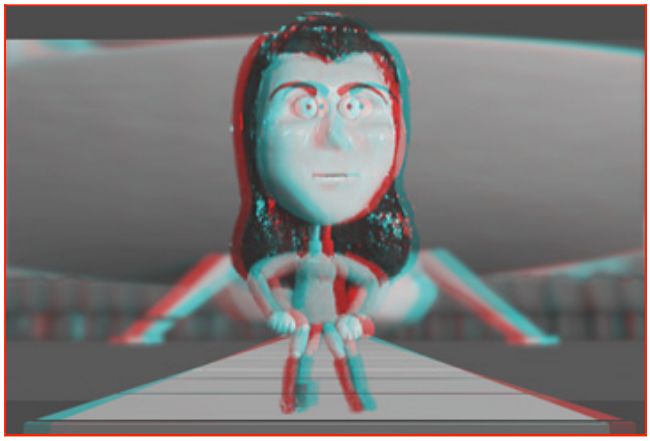
SHOWREEL MAGAZINE
THE INDEPENDENT MAGAZINE FOR FILM AND TV PRODUCTION

The animation route

Alexander Lentjes argues that there are advantages in creating 3D movies using animation techniques, rather than shooting them with stereo camera rigs.

Article first published: January/February 2008 publication: www.showreel.org



It's no surprise that the path to the current 3D boom is being beaten by animated and motion-captured feature releases. *Chicken Little*, *The Polar Express*, *The Nightmare Before Christmas*, *Monster House*, *Meet the Robinsons*, *Beowulf* and the upcoming *Tin Tin* and *Avatar* are all animated and mocap CGI titles. Animation provides pixel-perfect camera alignment and control, and in 3D stereoscopic film that is a very good thing.

3D has always been – and still is – a technically challenging medium on the filming side because of the camera alignment factor. Slight misalignment means a disturbance of the 3D, resulting in eyestrain, unless the misalignment problems are corrected as much as possible in post. One bad live-action title now, and 3D runs the risk of dying a premature death (again). As 3D has proved in the past, it can acquire a bad name very easily.

To explain the beauty of animation for 3D versus live action, it is important to explain the difficulties inherent in live-action 3D. There are three approaches to 3D filming. The first and most obvious is to put two cameras side-by-side. This clearly introduces the physical restriction of the lens diameter and the camera body width, making it practically impossible with most professional quality cameras and lenses to get the optical centers of the lenses closer together than 75mm to 95mm. This creates a lens spacing that can already be more taxing on the eyes, and it stops you from using natural and smaller-than-natural interaxials.

The second and more complicated and restricting way is to build a mirror rig that enables the optical paths of the camera lenses to get as close together as possible; down to 0mm (overlapping) and even beyond, to an inverse layout. The cameras are angled at 90deg to each other and are aimed at an optical-grade semi-silvered mirror. These can introduce light-loss, glare, dust collection and a large physical size because of the required L-shaped camera layout. Machine cameras such as the SI-2K HD camera (used extensively on *Dark Country*) can take away a lot of weight and size, but the required mirror can be cumbersome and will add weight and frailty to the rig. To make things worse, every camera model and lens choice requires a custom configuration of the 3D camera rig, because of focal length, lens and camera body differences. Besides this, rigs have to be realigned before every shoot because they can go out of whack easily.

As a third option, it is possible to dust off the single-lens 3D adapters of the 1980s and shoot on film or, with a 35mm adapter or a BNCR mount, shoot HD. The greatest advantage of this approach is the requirement of only one camera. However, working with mirrors and prisms does mean that there is a varied amount of image distortion and, again, light loss, as well as a halving image resolution, which is also the reason why most stereographers abandoned this approach after the failed 3D boom of 1983. However, if you are looking for quick, easy and foolproof 3D shooting and you can live with distortion correction in post, give it a go.

The CGI route

In CGI, these issues do not come into play at all. Apart from the pixel-perfect camera alignment, one of the other big advantages for CGI for 3D is the ability to have a camera setup and perform camera moves that are impossible to achieve in live action. Not just flying around chasing a dragon through the air and diving underwater with breakneck speed, but mainly the way in which you control the interaxial and convergence during those shots. A wide or establishing shot will require a bigger interaxial than a close-up shot. Should you want to move from a faraway shot of a mountain range to a close-up of a flower on one of those mountains, for example, the interaxial will have to move from possibly 100m apart to 10mm together. A feat impossible to achieve with a real-life camera rig.

Another advantage of animation vs live action is the lack of need for camera syncing. One frame drop can mean a lot of work in post for real camera imagery. In animation, this will never happen. Stereo 3D rendering of CGI is technically an easy thing to do. Of course you will need to keep track of twice as much data and twice as many render passes. A proper management system needs to be employed to handle synchronized multi-passes adjustments and compositing decisions.

