3D Demystified

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Abstract

In the evolving industry of digital fulldome, another technology is growing in popularity – boasting a list of increasingly interactive and innovative shows and hoping to repeatedly attract wider audiences with the 'wow' factor. Stereoscopic projection solutions are being integrated into (or even replacing) existing immersive theaters:

What, How, and Why do you choose?

With a portfolio that includes the design and installation of more than one hundred 3D solutions, the team at Global Immersion are well placed to educate on the 'ins and outs' of digital stereo projection. During this session, Martin Howe will take you through the different tools and techniques that are available and already in use around the globe – uncovering key benefits and potential setbacks of integrating this innovative medium into dome theater environments.

Introduction

High field-of-view displays, typically large cylindrical, spherical or partially spherical displays, are able to be adapted to project stereoscopic electronic images and movies. There is a growing interest in adapting these high field-of-view public theaters to show stereoscopic content (sometimes referred to as 3D). It is considered that '3D' can attract a broader audience, differentiate that theater from others without 3D and add additional data and depth cues for interpreting specific data.

However, some argue the spatial immersion that stereoscopic projection offers is already inherently provided by the high field-of-view nature of the display environment and that truly accurate stereoscopic representation can only provided for a very narrow viewpoint; an audience as small as one, thereby rendering it inappropriate for large theaters.

Perception

To understand the issue, it is necessary to firstly understand how we, as humans, perceive the World around us - to see how we see. In reality this is a very complex subject which cannot be fully expressed in this paper, suffice to say that the basic principles are generally understood and acknowledged but there are still significant areas of 'grey' that are a factor in this particular area of spatial immersion.

The brain can be regarded as a guessing engine, constantly evaluating input and comparing it to experience to create its interpretation of the World outside. Visual and audible cues are the main input channel reinforced by touch, experience and learning. Depending upon the situation the main visual cues are:

Occlusion – Depth of a scene, and in particular, depth order can be derived from occlusion, where an object closer to the viewer will obscure objects behind it. Head movement or movements in the scene, even very small ones, can derive overall depth relationships.

Perspective – Known shapes, such as circles (coffee cups), rectilinear surfaces (table tops) provide strong visual clues for location and orientation.

Lighting, contours and shadows – The nature and type of lighting provides crucial data for interpreting shapes of objects (contours) and positions (shadows). Collimated light from direct sunlight for instance is typically more helpful that diffuse light of a cloudy day.

Texture gradient – Regular patterns, such as carpets, wallpaper, fields of wheat, can help identify depth, perspective and contours.

Known references – Objects of a know size, such as chairs, cars, and people, provide important reference data to the local scene for size and position.

Binocular vision – Along the plane of eye separation, relative distances of close object become obvious (as each eye has a slightly different view). Perpendicular to that plane (typically vertically) binocular vision has no effect, nor does it over larger distances, especially if the viewer has a dominant eye (which is typical).

Stereoscopic Projection

Stereoscopic projection uses binocular vision and the attribute of eye separation to replicate scene depth by allowing each eye to see a slightly different image of each scene. This eye separation is replicated in the content by having two separate physical or virtual camera positions. There are a number of methods of achieving this. In a projected large screen theater, they all use some variant of image filtering to each eye which is facilitated by glasses worn by each member of the audience.

The methods and their attributes include:

Active systems: The viewer wears glasses that alternately blank each eye from the screen (left eye, right eye, left eye, etc) at a high rate that is not particularly obvious or intrusive to the viewer (at least 60Hz, ideally as high as 120Hz). The projection system sequentially projects the image sequence for each eye at the same rate. A method of synchronizing the glasses to the projection image frames is used (typically infra-red emitters in the theater transmit the synchronizing signal to the glasses and more recently techniques that add 'invisible' data into the video content to synchronise the glasses).

Passive systems: Passive systems use inactive glasses that filter light to each eye by some optical method. Common systems today use either i) two projectors with polarizing filters to polarized the light differently for each eye with corresponding filters in the glasses ii) anaglyph which use red and blue filtered lenses for each eye and corresponding red and blue filtering applied to each projected image iii) Infitec™ which is a trademark for a method using very narrow band light filters for each of the primary colors of the image (red, green and blue) shifted slightly in frequency for each eye with corresponding filters in the glasses. More recently Dolby has introduced a very high quality passive glasses solution and ColorCode have introduced a low cost solution that works on all display types.

