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CINEMATOGRAPHY IN VIRTUAL REALITY: CHALLENGES AND OPPORTUNITIES FOR A NEW VISUAL STORYTELLING

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I declare that I have prepared my Bachelor's Thesis/Master's Thesis, Dissertation independently on the following topic:

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Abstract (ENG)

Virtual reality (VR), initially employed in the world of gaming, has been garnering significant interest among filmmakers. As an alternate method in filmmaking, VR has led to the emergence of the VR cinematographer who plays a major role in the new medium. Notably, VR cinematography remains a work in progress at this point, with challenges and opportunities related to this role, abounding. VR narrative filmmaking faces many challenges; from scripting, to lack of framing, to synchronizing the audience's angle of viewing to the field of action, to film language and editing. One of the most challenging challenges in VR film language for a cinematographer is framing because, in VR films, the viewer enters a 360° environment, just as if they are entering a real world. The traditional concepts of composition do not exist in VR cinematography. There are no close ups, over the shoulder shots or any other rules of composition from rule of thirds to golden ratio. One way to compensate framing in VR cinematography is to look to theories for guidance. For example, VR films need to be considered as a non-traditional narrative medium because the goal here is to tell a story albeit with a more in-depth, spatial experience. The viewer undergoes deep immersion in the VR narrative, with a strong presence in the story setting even though the latter is synthetic. Through VR cinematography technology and techniques, the viewer suspends belief and feels that he or she is actually in the setting the narrative entails. Often in classical cinema storytelling, the build-up of a scene can take a longer time, even minutes, whereas, in VR, the audience is pushed immediately right into the scene.Moreover, since the medium is so experiential that the viewer understands the situation instantly, they understand the set, the back story immediately. It is unto the director to choreograph different viewing experiences to a common goal. There is more choreography

involved in scriptwriting and thus the film language. In light of these, the role of the VR cinematographer significantly changes from traditional approaches, methods and perspectives, particularly in traditional terms of camera work, lighting and camera movement. The role of a cinematographer starts from preproduction and is more heavily involved in post production. Unlike traditional film process, if the treatment is executed right, the role of a cinematographer is limited to color grading. Whereas in virtual reality, due to lack of framing and on set 'monitoring', the image is highly dependent on post production stitching and can be perceived only when looking through a headset or an HMD. For many analysts, VR film and cinematography represent the future of realistic cinema. Whether this will come into fruition, opportunities in the field are driving discoveries and development, while essential challenges are surmounted, as discussed in this study. This study aims not just to highlight the creative and technical challenges faced by a Director of Photography working in a VR medium but also questions of how the role of a DoP is affected in VR fiction filmmaking with comparison to classical narrative filmmaking. A virtual reality cinematographer can do documentary VR, live-action fiction VR, games as well as CG animation and the role, workflow and challenges would be completely different. This study concentrates on live-action fiction VR and the challenges in cinematography therein. Deductions on cinematic tools in VR have been made reading the research made on Narration, films and human perception; into the context of VR experiences.

Can we re-apply the established rules of filmmaking and how does that affect the techniques incorporated by a cinematographer?

Abstract (CZ)

Virtuální realita (VR), původně využívaná pro svět her, postupem času začala zaznamenávat značný zájem mezi filmaři. Jako alternativní metoda při tvorbě filmu, VR vedla ke vzniku role kameramana pro VR, který hraje významnou roli v tomto novém médiu. Je nutno zmínit, že v tomto okamžiku kinematografie VR zůstává nedokončenou prací, s mnohými výzvami a příležitostmi, hojně spojenými s touto činností. Narativní filmová tvorba pomocí VR čelí mnoha výzvám, od psaní scénáře, přes problematické rámování, synchronizaci úhlů pohledu diváka na pole působení, po filmový jazyk a úpravu. Jednou z nejnáročnějších výzev ve filmovém jazyku VR je pro kameramana rámování, protože ve filmu VR divák vstupuje do 360° prostředí, obdobně jako by vstupoval do reálného světa. V kinematografii VR neexistuje tradiční pojetí kompozice. Nejsou v ní žádné záběry z blízka, přes rameno nebo jiná kompoziční pravidla jako pravidlo třetin či zlatý řez. Jedním ze způsobů, jak kompenzovat problematiku rámování v kinematografii VR, je využít teorií pro náhled z různých perspektiv. Například filmy VR by měly být považovány za netradiční narativní medium, jelikož cílem je vyprávět příběh, i přesto, že je prezentován s hlubším, prostorovým zážitkem. Divák prochází naprostým ponořením se do příběhu VR, s pocitem silné přítomnosti v jeho prostředí, i když je uměle vytvořený. Pomocí technologie a technik kinematografie VR se divák oprostí od reality, a cítí se, jako by byl v prostředí příběhu. Při vyprávění příběhu u klasického filmu může rozvoj scény často trvat delší dobu, klidně i minuty, zatímco ve VR je do ní publikum okamžitě vrženo.

Vzhledem k tomu, že médium je tak zážitkové, divák okamžitě porozumí situaci, stejně jako hned pochopí danou scénu a pozadí příběhu. Na režisérovi zůstává zchoreografovat různé zážitky ze sledování do jednoho společného cíle.

Ještě více plánování je zapojeno do psaní scénáře a tím pádem i do jazyka filmu. S ohledem na tyto skutečnosti se role kameramana VR zásadně mění od tradičních přístupů, metod a perspektiv, zejména v otázce tradiční práce kamery, osvětlení a pohybu kamery. Práce kameramana v tomto případě začíná předprodukcí a je mnohem více znát v postprodukci. Narozdíl od tradičního filmového procesu, kde, pokud je vše provedeno správně, je role kameramana omezena na barevnou korekci, ve virtuální realitě je, kvůli problematice rámování a "monitoringu" na scéně, obraz vysoce závislý na postprodukční úpravě a může být zachycen pouze přes náhlavní soupravy nebo brýle pro VR. Pro mnoho analytiků představuje VR film a kinematografie budoucnost realistického filmu. Nehledě na to, zda se toto vyplní či ne, příležitosti v této oblasti jsou hnací silou objevů a vývoje, zatímco základní výzvy jsou již překonány, jak je uvedeno v této studii.

Tato studie si klade za cíl nejen upozornit na kreativní a technické výzvy, kterým čelí kameraman pracující s médiem VR, ale také na otázku, jak je jeho role ovlivněna při filmové tvorbě fikce VR v porovnání s klasickou filmovou tvorbou. Kameraman virtuální reality může zvolit dokumentární VR, hranou fikční VR nebo hry, stejně jako CG animace, a jeho role, pracovní postup a výzvy budou v každém případě diferenciálně odlišné. Studie se zaměřuje na hranou fikční VR a na výzvy v kinematografii s ní spojené. Dedukce filmových nástrojů ve VR byla provedena na základě aplikování poznatků z výzkumů, zaměřených na vyprávění, film a lidské vnímání, do kontextu VR.

