EARLY VISUAL MEDIA LAB

CICANT

filmeu EUROPEAN UNIVERSITY

Scopus®

European Commission | Horizon 2020 European Union funding for research & Innovation

Bruce Fitter is a filmmaker and academic who specializes in stereoscopic 3D and immersive cinema. He created and led the world's first undergraduate degree program in stereoscopic production and has over twenty years of international teaching experience. His research combines perceptual science, creative practice, and emerging technologies.
ORCID: 0000-0002-6047-8618

Corresponding Author
Bruce Fitter
Griffith Film School, 472 Stanley St, South Brisbane QLD 4101
bruce.fitter@griffithuni.edu.au

INTERNATIONAL JOURNAL ON STEREO & IMMERSIVE MEDIA, Vol. 9 No. 2
pp. 76-95
DOI: 10.24140/ijsim.v9i2.9443
ijsim.ulusofona.pt

NEW APPROACHES TO STEREOSCOPIC 3D FILM PRODUCTION:

ENHANCEMENT OF A UNIQUE MEDIUM

BRUCE FITTER
Griffith Film School (Griffith University), Australia

Abstract:

This article presents a research project exploring the unique potential of Stereoscopic 3D (S3D) cinema through experimental techniques that challenge traditional 2D filmmaking conventions. The research identifies two key areas for experimentation—frame shape and haptic vision—to demonstrate how S3D can offer immersive experiences that are not possible or are greatly diminished in 2D formats. This study investigates non-rectangular screen shapes, such as ovals, and their effects on depth perception and emotional engagement. Additionally, it explores haptic vision, aiming to evoke tactile-like sensations through the manipulation of convergence, focus, and colour. The research culminates in the S3D film *No Race*, which incorporates Indigenous Australian-inspired contemporary dance to illustrate the narrative possibilities of these experimental methods. This article highlights S3D's transformative potential for multi-sensory storytelling and challenges traditional 2D biases in cinematic production.

Keywords: *Stereoscopy, Haptic Vision, Frame Shape, Immersive Media.*

Introduction

This paper aims to significantly enhance understanding by redefining the role and perception of Stereoscopic 3D (S3D) cinema in both academic and practical contexts. Rather than seeing S3D as a 'cinema of attraction' that relies on perceptual tricks such as objects appearing to emerge from the screen, this research presents S3D as a distinct medium with unique narrative potential.

S3D cinema holds a unique and paradoxical place in film history. It has long promised to revolutionise visual storytelling through adding depth and dimensionality yet it remains critically and industrially marginalised. Despite waves of technological enthusiasm—from the early anaglyph experiments of the nineteenth century to the digital revival of the twenty-first—S3D is often seen as a novelty rather than a distinct artistic medium. Its ability to create immersive experiences is frequently seen as a perceptual trick, viewed simply as an improvement of two-dimensional (2D) cinema rather than as a major reimagining of the cinematic experience. This paper argues that the marginalisation of S3D is driven less by technological limitations and more by a dominant bias towards 2D within film theory and practice. This conceptual approach restricts the perception, creation, and critique of stereoscopic imagery, confining it to the norms of flat cinema.

The central research question guiding this investigation is 'What innovative and experimental techniques are particularly feasible in stereoscopic 3D (S3D) cinema that highlight its unique medium?' Addressing this question requires understanding S3D not merely as an extension of 2D cinema but as a fundamentally different perceptual and aesthetic system. Its immersive potential stems from the interaction between visual and tactile aspects of experience. The argument here positions S3D as a space where technological processes and artistic goals converge, creating new opportunities for cinematic expression through a combination of optical science, phenomenology, and creative practice.

This paper is based on a practice-led research project that results in the stereoscopic film 'No Race,' serving as both an artistic outcome and a methodological trial. Through repeated production and post-production experiments, the research investigates how S3D can provoke embodied and multisensory engagement by manipulating two interconnected variables: frame shape and haptic vision. Each of these experimental areas explores how the perceptual field of cinema can be transformed to evoke sensations of spatial and emotional presence that are impossible within 2D paradigms. Therefore, the project positions artistic creation as both a tool for investigation and a mode of epistemology, enabling knowledge production through the act of creation.

The inquiry in this paper highlights the complex link between form and perception, emphasising their mutual shaping within S3D cinema. It argues that a full understanding of S3D goes beyond just technological details; instead, it requires examining its affective and phenomenological effects. The section titled 'The Significance Behind the Artefacts' reinforces this point, suggesting that each technical choice, such as camera setup, depth map adjustment, and compositing, holds both aesthetic and conceptual significance. Therefore, the artefact is not just a research byproduct but a crucial way of embodying knowledge, supporting the idea that the creative output is as important as any theoretical insights it offers.

To support this perspective, the paper is arranged in several key stages. After the introductory remarks, a concise historical and critical overview re-examines the positioning of S3D within cinematic discourse, highlighting the theoretical gaps that have traditionally limited it to a secondary status compared to 2D film language. A subsequent methodological discussion clarifies the practice-based approach used in the research, explaining how iterative experimentation has enhanced both technical workflows and aesthetic investigations.

