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Visual Resonance

Fine Art and 3D Stereo Pictoriality

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Abstract—The paper will present art practice based research as perceptual, cognitive and interactive digital imaging, with focus on 3D stereo animated painting and virtual environments. An opportunity afforded to artist by the current research environment at the Nanyang Technological University, the School of Art, Design and Media, is providing the flexible venues for collaboration among the academia faculty from art and media and engineering school, along with collaboration from the local industries. The enthusiasm for painting and the magic of stereo are at the core of the write up.

Keywords—stereo; Stereo 3D (S3D); painting; experimental; animation; fine art

I. INTRODUCTION

To what extent did the recent surge in 3D stereo media inspire the desire to alter the viewer's experience of the painted surface? It was left to the advancements in visual effects and image manipulation to influence artists to definitely break with easel painting and to account finally and determinedly for emergent binocular vision of the 20th century abstraction [1]. The influence of cinema alone with the surprise and marvel at the magical trick of 3D stereo illusion is addictive as the spectator wants to immerse oneself in the 'optical fantasies.' Paradoxically, when used in arts, 3D stereo technology holds complains [2]. The inevitable threat of danger continues in crossing the boundaries between popular media and traditional painting media. Consequentially the 21st century painting practice continues dancing in circles with technology, while the physical materiality of the still, flat canvas, and the magic of projected animated visuals 'are chasing each other's tail' [3].

Professor, Anne McCauley said in her essay on "Realism and its detractors," "The undeniable commercial success of stereoscopic views was met by charges that the stereo images appealed to the young and ignorant, enticed the masses with the objects beyond their means, undermined the taste for the ideal, and encouraged idleness. The contemplation of images, particularly those that seem to dissolve their mode of creation into the transparency of nature when it is confronted directly, has always been fraught with danger: the danger of confounding the icon with its unknowable referent, the danger of desiring things of the world, the danger of being fooled into thinking that the illusory is real. And yet, at the

same time, the production of images that go further and further in recreating the effects of lived experience reveals how widespread is the public's willingness to succumb to phantoms, dreams, *simulacra*¹, where the body vaporizes into pure visuality and effortlessly travels in space and time. Nowhere can this conflict between the popular craving for visual thrills and the condemnation of such desires be better observed than in responses to stereographic arts-photography and moving image" [2]. Prof. Anne McCauley illustrates popular beliefs that 3D stereo invention in particular, carried 'apocalyptic predictions of the end of creativity' for the traditional fine arts. However, both practices can benefit from each other, as will be illustrated in this paper. In the pictures bellow, the unique animated art forms derived from traditional image making methodologies are dimensionally composed in virtual space with a heightened sense of emotion and immersion through new element of 3D stereo depth (Fig.1 and Fig.2).

Figure 1. In any artwork 'pictorial depth must always be made explicit, weight and volume, light and dark must be clearly present for illusion to work'. [4] Simple paintrely composition laws are coupled with 3D stereo in animated to experinece sun in *Le phénomène Atmosphérique*, 2011

¹ More than real, hyper-reality, reflection of reality

In computer graphics, recent improvements in speed, resolution, and economy made interactive stereo an important capability for a long time. 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 Stereo 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 animated or live feature movies only, however the 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 of today [5].

Figure 2. Example of Anaglyph 3D stereo projection that immortalizes painterly gesture by carving convincing space for modern pictorial drama. Still image captured from *Le phénomène Atmosphérique*, 2011

The concretization of objects in three-dimensional space is not necessary for digital painting or animated image to become immensely popular, because the imagination is usually sufficient for the recreation of the impression of depth unaided. However, 3D stereo images possess an intrinsic richness. The films fascinate us because they create an impression of depth and presence that no other type of representation (painting, drawing, 2D digital print or traditional cinematographic sequences) has ever equaled. These new experiences are allowing us to continue our pursuit of the age-old, and unrealizable, utopian dream of creating an identical facsimile of physical life, the ancient fantasy of obtaining integral and dematerialized image [6].

Present day techniques for producing computer-generated 3D images have impelled a new interest in the field. Extensive experiments have been made in simulation of different aspects of reality (such as flight, architecture or medial operations) and 3D Stereo has been widely used in computer games and advertising.

In addition using stereo depth as part of the art and design process, gives fine artists the opportunity to develop entirely original creative experiences. For both the artist and

the viewer, the core benefits behind stereoscopic 3D technology is that it offers unique and superior immersion, more visual beauty, and it is an effective tool to help depict interesting stories in site specific sites. Resulting art works are at the same time pushing the expressive capabilities of existing 3D tools, demonstrating alternative aesthetics for 3D stereo

The paper will present brief history of stereo and production on experimental 3D stereo animated film titled *Le phénomène Atmosphérique*, 2011 produced (Fig.2).