3D conversion

3D conversion is a hot topic and it is not difficult to convert to 3D – just a lot of work. It requires rotoscoping of all the in-shot elements and frame-by-frame re-animation of the film with CGI models. This is then followed by fringe removal, which means more frame-by-frame manual labour.

What's been done since 1895 is to shoot 3D film with two cameras. Surprisingly, however, 3D stop-motion has only happened three times in film history – *Motor Rhythm* in 1939, *The Adventures of Sam Space* in 1955 and *The Incredible Invasion of the 20,000 Giant Robots from Outer Space* in 2000, which was my graduation film. The first stop-motion feature is currently in production for a 2008 release: *Coraline* by Henry Selick's Laika.

Multiplaned 2D animation, drawn or computer-based, has about five stereoscopic titles in existence, all produced in the 1950s. Disney showed one of those titles, *Working for Peanuts*, before the presentation of *Meet the Robinsons*. As drawn animation is currently a dormant medium for theatrical releases, it is very doubtful that we will see more stereoscopic drawn animation titles in the future. But the night is still young and anything can happen!

Costs involved

Overall, one should count on a 130-150 per cent cost compared to regular animation. First, you will need to get a 3D professional involved. Storyboarding needs to be done with extra panels for the 3D layout, which will cost extra time. 3D camera setups need to be laid-out, which adds to layout time. Animation needs to be done with an extra dimension in mind, adding to the time spent animating and checking. There are more reshoots, and there's double the compositing difficulty. And then there's twice the amount of rendering and disk space required for editing and delivery.

Human eyes are actually very short focal length lenses. What happens in real life is that they scan a room, focusing briefly and very rapidly on a lot of different depths, allowing the brain to build up a sharp composite image of that room. And when this image is built up in the brain, a lot of the recognition of its contents, including depth perception, is done through interpretation of the image elements by the brain. Both the left eye and the right eye see the left-side visual cortex image and the right-side image, but catch these on different parts of the retina. That information then travels to the visual cortex and crosses paths. So there is bleeding of left-side and right-side visual information. It all adds up to explain the fact that the 3D images we perceive by using our eyes are not the sum of two image parts but rather a blended volumetric image. In 3D cinema, we present images to the left eye and the right eye in a way that is different from real life, which comes down to a forced way of seeing 3D. By the very nature of stereoscopic cinema, it is a taxing experience on the eyes and brain. This is a big case for calm depth 3D and going from 2D to 3D within sequences. Less is more, and it will definitely allow for more impact of the really punchy 3D shots.

A stereoscopic 3D image often presents an image with full depth of field, allowing the eyes to scan the image and take in different depths. The problem with this is that the depth is a virtual one: the real image lies on the screen and the eyes should be focusing on the screen plane only. It is an unnatural situation and one that causes fatigue with the audience unless due care is taken to avoid too much eye gymnastics.

Ways to avoid too much stress are a reduced interaxial, shallow scenes with close-by walls, well staggered depth planes and objects in depth, slow camera moves, longer shots and, yes, a narrow depth of field. Advising use of a narrow depth of field may be at odds with what most stereographers say, but it has been proved time and again that shots with a narrow depth of field allow for much calmer experience of the 3D because the eyes will not attempt to scan further into the depth than what's in focus. In that way, you are basically putting an optical wall behind the object in focus. The other problem with full depth is that the image, especially with CGI animation, will quickly look like in-game cinematics rather than a narrative feature film. Cinematography mustn't be discarded for the sake of a sharp 3D image!

The interaxial

To sum up the effect of the interaxial distance: the interaxial, or interocular, is used to increase or decrease the perceived size of the filmed scene. So a large interaxial will reduce a scene to perceived miniature size, as if seen by a giant, while an interaxial below 65mm flattens out the 3D considerably, creating cardboard cut-out results.

Smaller than natural interaxials are often required for close-up shots, and the interaxial has to be tuned to the size of the intended projection screen size to prevent eyestrain. Too large an interaxial can result in an on-screen stereo base that makes the eyes diverge, and over one degree that's unnatural and painful to the muscles of the eyes. As a rule of thumb, an interaxial of 65mm for a 6m wide screen with 2K projection means 22 pixels of source image separation, while an 18m wide screen should have seven pixels of separation. The distance of the viewer to the screen will complicate this matter even more. This is a tricky situation, but basically an average interaxial should be chosen that is lower rather than higher.

In the same way, smaller screens need larger frame distance or the imagery will look unimpressive and too flat. This interaxial balancing act is something regular 2D film does not have to cope with, and it is not surprising that distributors don't want to hear about it (and often ignore the facts). With 3D, creative choices and sacrifices have to be made to facilitate theatrical screen exhibition and DVD home viewing at the same time – unless your budget permits the shooting or rendering of two different versions of the movie.