The findings are divided into two main areas: frame shape and haptic vision. Both areas show how interdisciplinary approaches, drawing from fields like vision science, perceptual psychology, and media philosophy, can greatly improve creative production. This exploration is summarised in the case study of 'No Race,' which combines the research threads mentioned earlier to demonstrate S3D's ability for intercultural and multisensory storytelling.

The concluding reflections explore the broader implications of these findings for the aesthetics of stereoscopy and the developing conceptualisation of immersive media. By advocating for S3D's recognition as a distinct art form rather than just a technological novelty, this study aims to reposition it as an immersive medium with the potential to transform spectatorship into an embodied, affective, and multisensory experience. From this perspective, it seeks to foster a renewed understanding of stereoscopic cinema as both a vibrant creative space and a philosophical framework for reconsidering the future path of moving-image art.

Getting Past a 2D Bias

Over the past 120 years, 2D cinema has remained dominant, leading several generations to be socialised into interpreting and expecting cinema in two dimensions. This long-standing tradition has fostered a 2D bias, creating significant difficulties when analysing S3D cinema as a distinct medium. The question is: how can S3D cinema be examined without referencing the well-established framework of 2D cinema? It becomes challenging to view S3D through anything other than a 2D lens, inherently restricting the exploration of its unique qualities.

This dilemma is similar to describing a sculpture when one's only experience is with paintings; the absence of a three-dimensional reference frame hampers the full appreciation of the medium's subtleties. In my experience, I have found that when I face a mental impasse, it is often more effective to circumnavigate the obstacle rather than attempt to overcome it. Once I go around the barrier, I can resume my thought process, usually with renewed enthusiasm. With this approach in mind, I have organised my research into three main thematic areas: optical neurophysiology, behavioural science, and vision science, aiming to avoid any ingrained 2D biases.

By engaging with these diverse disciplines, the study aims to examine S3D free from the preconceptions rooted in 2D cinema. Importantly, this scientific exploration is inspired by art rather than turning the research into a purely scientific project. A century of socialisation within 2D cinema calls for a new perspective to explore the aesthetics of S3D filmmaking.

The central argument of this research is that a profound understanding of visual perception can spark a new aesthetic paradigm that surpasses traditional 2D standards. The creative journey ventures into 'uncharted waters,' employing unfamiliar methodologies to explore new territories in S3D aesthetics. As Campen notes, '...in the study of perceptual phenomena, scientists and artists have often used each other's discoveries to start new directions in their own disciplines' (Campen, 1997, p. 6). This synergy between art and science serves as a source of innovation, offering fresh insights into the aesthetic potential of S3D cinema.

Exploring S3D aesthetics is fundamentally a phenomenological endeavour, since cinema acts as a cognitive stimulus that provokes various psychological responses. A phenomenological approach is especially suitable for this research, as it aims to uncover the essence of S3D as a cinematic experience. This qualitative methodology investigates the underlying meanings that shape our perception and understanding, using an inductive approach to address the fundamental questions of 'what,' 'why,' and 'how' related to phenomena such as S3D. This contrasts with the quantitative focus on 'how much' and 'how many' (Tuffour, 2017). By adopting this approach, the research seeks to avoid the inherent 2D bias and fully engage with the unique attributes of S3D cinema. This allows for a more authentic examination of S3D's potential as a distinct medium, contributing to the development of a new aesthetic framework that embraces its multidimensional capabilities. Ultimately, this interdisciplinary and phenomenological exploration aims to expand the understanding of S3D, not merely as an extension of 2D cinema but as an innovative art form in its own right.

Interdisciplinary Insights: Transforming the Artefact

Drawing from interdisciplinary investigations, this research identifies two primary areas within the artefacts to address: projected frame shape and haptic vision. These focal points represent significant departures from prior explorations in S3D cinema yet they are not exhaustive. Future advancements in S3D production and post-production are expected to introduce additional innovative approaches, further expanding the medium's potential.

Moving Away from A Rectangular Screen Shape

The choice of these two elements needs explanation. The influence of visual neurophysiology on cinematic experience is an exciting and growing area of interdisciplinary study. Notably, the work of Dhanraj Vishwanath and Paul Hibbard provides a transformative view on stereopsis, challenging traditional cinematic aesthetics. They argue that 'contrary to long-held beliefs, stereopsis is not merely a by-product of binocular vision or visual parallax' (Vishwanath & Hibbard, 2013). Furthermore, their empirical research showed that 'the qualitative characteristics associated with stereopsis can be experienced through static two-dimensional images without the need for binocular vision' (Vishwanath & Hibbard, 2013). These pioneering findings raise compelling questions about the setup of the cinematic screen and its influence on depth perception.

While some scholars, such as (Rogers, 2019) and Richard Born (Shugart, 2013)may question the scientific robustness of these findings, often citing the limited sample size of fewer than 30 participants as grounds for scepticism (Rogers, 2019; Shugart, 2013), the research nonetheless prompts compelling questions that merit further investigation. One intriguing avenue this study suggests is whether altering the screen shape to an oval configuration, as used in the experiments, influences audience perception similar to stereopsis. Though not producing a strong effect, this idea—that an oval screen might affect the perception of a 2D image, making it akin to an S3D image—raises more questions: could other shapes or multiple windows produce similar or enhanced perceptual changes? In graphic design, shapes are known to carry inherent meanings based on their form, suggesting potential for their application in cinema.