II. THREE-DIMENSIONAL PERCEPTION

A. Brief Historical Overview of Stereo

In 1584, Leonardo Da Vinci wrote, "A painting, though conducted with the greatest art, and finished to the last perfection, both with regard to its contours, its lights, its shadows, and its colors, can never show a *relief* equal to that of the natural objects unless these be viewed at a distance and with a single eye" [7]. The fifteenth century artist provided an example of the difference between monocular (one-eye) and binocular (two-eyed) vision. An object in a painting will cover all of the space behind it. Yet in reality, we can see past a small object, since what is hidden from the left eye is visible to the right eye and vice versa.

Figure 3. Stereograms and retinal images-illusion of depth
A stereogram is formed by two projections on the same plane of an object in space, the projections being produced from the optical centers of the two eyes (left-hand figure). Observing the two 2D images superimposed results in the illusion of three-dimensionality by virtue of the fact that object depth is encoded as right/left position difference, -objects at different distances from the eyes project images in the two eyes that differ in their horizontal positions. In principle, both eyes receive the same information whether this comes from the object itself or from the stereogram leaving aside any deviations made by the rays as they pass through the optics of the eye, two retinal images are also projections, but on different surfaces (right-hand figure) [8].

In 1832 Stereopsis² or "depth sense" was formally discovered by Sir Charles Wheatstone, a British Scientist. He invented the *stereoscope*, a device to view stereoscopic imagery, or two-dimensional counterparts and their differences resulting from the eyes' different positions in the head. The stereoscopic images developed by Wheatstone were pairs of drawings representing two projections of the figure on a single frontal plane as they would be seen by two eyes. The ability to see relief resulted from comparison of

² Stereopsis -from stereo- meaning "solid" or "three-dimensional", and oipsis meaning view or sight

the two retinal images, and from the small differences in position of the same points in two images, such as ‘horizontal disparities’³ (the relative positions of near and close object), ‘orientational disparities’ (the effects of perspective that modify the orientation of plunging lines), and ‘vertical disparities’[9] (Fig. 3 and Fig. 4).

Figure 4. To view stereo image without the use of the instrument, two images (here of the spiral) have to be ‘fused.’ An effective method to achieve this is to place two images very close to the eyes and then gradually moved them away. There comes the point when an image of the spiral is in the center, either alone or accompanied by spirals to the left and the right. At this point, the observer should try to retain the image of the central spiral for as long as possible and wait for it to become three-dimensional [11].

Professor Vibeke Sorensen says, “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 this and their forms of stereoscopic imaging” [12]

As shown, 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 the 20th century, 3D stereo was generally referred to as a variety of presentation methods including immersive virtual realities of CAVE environments, interactive virtual realities and projection installations, wide screen cinema, holography and stereoscopic IMAX cinema movies.

B. 3D Stereo Filters and 3D Stereo Systems

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. 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 types of filters [13].

Here, summarized, these systems are:

1) *Anaglyph* - Anaglyph employs a pair of complementary color filters for each eye, 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 relatively accurately, from print to television. However, it suffers from poor color fidelity (Fig. 5).

2) *Polarized* - In typical polarized system, 2 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 as an active stereo projection reduces light by about 50 percent, so highly reflective silver screens are needed.

3) *RealD system*- Circular Polarization is based on polarized stereo, the RealD projection system is used by most of today's 3D theatres and 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.

Figure 5. Still frame captured from *Le phénomène Atmosphérique*, 2011. Anaglyph composite viewed with passive Red/Cyan Glasses.

³ Also known as *retinal* disparity and as *binocular* disparity.

4) *Active Shutter Glasses* - Technically, these are liquid crystal shutters (LCS), they blind the left and right eye in-sync with a display that shows the left and the right image alternately. *XPand 3D Cineam* also uses 3D shutter glasses. Recently, with built-in electronics to support the latest pure 120 Hz LCD displays, active /passive polarized projection using a single 3D stereo projector is available [14].

5) *Dolby 3D* uses a projector with an alternate color wheel placed in the 2D projector. This color wheel contains one more set of red, green, and blue filters in addition to the red, green, and blue filters found on a typical color wheel. The additional set of three filters are able to produce the same color gamut as the original three filters but transmit light at different wavelengths. Glasses with complementary *dichroic* filters in the lenses are worn which filter out either one or the other set of three light wavelengths. In this way, one projector can display the left and right stereoscopic images simultaneously. This method of stereoscopic projection is called wavelength multiplex visualization. The dichroic filters in the Dolby 3D glasses are more expensive and fragile than the glasses technology used in circular polarization systems like *RealD Cinema* and are not considered disposable. However, an important benefit of Dolby 3D as compared to RealD is that no special silver screen is needed for it to work [15].

