Future Shock:

Why Stereoscopic 3D may be the key business opportunity for Broadcast and Post

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June 2008

Just one year ago – June 2007 - Stereoscopic 3D was hardly registering as a subject for the vast majority of people worldwide in our industry or outside of it. Now for Film makers, Post Houses, Broadcasters and increasingly consumer electronics companies. It is the single hot topic.

A year ago, Hollywood lead the way in arguing the case for Sterescopic movies. Now, more and more Broadcasters are researching Stereoscopic services. Meanwhile the Post houses that provide services for Film, Broadcast and Corporate are starting to equip for Stereo.

Here at Quantel we've been out on the road for nearly a year, showing Stereo to everyone we can and learning a great deal from individuals and companies who are already involved in Stereo.

Our first conclusion: There is a lot more Stereo happening out there than people realise.

Our second conclusion: This is potentially the biggest opportunity for our industry in years and we need to work as an industry to make it happen. If we get it right, everyone wins.

In this white paper, we'd like to share what we've found and hope this sparks off yet more interest.

"Hannah Montana & Miley Cyrus: Best of Both Worlds Concert" smashed box office records, showing the business potential of Stereo

Early Stereoscopic content

Stereoscopy has a 150 year history

When I think of 3D I think of the 'creature features' of the fifties or the theme park movies of my childhood. However stero stills cameras were on the market from the 1830's and the first test moving films were shown very early in the last Century – some say 1902, others 1915.

The first feature length screening 'The Power of Love' showed around 1922.

A 1922 Stereoscopic movie camera

The so called 'Golden Age' of 3D movies ran from around 1952 to 1955. At that time, the Studios were under attack from TV and were looking for the 'next big thing' to lure audiences back to the theatre.

Some classic 3D movies from the 1950s

One widely held view is that 1950's 3D movies suffered from three main problems.

- They were very complex to shoot, (you had no idea what 3D shots would look like until a day or more later) which explains how inconsistent and poor much of the photography was and how some 3D effects are uncomfortable to watch.

- They were very slow and difficult to post produce. Traditional optical and chemical effects are cumbersome enough even with a conventional 2D movie as you have no idea what the effect looks like until it has been printed.

- They were very tricky to project. Keeping two projectors in harmony was very difficult so screenings were inconsistent[1] – plus traditional 3D glasses[2] were uncomfortable to wear. Some audience members often went out with a headache!

Others say that the real problem was that there was a knowledge gap in production and distribution – as the rapid growth in demand got ahead of the numbers of skilled people. In any case, 3D cinema wasn't a really commercial product.

It seems from the 1960s onwards the film 3D market settled into specialist areas like IMAX with the odd high profile side project to a big movie (Amityville 3D, Jaws 3D, Terminator 2) often linked to theme parks and museums.

Things started to change a few years ago. As someone involved in conventional Digital Post, it makes sense to me that 3D Stereo Digital Post is more agile and less error prone than optical and chemical methods. So the growth in Digital Effects and later in DI potentially makes stereo 3D post quite a bit easier.
Another new tool is stereo digital acquisition. Unlike shooting film, a cameraman or director can view digital on location while it is being shot. Also unlike film, digital doesn't suffer from weave or hop and doesn't need to go through a chemical development process which can lead to differences between the 'eyes'. One of the pioneers of this process is Vince Pace who worked closely with directors like James Cameron.

Finally, digital projection is eminently suited to 3D. Unlike optical projectors, there are no issues with film movement, scratches or dirt. There are now various different digital projection choices[3] that can handle conventional 2D films as well and from what I've seen of them they all look good.

These three steps forward – digital post, digital capture and now digital projection, have removed a lot of the complexities and costs of film.

Stereo 3D Cinema now
DreamWorks have announced all their animated movies will be 3D from 2009 and with many other new stereoscopic projects in the pipeline, demand for Post services is growing and growing fast.