To explore the phenomenon of shape association more deeply, the 'Kiki-Bouba Effect' offers an insightful case study. V. S. Ramachandran observes that this effect remains consistently observed across different linguistic groups. In his paper, Ramachandran shows that the less rounded vowel word 'Kiki' was mainly linked to the star shape, while the rounded vowel word 'Bouba' was associated with the round, organic shape. This experiment was carried out with speakers of various languages, producing similar results (V.S. Ramachandra, 2001). Originating from Köhler's Takete-Maluma Effect (Kohler, 1929), this effect supports the idea that geometric shapes have universal associations which could be utilised in cinematic contexts to evoke specific emotional or cognitive responses.

Feeling Touch Through Vision

Defining the distinction between haptic and optical vision is essential when investigating haptic vision. David Trotter contrasts these concepts, stating:

> 'the optical, which delivers a survey, an account of (and accounting for) distinguishable objects in deep space; and the haptic, which feels its way along or around a world conceived as an infinitely variable surface, alert to texture rather than outline'. (Trotter, 2004, p.39)

Miriam Ross explains that hyperhaptic visuality in cinema manifests as an 'uncontrollable, infinite depth in its image,' distinguishing it as a unique visual experience (Ross, 2012, p.384). Exploring haptic imagery reveals its complex and transformative qualities, which go beyond visual representation to involve other sensory perceptions, especially touch.

Consequently, stereoscopic cinema offers opportunities for richer multisensory experiences that are both transformative and intangible. A significant debate is emerging within the field regarding the role of haptic experiences in S3D cinema. Ross critically notes that the mainstream approach to S3D has mainly emphasised a strictly visual approach to its production, utilising stereopsis as an effect rather than integrating it as a fundamental aspect of the artform (Ross, 2012). This observation indicates a possible oversight in the traditional understanding of S3D cinema, where the medium's full sensory potential remains largely unexplored.

By integrating these interdisciplinary insights—altering frame shapes to influence perception and emphasising haptic vision—the artefacts aim to push the boundaries of S3D cinema beyond traditional visual effects. These elements collectively seek to create a more immersive and multisensory cinematic experience, challenging the audiences' perceptions and expanding the medium's expressive capabilities. While these areas represent significant advancements, they are by no means exhaustive. Future research and experimentation are expected to continue unveiling new approaches to S3D production and post-production, further enriching the medium.

Context

The emergence of S3D moving images in the late 19th and early 20th centuries marked what was widely seen as a peak of photographic achievement. To truly understand this phenomenon, it is important to consider the cultural contexts in which photography and, by extension, cinema were celebrated for their ability to capture reality with an objectivity that traditional painting could not achieve. André Bazin clearly expressed this distinction, arguing that photography and film, fundamentally, addressed humanity's persistent 'obsession with realism' (Bazin & Gray, 1967, pp. 14-15). Unlike painting, which consistently reflects the subjective influence of the artist, photography was viewed as a mechanised, objective witness. Bazin's emphasis on this contrast highlights why stereoscopic images were so fascinating during an era enthralled by the promises of science and industrial modernity: they offered more than just photographic precision, exploring the realm of depth-based realism.

While two-dimensional photography marked a significant advancement in realism, S3D still photography enhanced this sense of authenticity even further. By depicting volume and spatial depth, S3D images conveyed a tactile presence that flat images could not achieve.

> 'The first effect of looking at a good photograph through the stereoscope is a surprise such as no painting ever produced. The mind feels its way into the very depths of the picture.' (Holmes, 1859, p. 148)
> 'The search for depth is not a novelty but a continuation of cinema's original vocation: to restore the world in its continuity, its volume, and its presence.' (Bazin, 1952, p.4)

The Lumière brothers, often recognised for introducing cinema to the mass media landscape, demonstrated this pursuit of three-dimensional realism from the outset. After the success of their film 'L'Arrivée d'un train en gare de La Ciotat' (Lumière, 1896), they re-filmed the piece in stereoscopic form and showcased it in 1935, reflecting their ongoing dedication to depth-based visuals. This commitment to S3D appeared even before their conventional moving images were publicly shown, emphasising the natural appeal of dimensionally rich imagery and immersive media (Patrick, 2016).

It must be emphasised here that immersive media is defined as any forms and technologies of media designed to envelop the user's senses and foster a heightened sense of presence or 'being there' within a mediated environment. Slater and Wilbur state that

> Immersion is a description of a technology, and describes the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant. (Slater & Wilbur, 1997, p.604)

and

> Presence is a state of consciousness that may be concomitant with immersion, and is related to a sense of being in a place. (Slater & Wilbur, 1997, p.605)

From the earliest experiments in stereoscopic imaging, both industry creators and audiences expected that S3D would eventually become the dominant form of cinema. This optimism is captured by Sergei Eisenstein's assertion that 'to doubt that tomorrow belongs to stereocinema is as naïve as it is to doubt the very coming of tomorrow' (Eisenstein, 2013, p.16). Although the development of S3D has experienced fluctuations between periods of technological enthusiasm and industrial retreat, Eisenstein's conviction reflects an enduring belief in the potential of stereoscopy to redefine the language of film.