What about convergence?

One of the most controversial and hottest debated subjects in the world of 3D stereoscopics is the use of convergence. From the very beginning of 3D photography in the Victorian age, it has been well known that parallel, straightforward shooting gives a much calmer image than converging, toeing-in the cameras. This is not only due to the vertical parallax caused by keystone distortion in the converging setup, but also because of divergence – the outward rotation of the eye, an unnatural and painful happening. A limited depth of scene needs to be used to prevent divergence from occurring in a converged setup.

Creatively, the depth is compressed in different ways between parallel and converged 3D. And, as most people will know, converging cameras set the stereo window at the point of convergence, while parallel cameras set the point of convergence at infinity. So everything is in front of the screen (a setup IMAX practises as well). The point of convergence can then be brought forward (and the scene moved backwards in depth) by shifting frames in post, changing the distance of the centres of frame and thus losing information on the sides of the image. The obvious issue with this approach becomes apparent when shooting on 35mm or 2K HD video, as there is less frame size and detail to work with. So you don't want to have to blow up material to a large extend and cut off the edges to facilitate recentration (although there is more room to zoom and cut in with 4K). With animation it is far easier, as it is possible to simply render a wider frame and recenter (shifting the point of convergence) to your heart's desire.

Composition of a 3D shot and handling of movement and cameras is extremely important in relation to a good 3D shot because 3D is infamously dependent on reference. Reference is the way the human brain works to assess depth, and a well dressed set can do more for a successful 3D experience than interaxial and convergence setting alone. So use reference and create a better emotional experience, rather than trying to force perspectives and depths on your audience. The best 3D shots are those with the least depth, but with a strong sense of volume.

You may, for example, want to avoid high contrast scenes, such as nighttime shots with bright lights; use multiple planes of props and backgrounds; have enough texture on large surface planes; shoot tunnels and other deep, eye-guiding backgrounds; use geometric objects and patterns; use volumetric props, costumes and background objects; travel with the camera, but not too fast, and make sure there are enough small objects to come out of the screen.

Eye-poking 3D

There is a lot more possible in stereo 3D than poking stuff in the eyes of the audience, but it's usually the one part that everybody remembers in a 3D film. In fact, it is probably the very thing that made you interested in 3D films and 3D film production in the first place! So out-of-screen (negative parallax) 3D is a good place to start when thinking of producing a 3D stereoscopic film or video.

It doesn't hurt to understand what it really is you're trying to accomplish here! Creatively, the 3D in your project needs to pay off to actually be worth all the trouble and still integrate with the story being told. Because, narratively speaking, there is no good reason to poke stuff in the eyes of the audience. Normally, that only takes the viewer out of the story and reminds them that they are watching a 3D movie.

Overall, the dimensionality easily distracts the viewer from the story and its characters. This way, the viewer is removed from the experience of enjoying the story and has to switch brain sides to enjoy the technicality of the 3D spectacle. And herein lies the paradox of 3D film: you need the off-screen effects, but they can take the viewer out of the movie. Subtlety needs to be employed.

This is something that special effects-driven movies without a good plot have in common with stereoscopic cinema, and its audience may be wooed in the first few minutes, but will be unimpressed by the whole thing at the end of the movie. Also, when watching a 3D movie that does not perform the usual bag of out-of-the-screen tricks, its audience will question the need to shoot the film in 3D in the first place.

Can 3D out-of-screen shots be used without acknowledging the existence of the camera (camera access) and the existence of the audience? How can in-your-face 3D be used without taking the viewer out of the story? The 3D directors of today and tomorrow have to ask themselves these questions to take 3D film to the next level of cinematic evolution. Because not employing intelligent 3D is going to be seen as clumsy as the first attempts at cinematic storytelling of the 1900s.

Adverse elements

There are a few elements that should be prevented from appearing as much as possible to avoid retinal rivalry (unequal left eye and right eye image elements) and eyestrain. The biggest culprits are water and other quick moving, highly detailed surfaces and objects, light reflections, flashes and lens flares. Another sensitive area of 3D cinematography is 3D composition with guiding depth planes and a required avoidance of object placement with too large a distance to the next plane in depth. This kind of knowledge falls into the realm of advanced stereoscopics. A stereographer will have seen thousands of 3D photographs, animations and film material and will know these problems through and through and they can help you find the best way to avoid them and to find working alternatives.

It is easy for a novice in 3D to get overexcited and desire 3D shots that are too extreme and too taxing on the eyes, and a common situation where this happens is with film directors, new to 3D, helming a stereoscopic film project. A stereographer can do their best to guide the director through the do's and don'ts of 3D, which often results in the director feeling restricted and getting frustrated. The stereographer should work together with the director's creative vision and offer compatible solutions for the challenges of 3D. A better solution than on-set arguing and ignoring of advice is to sit down in the pre-production phase and look closer at storyboarding and previzing. This way, the director will better understand why certain setups and elements will work better than others in 3D. If you are going to tell a story in the medium of 3D, you need to work with its visual language.

