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Optimal Usage of LCD Projectors for Polarised Stereoscopic Projection

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ABSTRACT

Polarised stereoscopic projection involves the polarisation of the two projected images in orthogonal directions - e.g. +/- 45 degrees for linear polarisation, or clockwise and counter-clockwise for circular polarisation. When LCD projectors are used for polarised stereoscopic projection it is important to take into consideration the fact that the output of these types of projectors is already polarised - but not necessarily in the directions required for stereoscopic projection. The paper considers the amount of light loss of various polarised stereoscopic projection configurations to recommend optimal configurations.

The paper also points out that it is advantageous that the output of an LCD projector is already polarised. In general, there will be less light loss in the polarisation process when an LCD projector is used for stereoscopic projection as compared to when a projector which outputs unpolarised light is used (e.g. CRT and DMD/DLP).

1. INTRODUCTION

Polarised stereoscopic projection involves the polarisation of the two (left & right) projected images in orthogonal directions. The defacto standard for linear polarised stereoscopic projection is +/- 45 degrees from the vertical axis (as shown in Figure 1 below), however, vertical and horizontal polarisation for the two views can also be used. For circular polarisation, the two views are clockwise and counter-clockwise polarised.

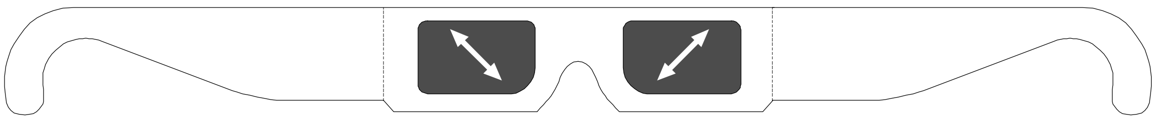

Figure 1: The defacto standard orientation for linear polarised 3D glasses

In the past, projectors with unpolarised outputs were generally used, such as slide projectors or movie film projectors – hence the orientation of a polariser placed on the front of the projector didn't need to be given much thought. However, the output of projectors based on an LCD[1] optical engine are already polarised, so some attention must be given to the possible interaction between the polarisation orientation of the projected output and the desired polarisation direction for stereoscopic projection.

The output polarisation of commonly available video projectors fall into three main categories:

a) unpolarised output – as with CRT[2] or DMD/DLP[3] projectors
b) linear polarised output with two colours in one direction and the remaining colour in an orthogonal direction (e.g. Red and Blue vertical and Green horizontal) – most 3 panel LCD projectors are in this category. For the purposes of this paper, let's call this a Type 1 LCD projector.
c) linear polarised output with all colours in the same direction – as with single panel LCD projectors and some 3 panel LCD projectors. Let's call this a Type 2 LCD projector.

These categories are illustrated in Figure 2.

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[1] Liquid Crystal Display
[2] Cathode Ray Tube projector – also known as a 3 gun projector
[3] Digital Micro-mirror Device / Digital Light Processing projector as patented by Texas Instruments (DMD=DLP).

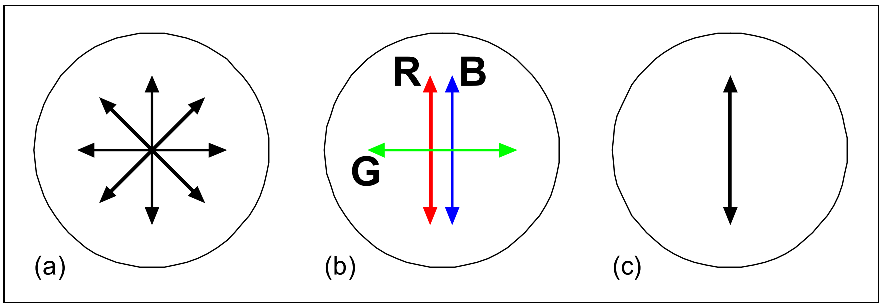

Figure 2: Illustration of output polarisation of various projector types: (a) unpolarised output (CRT or DLP), (b) linearly polarised but with green (G) polarised differently to red (R) and blue (B) (Type 1 LCD), (c) linearly polarised with all colours polarised in the same direction (Type 2 LCD).

2. METHODS FOR POLARISED STEREOSCOPIC PROJECTION

In order for the three categories of video projectors to be used with polarised stereoscopic projection, various configurations of optical filters must be used to obtain the correct polarisation output with minimal light loss and minimal colour distortion. The various configurations for configuring projectors for linearly polarised stereoscopic projection are illustrated in Figure 3:

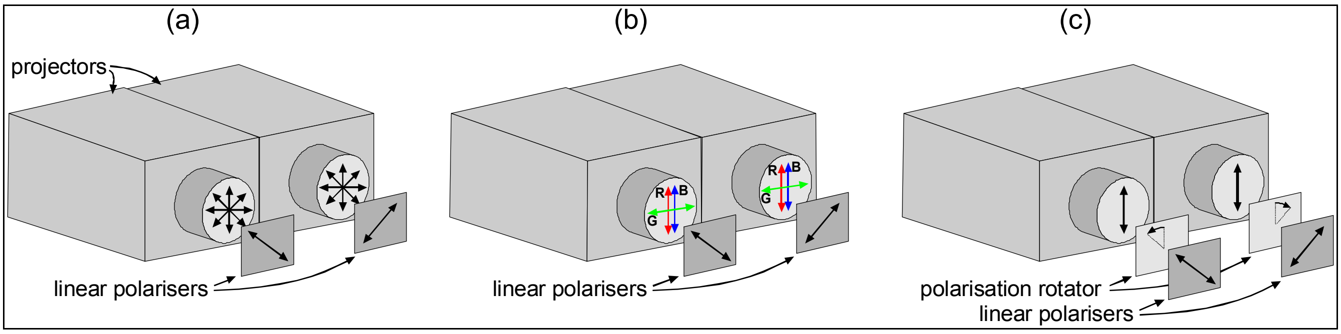

Figure 3: Methods for linear polarised projection for various output polarisation types.