For very high field-of-view theaters, typically domed screens with 360 degree by >150 degree field-of-view, certain techniques are better than others. Polarized systems are generally not suitable due to their requirement for high gain non-polarizing screens. The high gain of these screens causes too much light scatter back onto the screen surface dramatically reducing image contrast. Anaglyph systems, although much lower in cost, have poorer image separation between eyes (causing image ghosting) and poorer color reproduction. Active systems and others such as Infitec™ (and even combinations of the two), although being typically more expensive, will yield better results in terms of color reproduction and image contrast along with negligible image flicker and ghosting.

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Issues of distance and audience positioning

A prime consideration in certain theater configurations, particularly ones with dome screens, is that of head orientation and inter-ocular distance (eye separation). The problem arises in two instances. If the seating in a theater is concentric, where all seats face the center of the theater, then there is no common view of where 'left' and 'right' is on the screen, and since stereoscopic projection is based upon generating two sets of image data horizontally and in line with the plane of the viewers eye, it is likely that only a few of the audience members will experience the scene as it was intended. Some will see the correct eye separation as they will be seated parallel to the plane of view of eye separation, some will see no separation as they will be seated at right angles to the plane of separation, some will see the exact opposite, with left of the right and vice-versa, and of course all variations in between.

The other instance is unidirectional (forward facing) seating under a dome screen. In this case, although the audience are all seated facing the same way, by the very fact that the screen is all around them they will move their head to look around the image. In one instance, two people on opposite sides of the theater will look up to the center of the dome and have opposing left and right views of the data, in other cases one person could see the same part of the screen by either tilting their head back or by rotating their head around – in either case the plane of the viewers eye will be different to the plane of stereo separation of the content and in both cases they will be different to each other – it depends how you look at it, literally!

Peripheral vision

There is an additional, but less well understood attribute to human vision that lends itself well to immersive display in high field-of-view theaters, especially dome screens, which is peripheral vision.

Recent knowledge and theories explain that image data flows to the brain via two discrete channels, not the left and right channels that are normally considered, but the separate channels of central and peripheral vision. Central vision is the data flow to the brain that focuses on objects and places in a scene. This focus is typically also the focus of attention, where we concentrate on, or at least notice, detail. Almost photographic in nature, it is believed that images are processed as a sequence of data, where blinking provides a critical method to reframe scenes. Peripheral vision is quite different and is thought to comprise a continual flow of data of the complete environment.

Whilst most of us will understand the importance of peripheral vision for recognising danger entering our scene, it is less well understood how important it is for creating an internal representation of the external 3D World. Peripheral vision provides a constant flow of wide area data to provide context and spatialization of the 3D World and provides it in a spherical context. The center of this spherical context coincides exactly with the fixation point of the central vision, thereby creating a spatial relationship of the whole scene relative to the part being 'looked' at (focussed on). Because by default we are focussed (concentrating on) the central vision, we are not constantly aware of the peripheral vision but it provides crucial scene and depth cues to the brain to fully recreate the 3D World outside.

The uniqueness of a dome theater environment is that the data being projected is sufficiently broad in terms of field-of-view, so that central vision and peripheral vision are both fully employed in relation to interpreting the data (whereas in television or cinema peripheral data is either absent or out of context; the room in which the data is being viewed is also visible and as such is out of context with the data being presented, therefore the spatialized peripheral data of the scene is absent). This cohesiveness and concurrency of central and peripheral vision in a dome theater can add significantly to the realism and immersiveness of the experience because the peripheral data allows a true 3D representation of the data to be created in the brain.

Finally it should be noted that the use of glasses in a high field-of-view theater implicitly reduces the instantaneous field-of-view and obscures peripheral data. Therefore whilst 3D stereoscopic projection adds obvious and noticeable additional depth cues to content (sometimes exaggerated for effect) the subtleties and perhaps more realistic and natural representations available in very high field-of-view theaters obviates the need for additional techniques.

The true benefit of fulldome 3D

At present, views are divided on the true benefits of employing 3D in high field-of-view theaters and implementations need to be carefully considered and reviewed against agreed objectives and goals. As ever, the choice of content should be a key driver in choice of solution and in many cases theaters are deciding to employ stereoscopic systems in addition to those optimized for monoscopic viewing (where high contrast and resolution are more crucial for providing realism).

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