The undiscovered country : the art of pictorial 3-D stereo animation

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The Undiscovered Country

The Art of Pictorial 3-D Stereo Animation

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Abstract—With new electronic media, novel ways of thinking in visual arts have emerged that are constantly redefining traditional and digital painting methodologies. By taking advantage available 3D hardware and software technologies, it is possible to introduce stereo imaging as a novel visual art form and to a wider audience. While refashioning earlier media of painting, perspective and experimental digital animation, artists are closely exploring the relationships between the overlapping worlds of visual art, architecture, and new technologies. At the same time, the viewer is becoming essential in the construction of the image contributing to a new set of aesthetic and cultural principles. *The Undiscovered Country* will focus on 3D stereo art content development.

Keywords: *pictorial, experimental animation, 3D stereo, painting, monoscopic surface*

I. INTRODUCTION

As digital imaging fuels stereography at every level of image capture (generation, manipulation and display) the need for a fundamental pedagogy and toolset is evident daily [1]. Recently completed research into artistic digital image methodologies has continued with explorations of 3D Stereoscopy in the art of animation and digital media expression. The major advantage of stereoscopy in fine art is that the work no longer remains flat and restricted to the two-dimensionality of the canvas. Once fused by viewer, pictorial elements appear to protrude in front of the display surface and others recede, making the experience more immersive (Fig 1).

[1] Example of using fluid dynamics to paint. Anaglyph view of 3D stereo animated piece titled *Chryscholla* © Yew, Y. X. I.[2]

II. “UTOPIANS OF THE IMAGE”

In fine arts, human perception plays a central role in establishing a channel between the artist and his audience, over which emotions, feelings and ideas may be communicated. Our intellectual experience complements spatially and formally, to the optical phenomenon perceived by the eye, and renders them into a comprehensible whole. On the other hand, photographic camera reproduces the purely optical picture. In painting, some of the monocular depth cues such as light and shade, relative size, interposition, textural gradient, aerial perspective, motion parallax, linear perspective, have been vastly exploited and exaggerated to compensate for the absence of binocular depth cues (binocular disparity and convergence¹ [3]. Binocular depth cues are provided by the two retinal images perceived, from our left and right eyes. In the presence of binocular depth cues, the human visual system is able to evaluate and appreciate depth information [4]. When stereo pairs of images are created and presented to each eye, care must be taken to properly reproduce these cues, otherwise the viewer will experience discomfort.

The suggestive phrase ‘utopians of the image’ is used by stereographer, artist, Ray Zone in his article on 3D stereography. He said that the discovery of stereography² preceded the invention of photography as well as motion pictures. He says: “In fact, the realism of the very first stereo view cards drove the invention of motion pictures. These inventors looked through the stereoscopes and saw a 3D image, and asked themselves, ‘What’s missing?’ Well, motion was missing, so as utopians of the image, they set out to add not just motion, but sound, and color, and depth” [5]. The artists, painters, filmmakers are continuing to create experiences that are not simply mimicking reality. In fact, they are embracing the ways that works of art are different from reality [6]. In today’s hybrid mixed media art works, depth is still very powerful perception tool. To arrive at “a painting which shall not be distinguished in the mind from the object itself,” is

¹ The simultaneous inward movement of both eyes toward each other on the object of attention in an effort to maintain single binocular vision

² literally meaning is rendering the forms of volume on a flat plane

becoming easier with improvement in 3D stereo, where forms can be made to exist synthetically in a binocular space-field that is itself consonant with reality [7]. Mobilizing 3D stereo would add to the new kind of pictoriality, one that is just as potent as the pictoriality that began to develop in Renaissance Arts.

In his article, "On Stereoscopic Painting", artist and educator, Roger Ferrgallo points out, as far as 1838, into Charles Wheatstone's discovery of the psycho-optical consequences of our binocular vision of reality, where one sees that this reality is the product of our two spaced-out eyes rendering two different retinal views of forms in the visual field, so called stereopsis (Fig 2).