Quantel Post customers have already played a part in digital 3D. For example, in Ghosts of the Abyss, Aliens of the Deep (James Cameron) Spy Kids 3D and Shark Boy and Lava Girl (Robert Rodriguez).

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[1] There were single strip systems that solved the issue of projector synchronisation but at the expense of introducing other complexities.
[2] Typically Polarised, not Anaglyph.
[3] RealD (passive polarised glasses), Dolby (passive frequency based glasses) and McNaughton (active glasses) are three well known examples.

Every month brings announcements of new projects. As well as the creative push, the obvious commercial angle is that good 3D movies enjoy a premium at the box office. Interestingly, 3D movies also can't be shown on conventional VHS, DVD or Web which is a new angle on anti-piracy.

Watching modern stereo 3D is a quite different experience from the preconceived idea of uncomfortable coloured cardboard glasses used on comics. Today, it's much more like wearing comfortable Polarised 'sunglasses' and there are also non polarised frequency based glasses. Both can give excellent results.

3D Broadcast
At Quantel we work with Post and Broadcast customers. Some Broadcasters today are a little bit in the same position as Filmmakers in the 1950s – they want to tempt audiences back from new kinds of competitors – today it is the Web and Games. High Definition is part of the answer – compare watching a big sporting or music event on the web or your phone and then on HD with 5.1 sound and there is no doubt that Broadcasters have a powerful new tool for attracting audiences – *but just supposing that tool could be made even more compelling.*

The gut reaction to Stereo Broadcasting is almost always positive – audiences love it. There is no question of demand - but of course it has to work as a business model too.

Our industry is ultimately about entertaining and educating people. Channel proliferation has changed the economics of Broadcasting as have Games and the Web. Broadcasters are adapting by cutting costs, improving efficiency, offering HD services, increasing the use of user generated content and looking for new delivery revenue streams.

These are all good measures to improve their position versus other Broadcasters – but Stereo offers the prospect of grabbing back viewers who spend their time on the Web or playing games.

Of course Stereo presents technical challenges to a Broadcaster for roll out - but far less now than even a few years ago. Analogue Stereo TV was a commercial non starter.

Today, if you shoot digitally, post digitally and transmit digitally, Stereo is less difficult than many imagine. Also, well shot stereo may have some compression friendly characteristics - there is similarity between the 'eyes'.

Let's not forget Color TV was difficult too.

OK, so what are the objections to Stereo Broadcasting? One statement that you'll hear is 'not all material is suitable for 3D'. I find that rather hard to understand. During the course of a day, how much time do you spend with one eye closed? Another one is the 'you'll never get people to watch 3D at home with glasses'. I really don't know how we can be so certain about that – many of us wear spectacles – or at least sunglasses – without objection. Sales of walkmans or iPods doesn't seem to have been affected by the need to wear earphones. People will happily go to a 3D movie and wear special glasses – the same may soon go for computer games. So while of course glasses - free viewing (autostereoscopic) would be ideally preferable, it doesn't seem to be mandatory and in any case auto stereo TV sets using picket or lenticular display methods are coming on the market as a possible future choice for Broadcasters to use.

Stereo 3D broadcast is amazing – I've seen tests with my own eyes. Maybe you can if you are my age – just – remember the first time you saw colour TV compared to Black and White. The difference is that big. No point in saying more – just wait until you see it.[4]

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[4] *Try this thought experiment: Anyone you know from outside of the industry (say a 4 year old) goes into a TV store and sees their favourite programme on a normal set then an HD set. Now, repeat the same experiment with a normal TV set and a 3D set. Which one has more impact?*

So, the real long term business may be in Broadcast. Early 3D domestic sets are here – an estimated 3 million by end of 2009. Test broadcasts are underway in Japan. Test shoots have happened with Basketball, American Football, Rugby, Boxing, Motor Racing and Ice Hockey. Keep an eye on broadcasters in China and Korea but also Europe and North America.

Also expect most of the major electronics vendors to make a move some time soon – the long term business opportunities are obvious. Mitsubishi, Samsung and Hyundai are amongst the vendors shipping TV sets already. There are many proposals for delivery, either to the home or for narrowcast. There are many interesting proposed schemes that could be deployed.