In contemporary cinema, directors such as Ang Lee and Martin Scorsese continue to champion the aesthetic and narrative potential of S3D. Lee has spoken extensively about the developing 'film language' of stereoscopy, especially regarding his film 'Life of Pi' (Lee, 2012), arguing that certain phenomena, notably the movement and dimensionality of water, are more effectively captured through stereoscopic imaging (Pierce, 2012). He later described 3D as 'pure cinema,' framing it not as a mere novelty but as a medium with significant expressive potential that remains underexplored yet highly promising (Lee, 2019).

Similarly, Scorsese has emphasised S3D's capacity to enhance narrative engagement. His work on 'Hugo' (Scorsese, 2011) demonstrated how stereoscopy can strengthen the relational dynamics between actors and audiences, thereby enriching dramatic presence. Scorsese's statement, 'I love 3D… I'm a fanatic about it' (sbblog, 2012), underlines his belief that S3D surpasses mere spectacle, serving as a genuine artistic tool. Historical and contemporary perspectives show that S3D is both a timeless and continually evolving medium. Early pioneers viewed it as the pinnacle of photographic realism, while modern directors like Ang Lee and Martin Scorsese utilise it to explore innovative aesthetic possibilities. Collectively, these viewpoints highlight S3D's ability to combine realism with immersive and progressive cinematic expression.

Technical Details Behind the Process of Creating Artefacts: Split Beam Mirror Rig

For the stereoscopic film 'No Race,' a split-beam mirror rig was used to capture the footage, as traditional side-by-side setups limit the minimum achievable interaxial distance between cameras. This parameter is crucial because it influences not only the volumetric extent of stereopsis—the spatial depth rendered within the image—but also determines the minimum camera-to-subject distance permissible. According to the '1/30th rule,' to prevent viewer discomfort, the camera should not be positioned closer than thirty times the interaxial separation. Following this guideline is essential for creating comfortable, naturalistic depth cues, especially in sequences featuring human subjects (Mendiburu, 2009; Lipton, 1982).

The lack of available professional split-beam rigs for rent or loan in Australia led to the design and manufacturing of a custom system. Using SolidWorks® CAD software, a rig was designed to support two Blackmagic Design® 4K Pocket Cinema Cameras® (4KPCC). These cameras, which feature Micro Four-Thirds sensors, were chosen deliberately because their relatively large depth of field helps reduce the unnatural defocus that can undermine stereoscopic realism (Mendiburu, 2009; Lipton, 1982). The rig was assembled from components commonly found in 3D printer construction, enhanced by a precision optical beam splitter imported from the United States and custom CNC-milled aluminium parts. Although the system functioned well after a year-long build process, delayed by COVID-19 restrictions, the completed rig weighed around 40 kg, making single-operator location shooting more difficult. Furthermore, the lack of genlock capability in the 4KPCC units posed an additional challenge. Synchronisation was managed through 'jam-syncing,' which re-initialises the timecode at the start of each take. As long as individual clips remain brief, this method provides nearly perfect frame alignment, which is adequate for stereoscopic post-production (Ward, 2014).

Plan B - 2d to 3D Conversion

Owl3D®, an AI-driven conversion platform, creates stereoscopic images by first generating a depth map from 2D footage and then synthesising a second-eye view using machine-learning inference. This software became essential to the project after the split-beam rig was finished as it became apparent that operating the rig effectively would need a multi-person team. Initial tests of Owl3D® produced results of unexpectedly high quality. Although minor artefacts and depth inconsistencies existed, the converted footage was adequate for the research goals, especially given the project's focus on aesthetic experimentation rather than commercial delivery. After communication with the developer, Leon Lu, access to the Pro version of the software was granted, enabling 4K output. This higher resolution proved vital, providing enough pixel density for subsequent stereoscopic corrections and depth-map refinements during post-production.

A further phase of testing was necessary to establish a workable post-production pipeline. In native S3D acquisition, Blackmagic Design® RAW (BRAW) would usually be preferred for its extended dynamic range. However, Owl3D® currently does not accept RAW codecs. This required a series of workflow trials to find the best balance between colour accuracy and conversion compatibility. After testing various configurations, the most effective pipeline involved performing the initial colour correction in Blackmagic Design® DaVinci Resolve® (DVR), then exporting the material as Apple ProRes 4444 XQ intermediate files with separate left and right clips. Owl3D® both accepts and renders in the 4444 XQ format, which offers a high-quality codec with high bit depth and minimal compression artefacts. This method provided the greatest flexibility for later stereoscopic adjustments, compositing experiments, and depth-based manipulations, which were central to the research.

One of the main advantages of Owl3D® is its ability to generate a depth map independently from the original 2D source clip. The software enables users to combine an externally supplied depth map with the footage to create a stereoscopic pair. This feature supports a hybrid workflow, where the initial depth map produced by Owl3D® can be imported into DVR® for creative adjustments, such as enhancing or reducing depth cues, before being re-uploaded alongside the 2D clip. As a result, the stereo pair reflects intentional, artistically driven depth modifications, expanding the potential for experimental control in S3D image creation.