[2] Example of stereoscopic drawing of two cubes by Wheatstone. Two simultaneous projections of the two monocular projections, one for each retina. These two flat sub-images are of the same subject, but vary to a small degree in their perspective. By looking at the separate sub-images with a stereo viewer or some other type of separation device, each eye sees its own perspective viewpoint. A phenomenon called *stereopsis* allows for the brain to fuse the two flat subimages into a single picture that is perceived as having a real dimension of depth. With the arrival of the digital computer and 3D software, it became possible synthetically to emulate features of the human visual system that are essential to the stereoscopic process. Challenge is how to synthetically create illusion of 3D, out of left and right image stacked together [8].

Discovery caused new and long lasting excitement in the arts. To quote Ferrgallo from his Manifesto, *"Painting is reborn. Enter the new awareness of stereo space and a new aesthetics. The century's long conquest of plastic forms within a monoscopic pictorial space may be at the end. A new powerful illusion of the three-dimensional space-field is possible. It asks nothing more than the trance-like stare of the middle eye to waken Cyclops from his 35,000-year sleep. This primeval giants reward will be the sudden revelation and witness to the dematerialization of the picture surface into an aesthetics of pure space where visible forms will materialize and release themselves into forms that are suspended, floating, hovering, poised, driving backward and forward, near enough to touch and far enough away to escape into the void. So now, enter a new aesthetic empathy, meditation, subjective intensity and an unparalleled form-space generation and communication. All of this exciting injunction could have been declared 134 years ago had it not been for the invention of photography. But at that time, in 1838, the full investigation of form within the limits of the monoscopic surface had not yet been fully realized: the*

genius of Cezanne, Picasso, Braque, Duchamp, Balla, Mondrian, Kandinsky, Moholy-Nagy, Pollach and Escher lay ahead. Awaiting the future, too, would be the subjection of the picture plane to the forces of sculpture" [9].

III. "THE MIDDLE EYE OF CYCLOPS"

A. Stereo in 20th century

Continuing interest in stereo painting, immersive art installation, and environmental aesthetic experiences can be traced through nearly all epochs of art history. Through the later part of 20 century, 3D stereo was generally referred to a variety of presentation methods including immersive Virtual Realities of CAVE environments, VR interactive and projection installations, wide screen cinema, holography and stereoscopic IMAX cinema movies. The advances of 3D stereo technology are rapid, and there is a continuing impulse to develop more content and complex illusionistic effects with newly developed tools. All the technological display systems essentially have the same aim: to immerse the onlooker deeper and deeper into the image. As for artistic visualization and creation of new pictorial space, these efforts continue to represent an ongoing search for richer illusion, using the most advanced methods available in order to more fully address the human sensorium [10].

In computer graphics, the improvements in speed, resolution, and economy made interactive stereo an important capability. True 3D is rapidly becoming essential part of computer graphics, visualization, virtual-reality systems, and computer gaming. While enthusiasts have been excited about this technology for decades at least, it is only within the last few years that inevitable commercial success with Stereoscopic 3D, (S3D), technologies is becoming apparent. Many recent S3D projects have been full-CG movies: Shrek 4D, Monster vs. Aliens, etc. Because of these successes, many associate S3D with only animated features, however recent advancements in S3D live action have enabled other kinds of production and can be implemented in broader aims towards more experimental fields in art, interactive design and science practices [1].