Můžeme znovu využít již zavedená pravidla filmové tvorby a jak to ovlivní techniky používané kameramanem?

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1. INTRODUCTION

Virtual reality (VR) is one of the fastest emerging technologies today that aims to provide an immersive experience to its users. VR is usually seen as an interactive medium which lacks the emotional substandard as provided by the classical cinema. Using a VR device, users can play the role of their character and do/see anything according to what the character needs to act. The British Museum also launches its VR experience recently to encourage visitors to experience technology and art at the same time. Through the 3D headsets, projects, and tablets, visitors can experience the images in the gallery as if they are part of it.

Another example is the tilt brush launched by Google. Artists using this tilt brush along with the VR device, see a different perspective of their artwork. In the context of cinema, VR is also used in both fictional and documentary films. Although VR mostly seems to be the ideal medium for gaming, filmmakers began to explore it as a fresh alternate medium to narrate stories, which includes both, CG animated VR experiences and filmed live-action 360-degree films. It was eventually discovered that planning and filming in 360 do not work as typical classical films. The viewer takes the perspective of the camera and can choose as to where to turn and look. Which means there is a high probability that the viewer might skip parts of the action because his/her gaze was focused on something irrelevant to the story.

Similarly, if the pacing is off, he/she can become either disinterested or completely exhausted and overwhelmed by a scene. Established Camera movements, shallow depth of field and traditional editing cuts and shot magnification may seem to distract in VR film experiences. The classical film

language does not work when applied to VR 360 films. Filmmakers are heretofore creatively experimenting with alternate solutions that involve rather artistic choices; however, there is little to no scientific research yet on those specific challenges. VR is used to make viewers feel more in-depth about the time and space of the film and make them more connected to the characters and story.

Several scenes from classical narrative films nowadays are readapted in the VR version to make the experience more profound and live than typical or traditional viewing. In this case, there are no changes in the story or the whole film, except the film language and the viewing device (HMD) to experience more of the setting, mise en scene, characters, time, and space. A camera is placed either in the center of the space or through a POV of a character. Though no full-length films are created explicitly for VR, there is a reason behind VR films not to be traditionally long which shall be explained further.

Against this backdrop, this paper seeks to delve deeper into the context of VR live-action cinema. It aims to explain different perspectives about cinematography in VR and as a whole. With its growth and continuous development, as well as cinema's dependence on changing technology, is VR a promising technological device that can bring deeper connection and experience to the viewers' understanding of the story?

The specific objectives of this paper are to:

· Delve into scripting and film language choices based on the viewer is an active participant to the story or a passive objective observer.

· Explore how the role of the director of photography changes according to the choice of using the 360 degrees shooting

· Explore various tools of guiding audiences' attention to the relevant story

elements.

· Investigate how VR transforms framing in cinematic works

· Explore the choice of placement and position of the camera and how it interacts with the story and the viewers' perception.

· Determine how the process of set lighting would vary together with the production design.

The challenges, as mentioned above, have been explored by examining already applied techniques in VR filmmaking and parallel analysis of once challenges and tools formed in classic films and cinema. There are also deductions been made from a personal interview with Jannicke Mikkelson at Camerimage Festival, Poland, 2018. Unlike the classic work on photography, in fact, there would be a need for the development of techniques that would help to create a literally broader perspective that may still allow the cinematographer to preserve the magic of film language while, at the same time, would empower the viewer in choosing his point of interest and what to look at, to enter the story and participate it according to his feelings and attention focus.

The paradoxical challenge is that the use of "magic" with VR may also spoil THAT kind of "old magic" thanks to which cinema would lead the spectator by hand - since the inception of filmic language as such - through the visual storytelling embroidered carefully by the director, the DoP and the crew. On the other hand, coercing the viewers' attention to a particular element of the plot destroys immersion, thus contradicting the fundamental characteristic and potential of VR.

In a nutshell, VR in fiction films is not the ideal progressive leap in visual storytelling approach much more than, it is for documentary film genre. By nature, observational documentary films lack that exceptionally staged and

directed set production which has always been - at least, till date - the fundamental intrinsic factor and tool of fiction films.

1.1 Virtual Reality

The VR is one of the fastest technological devices used in entertainment and different forms of media today. It is often used to make the viewers and users feel their environment and take action according to what they have to do as gamers, painters, and viewers. Through VR, time and space are profoundly and widely explored as if the naked eye is the one experiencing the scene, shot, or frame. Fundamentally, a VR is a panoramic viewing wherein users can explore 360 degrees vision without moving. Which changes how users can experience the different scenes flashing before them. Instead of being mere spectators, VR allows them to be immersed and feel involved in what is being shown to them. There is two fundamental range of roles a viewer can take in a VR viewing experience.

"*Panoramas are generally regarded as widefield images; often, they represent a full 360-degree field of view. A panorama represents a single point of view and is, by definition, two-dimensional. Panoramas allow a viewer to look but not to move*"[1]. Panoramas provide a broader scope of space than other frames. It provides 360 degrees illustration of what happened in the character's environment. In other words, it gives a better perspective because of the wider angle. In VR, panoramic point of view is experienced, wherein the viewer feels being part of the vista. Through the VR device, viewers can see the whole setting—back, front, left and right—without moving. The device can help them

[1] Naimark, Michael "World's First Interactive Filmaker".
Interval Trip Report n.27, 1998
www.naimark.net

see everything to experience more of the setting and space—whether it is in gaming, painting, or film. In films, the purpose of VR is to expand the perspectives of the viewers. They are provided with larger frames—enabling them to see more of the people, situations, and conditions in each frame. From this sense, it can be said that VR offers a realistic experience to its cinema users because viewers can expand their understanding of the story by being connected to the setting, characters, time and space. Through this device, they can experience a panoramic point of view that enables them to understand the wholeness of the plot, emotions of the different characters and the whole setting of the scene. Virtual reality can be categorized into interactive and non-interactive 360 films. In interactive 360 medium, viewers have an agency not just to choose where to look at but also move within a space according to his/her own will. Which is used mostly in VR gaming. Whereas in non-interactive 360, the viewer has an agency to pan around and choose his/her FOV but not necessarily be able to move at his/her will. One of the challenges with viewer experience is how to find the right balance between viewer agency and a pre-scripted narrative.