Experiments

As stated, the workflow ultimately relied on 2D acquisition; however, it was crucial to capture footage that could translate effectively into a stereoscopic format. The lack of native S3D monitoring on set prevented a direct evaluation of stereopsis during production. Nonetheless, insights from previous experience in shooting native S3D short films showed that stereographers rarely adjust stereopsis throughout acquisition. While interaxial spacing is consistently monitored, the most influential factor on the depth effect is framing decisions. This understanding informed the implementation of a 2D-for-3D strategy, where compositional planning served as the main method for predicting stereoscopic effects. Generating effective S3D imagery requires a clear understanding of the mise en scène elements that will translate smoothly into stereoscopy versus those that could cause geometric conflicts or depth ambiguities. Therefore, the footage was framed with extra spatial margin, exploiting the benefits of 4K resolution to allow controlled depth adjustments before downscaling to a 1080p stereoscopic master.

The choice of post-production software was equally crucial to the overall workflow. Blackmagic Design's DaVinci Resolve (DVR) offered the most comprehensive stereoscopic toolset within an integrated environment. DVR enables the immediate merging of left-eye and right-eye image streams upon ingestion, resulting in a unified S3D clip that can be managed as a single entity throughout the workflow. Standard features in the Studio (Pro) version include convergence adjustments, vertical and rotational alignment, colour matching, and depth-space corrections. In contrast, Adobe Creative Cloud lacks native support for stereoscopic workflows, and the limited S3D functionalities available through third-party plugins do not provide the same level of control. Although Avid Media Composer supports stereoscopic editing, it falls short of offering the integrated compositing features provided by Resolve's Fusion module.

Cost considerations also affected the decision-making process. DVR Studio uses a one-time licensing model that includes lifetime updates, and it is offered at no extra cost with Blackmagic Design cameras. On the Fusion page, node-based compositing provides extensive control, including S3D-specific nodes that enable the creation of a 'new eye' to adjust interaxial distance effectively. Overall, these features make DaVinci Resolve the best platform for stereoscopic post-production.

Preliminary Findings – Screen Shape Variations

Variations in screen shape were crafted in DVR's® Fusion by masking specific sections of the image to unveil a black background. This technique parallels the traditional use of letterboxing where black bars create the illusion of altered screen proportions by marking off areas that are not projected. Similarly, the introduction of black geometric forms redefines the projected frame, with the black areas representing segments of the screen that are intentionally concealed from view. This method offers a controlled and repeatable approach to examining how different frame shapes impact perceptual and aesthetic responses within stereoscopic imagery.

Experimenting with Different Screen Shapes:
Experiment 1 – Screen shape directed by existing content

In this sequence, a prominent foreground structure informed the design of an alternative frame shape. The footage was captured on a harbour breakwater, where a large wooden support frame holds maritime navigation markers. Shooting through this structure as a ship, escorted by tugboats, entered the harbour created an implied multi-frame composition within the recorded image. If left unmodified, the wooden frame would serve both as a diegetic object and unintended internal border, with its volumetric presence perceived stereoscopically. To avoid this conflation, the same masking pattern was consistently applied to both the left-eye and right-eye images, rendering the wooden structure a solid black. This process eliminates its role as an in-scene object and shifts the masking to the perceptual screen plane. Consequently, the viewer's attention is redirected toward the vessel's movement through the newly defined spatial apertures, enhancing the scene's layered stereoscopic composition.

Figure 1 Ship entering harbour shot through wooden frame

Figure 2 Ship entering harbour with multiframe

Experiment 2 – Creative Reframing

Figure 3 Young woman at vending machine

Figure 4 Young woman with circular frame

This sequence depicts a young woman pausing in an arcade to retrieve an item from a vending machine, set within a busy environment populated by numerous moving background figures. For this shot, a circular frame centred on the subject was selected, strategically excluding much of the surrounding activity. Positioned at the screen plane, the circular aperture focused attention on the woman while simplifying the visual field. Initial tests using a feathered edge were abandoned, as the result resembled an exaggerated vignette and diminished the intended formal clarity. Determining the circle's scale required iterative adjustment; a full circular mask obscured too much of the subject, producing an unintentionally restrictive composition. To resolve this, a segment of the circular frame was cut away to reveal the arm closest to the viewer. This was achieved using DVR®'s Fusion 'Magic Mask,' which enabled frame-accurate tracking of the cutout. The resulting composition concentrates the viewer's attention on the subject while preserving sufficient background detail for contextual coherence.

Experiment 3 – adding an extra shape

In this experiment, the circular frame previously applied to the shot was enhanced by the addition of a rectangular framing element. This rectangle spanned the full width of the image while occupying only a small portion of its vertical height. This configuration created an intriguing perceptual effect: the background appeared more expansive, enhancing the sense

Figure 5 Double frame circle and rectangle

of spatial breadth, while the circular frame continued to focus attention on the young woman. Notably, the inclusion of the horizontal rectangle did not diminish the primacy of the circular aperture. Instead, it complemented it by unveiling a broader horizontal field that enriched the environmental context. Thus, the combined framing system maintained the subject's centrality while offering supplementary spatial cues that expanded the viewer's awareness of the surrounding setting. The outcome illustrates how layered geometric frames can effectively balance focal emphasis with contextual expansion in stereoscopic compositions.