In the case of Figure 3a, the linear polarisers at the output of the projector can be oriented at any angle since the projector output is unpolarised. In this case the linear polarisers are oriented to match the orientation shown in Figure 1. In the case of Figure 3b, the linear polarisers must be placed at either +45° or -45° in order for the correct colour balance to be achieved. Luckily this corresponds with the desired polarised projection orientation as shown in Figure 1. In the case of Figure 3c, it is desirable that the bulk of the light being output by the projectors in the vertically polarised direction be rotated into the desired +45° or -45° orientations – this can be achieved with a ½ wave retarder. Linear polarisers are then placed at the output to purify the linear polarisation in the desired directions - to match the orientation shown in Figure 1. The projectors of Figure 3c could be configured the same as Figure 3b (i.e. without the retarders) however the image is brighter when the retarders are used.

3. LIGHT LOSS

The relative efficiency of each of the projection methods illustrated in Figure 3 have been calculated and measured[4] and the results are summarised in Table 1. The percentage figure quoted for each configuration represents the amount of light that reaches the screen from the projector's output lens – i.e. 0% efficiency represents no light reaching the screen (100% light loss in any optical components between the output lens and the screen) and 100% efficiency would mean that all light emitted at the projector's output lens reaches the screen (0% light loss).

[4] These figures are based on the use of HN38 polarisers. The figure quoted is the percentage transmission for the most highly attenuated colour.

Projector Type and Configuration	Efficiency Measured	Calculated
(a) Unpolarised output (CRT/DMD)	~25%	~35%
(b) Linear polarised with colours non-co-linear (Type 1 LCD)	~32%	~50%
(c) Linear polarised with all colours co-linear (Type 2 LCD)	~57%	~62%

Table 1: Relative optical efficiency of the various polarised stereoscopic projection methods.

Both measured and calculated figures are listed because the difference between measured and calculated provides some assessment of the approximate accuracy of the figures. However, both the measured and calculated figures show the same trends therefore providing some confirmation of the overall results. The differences between the measured and calculated figures could be attributed to measurement error and/or differences between product literature and actual shipped product.

4. DISCUSSION

It can be seen from these figures that the least efficient projection configuration is configuration (a) (the unpolarised output projector) and the most efficient configuration is configuration (c) (where all colours are polarised in the same direction). Considered another way, if three projectors of all equal brightness were used (one of each projector type), the image from configuration (c) would be ~130% (measured) or ~75% (calculated) brighter than the image projected by configuration (a). Therefore, there is a significant advantage to using LCD projectors for polarised stereoscopic projection due to the fact that their light output is already polarised. Even configuration (b) produces an image ~28% (measured) or ~41% (calculated) brighter than configuration (a), although the non-linear response of the eye to brightness may make this brightness difference somewhat hard to distinguish.

If, for example, you were considering a pair of 1000 ANSI lumen DLP projectors versus a pair of 1000 ANSI lumen LCD (type 2) projectors for stereoscopic projection, the DLP projector would produce a stereoscopic image about 600 ANSI lumens bright (1000x30%x2) whereas the Type 2 LCD projector would produce a stereoscopic image about 1200 ANSI lumens bright (1000x60%x2).

Obviously it is unlikely that the projectors you will be considering for a stereoscopic projection system will all be the same brightness, the figures shown in Table 1 should therefore be used to de-rate the brightness of the projectors you are considering. This may well produce a considerably different set of price/performance ratio figures that you might have originally considered.

It should be noted that the various optical filters can change the colour balance of the projected image so this may need to be corrected by adjusting the gain of each appropriate colour at the projector. It should also be noted that the more optical filters that are used, the sharpness of the projected image may reduce but this will depend upon the quality of the optical filters being used.

5. CONCLUSION

The main point of this paper is that there can be a significant advantage in using certain LCD projectors for polarised stereoscopic projection versus using DLP or CRT projectors. More light is lost when DLP and CRT projectors are used for linear polarised stereoscopic projection versus the amount of light lost when using LCD projectors.

Unfortunately this paper comes at a time when very few Type 2 LCD projectors are being produced. A recent survey of LCD projectors revealed that almost all are of the Type 1 variety. If the value of Type 2 LCD projectors for polarised stereoscopic projection are not recognised, the Type 2 LCD projector may well totally disappear from the market.

Although this paper has only considered linear polarised stereoscopic projection, similar principles apply to circular polarisation but this will be left to the reader to explore or it may be the subject of a future paper.

6. REFERENCES †

1. Hecht, E. (1998) "Optics", Addison Wesley Longman, Reading, Massachusetts.

† *Subsequent to the presentation of this paper, the author was made aware of another reference which has some relevance to this paper: Lipton, L. (1991) "Stereoscopic Video Projection System", US patent 5239372.*