1.2 Virtual Reality in Cinematography

The use of VR in cinematography is less common than in the gaming industry. The advent of VR in cinematic narration was to provide a more 'realistic' and immersive experience to the viewer. In the recent past, what was more common is the use of 3D in films or on bigger screens to give viewers better and more realistic views of each scene, which allows people to almost feel that they are part of what they are watching. However, today, cinematographers are considering the use of VR in films just like in different forms of media and entertainment. The term VR cinematography "*refers to the cinematic projection of scenes occurring in a 3D graphical environment onto a flat screen, with a virtual camera serving the role of a physical one*"[2]. The definition shows that VR is contextualized in the field of cinematography, which means that the use of the device in cinemas is now being explored[3].

Nevertheless, it is vital to know the significant differences between VR and traditional film experience. According to an interview with Paul Raphael, a VR cinematographer, "*It's just very different from traditional cinematography where you are thinking inside of a frame, and you've basically got this planar, two-dimensional image in front of you. When you're framing in VR, you still have composition. You're positioning the camera in a very specific place.* [...] *The way we tend to go about composing for our VR [at Felix & Paul] is to think of the camera as a person. Ultimately, someone is going to put a headset on and they're gonna see this shot as if they were there. So, by really thinking of the*

[2] Elson, David K., and Mark Riedl. "A Lightweight Intelligent Virtual Cinematography System for Machinima Production.", 2007. http://ict.usc.edu/pubs/A%20Lightweight%20Intelligent%20Virtual%20Cinematography%20System%20for%20Machinima%20Production.pdf

[3] Nanimation - Company, Facebook. https://www.facebook.com/nanimationinc/posts/

camera as a person, you tend to get a better feeling for where the camera can and should be. Can someone actually be here or not?"[4]. This statement justifies that VR has a definite distinction from traditional cinematography because of its broader perspective and real-time and space experience. Though it is possible, films require extensive use of technology to provide broader, but specific time and space. Cinematographers need to provide higher and wider spaces to offer better experience and connection to the story. It was also realized that the camera language is dependent more on the spatial reconstruction and choreography than in framing and composition. Preproduction stage before shooting a VR project are quite the same for a cinematographer as preparation of a traditional film project. To choose an adequate camera technology according to the script and concept of the project.

However, there is a change in the use of the camera. It is still a camera, of course. it is a whole set of cameras. Standard rig for 360 has 10 or more cameras built into it facing in all directions. The preproduction will be even more important than filming in virtual reality and its foundation is based mainly on communication between all departments. The cinematographer will be more in charge during post production. With traditional filming, filmmakers have comfortable options

for example, to verify that everything managed to be filmed according to ideas and therefore avoid the problems associated with the post-production part. When filming in virtual reality, you are essentially dependent on postproduction from the beginning. You're unable to check any shot without getting getting all the ten cameras stitched together, which you then play on the headset and

[4] Anderson-Moore, Oakley, 2016, Interview with Paul Raphaël of *Felix and Paul Studio, https://nofilmschool.com/2016/05/vrs-most-cinematic-studio-camera-philosophy-behind-new-oculus-series-nomads*

only then you see the filmed material. Choosing the right camera technology according to the concept, involves the size of cameras, camera movements and quality post production time for composing the image. Before elaborating on that process, lets' understand the challenges and the remnants for a classical DP entering into the world of VR production.

The cinematographer still works on the tools/mise-en-scene using lighting and movement to provide an emotional interface to the immersive experience. *"But the nature of VR is best suited for, in my perspective, to make you feel a space. It's a more visceral experience. It's something that cinema has never fully been able to do. The best films really bring you somewhere, whether that's through a feeling or an insight. With VR, there's an unspoken feeling that doesn't need to be described. That's a type of communication that I'm fascinated by. I enjoy exploring the question, what was it in the past we could not communicate with films that we can now communicate using VR? A lot of that is just actually being in the presence of someone, and not so much about the specs or the statistics or didactic information of the subject you are observing"*[5]. A spectator is not just witnessing the story but is experiencing the story by being a part of it. Can VR also be emotional than just immersive? So far it has been already experimented in VR cinematography that it is not just possible to move the camera to establish the *presence*, but it is also possible to have quicker cuts and transitions in order to help with the story. Even though according to Paul Raphaël and his experienced studio*: "We're used to having all sorts of transitions. Well, there's not too many: either the cut, the fade, the cross dissolve. Anytime we've tried to do anything other than fade to black in VR, it's*

[5] Ibidem

been a disaster. I've never seen a cut work in VR"[6].

[6] Ibidem

2. VIRTUAL REALITY IN CINEMA

People have their reasons for watching films, such as mise-en-scene, film language, special effects, story, and actors. The reason why filmmakers have continued to find ways to enhance viewer experience is because of the people's need to see each scene as realistically as possible. Films are intended to grasp the attention and engagement of the viewer. Believability and relativity become helpful tools for audience engagement. Thus, filmmakers strive to create scenes and elements concerning their perceived realism while adding effects to challenge the visual needs of viewers. Computer graphics have been widely used in order to enhance viewer experiences. As a continuing development of technology in this industry, new forms or media are being explored to give more special effects and alternate narrative mediums. Also, unique mediums include VR—and it is a great advantage for films using this technological tool to encourage more viewers. In current 3D theatres, viewers are given glasses to allow them to appreciate the three-dimensional effects that are shown on screen, still omnipresent. In VR on the other hand, each viewer is given a VR equipment/headset so that each one will feel that he is individually submerged in the experience taking a first-hand look at the story. At the inception of VR technology, unexpected challenges had to be faced: viewers experienced motion sickness which resulted in VR films having a less dynamic opening where there are no dynamic camera movements and the essential plot elements are not introduced until the first few minutes where the viewer gets accustomed to the panoramic mind-body experience. Much similar to vintage classical cinema having long opening credits for accustoming the audience.

Meanwhile, VR is also an essential tool in understanding the story of the film, how and why it is presented to the target audiences. Studies are conducted to determine the correlation between VR and the narrative of the film. Researchers like Sandy Louchart and Ruth Aylett argue that "*VR displays in real time, tying it very strongly to a specific space and time*". Quite surprisingly, the research shows how *"spectators and participants mark different stories as the most interesting, showing that this role difference does indeed impact their assessment of a narrative experience*"[7], which is different from other forms of media, but time and space are clearly explored to make the viewers experience the structure and scene of the story. The viewer is not anymore a disinterested third person who sits from afar and could not be affected by what is going on. With VR, the viewer is brought closer to the story, making him feel part of what is unfolding before his eyes.