B. "Virtual Eyes"

Professor Vibeke Sorensen elaborates on the role of the stereo in arts and digital media: "Stereoscopy has certain innate features that could significantly alter the way we think about art and communication in the years ahead. As imagery, stereography is a palpable construct with concrete physical characteristics, but because it is an illusory impression, it also has a certain ethereal quality similar to music. Computers are capable of creating models of our ocular apparatus—virtual eyes, in effect—that behave remarkably similarly to our real eyes and are able to replicate the complicated function of binocular vision. Each parameter used in these computer models can be explored on an individual basis, helping us to understand better, how the two eyes work together to

create the effects of stereoscopy. For example, for the effective display of stereoscopic motion pictures, homologous images (meaning corresponding pairs of left- and right-eye images), must be perfectly aligned vertically and shown precisely at the same instant in time; otherwise the illusion of depth breaks down and the viewing experience becomes confusing and uncomfortable. An advantage of the digital computer is that it can quickly and accurately calculate these types of requirements and eliminate many of the problems and limitations that are so often encountered in forms of stereoscopic imaging" [8].

C. 3D stereo Filters and 3D Stereo Systems

Exploring various output methods to give correct image to the correct eye as well as perfecting the final format for different 3D systems usually revolves around few basic type of filters. Here summarized systems are:

1) *Anaglyph* Anaglyph system employs a pair of complementary color filters for each eye, with the most common being red and cyan. The red filter will only allow red to pass through, while the cyan filter allows the transmission of blue & green. The viewable image is treated in a way that the left stream contains only red channel and the right stream contains green and blue channels. Anaglyph is flexible and can be viewed through practically any medium that can display the spectrum of colors accurately, from print to television. However, it suffers from poor color fidelity. In the experimental art works anaglyph works really well with monochrome, black and white imagery (Fig 5).

2) *Polarized* - In typical polarized system, two projectors are used to play the movie, one for the left and one for the right eye. Both projections are aligned perfectly so that both images overlap. A polarizing glass is then placed in front of each projector, one angled to allow horizontal light through, and the other vertical light. Corresponding passive eye glasses have one horizontal polarized lens and one vertically polarized lens, each side being able to allow light of that particular polarized type through the eye. Polarized systems are the basis of modern movie projection set ups. In addition, compared to anaglyph; color fidelity is not affected by polarized lenses. Light efficiency however is reduced for about 50 percent, so highly reflective silver screens are needed.

3) *Active Shutter Glasses* (Fig 3b)- technically, these are LCS, liquid crystal shutters, they blind the left and right eye in sync with a display that shows left and right image alternately. Recently with built-in electronics to support the latest pure 120 Hz LCDs and DLP® HDTVs (Samsung) active /passive polarized projection using single 3D stereo projector is also available [11].

4) *RealD system- Circular Polarization* (Fig 3a) - system is based on polarized stereo, also known as the RealD projection system. It is used by most of today's 3D theatres and it is one of the major reasons that brought about a 3D renaissance. A single projector plays at double rate, alternating between the left and right frame. A mechanized polarized lens in front of the projector

switches between clockwise and anticlockwise polarization every other frame. Plus, in contrast with vertically polarized lenses, where the image is lost if the head is tilted, circular polarization allows for a certain degree of head tilting. [12]

[3] Example of a two different types of 3D Cinema systems: (a) polarization-based/3D- REAL-D/Master Image; (b) 3D with Shutters/Nu-Vision/Expand [11].

[4] Example of an active glasses synced with projector and emitter in *Ars Electronica, 'Deep Space' Hall*, in Linz, Austria. The technological heart of *Deep Space* consists of eight 1080p HD and active-stereo capable Barco Galaxy NH12 projectors. The images are projected onto mammoth, 16x9-meter display screen mounted on the wall, as well as projected on the floor. A great vantage-point view and a dizzying shift of perspective is available from the *Deep Space* Platform, set up at an altitude of about five meters. The technology installed in *Deep Space* makes it possible to produce uniform displays with a resolution measuring 2,160 pixels high and 3,840 pixel wide. Through the use of edge blending, the images projected next to each other on the wall and floor can be merged together pixel by pixel until the areas of overlapping are ultimately undetectable. One can enlarge a few square millimeters of a painting, up to 16x9 meters and reveal all of its hidden details. In doing so kilometer-distant objects appear as if one could reach out and touch them. The viewer could actually feel the fascinating textures and see them emerge with great clarity, and could experience hidden details revealed by perspectives that are impossibilities in the real world" [13].