3D Narrowcast and point delivery
The NBA have already conducted stunning 'narrowcast' experiments of relaying basketball from one stadium to another which shows huge potential for 3D events (sports and shows). You can only get a fixed number of people in a concert area or sports stadium. For really big sports events (think Superbowl, the World Cup, Boxing title fights, the Olympics) or really big music events (think of the recent one-off Led Zeppelin reunion concert that sold out in minutes) the demand for tickets can be tens, hundreds or even thousands of times greater than the capacity of the venue – or the worldwide audience simply can't travel.[5]

Narrowcasting to Stereo equipped venues and also Cinemas has huge business potential. Now think worldwide product launches. Big trade shows. Regular sports bar narrowcasts. Even autostereoscopic (no glasses) digital signage in shops and public places. There are many many opportunities just waiting to be grasped.

Post Production in 3D
So, is making a 3D project now easy? Speaking to folks doing it right now the answer is 'no'. I was told that there are still many issues in Post. Customers have all the day to day issues of conventional 2D projects multiplied by at least two:

- 3D projects mean double the recorded material – that means double the disc space, double the rendering overhead and double the issues with moving media.

- There are issues in off-line. You can't judge depth effects, you can't judge the pace of the project (3D feels better with longer, slower shots), you can't easily see if there are colorimetry, positioning or synchronisation issues between the cameras etc. That all means off lines are guesswork and much more fixing needs to be done in the online sessions. That can mean using a team of VFX, Colour and Editing applications to fix the problems in the edit or during DI – but that is complex and slow – guesswork again.

- You can't accurately on-line projects. Customers tell us that the systems they are using now either work 'one eye at a time' (lots of opportunities for errors) or use proxy/rendering workflows (lots of time waiting for renders and opportunities for technical errors). Either way, 3D post is still really difficult.

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[5] *Music downloads have changed the economics of the Music industry. Now, live music is becoming commercially far more important again. Recording or transmitting live events may be a key new part of the Stereoscopic business.*

So, seems like someone should do something to help make Stereo 3D post easier, which is why we rolled out a family of stereoscopic systems at IBC 2007.

3D Business now
Almost any member of the public who sees Stereo likes it – and after all they are the people who pay all our wages. Stereoscopic cinema is here now. Corporate video are using stereo now and even Stereoscopic broadcasting is being seriously considered.

Our industry has been through some painful structural changes in the last 10 years. The rise of the desktop, broadcast channel proliferation, film piracy, chat rooms and video games have seriously impacted industry profitability.

Now we have an opportunity to re-engage with the public, especially the new generation of viewers we are losing to games and the web, to provide some enthralling new entertainment forms and win back audiences.

In the long run these guys will be paying our wages.

Our industry is ultimately there to entertain and educate and the public reaction to Stereo is tremendous. Stereo is a fantastic opportunity for all of us.

As I said at the beginning – please drop me a line if you have anything you want to add or comment on.

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Appendix: Stereo Terminology

Here are some common terms you may come across when you hear Stereo being discussed:

Accommodation

The ability of our eyes to refocus at a new point of interest.

In normal vision, the processes of focusing on objects at different distances (accommodation) and convergence/divergence (the angle between the lines of sight of our eyes) are linked by muscle reflex. A change in one creates a complementary change in the other. However, watching a stereoscopic film or TV programme requires the viewer to break the link between these different processes by accommodating at a fixed distance (the screen) while dynamically varying eye convergence and divergence (something we don't do in life) to view objects at different stereoscopic distances.

Anaglyph

A type of stereoscopy in which the two pictures are individually coloured and then superimposed as a single image rather than two separate images. Each eye sees only the required image through the use of coloured filters (e.g. red and green or red and cyan). Anaglyph glasses have been popular over the years for viewing 3D comics and some 3D films (particularly on VHS and DVD).