The most significant difference in storytelling in traditional filmmaking and virtual reality filmmaking is that the 'buildup' to the scene might take 10-15 minutes in traditional storytelling as opposed to VR filmmaking where the audience is pushed right into the scene. And since the medium is so experiential, the viewer understands the situation instantly. The viewer is not sitting at a distance and watching a two dimensional screen, but panning his/her head and discovering just as he/she would in real life. They understand the setup, the back story immediately. It is then unto the director to choreograph different viewing experiences to a common goal. There is more choreography involved in script writing, as viewers' attention needs to be guided through contextual stimuli and cues rather than cuts, shots sizes and camera movements which are the "manipulation tricks" of traditional filmmaking. It is to be found out whether

[7] Louchart, Sandy and Aylett, Ruth , *Being There: Participants and Spectators in Interactive Narrative* - International Conference on Virtual Storytelling, Saint-Malo, France, 2007.

this is a big challenge which carries an opportunity or only limitations to storytelling. Because of which even though, the budget required for producing a 20-minute VR film is as much as producing a 2 or 3-hour feature film, the journey or the experience by the viewer in that 20 minutes is the same as a 3-hour feature film. This is important for any aspects or tool of films to contribute to the story because more than anything, the plot is the most important thing to consider—to show viewers the importance and essence of the film. To understand film treatment in VR, it is crucial to study the research about in other areas such as games, theater and human perception. When the viewer locates himself/herself in a VR space, he/she might address and react like in a real-world situation, which can have a huge impact on his perception and interpretation of the VR scene. This, for instance, is reflected by the effect of proxemics in Virtual reality. Depending on how the characters are placed around the camera, the viewer has an emotional impact with the proximity of the characters in the space. Regarding navigation in VR and proxemics, it is often suggested to use theatrical techniques of staging and choreography. There has been various research in the past few years on scriptwriting and screenplay for VR films. The research "Screenwriting Framework for an Interactive VR Film"[8] which provides the dramatic structure of the hero's journey in interactive VR and 360-degree films, shows how "*360 degrees interactivity shapes the flow of the story and user's enjoyment as much as, on the other, leads towards a medium-conscious narratology for VR*. [...] *The writing of a screenplay for an immersive film needs to consider in the first place the aspects related with the 360º environment. This conceptual exercise creates several narratological issues that haven't been completely addressed by theory: Who*

8 Reyes, Maria Cecilia *Screenwriting Framework for an Interactive Virtual Reality Film*, Immersive Learning Research Network, conference in Coimbra, Portual, 2017

tells the story? Who is the user inside the story? Is the user part of the story at all? The creation of an interactive story is another challenge for the author: What kind of interactions are going to be used and in which way will they affect the story, how to write a fluent and coherent story where a single narrative node is both source and destination of another one or multiple nodes"[9]*.* While these issues may sound strictly related to the scriptwriting, they indeed need to be addressed by the cinematographer who needs to interpret and give viewers the actual opportunity to experience the story together with the space as well as to create his/her own narrative.

Amongst the others, D. J. Roller, Co-Founder of NextVR, Inc. in Los Angeles, states that in VR, "*viewers are not watching a story, they are in a story. Instead of crafting a scene to be watched, we are creating an environment to be explored. Viewers will want to have control, choose where they look and how they interact with the environment*".

The role of cinematographer is challenging and crucial in creating a VR environment. VR narration entails a panoramic Field Of View in a spatial 360 setting, hence, how does a cinematographer guide the spectator 's angle of viewing to the story or the plot?

[9] Idem

2.1 Synchronizing the viewers' attention

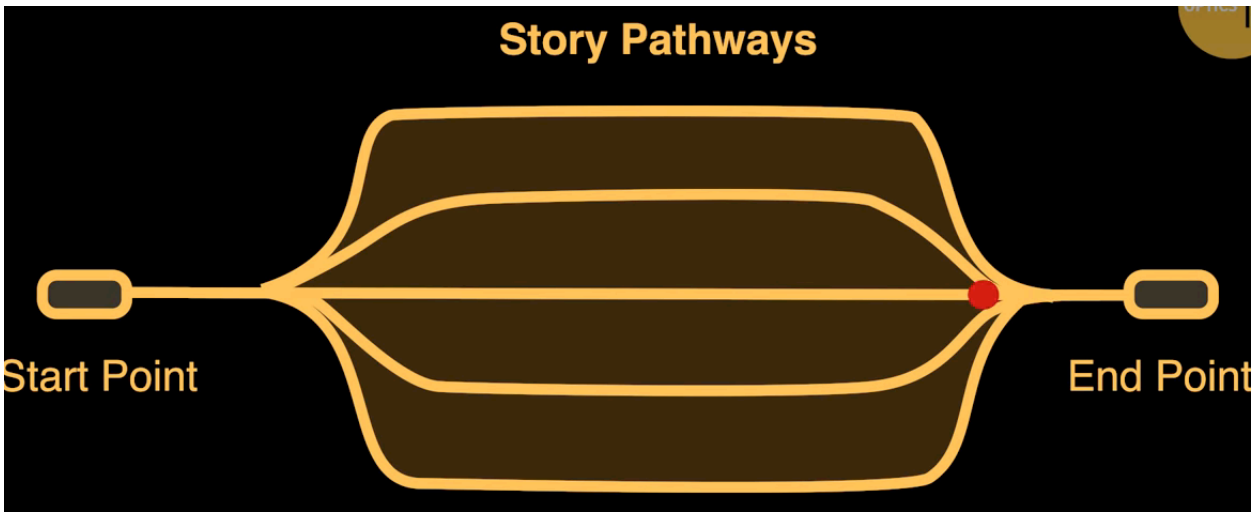
One of the essential needs as well as challenges of VR filmmaking is to synchronize the viewers' direction of viewing (FOV) in the interest of the plot. The films are designed in 360 degrees but the angle of viewing is limited to the human FOV. Anatomically, the human field of view is composed of two monocular FOVs which our brains stitch together to form one binocular FOV. Individually, our eyes have a horizontal passive FOV of about 135 degrees and a vertical FOV of just about 180 degrees[10]. Although our peripheral vision has such a wide focal length, out actual focusing angle is roughly 40-45 degrees. If a bear jumps in your peripheral passive vision, your eyes would pan, focus and zoom at the bear to focus better and avoid the danger. This acute angle of concentration is guided by external stimuli such as color, movement and light. So how does a filmmaker consistently direct the active human FOV to the desired axis at the right time? This can be achieved with a combination of tools in all three stages of the film.