Understanding 3D projection systems and ensuring image quality is the key factor in 3D perception. The color quality of the originally designed art piece/film has to work well for the major cinema theatres venues, as well as for the alternative spaces such as museum, art installations, and public spaces (Fig 4). How to make the same art piece's color and 3D depth illusion work and deliver same quality image for various outputs, is representing a challenge.

In addition to technical potential difficulties, the final trial for the film-maker-artist comes when considering how to use 3D as a narrative device. Aside from the technical challenges, (such as for example the decision to use what is commonly considered the "ideal" distance between the centre of the two cameras lenses/ interaxial, being about

the same as the distance between human eyes/ interocular, and how these effect shooting on the set where forced perspective or miniaturization is involved), there are other consideration the artist must make. How does 3D stereoscopy affect the audience? How does filmmaker use 3D to create varying emotional tension in a well-written script? These questions impact the approaches taken in film-making; specifically cinematographic approach, the series of compositions chosen that support the narrative, the editorial narrative or the pacing of the film and the use of deep, flat, limited and ambiguous space. These issues are the challenges that are commonly faced by the filmmaker, however, with the advent of 3D stereoscopy as a filmmaking tool, taken away from the carnival gimmickry of 3D, a potentially more subtle intimacy and perhaps more potent sense of presence is possible [14].

IV. ART WORKS

Using stereo depth as part of the art and design process, is giving the opportunity to further develop entirely original creative experiences. For both the artist and the viewer, the core benefits behind stereoscopic 3D technology are that it offers unique and superior immersion, and more visual beauty. The past and current artwork projects that will be presented here, continue to explore possibilities of 3D stereo imaging exclusively in relation to alternative painting and animation. They are: 1) animated film titled *Emotion Study*, with the short 3D stereo component; 2) *Chryscholla* [2], short experimental animation composited for anaglyph viewing [15]; 3) *Dreams* – 3D stereo animated piece (Fig 16 & 17).

[5] Example of an expressive fluid painting: fluid dynamics emulating paint dripping and pouring in the manner of expressive painting © Yew, Y. X. I.[15]

A. Creating Stereo Animated Content

1) *Emotion Study* is a film exploring possibility of creating immersive pictorial spaces. The idea of fundamental study on perceptions of emotion provoking images originated within Co-Space research into cinematic storytelling with real-time and rendered imagery. At the time emotion study survey was to assist in planning visual and behavioral representation of animated form. Production of digitally generated stills, photographs, and paintings depicting various emotional

states proceeded. Over 120 Still images using hybrid-painting methodologies were produced, within period of few months. The study addressed the audience's emotional perception and reaction when they are exposed to non-representational images. All the created imagery were organized into corresponding six emotion categories: anger, disgust, fear, happiness, sadness and surprise [16]. From those still images, experimental short sequences were developed and pieced together into a painted animated setting. Although the final film inspired after this study, remained as non stereo HD version, experimental animated 3D stereo of painterly fluid dynamic was compiled for anaglyph viewing.

[6] Emotion Study: (a) Fear (b) Torment
Stills from the movie© Conradi, I.