Understanding 3D projection systems and ensuring image quality is the key factor in 3D perception.

III. THE NEW WORKING SPACE

The main motivation behind the featured artwork is to break away from two-dimensional easel painting and move towards a 'freedom of materiality' that Kandinsky⁴ was seeking. and which would allow the painting to expand beyond the physical boundaries, and by contrast, expose a lack of 'pictorial expansiveness' in contemporary paintings [16] (Fig. 6 and Fig.7).

To quote Frank Stella from his book, *Working Space*, "Painting today stands in an awkward position in relation to its own past. It needs to create for itself new kind of pictoriality, one that is just as potent as pictoriality that begun to develop in Italy during Renaissance. The challenge for painting is not the problem of perspective, -either linear or atmospheric; nor is the problem of flatness that would make this space so different. Rather it appears to be something in the intention, in the acceptance of given configuration, in the attitude toward covering a given 2D surface that held the painting back, that actually kept it from creating a surface that was capable of making figuration look real and free"[17].

⁴ Wassily Wassilyevich Kandinsky , late 19th and early 20th century Russian Painter and art theorist

The justification for any new and worthwhile development in painting must be founded in extending 'working space' into virtual space that will be integrating Stereo3D animation and projection, motion and sound.

Figure 6. Image captured from *Le Phénomène Atmosphérique*, 2011
The power of light and dark in *Precipitation* is forming droplets via collision with other raindrops, and thus ice crystals are forming a cloud. The paradox of introduced 3D stereo depth results in the 'freedom of materiality', making even more obvious that what we are depicting are nothing but 'small parts of an expanding whole' [16].

Figure 7. 3D Stereo Working Space The notion that we 'see' the precipitation droplets sometimes on the screen surface and sometimes floating in front of it, leaves the space and voids in between them, with an ambiguous but strangely compelling set of intangible stereo coordinates. Stereo Still image captured from *Le Phénomène Atmosphérique*, 2011

IV. LE PHENOMENE ATMOSPHERIQUE

Le Phénomène Atmosphérique, is a 3D stereo animated film inspired after the works of Olafur Eliasson and his on-site constructions of nature, as well as the *Light and Space Movement* associated with figures such as Robert Irwin and James Turrell and their works in Southern California during 1960 and 1970s.

In his essay, Robert Irwin talks about painting creating a physical space which would be occupied with a 'perceptual kind of energy'. He asks a simple artistic question: "How do I paint a painting that does not begin and end at an edge but rather starts to take in and become involved with the space of

the environment around it?"[18]. Irwin was trying to create a painting that would simply dissolve into its environment; and while some artists used the light to enhance the presence of painted image, Irwin was concerned with light itself as an integral part of painterly aesthetic. Light and paint, become equal elements in his art palette.

Le Phénomène Atmosphérique is not a homage to these works, rather it is an attempt to continue to elaborate on possible role of heightened spatial displacement and how we experience depth, space and color.

A. About the Film- Workflow

The film uses *Next Limit Technologies Real Flow* software that creates a unique fluids and physical body dynamics for realistic water simulations in visual effects. The scenes were composited in 3D stereo to create general feel of weather formations such as clouds, participation, rain and windstorm.

To highlight the distinctive beauty and unpredictability when water and light work together, various caustics were generated. Almost every shot in this film has been derived directly or indirectly from a caustic image sequence (Fig. 8).

Caustics are a visual effect seen when light is reflected off a specular or reflective surface, or focused through a refractive surface, so that it indirectly illuminates other surfaces with focused light patterns. In 3D graphics, caustics are rendered as a type of global illumination, often using Photon Mapping or Bi-directional Raytracing techniques [19].

(a) (b)

Figure 8. Caustics: (a) In RealFlow, a water drop is simulated and particles are generated. (b) In Maya, a light is created beneath the water surface. This light emits photons to be used to render a Caustics Ray.

It was found that mesh generated by RealFlow particles is unstable and causes the caustics to flicker. RealWave was used instead to diffuse flutter in animation (Fig 9 a & b).