1) Scripting
2) Staging / Treatment / Cinematography
3) Editing choices

Filmmakers have tried various narrative tools to tell a story in a VR film. One of the creative forms of narrative writing is to write multiple arcs according the the angle of viewing which meets the same ending or the grand finale. Much similar to 'hyperlink cinema' or 'hyperlink narrative' like *Amores perros* by Alejandro González Iñárritu (Mexico, 2000) or *Code unknown* by Michael Haneke (France, 2000) the viewer witnesses a dramatic episode from the perspective of multiple characters alternating from one character to the other neatly designed with well-

[10] whatis.techtarget.com. https://whatis.techtarget.com/definition/field-of-view-FOV (accessed December 21, 2018).

formulated continuity and filmmakers (both in traditional cinema and VR one) need to develop branching narratives which lead in the interest of the common plot.



The goal of the above framework is to develop an interactive script which is independent of the viewers' journey while watching it in the traditional cinema whereas it depends on it in VR cinema and storytelling.

The other elements of guiding the viewers' attention is the use of diegetic and non diegetic cues which brings the attention to the treatment of the script. There are various ways to lead the viewers' attention with visual cues. The cinematographer along with the director develops these cues with respect to the emotions / drama of the plot. Of course, the cues have to be placed within the viewers given field of view. Having additional or multiple cues helps increasing the probability of guiding the viewers' attention.

Few of the diegetic cues concerning the choice of the cinematographer have been categorized as follows.

1) **Eyes**

   Eyes have always been the center of attention for a viewer, even in traditional cinema. Eyes or the gaze of a character can be used to guide

an audience to change their field of view. The viewer would generally follow the direction of the gaze of the character.

2) **Movement**

This can be further subdivided into two categories:

A) Camera movement – Camera movement strongly affects the viewers' attention. Camera movements gather attention and, if not used right, can be extremely distracting. Therefore, POV action scenes at times are more exhausting than entertaining. Stark camera movement may often result in motion sickness of the viewer. This happens because of disruption in synchronization of movement between the mind and the body. With human perception, chances are the viewer follows the direction in which the camera is moving to. So tracking back or dolly out shots might result in the viewer facing the opposite direction.

B) Motion – Movement of characters or elements helps guide the field of view of the viewer. Locomotive motion helps follow the gaze of a viewer. If there is a character moving across the frame, the viewer would be likely follow the character with his/her FOV.

Contextual motion needs to be implemented. Two conflicting characters/object movements might result in confusing the viewers' FOV. Having moving objects within the frame also attracts the viewers' attention. Let's imagine, as a simple example, a swinging pendulum.

3) **Lighting**

There are two ways lighting is used to direct the viewers' gaze:

A) Light contrast and Color contrast – Darkness or negative space generally coerces the viewer to follow towards the light or brighter elements. Color contrast can be effectively used to deduce an important element. For instance, if a film follows a complementary color scheme until a third foreign color is introduced outside the periphery of the viewers FOV and attracts the viewer's attention. The viewer would generally navigate to find the source of that alternate color.

B) Animation – Moving or light effects has more probability of seeking attention than non moving lights. Effects like a flickering light - from a TV for instance, changing of direction of light and shadows garnish the viewer to turn and try to find the source of the lighting animation.

4) **Perspective**

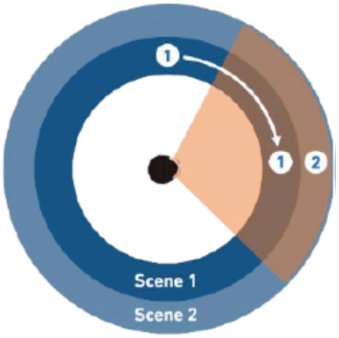
Spatial perspective also guides the viewers' attention.

Much like paintings, parallel lines and shapes helps guide the viewers towards the vanishing point. It is essential to capture objects as a whole which can fit in the visual periphery of the viewers' subjective distance. Objects closer to the viewer hold more attention compared to the same objects places at a distance.

Perspective and some of the above mentioned cues are further discussed in the following chapter.

The other stage of VR filmmaking which influences the viewers' FOV is editing and technology. VR technology and viewer's reception has advanced to the stage where viewers are accustomed to quick cuts and smart transitions. In VR though, it is still suggested to avoid jump edits in time and space and rather have seamless transitions coherent to the visual cues. For instance, assuming that in the first scene a character walks from left to right, the filmmaker assumes that the viewer follows the 'motion cue' of the character and follows him/her left to right. The editor can seamlessly add a wipe/stitch at the end of the pan which introduces the second scene and also makes sure that the viewer is looking at the right direction.

The viewer might still need some time to orientate in the new scene, therefore, the crucial elements should gradually fade in the second scene. Henceforth an editor usually has several in and out points in a panoramic scene where the viewer can transcend and navigate easily into the following scene.



Another recent development in VR is the that the viewing software itself triggers the viewers' angle of viewing. Many VR software and environments use gaze detection to determine which part of the 360 degree a viewer is looking at. This interactivity helps the filmmaker control many aspects of the viewing. For instance, if a viewer faces the 'wrong direction' the scene pauses automatically until the viewer orientates himself/herself back in the correct FOV. This viewing experience does help the audience to have a common and a similar

understanding of the plot, because of which the duration of the film might vary for each and every viewer. A viewer consistently watching in the 'correct direction' would watch a shorter film than a viewer navigating in and out of the 'wrong direction'. Furthermore, understanding which is the choice of directions the viewer has through the triggering software, also helps the cinematographer timing the lighting changes consequently along the different angles. Can 'gaze detection' be used in further advanced technologies where lighting can be adapted or the characters can be relocated in the viewing interest/angle of the individual viewer?

2.2 Framing

VR films almost cover almost 360 degrees, so typical conventional framing as such does not work in VR films. The framing is dependent on the viewers' FOV and head movement. The viewer, according to his/her instincts, decides the framing or the 135 degrees of angle of viewing. In VR, framing is highly dependent on the position of the camera which needs to be placed in a way that there is no blind spot for the viewer to end up to. The position of camera is essential in traditional filmmaking too but in VR, the position is dependent not just with the psychology of the viewers' experience but also behind the camera. Virtual reality evokes a greater sense of intimacy, so positioning the camera with respect to the observer, with respect to the location or actor plays a huge role.

If the distance to the subject is greater, something between 5 - 10 m, the recognition of the face becomes more challenging. The stitching and composing of the images might result in a parallax error with double vision of that face. We must therefore take this fact into consideration and for the action in which to be clearly recognizable, we have to count with an action radius of 5 m.

Considering, the staged mise-en-scene cannot be changed or readapted

over time; it becomes highly crucial to decide the position of the camera. Shot magnifications do not exist in VR. One cannot simply have an insert of an eye. Similarly you cannot also have a Wide shot in VR. A character placed over 15 meters of distance might go unnoticed by the viewer. So an extreme wide shot of a boat sailing in the horizon might go completely unnoticed by the viewer or would not have a similar impact as it would with a traditional film.