[7] Example of an anaglyph composite to be viewed with passive Red/Cyan Glasses. Images are created in Next Limit Real Flow, where particles are generated. Responding to environmental variables such as flow, gravity, turbulence and wind, fluid animation results in unpredictable dynamics similar to expressive art of painting. Image Still from *Chryscholla* © Yew, Y. X. I. [2]

2) *Chryscholla* features effects that action painting is simulating, - such as paint dripping. Two software side by side were used, Next Limit Real Flow 4.3.8 and Maya 2011. Realflow is used for creating the meshes/the animation and Maya is mainly used to create the camera movements as well as for rendering particular effect (Fig 7). Next Limit's Real Flow is a software primarily used for visual effects, for generating particles designed to simulate realistic liquid like effects. Here software was use to mimic paint textures and markings of the brush. Particles are generated using emitters; fields are then created to influence, move and sculpt them, resulting in the creation of abstract shapes and form. Due to the erratic nature of these particles, trial and error is required

to get the desired effect. A layer of polygonal mesh is generated over particles to materialize its surface and shape; these are then exported out as *.bin files and imported into Autodesk Maya via a plugin (Fig 8).

[8] Example of fluid sculpting in Real Flow
Chryscholla © Yew, Y. X. I.

[9] Example of a polygonal mesh rendered and imported as *.bin files into Autodesk Maya via a plugin
Chryscholla © Yew, Y. X. I.

B. Methodology for Stereo Camera Set Up

The following description on methodology Maya 2011 ready-made stereoscopic camera rig was used for the project *Chryscholla* [2] [12]. The basic stereoscopic rig consists of three cameras, *Stereo Camera Left*, *Stereo Camera Right* & *Stereo Camera Center* (Fig 10). These are connected to one another via expressions and the primary controls are located on the Center Camera. The first step after creating the camera was to position it for the desired composition, and while doing so to scrub through the timeline was needed in order to view the entire sequence. This assisted positioning of the camera correctly for the duration of the animation. After locking in the position of the camera and selecting a *focal length*, the cameras stereo specific settings are adjusted. In the attribute editor of the camera rig (Fig 11), options and settings would allow numerous variations. The first important task would be to set the Stereo type to *off-axis*,

so as not to suffer from vertical misalignment that is seen in the traditional converged method.

[10] Example of Maya stereoscopic camera rig. Stereo Camera Left, Stereo Camera Right and Stereo Camera Center.
Chryscholla © Yew, Y. X. I.

[11] Example of adjusting Stereo Interaxial Separation & Zero Parallax settings in Stereo Camera Parmeters Attribute Editor
Chryscholla © Yew, Y. X. I.

The *Interaxial Separation* & *Zero Parallax* settings are main key in getting the desired stereo effect. Setting the right values is crucial as it could result in a good stereoscopy with convincing spatial depth, or one that is painful to watch (Fig 11 and Fig 12).

[12] Interaxial separation (a) A large value of 5.0 would make the object appear smaller and near, while (b) a smaller value of 1.2 would make the object appear larger and far. Stereo design by T. C. Quan © Conradi, I.

Interaxial Separation determines the distance between two cameras, in real world scale it would be set to a value of 6.0-6.5 cm, or (2.4"-2.6"). This is to simulate the average distance between the human eyes. However in the case of these art works, the Real Flow mesh is abstract and relative in its size. Hence, value had to be generated via trial and error by using the anaglyph preview window. From tests, it is apparent that *Interaxial Separation* value is inversely proportional to the apparent size of the 3D object. A large value would make the object appear bigger and near while a smaller value would make the object appear smaller and far (Fig 12).

The *Zero Parallax* determines the point in depth where both images converge. In stereo terms, an object in point of the zero parallax from the camera will have zero depth, while anything between the camera and zero parallax point will have *negative depth* (appear to pop out from screen). Anything behind Zero Parallax Plane will have *positive depth* (appear to recede behind screen). A visual representation of the Zero Parallax plane and a safe volume cone can be generated in the controls to assist in the setting (Fig 13 and Fig 14).

The optimal point judging from the stereo tests is to have the zero parallax at an average of the distance between the furthest object and the nearest object to screen as well as keep the object/s within the safe volume cone.