Although Anaglyph itself has fallen out of favour for quality Stereo work there is modern work going on with other somewhat anaglyph like colour based systems (e.g. Trioviz or ColorCode-3D)

Breaking the Frame

Stereo objects in front of the screen plane (negative parallax) are problematic if they intersect the edge of frame, as contradictory depth cues are sent to the viewer. Essentially one cue is saying that the object is in front of the screen and another is saying that the object is behind it.

This problem can be reduced in Post by a technique known as a 'floating window'. This involves applying a partially transparent mask on the left of the left image and on the right of the right image, reducing the strength of the cues on which ever side the object is breaking frame (and simultaneously if there are objects breaking frame both left and right).

Another kind of issue is caused by objects moving backwards and forwards over the edge of frame. As an object moves off the edge of a screen one stereo camera signal is lost before the other. The result is that the stereo signal temporarily 'switches off'. This can sometimes be solved by sizing up both images in Post, causing the object to move off screen altogether.

Objects breaking the frame aren't necessarily a problem. It happens in IMAX all the time and also is common in conventional stereo films - the audience is encouraged to concentrate away from such an object by well thought out shooting.

Cardboarding

Lack of true 3D feel to a shot making it look like it is made from cardboard cut-outs. This is also referred to as Cut-out Planar Effect. Caused by inadequate depth resolution due to an incorrect matching between the focal length of the recording lens (or CGI camera) and the interocular distance between the cameras.

See: Interocular

Convergence
In human eyesight, the ability of our eyes to divert eye optical axes horizontally in an inward direction. The convergence 'near point' is the closest point which is still possible to perceive one image. In practice, the eyes can easily converge inward but have much less ability to diverge outward, as it is something we don't do in life and only when looking at 3D images that have positive parallax beyond the individual human interocular.

In cameras – 'toeing' of the cameras (to simulate the eyes converging)focusing on a depth point in the scene, either in front of, behind or at the point of interest. The 'convergence point' is where the axes of toed in cameras align on the Z-axis. Convergence can be adjusted in Post by horizontal movement. Note that sometimes the term 'vergence' is used to describe both convergence and divergence. Convergence pullers are camera-crew members on a Stereoscopic shoot who are responsible for setting up and shifting the convergence during a shot.

See: Parallax

Depth Grading
A post production process where negative and positive parallax convergence and divergence are adjusted. This is not only a creative tool used to place objects on the Z axis but also a way to ensure that stereoscopic content can be comfortably watched on the screen size it is intended for. For example, in a Post suite the Director may be viewing a film on a small projection screen but the final delivery format may be a large theatre or Imax.

In practice the eyes have little ability to diverge (up to one degree is considered the rule of thumb) and this is especially a consideration in depth grading for very large screens with positive parallax images, where the distance between the left and right representations of an image may be very widely spaced.

Sometimes the term Depth Budget is used to refer to the combined value of positive and negative parallax and expressed as a % of screen width.

See: Parallax

Floating edges or Floating Window

See: Breaking the Frame

Ghosting
Artefacts typically caused by signal leakage (crosstalk) between the two 'eyes'. A secondary 'ghost' image can be seen. There are several possible causes that can introduce the problem during acquisition, post production and display. One reason can be high contrast levels between an object and its background.

Gigantism
Confusing Visual cues in a stereoscopic scene that can make an object appear to be the 'wrong' size i.e. the impression of strangely enlarged size of objects. This is due to the choice of interocular distance relative to the focal length of the camera lenses, e.g. shooting with an interocular distance much less than adult human eyesight can make a figure appear to be a giant.

See: Miniaturization, Interocular

Hypostereo
Using closely spaced cameras (e.g. less than 50 mm interocular) which record less stereo effect than the eyes can see. Such a small interocular distance can produce the effect of gigantism. If standard cameras are used, the minimum interocular distance is typically limited by the thickness of the cameras so a mirror or beam splitter system is often used, enabling interoculars down to millimetres.