The fact that a character or an object has to be closer or further to the camera, decides the camera position altogether. The relative distance of the scene and objects to the camera is highly important, which is also defined as *proxemics*. A VR cinematographer should have a profound understanding of proxemics in VR: a character coming closer to the viewer in VR is not considered as a close-up. Instead, it is quite an extreme experience for the viewer. The viewer might be frightened or feel empathetic to the character. The positive and negative feedback is dependent on the context of the plot, therefore it is essential to stage and choreograph the entire scene around the camera. This can be referred to as 'blocking for the camera' in conventional terms. While VR filmmakers struggle to provide narrative coherence with guiding the viewers' angle of viewing and interactivity, in the art of theatre all these elements have been explored highly through the choreography of physical space and spatial relationships.

Theatre experts not only narrate a story using spatial cues but also orchestrate the spatial relationship to its complicated audience viewing. That's what VR filmmakers have tried to seek solutions to challenges of blocking from theatre practices. It is as placing a floating virtual camera in between a theatre performance where the proxemics of the characters and their evolving spatial relationship has an immediate interactive experience to the viewer. We'll have a

lot of detail to shoot and hide things on the scene, put a lot of things closer to the camera's field of view, etc. This whole process is very complex. As mentioned above, it applies to not just one but all angles and directions in space.

For the context of reference in classical cinema, a scene from *The deer hunter* by Michael Cimino (US, 1978) is experimentally blocked as if we were positioning the camera in VR framing. The scene taken from the film is the classical *'Russian roulette'* scene. The scene entails an intense game of Russian roulette while the characters of De Niro, Walken and Savage are tied up in bamboo cages along the river. The scene has been actually broken down into shot-reverse shots and builds up the suspense with inserts of the gun and reaction shots.

Below are the different kind of shots in the scene:

1) **Establishing shot** – This shot shows De Niro and Walken facing each other and being held up by the Viet Cong. They are being forced to a game of Russian roulette. This gives the spectator the opportunity to understand the space and the proximity and orientation of the characters around the table while giving the cinematographer the autonomy to design the suspenseful scene with close-ups of faces and inserts.

2) **Insert** – The establishing shot is followed by an insert of the revolver rotating on the table and stopping. The following shot shows is a close-up of De Niro's face which clearly shows who the gun pointed at.

3) **Reaction shots** – The leader of the Vietcong laughs at De Niro after the revolver stops and points at him.

4) **Over the shoulder (OTS)** –The leader forces De Niro to take the shot.

And the similar language continues with Walken all over again.

The scene follows De Niro's turn-taking a shot which ends up in a dramatic quick-firing back at the Viet gang.

The camera cuts to quick reaction shots which edited in a fast pace contribute to creating the intensity of the scene as far as adding up to the dramatic momentum.

For the sake of readapting this scene in VR, the setting and the characters have been loosely simulated in *SketchUp,* which shall serve as a reference for different viewing angles in VR.

As mentioned earlier, VR cannot include quick cuts and transitions, at least in the same space. This removes all possibilities of having CLOSE UPS, INSERTS or OTS shots like in traditional cinema. Therefore, the positioning of the camera as well as the camera movement becomes extremely crucial for the dramaturgy of the entire scene altogether. The camera position is decided to not just provide the viewer of the right coverage angles but also the right emotional

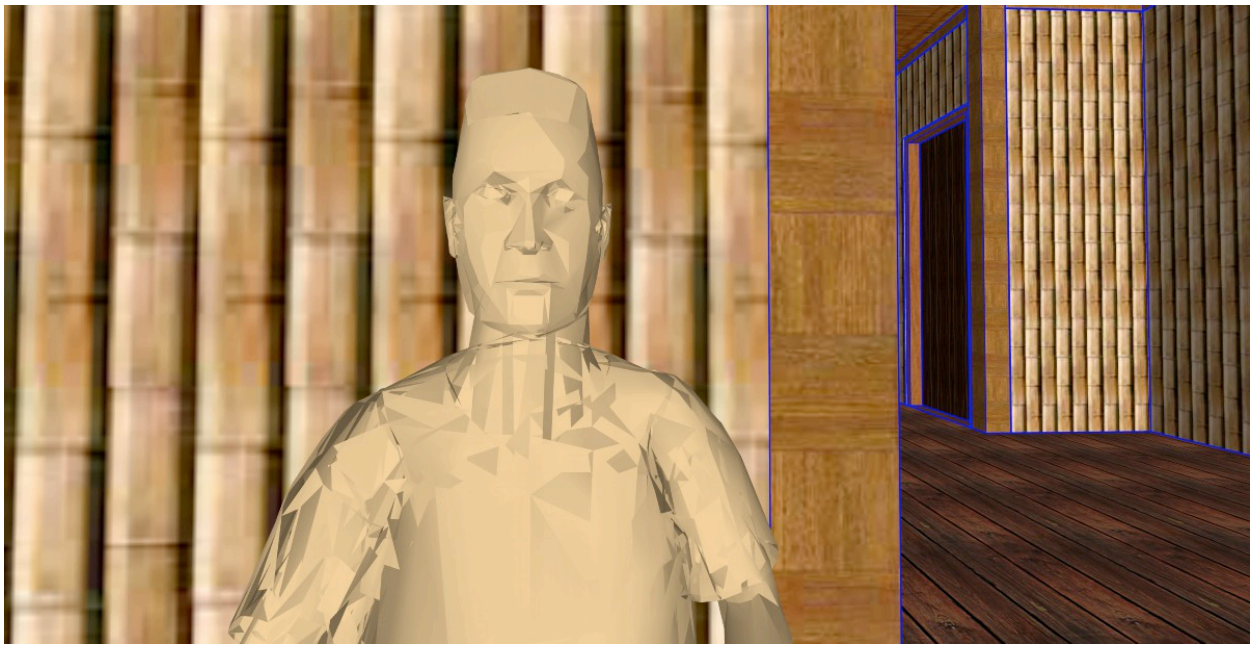
angles to the entire scene.

Technically there are various positions where a camera can be placed:

1. the camera may choose to follow one of the characters and the unfolding of events from their perspective.

2. the camera can also be positioned right in front of the main character we want to empathize with. Which would help in watching the entire even unfold but also watch our main character up close and empathize with him. It would also help the viewer pan around and follow his gaze to wherever he looks or interacts. Throughout this scene, *De Niro's* character goes through the most dramatic arc. This scene has been originally masterfully crafted for the exposition of *De Niro's* acting and intercuts to different shots following the *eyeline* or the *gaze* of the characters. In VR, the gaze shall also provide the cue for the viewer to pan around to see where the characters are looking at. Which would help the viewer navigate across the scene in the right angles and pacing. For the dramatic vision of the scene, the 360 camera has been placed closer in the *proxemics* of *De Niro.*

The different FOVs with this camera position



That camera position keeps the viewer closer to the main character, which in this case would be De Niro. It would also provide an efficient vantage to follow the scene and the other characters through the perspective of De Niro's character. The viewer would feel closer to *De Niro's* buildup through out the scene. This camera position and height would not just give the viewer a perspective to empathize with, while witnessing *De Niro's* actions in proximity but also establish what his character is witnessing from his perspective.