Preliminary Findings – Haptic Vision:

Depth Map vs. Disparity Map

In stereoscopic imaging, disparity and depth maps serve crucial yet distinct functions in representing spatial information. A disparity map is created by comparing two slightly offset images (typically the left-eye and right-eye views) captured from horizontally separated cameras (Mendiburu, 2009). Each pixel in one image is matched to its corresponding pixel in the other, and the horizontal shift (or disparity) between them provides vital depth cues. Larger disparities indicate closer proximity to the camera, while smaller disparities suggest greater distance (Bourke, 2022). Consequently, a disparity map functions as an intermediate representation, directly linked to the stereo baseline and supporting tasks such as stereo alignment, 3D reconstruction, and the refinement of depth relationships during post-production.

In contrast, a depth map encodes distances in more absolute terms. Each pixel's grayscale intensity indicates how far that specific point in the scene is from a reference camera (Szeliski & Szeliski, 2011). Depth maps can be generated from diverse sources such as time-of-flight sensors, LIDAR, multi-view computations, or even single-view estimations, and they do not necessarily depend solely on binocularity (Müller et al., 2010). This independence from the stereo camera setup often makes depth maps more adaptable in filmmaking and visual effects, where they can assist with compositing, virtual object placement, and post-production focus pulls. While it is feasible to convert a disparity map into a depth map if the camera parameters and scene geometry are known, reversing the process is less straightforward (Szeliski & Scharstein, 2002). As a result, each format presents unique advantages for stereoscopic workflows, and selecting one over the other depends greatly on the specific needs of a given pipeline or creative goal.

The Decision to Use Depth Maps for Stereoscopic Image Manipulation

Two main considerations influenced the decision to use depth maps for 3D manipulation in this study. First, the primary software used, Owl3D®, only accepts depth maps for creating S3D images. This technical limitation provided a clear reason: working with depth data ensured a smooth process without compatibility problems. Second, depth maps are generally easier to understand for artistic editing. Since each pixel's brightness indicates a specific distance from the camera, editors can simply darken or brighten areas to push them back or pull them forward. Disparity maps, on the other hand, encode pixel shifts that are less visually intuitive to interpret or edit. As a result, depth maps provide a more straightforward and adaptable way to improve 3D space, making them suitable for creative tasks that require precise, localised depth adjustments.

Experimenting with the Compositing of Texture Maps onto Depth Maps

Experiment 1 – Depth Map with a Composited Bump Map

In this experiment, a cobblestone bump map was composited onto the original depth map using DaVinci Resolve's Fusion module with a multiply blend mode. The aim was to introduce subtle textural modulation that could enhance the perceived three-dimensionality when processed through Owl3d. However, the resulting stereoscopic clip revealed significant geometric distortions. The complexity of the cobblestone pattern disrupted the coherence of the depth gradients, leading to inconsistencies that undermined the spatial stability of the final image. This outcome suggests that integrating highly detailed or irregular textures into depth maps can undermine perceptual clarity rather than enhance the viewer's sense of volume.

Experiment 2 – Depth Map with a Ring Shape

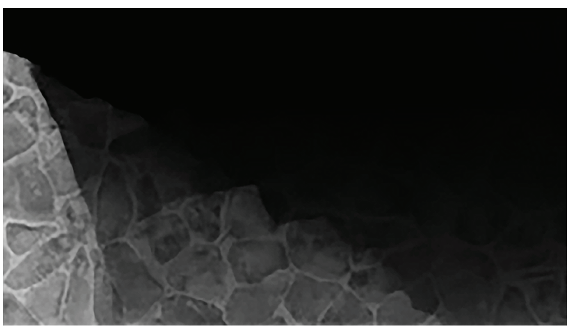

Figure 6 Depth map with bump map composited

Figure 8 Depth map with solid ring composite

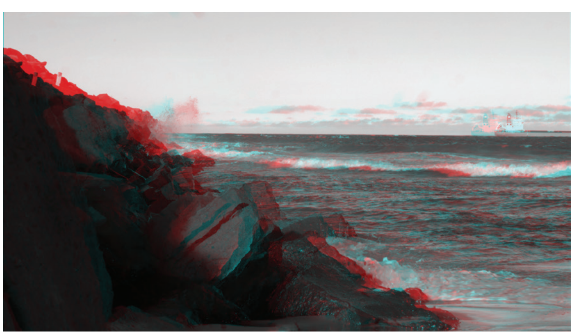

Figure 7 Render of depth map with bump.

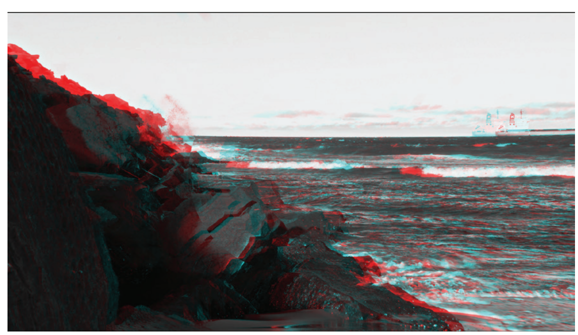

Figure 9 Anaglyph render of depth map with solid ring

A more direct method involved adding a white ring to the centre of the depth map. Since white indicates near distance in the depth map, this ring is projected forwards in the stereoscopic render, effectively flattening any visual content behind it. The result is a clear, protruding shape without internal volumetric detail. This outcome is visually striking but not seen by viewers as an error, confirming that using simple shapes can effectively create separate forward planes in S3D space.

