the screen were then photographed from the respective left and right viewing locations to capture the screen's ability to separate the left and right pixels. These results are tabulated below.

LEFT VIEW	RIGHT VIEW
 LV 1	 RV 1
 LV 2	 RV 2

Clearly the images have visible amounts of crosstalk especially on the edges. The left red pixels all have small green parts in the corners. Similarly the right green pixels have visible red portions in the corners as well. However, the very fact that crosstalk in the images appears on the edges of the left and right pixels actually acts to lower the perceived crosstalk when both eyes are used.

However, the overall effectiveness of the screen to separate the left and right pixels as a proof of concept is apparent. The visible crosstalk from our experiments were largely due to alignment issues between the projector and the 3D screen rather than from the soundness of the concept's design. The high resolution of the projector coupled with close proximity of projection distance meant the pixels were very small thus challenging to align perfectly with the prismatic structure of our free standing 3D screen. Needless to say, better alignment techniques are currently being sought and experimented with to find the best fit for out case with automatic optical alignment methods being high on that list.

Impact

The design achieves an almost characteristic *oxy-moronic* property of a staggeringly high optical efficiency, >90%, at drastically low crosstalk level, hovering around 0% at viewing locations which we aim to resoundingly achieve by using better alignment techniques than in the current set up. Comparatively, apples to apples, with other current leading multi-user 3D systems in its class the design surpasses most whose crosstalk levels range from 5% to ~ 15%. Those with higher than 15% Crosstalk were not considered as it is generally been observed that crosstalks higher than that significantly affect viewers' comfort.

When compared to non-autostereoscopic 3D systems there are still optically superior qualities since most have about 0.1% crosstalk with ~50% optical efficiency apart from their need for users to don polarizing glasses. Cost effectiveness was also built into our designed system because the systems use conventional Projection Displays which are then coupled with our designed projection screen to produce 3D images.

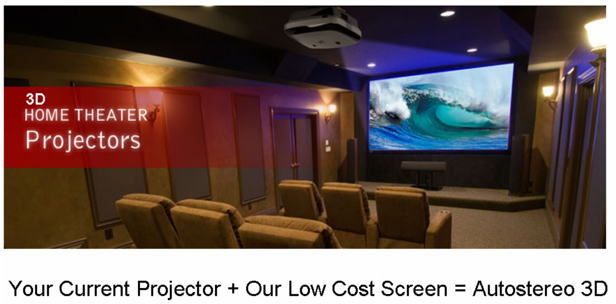


Fig. 9. Set up of the example Autostereoscopic 3D home theater system [Image Courtesy : Expediant Audio/Video]

For our experiments and all the above simulations a conventional off the shelf XGA Projection display was used onto a 40 inch diagonal patterned 3D screen. The computed cost for realizing the 3D screen was done in conjunction with our collaborating company. It was found to be NT$5000 or about US$150 if the user already has an XGA Home Theater Projection system as shown in Fig. 9 above.

Conclusion & Discussion

The herein presented system has advantages that are aimed at finally bypassing the current stumbling blocks in the adoption of 3D display systems by the mass market. These not only include the technical difficulties, crosstalk and optical efficiency, but also price which under current global economic conditions cannot and should not be ignored. However, as high as the system has raised the bar in the above stated categories there is still need for more work to be done. We are currently collaborating with our partner company to realize, *ceteris paribus*, a 100 inch diagonal and >9 concurrent 3D viewers to demonstrate the effectiveness of the design in a cinema type environment. The fabricating process of larger patterned film stacks greater than 40inch diagonal is currently hampered by equipment size. Thus our future work is geared at overcoming this obstacle by either enhanced alignment techniques for stitched films or bigger equipment. Alignment of a different kind is also being experimented with in order to automate and efficiently align the projector and the 3D screen's patterned surface and thus effectively remove the experimentally observed alignment caused image crosstalk.

References

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