The other creative choice to build up the suspense through the camera position and camera movement would be to have a boom-up shot, which starts from the perspective of the revolver on the table.

The viewer sees the revolver spinning and stopping which would help the viewer navigate in the direction of whom the revolver is pointing at.

The viewer hereafter shall follow the scene by the gaze and reactions of other characters. As the intensity of the scene heightens, the camera gradually booms up/levitates.

Since the camera would be above the eye level, the viewer would have an objective yet discrete viewpoint. Which would help realize an objective reading of the scene yet dynamic as the viewer would follow the theatrics of the actors. The viewer would also have a 'comfortable' vantage to when De Niro gets up and

fires at all of them at the end of the scene. The viewer from the eye level of standing De Niro would also have an elevated empowered view of the falling bodies on the floor.

The above VR breakdown does provide a various access points for a viewer to be in experience / 'cover' the whole scene from. But does the original scene with its 'perfect' breakdown translate the gruesome and suspenseful emotions in VR? How would a VR experience of the same scene add to the already chilling experience to the classical scene established through the acting and the editing?

It, therefore, becomes imperative for a DP to not just understand the dramatic context of the plot/scene/genre but also reflect on why VR would be the ideal medium for that school of thought and accordingly orchestrate the mise-en-scene and the action concerning the decision of camera position and movement for all angles.

The best way to frame VR cinematography is through the help of narrative, discourse and/or transportation theories. This is because the narrative is a powerful form for communicating particularly if channeled through a such a complex visual medium which may as well give opportunities without any precedent.

It is important to note that literature on computational cinematography has largely focused on the denotative meaning of shots. The basic objective of the camera is to provide an *occlusion free view* of the salient elements in the virtual world. In addition to this, effective camera placement techniques must also address the issue of choosing the best position and angle for the camera as real-world scenarios determine the selection of camera shots while geometric

accuracy of camera placement facilitates the realization of contexts. Hence, cinematographers have to consider the connotative meaning of sequences of shots that clearly establish the rhetorical relationships between consecutive shots as well as the coherence of the visual storytelling[11].

2.3 Framing through Narrative

Notable researchers suggest that VR should be considered as a narrative medium the same way as traditional narrative forms such as theatre, literature and cinema are. Each of these mediums are distinguished from one another as narrative forms, channels of communication and displays of content relative to story. The very different natures of media result in a narrative that is either told or shown in varying ways and intensity in order to satisfy viewers targeted by the said media.

For example, the cinematic version of "The Lord of the Rings" strays in important ways from the original narrative because it primarily seeks to highlight the external, visual aspects of film rather than the internal, character-driven commentary of a novel. This example shows that the strengths of a novel are not always realizable through film, and vice versa. Through these attributes, narrative media can produce a range of narrative forms that may be used to tell stories efficiently and effectively[12].

As a narrative medium, VR, due to its interactivity and other characteristics, is imbued with attributes that no other traditional media forms possess and VR should be recognized for this uniqueness. Traditional narrative

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[11] Jhala, Arnav and Young, R Michael, 2005. *A Discourse Planning Approach to Cinematic Camera Control for Narratives in Virtual Environments.* Department of Computer Science North Carolina State University, US

[12] Louchart, S. & Aylett, R, 2003. *Towards a narrative theory of virtual reality*. The Centre for Virtual Environments, University of Salford, UK

media, namely, literature, theatre, cinema or oral storytelling, have all been extensively studied. In VR, whereas technological capabilities are definitely essential, it is still necessary to look to theories and comparative views with traditional media. Doing so also legitimizes VR as a narrative form, rather than merely a novel development, and adequately explains the framing challenge in this medium[13].

To compare cinema, theatre, literature and VR, comparative dimensions have to be established. The four most relevant comparative dimensions are *contingency, presence, interactivity and narrative representation*.

Contingency refers to how far the narrative's time and space are contingent on real time and space.

Presence refers to how far the spectator/viewer physically shares the narrative's time and space.

Interactivity refers to how far viewers engage with the story process as well as through *narrative representation* in the medium.

By means of these four dimensions, using this perspective it shows how VR may be recognized as a narrative form, as well as, establish factors and parameters specific to the application of VR.

Literature and cinema can manipulate a narrative's time and space flexibly, whereas VR displays in real time which makes it more strongly attached to a specific space and time. These constraints are highly associated with the concepts of *immersion* and *believability*. A VR viewer typically undergoes rapid and repeated travel from location to location with time constraints as loss of control. In contrast, a novel or film does not require such control.

To capture viewers' interest, a narrative depicted in real time should be

[13] Ibidem

either "multiple, interactive or exceptionally rich in dramatic features"[14]. Here, it must be noted that real time is not compatible with some narrative forms, such as literature or cinema. From an author's perspective, the narration and display of a story occurs at the same time that the reader is reading or viewing it. From the perspective of the latter, narrative time is the time it takes to read a novel or watch feature length of a film. Albeit real time in literature is impossible because the author would have to know how long it would take every reader to finish a book, among other things, theoretically, it is impossible to direct a "movie that could achieve, at screening, a simulation of real time for the spectator"[15].

Nonetheless, it is only the theatrical medium that requires the spectator to be present at in the delivery of the narrative. With literature, narration is usually a mental process while in cinema where narration does not physically happen in front of audiences but months or even years before screening across various locations, therefore real time is also not achieved or even sought. VR presents an interesting case in terms of real time because just like in cinema, the presence of the viewer in the context of narrative is not physical, although there is a deeper engagement with actors compared with other mediums like theater, in spite of theater requiring the physical presence.

[14] Ibidem
[15] Ibidem

2.4 Framing through Immersive Environment and Presence

VR cinematography is opening up discussion on how to reconnect the traditional concept of 'suspension and disbelief' with the one of 'presence' and it looks like the Cinematic Virtual Reality may help with this. Unlike VR, CVR limits the control users have in the environment to choosing points of view rather than actually interacting with it.

CVR programmes started in 2015 launched by *Google*, *Jaunt VR* and *The New York Times* and have become by now an interesting territory of discovery in a almost totally experimental phase, involving even Hollywood actors and directors – as part of a strategy to raise the medium's profile publicly and within the film industry[16].