Experiment 3 – A better way - Distortion of Pixels

A stereoscopic image pair can be understood from two complementary perspectives: the perceptual experience, stereopsis, and the mechanism that generates it, namely pixel disparity. Disparity refers to the horizontal shift between corresponding pixels in the left and right images; the size and direction of this shift determine each pixel's perceived position along the z-axis. Although depth can be represented through a depth map and disparity through a disparity map, the individual left-eye and right-eye images remain fundamentally two-dimensional. It is the interaction between these 2D images that creates the illusion of three-dimensional space. This principle suggests that if the pixel positions within a flat image are changed, the resulting disparity between the two images, and consequently the stereoscopic depth, can also be altered.

DVR's® Fusion page features numerous nodes capable of distorting pixel geometry. To investigate whether such distortions could be repurposed as stereoscopic tools, a preliminary test used the 'Ripples' node, which simulates radiating surface perturbations similar to those produced when a stone disturbs still water. When applied independently to left-eye and right-eye footage, and with most parameters locked to ensure consistent distortion patterns across both streams, the resulting S3D image appears to display 'stereoscopic ripples,' a form of artificial depth modulation.

Further experimentation involved subtly offsetting the ripple centre along the x-axis in only one eye. This introduced controlled disparity variations between the corresponding ripple structures, causing each ripple to be perceived at a different depth plane when viewed stereoscopically. These trials demonstrate that traditional 2D image-warping techniques can be used to generate or adjust depth cues, offering an

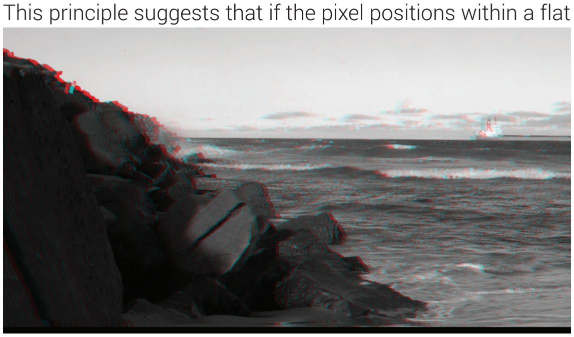

Figure 10 Image without ripple effect

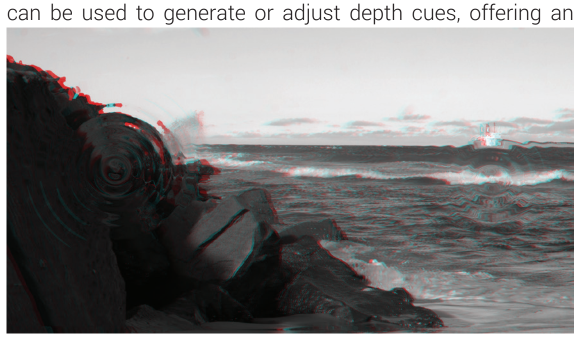

Figure 11 Image with 2D ripple effect

alternative creative approach for influencing stereoscopic perception without solely relying on depth-map editing.

Interim Conclusions

The variations in framing examined in these experiments notably affected the emotional tone of the sequences. Finding the best frame shape and how to incorporate it requires comprehensive testing to fully grasp its narrative and perceptual effects. Crucially, the dynamic nature of video—both the inherent motion within the scene and the potential movement of the frame itself—cannot be effectively demonstrated through static examples. Although not deeply investigated here, initial tests involved animating the circular frame to expand as the young woman stood, revealing more of the environment around her. This movement promoted a more natural integration of the framing device within the edit.

Three key insights emerged from the haptic trials: depth modifications are more noticeable when supported by familiar visual anchors; too much local detail in depth maps can cause perceptual instability; and traditional 2D tools, when used thoughtfully, can effectively improve stereopsis.

Conclusion

These initial findings indicate that two-dimensional (2D) and stereoscopic (S3D) elements interact closely, challenging the idea that S3D is simply an extension of 2D filmmaking techniques. Although S3D is often modified through changes in interaxial distance, convergence, and window violations, other cinematic aspects, particularly colour, contrast, and certain visual effects, have usually been considered from a purely 2D perspective. The research indicates that 2D depth cues can significantly affect perceived stereopsis, revealing a more integrated relationship between standard 2D elements and true stereoscopic features. Instead of viewing stereopsis as just adding '3D' to a conventional 2D frame, the interaction between these components enhances the overall visual experience. This may help explain why some S3D films find it difficult to justify their higher ticket prices, as Roger Ebert observed.

The investigation highlights that many historical criticisms of s3d—particularly those related to crosstalk, eye strain, and superficial aesthetics—are at least partly based on a limited understanding of s3d as simply an add-on effect. By moving beyond a strictly 2d perspective and recognising that all cinematic elements can be utilised to enhance stereoscopic perception, filmmakers can harness s3d's inherent capacity for immersion. This broader approach dispels the common myth of s3d as just a novelty, instead emphasising its potential for deep emotional impact and complex narrative depth.