See: Gigantism

Hyperstereo
Using widely spaced cameras (e.g. beyond 70mm interocular) which record more stereo effect than the eyes can see. Such a large interocular distance can produce the effect of miniaturization. Also used in order to achieve the effect of more stereo depth and less scale in a scene.

For close up work (e.g. miniatures etc.) special Interocular camera set ups of 5mm or less have been used (known as Hypostereo).

For stereo effects on very long shots (e.g. landscapes) Interocular camera set ups of several meters have been used (Hyperstereo). One extreme example of Hyperstereo is from cameras mounted in space to record the Sun in 3D.

See: Miniaturization, Interocular

Interocular distance
The distance between the centers of the lenses of two recording cameras. A typical distance would be 63.5 mm (approximating average adult eye layout).

The term 'Interaxial' is sometimes also used interchangeably with 'Interocular'
(when referring to eyesight , 'Interpupillary' is often used)

Keystoning
The result arising when the film plane in a camera or projector is not parallel to the view or screen, leading to a trapeze shape. On a stereoscopic image, where the cameras are 'toed-in' so that the object of interest coincides when viewed, there can be some mismatching of the outlines or borders of the two images. Techniques like corner pinning can be use to help correct this.

Miniaturization
Confusing visual cues in a stereoscopic scene that can make an object appear to be the 'wrong' size i.e. the impression of being strangely reduced in size. This is due to the choice of an interaxial distance of greater than 63.5 mm relative to the focal length of the camera lenses e.g. shooting with very widely spaced cameras. Subjectively this makes the audience feel like a giant looking at tiny objects, which is why miniaturization is sometime referred to as Lilliputianisism.

See: Gigantism, Interocular

Parallax
This refers to the separation of the left and right images on the projection device or display screen. Positive Parallax puts an object behind the screen (on screen objects in the left eye image are to the left of the same objects in the right eye image). Negative Parallax puts an object in front of the screen (on screen objects in the left eye image are to the right of the same objects in the right eye image). Zero or neutral Parallax puts an object on the screen (on screen objects in the left eye image are overlaid on the same objects in the right eye image).

The only difference between stereo cameras should be parallax or angle between the axes of the lenses as in Camera Convergence – anything else can disturb the stereo viewing experience. This requires close attention, so that the cameras are set-up the same and with the same filters. Color differences, skewing, vertical misalignment, differential weave and hop, lens flares, poor VFX fixes, scratches and dirt can all cause problems.

Fast cuts between shots with strong positive and strong negative parallax can be unsettling in some circumstances. This is because the eyes and brain are being asked to jump uncomfortably quickly between positions and then make sense of the result. This can be mitigated by the use of 'handing off' – dynamically changing the convergence of an outgoing shot in relation to an incoming shot. Another method of dealing with this is trying wherever possible to cut between shots that are somewhat close in parallax.

Continued

Vertical parallax is a vertical offset between stereo images and is very uncomfortable to watch – so it is necessary to remove during post production.

Note: The term 'Parallax' is sometimes used interchangeably with 'Congruence' or 'Disparity'

Pulfrich effect
Horizontal motion that can be interpreted as binocular depth. A stereo effect which is produced when 2D images moving laterally on a single plane are viewed at slightly different times by each eye.

Orthostereoscopic
A one-to-one condition where what is being displayed is the same as the 'real world'. For example IMAX 3D is often shot with parallel cameras spaced at the average human adult interpupillary distance (approx 63.5 mm) and with wide angle lenses that closely match an audience members view of the screen.

Psuedoscopic
If a stereoscopic signal is reversed (e.g. each eye is being fed the opposite eye signal or if there is a one frame offset between each eyes) a strange 'punched in' effect appears. This is also referred to as inverted stereo or reversed stereo.

Stereoscopic Window
The amount of Stereo image available to the viewer is dictated by the frame surrounding a stereoscopic image, e.g. the size of TV or projection screen. This boundary is called the Stereo Window.
Depending on their Parallax objects will appear either in front, at or behind this Window. IMAX has the largest window.