During the camera setup process, several anaglyph preview renders are made. Necessary adjustments are made from there. It is extremely useful to create full sized previews and tested at its intended location & projection size. Unlike traditional 2D movies, the stereo effect can significantly vary depending on the size of the viewing screen to the distance the audience is sitting from it (Fig 15). Once the desired camera set-up is completed in render settings the render able camera should be set to stereo Camera (Stereo Pair), this will automatically allow Maya to render both the left and right stereo images separately. Also, added should be <camera> suffix to the file name so it will be named accordingly from the camera, which it was rendered from (Fig 15).

[13] Example of zero parallax plane dividing positive depth (appear to pop out from screen) while anything behind this point will have negative depth (appear to recede behind screen).

Chryscholla © Yew, Y. X. I..

[14] Example of zero parallax plane & Coverage³ distance
Chryscholla © Yew, Y. X. I.

[15] Example of a stereo camera view, stereo pair
Chryscholla © Yew, Y. X. I.

C. Dreams

A kaleidoscopic journey into a cross-cultural exploration of imagery and sound, *Dreams* is a dematerialization of objective reality into an expression of emotive experience and abstraction. The piece was inspired after collaborative work with acclaimed Indian choreographer and dancer Raka Maitra and musician Philip Tan, for a piece titled *Boundaries* performed at the Gallery Theatre, National Museum of Singapore, Xposition 'O', Aug 17 2007. *Dreams*, is the winner of the Prize of Effort for the Singapore Regional Award of the 10th DigiCon6 contest hosted by TBS, Tokyo Broadcasting System, INC. Digicon 10 Singapore, computer graphic animation competition. In 2010, all 19 scenes of *Dreams* were edited for stereo, re-rendered in two HD video files for the left and right channel and with separate sound file. The film was previewed in 3dttv.at's Stereoscopic Player prior to submission. 3dttv.at's Stereoscopic Player allows for the input of left and right footages in various formats and automatically creates a stereo solution from an expansive list of Stereoscopic filters. The film was selected and screened at Dimension 3 Festival in France, 2010 [17]. The results are a unique art

³ The simultaneous inward movement of both eyes toward each other on the object of attention in an effort to maintain single binocular vision

form dimensionally composed in space with a heightened sense of emotion and immersion through element of depth (Fig 16).

[16] Screen captures from *Dreams*, Stereo Experimental Animation
Running time 04:37, digital previsuals for gallery installation © Conradi, I.

[17] *Dreams*, Stereo Experimental Animation
Screen captures © Conradi, I.

V. FUTURE WORKS: THE UNDISCOVERED COUNTRY

With the stereo as the final output for these works, understanding of stereo depth and stereo workflow will be crucial for future works. Continuing challenge is to be able to keep up with commercial, proprietary software and latest developments and technological resources in the field of stereo. Direct access to the professional 3D stereo pipeline would enhance the experience for screenings and one of kind art installations. Finding the platform to display works is becoming more and more important. Going beyond commercial theater screening venue is a challenge.

Currently works are done on a 3D stereo animated film titled *Weather Phenomena*. The works are being finalized and will be tested in an art installation setting within newly installed immersive room at the Institute of Media Innovation at Nanyang Technological University, Singapore (Fig 18 and Fig 19). The goal is to achieve an incredibly powerful simulated mood or experience with all 320-degree display, utilizing stereo sound and 3D stereo visuals. A video player that is able to sync across five computers is required. Because the sequences are pre rendered, the challenge is for stereo to work across the display. This can be overcome by adjusting the positions of the two channels in accordance to which part of the screen the viewer is looking at.

[18] *Weather Phenomena* experimental stereo animation; digital preview. Example of digital rendering and planning for the newly installed immersive room at the Institute for Media Innovation, Nanyang Technological University, Singapore
Digital preview by Yoon, W. C. D. © Conradi, I.

[19] To view the piece with complex imagery depicting weather phenomena, in the Immersive Room is to play a pre rendered stereoscopic video of it. Institute for Media Innovation, Nanyang Technological University, Singapore
Digital preview by Yoon, W. C. D. © Conradi, I

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