While these insights remain provisional due to ongoing research, they build on the practical demonstrations seen in No Race, a production that brings together cultural themes with innovative S3D strategies. The evidence gathered so far underscores the need for a wider recognition of stereoscopic cinema as a unique medium deserving careful artistic and technical consideration.

In conclusion, this study emphasises the potential of S3D to revolutionise cinematic storytelling. By integrating a deeper understanding of visual perception along with established film conventions, S3D can enhance narratives, expand aesthetic possibilities, and produce unique immersive experiences. Embracing its distinctive qualities is vital for fostering innovation in the cinematic arts and offering audiences a level of engagement and sensory richness that cannot be replicated through traditional 2D film.

Bibliography

Bazin, A. (1952). Un nouveau stade du cinéma en relief: Le relief en equations. *RCT*, *131*, 4-5.

Bazin, A., & Gray, H. (1967). *What is cinema?* University of California Press.

Bourke, C. (2022). UAS autonomous drop zone assessment and adaptive delivery. [USQ Project]

Campen, C. v. (1997). Synesthesia and Artistic Experimentation. *Psyche*, *3*(6). https://doi.org/10.1162/002409499552948

Eisenstein, S. (2013). On Stereocinema (1947). *Public*, *24*(47). https://doi.org/10.1386/public.24.47.20_7

Holmes, O. W. (1859). The Stereoscope and the Stereograph. *Atlantic Monthly*, *3*.

Kohler, W. (1929). *Gestalt Psychology*. Liveright.

Lee, A. (2019, October 9). *Ang Lee at Gemini Man RealD 3D Screening*. RealD 3D at Regal Cinemas L.A;

Lipton, L. (1982). *Foundations of the stereoscopic cinema: a study in depth*. Van Nostrand Reinhold

Mendiburu, B. (2009). *3D movie making : stereoscopic digital cinema from script to screen*. Focal Press/Elsevier.

Müller, K., Merkle, P., & Wiegand, T. (2010). 3-D video representation using depth maps. *Proceedings of the IEEE*, *99*(4), 643-656. https://doi.org/10.1109/JPROC.2010.2091090

Patrick, N. (2016). *In 1895 "The Arrival of the Train" was one of the first films shown to the public – it nearly caused panic*. The Vintage News. https://www.thevintagenews.com/2016/08/08/in-1895-the-arrival-of-the-train-was-one-of-the-first-films-shown-to-the-public-it-nearly-caused-panic/

Pierce, S. (2012). *Ang Lee On The Filmmaking Journey Of "Life of Pi"*. Fast Company. https://www.fastcompany.com/1682021/ang-lee-on-the-filmmaking-journey-of-life-of-pi

Rogers, B. (2019). Toward a new theory of stereopsis: A critique of Vishwanath (2014). *Psychological Review, 126*(1), 162–169. https://doi.org/10.1037/rev0000131

Ross, M. (2012). The 3-D aesthetic: Avatar and hyperhaptic visuality. *Screen*, *53*(4). 381-397. https://doi.org/10.1093/screen/hjs035

Shugart, J. (2013). *3-D effects may require one eye only.* Science News. https://www.sciencenews.org/article/3-d-effects-may-require-one-eye-only?utm_source=chatgpt.com

Slater, M., & Wilbur, S. (1997). A Framework for Immersive Virtual Environments (FIVE): Speculations on the Role of Presence in Virtual Environments. *Presence: Teleoperators & Virtual Environments, 6*, 603-616. https://doi.org/10.1162/pres.1997.6.6.603

sbblogs (2012, February 1). Martin Scorsese on 3D [Video]. sbblogs. https://youtu.be/pCxLzOLrr50?si=LUvmD0wcyT-Nm-BZU.

Szeliski, R., & Scharstein, D. (2002). Symmetric sub-pixel stereo matching. Computer Vision—ECCV 2002: 7th European Conference on Computer Vision Copenhagen, Denmark, May 28–31, 2002 Proceedings, Part II 7.

Szeliski, R., & Szeliski, R. (2011). Stereo correspondence. *Computer Vision: Algorithms and Applications*, 467-503.

Trotter, D. (2004). Stereoscopy: Modernism and the Haptic. *Critical Quarterly*, *46*(4), 20. https://doi.org/10.1111/j.0011-1562.2004.00596.x

Tuffour, I. (2017). A critical overview of interpretative phenomenological analysis: A contemporary qualitative research approach. *Journal of healthcare communications*, *2*(4), 52. https://doi.org/10.4172/2472-1654.100093

V.S. Ramachandra, E. M. H. (2001). Pyschophysical investigations into the neural basis of synaethesia. *Proceedings of The Royal Society B*(268), 5. https://doi.org/10.1098/rspb.2000.1576

Vishwanath, D., & Hibbard, P. B. (2013). Seeing in 3-D with just one eye: Stereopsis without binocular vision. *Psychological Science*, *24*(9), 1673-1685. https://doi.org/10.1177/0956797613477867

Ward, P. (2014, 08th Dec 2014). *Timecode versus Sync: How They Differ and Why it Matters*. B&H