(a)

Figure 9. (a) First, using the caustics generated, a Maya rendered displacement map is applied to the geometry shader and animated, producing these surreal landscapes. Then, the same map is applied to the incandescence node of the material to produce a glowing effect depending on the height displaced. With certain caustics generated, the contours formed with the displacement map can appear rough and sharp. (b) The caustic map is then smoothed out using After Effects and imported back into scene. Next, Depth of Field is applied to the render to produce a calm, soothing image. The normal mesh generation method in RealFlow required a mesh to be generated after a particle simulation has been carried out. RealWave in RealFlow allows simulations to be carried out on geometric planes which also contributed to less flicker.

(a) (b)

Figure 10. Prism: It was impossible to mimic the effect of white light separated into different colors when shone through a prism using rendering software, so the effect needed improvisation (a) First, seven lights were arranged in a row, each light shining a different colour; Red, Orange, Yellow, Green, Blue, Indigo and Violet. They all shine through a geometric plane with a material with a refractive index of 1.5 and a water bump map. The lights are all projected onto a plane with a white material. (b) The result: a rainbow effect is seen at the fringe of the white light as the colours blend when overlapping to produce white light. Although not physically accurate, it mimics the look of real white light going through a prism.

Figure 11. (a) Duplicating a displaced mesh around an axis, a circular pattern is achieved. (b) The colorful image is produced.

Figure 12. Example of Particle Experiments were conducted to find out how particles in Maya might work with the caustic maps generated in earlier sequences: (a) The particles were emitted through the use of the existing caustic maps. More particles were emitted on lighter portions of the image (b) The same method was applied with the caustic map generated in the earlier “prism” test.

B. Stereo Camera Set Up[13]

In order to create a stereoscopic image using computer graphics—or any other technique for that matter—two flat sub-images must be made graphically, one for each eye. These two sub-images are of the same subject, but vary to small degree in their perspective. As a result, 3D images, whether stereoscopic, anaglyph, line screen, lenticular, holographic or virtual, become plural images or groups of images. As already stated, by looking at these separate sub-images with a stereo viewer or some other type of separation device, each eye sees its own perspective viewpoint [10].

The basic stereoscopic rig consists of three cameras, *Stereo Camera Left*, *Stereo Camera Right* & *Stereo Camera Center* (Figure 13). These are connected to one another via expressions while 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 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. The task would be to set the *Stereo type* to the *off-axis* setting, as it does not suffer from vertical misalignment that is seen in the traditional converged method.

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

Interaxial Separation determines the distance between 2 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. The value has to be generated via trial and error by using the anaglyph preview window and/or as in this project, the preview was done using 3D 120Hz LCD technology with active shutter glasses where the composition of the left and right eye images were presented on alternating frames. Each eye still is seeing a full 60Hz signal that is equivalent to the refresh rate on LCD monitors. 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 smaller and near while a smaller value would make the object appear larger and far (Fig.13 & Fig 14).

Figure 13. Example of Maya stereoscopic camera rig and Decreasing Stereo Interaxial Separation & Zero Parallax settings in Stereo Camera Parameters Attribute Editor. A large value of Interaxial Separation would make the object appear smaller and near, while a smaller value would make the object appear larger and far.

The *Zero Parallax* determines the point in depth where both images converge. In stereo terms, an object in point of the 0 parallax from the camera will have 0 depth, while anything between the camera and the Zero Parallax point will have *positive depth* (appear to pop out from screen) while anything behind this point will have *negative 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 (Figure 15).

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 to keep the objects within the safe volume cone shape.

Figure 14. Example of Zero Parallax plane & Convergence distance 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) [20].

(a)

(b)

Figure 15. (a) Rain: 3D Composite (b) Anaglyph Preview is not used in stereo preview for the film; instead preview was done using 3D 120Hz LCD technology.

(a)

(b)

Figure 16. Still image captured from *Le Phénomène Atmosphérique*, 2011

(a) Anaglyph preview: The 3D volume illusion is only serving as an armature to support image's crumbling materiality. Relying on 3D stereo alone to create new perceptual experience is not enough.

(b) Energy of created 3D volume and mass has to be accompanied with the proper handling of stereo composition, color, light, and rhythm. They are the only anchors for the lightweight atmosphere of shallow moving surface.

V. CONCLUSION

When one hears of 3D stereoscopic animation, they often think of the latest blockbuster feature film. However, although stereoscopic animation can be applied to films and video, it can be used to revivify a 2D pictorial space, animating it just as well as an animator does a character in a feature film. And although it does not fit the traditional form of stereoscopic 3D animation, art painting methods combined with 3D stereoscopic effects can intrigue and excite, a viewer just as much as a 3D feature film. Contemplating 3D stereo as an additional tool for contemporary artistic production brings the biggest challenge, being able to view it independently from major cinema venues while delivering the same quality of output in color and 3D depth illusions.

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