Better still will be the birth of a new generation of directors who are well versed in 3D. Stereoscopic directors rather than directors who have worked with 3D – they do exist, but are still a rarity.

As a director and as a DP, you want to create the best possible visual experience for your audience. As with normal film shooting, there are some restrictions to 3D that must not be ignored if a positive experience of the end results matters to you. In 2D, you don't go over the line of action and you keep the editing logical in terms of direction of movement and rhythm. Likewise, in 3D you have to be careful with a few particular parameters.

3D from script to screen

A proper, effective 3D film is planned to be 3D from stage one, the script. This is because it will allow for effective 3D mise-en-scene and flow of 3D storytelling. Having a complete film in 3D, without going to and from 2D, makes the viewer unaware of the stereo because the brain adjusts to the 3D and gets comfortable with it. That is, unless off-screen 3D, strong 3D setups and special 3D camera moves are employed. As with compositional reference, the depth or flatness of 3D shots in sequence will dictate the effectiveness of the complete end result. No shot stands on its own, 3D or not, but in 3D rather than in 2D, it is important to know what 3D camera parameters will be used before shooting begins, as the editing will be much more restricted than with 2D.

Interaxial, convergence and stereo base values are already described in a movie script. A proper 3D film production will also prepare for the stereoscopic shoot with 3D storyboards and pre-viz. This is the only real way to determine what 3D setup will be used on the shoot, and for animation, what camera setup should be laid-out. Also, selecting locations, set dressing and shot preparation are impossible without knowing interaxial, convergence, stereo base and stereo window amounts, because they determine the required position of the actors and props and the permissible depth of the scene.

Animated 3D to watch

Only about 20 stereoscopic 3D animated feature films of a total of 220 stereoscopic titles have been released since 1915. In my opinion, *Shrek 4D* (2003) is the best piece of 3D film in cinema history. Dreamworks did an amazing job, and I am confident that their future 3D releases will be very good, in terms of 3D quality. Other excellent 3D titles are *The Polar Express*, *Popeye-Ace of Space* and the Disney 1953 classic *Melody*.

A title with botched animation and 3D is the 2001 IMAX release *Haunted Castle*. Yet IMAX has been running this title for over five years now! Totally safe and boring 3D is used in Disney's *Meet the Robinsons*. There's avoiding eyestrain and then there's not using the 3D at all. It's certainly a different Disney from the one that produced Melody 50 years earlier! Which brings us to a very interesting point about Pixar; the reason they haven't done 3D yet and are not planning on doing so in the foreseeable future is because, as Pixar's Peter Docter (*Monsters Inc.*) puts it: "So far, we haven't seen any 3D film where the 3D really enhances the story, the emotion and the motivation of the characters."

Can anything be 3D?

A very important question is whether 3D is suitable for all types of stories and films. Historically, stereoscopic movies have mainly told science fiction, fantasy and horror stories. The broader fantasy genre lends itself well for 3D, as we engage with that type of movie with a different side of our brains than, say, a romantic comedy. It is more intellectual and less emotional, and that connects exactly with how the brain experiences the stereoscopic image: intellectually rather than emotionally. Can you see a stereoscopic rom-com? Perhaps it is time we tried it to see if the theory matches our film market reality.

Of course, it all depends on proper use of 3D, both creatively and technically. An interesting point of view is that 3D is so exciting at the moment because it is special and rarely seen. Should every movie and television show become 3D from now on, it will lose its special charm and, what's more, theater box offices will not be able to charge more for performances like they can now…

Successful 3D projects are those that can employ the stereoscopic image to enhance the story, its characters and their interactions. So are you just creating a 3D space or are you actually using it?

Projection methods

The most frequently asked question I get in my inbox is whether the chosen projection format of the intended 3D project relates to the method employed to shoot the 3D film. It does not. Shooting in twin-strip, over-under, side-by-side, or any other 3D format does not relate to the way you project the material – polarized, anaglyphically, in ColorCode, field or frame sequentially, or on a plain Victorian stereoscope. Post-production will take care of that. With the exception of ChromaDepth and Pulfrich, that is, as those are different, semi-3D formats.

And please, don't be put off by anaglyph presentation – it works and has done so for over 200 years. And unlike polarized projection, anaglyph works for projection, web-based delivery and still print. Just because you see 3D movies in polarized 3D in a cinema doesn't mean you can't use an alternative system for presentation of your independent 3D production. Besides, anaglyph presentation is a heck of a lot cheaper than anything else out there right now.

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