Coming to the moment of shooting, of course there are challenges in the comparison between traditional filmmaking and VR cinematography and there are interesting empirical studies that, although brief and theory-driven from the realm of film or production, still give an interesting perspective and inputs for further reflections.

A study from the University of Seoul in South Korea classified seven specific topics and tested them with a VR camera. Actually the first difference appears to be the limits to the number of shots. During the VR film test, many cuts caused sudden changes in where the viewer would look and could cause trouble and confusion. Another difference is camera rotation. On VR film, camera rotation is only available with a viewer, so traditional camera rotation such as pan and tilt and high angle and low angle are not possible[17].

[16] Mateer, John William, *Virtual Reality: how traditional film director's craft applies to immersive environments and notion of presence*. Journal of Media Practice, University of New York, 2017.

[17] Chang, Wooksang. *Virtual Reality Filmmaking Methodology (Animation Producing),* Chung-Ang University, Seoul, Korea, published on *TechArt: Journal of Arts and Imaging Science*, Vol. 3, No. 3, August 2016

Traditional Film	Possibility in VR Film
Number of Shots and Cuts	Very limited—little shot or one-shot is recommended
Shot Size Variation (Close Up, Medium, Full Shot)	Available with camera movement
Angle Variation (High Angle, Low Angle)	No—camera rotation is not allowed
Lens Variation	Fine—but lens is not often adjusted in one shot
Camera Movement	Fine—dolly and crane shots
Camera Rotation	No—pan or any other rotation is not allowed
Editing	Very limited—shot editing is not allowed but scene editing is allowed

On VR film, instead of moving and positioning the camera, the characters have to move more dynamically toward the camera (stand up and down or move forward, backward, left, and right like theater blocking does)[18].

And, as previously mentioned, in VR lighting guides the audience where to look by using a contrast of brightness, darkness and colors.

The simple but still true and very interesting tip of this research, which represents good food for thought, is to implement long one-shot takes filmmaking and theater play methodology.

Different approaches have been explored to enhance user engagement with VR-based stories both through manipulation of first person with the user being directly addressed by a story character and thus present within the narrative, and as a third person where the user purely observes the action.

Studies are also exploring the concept of narrative comprehension with a focus on story and character and how they are impacted by VR cinematography as a narrative medium: while certain elements of a VR cinema environment may distract viewers, the latter generally follows the plot and empathize with

[18] Ibidem

characters. Nevertheless, guiding the viewers' attention seems to be the still challenging aspect of the virtual reality in cinema[19].

Even though a number of studies are conducted with the aim to provide insights about the immersive 360° environment in VR narratives, most of them do not adequately investigate the role of the VR cinematographer and formal techniques that may be used so that viewers capture the intended message of the narrative. Of course, the emphasis is given to theories because these provide insight about framing in VR cinematography as well as shed light on how current techniques may be adapted to create compelling VR experiences.

2.5 Transportation Theory

When it comes to reflecting on how VR is or can be experienced by the viewer, the concept of transportation comes into the picture as a mechanism whereby narratives can affect beliefs[20]. Defined as absorption into a story, transportation entails imagery, affect and attentional focus. It refers to how deep the experience can be between a user (reader, viewer, spectator) and the medium. Even though this specific research was held at time when VR was still very far from becoming a known topic worth investigating at different levels, the transportation theory seems to apply perfectly like an immersive *ante-litteram* VR experience. Moreover, the scholars developed and validated a 'transportation scale' through which they could measure the level of connection between the reader/user and the medium, which showed eventually and interestingly that transportation and corresponding beliefs (experience in presence, to adjust to

[19] Syrett, Hannah, Calvi, Licia, and van Gisbergen, Marnix. *The Oculus Rift Film Experience: A Case Study on Understanding Films in a Head Mounted Display.* In *Intelligent Technologies for Interactive Entertainment: 8th International Conference*, 2016.

[20] Green, Melanie C. and Brock Timothy C., *The Role of Transportation in the Persuasiveness of Public Narratives,* Journal of Personality and Social Psychology, 2000, Ohio State University

VR context) were generally unaffected by labeling a story as a fact or a fiction.

The most important requirement for the applicability of transportation is that the viewer or reader can acquire a compelling mental image of the fictional world and circumstances[21]. Here, the concepts of "suspension of disbelief" in the film, as well as "presence" in VR, are of utmost importance. In film and VR, it is the director and cinematographer who are primarily responsible of transporting the viewer.

2.6 Transportation in Film and Suspension of Disbelief

Suspension of disbelief is a concept that addresses viewers' engagement with film and cinematic narratives. For example, Ferri (2007) studied the concept of suspension of disbelief, from its origins as a literary term by Coleridge, up to the time that it had been increasingly used for studying audiences and the latter's immersion in film viewing.

Choices made by cinematographers and directors are highlighted because these determine how viewers engage with the narrative as well as interpretation of the story, and in the process, enhance transportation. Typically, the director's tasks start with analyzing the script for the following purposes:

- Develop a specific interpretation of the narrative;
- Establish the overall theme and message based on the interpretation;
- Determine how information should be revealed: Do viewers learn as the characters do?
- Does the audience know more or less than the characters?
- Determine the objectives of core characters and the dynamics between them. Who are the protagonists, antagonists? What do they want? How

[21] Ibidem

will they achieve it? And so forth.

- Highlight story elements that lead to viewers' realization, production choices, including, the director's vision (Proferes, 2013; Richards, 1992; Weston, 2003).

The VR cinematographer collaborates with the director when mood or tone is created utilizing strategic choices pertaining to the setting, production design, costume, lighting, sound and other presentational characteristics using blocking, pacing and delivery of performances or portrayal of activity, if documentary. In this regard, the director usually seeks to seize upon existing audience knowledge regarding genre conventions, archetypes and stereotypes in order to support or subvert viewers' expectations regarding the narrative and in the process, deepen transportation. In other words, suspension of disbelief occurs when viewers strongly engage with the story and this is enhanced when they are not distracted by technical matters.

Suspension of disbelief and transportation are highly relevant to VR films, although their execution may be somewhat different from that of film. "*The main difference between film and VR in this regard is in how continuity is treated. With films, continuity is achieved through different forms, such as continuity in viewpoint, motion, setting, and sound, among others. Consequently, the primary consideration in seeking to suspend disbelief is continuity. However, this perspective model is underpinned by the belief that different camera angles are to be used in film presentation – the scenes may be edited, making it highly different from VR cinema if continuous recording is used*. *It must be emphasized that it is common for VR cinematic experiences to be contiguous and presented to viewers as if in real-time, although the possibility of editing is currently being*

studied"[22].

Nonetheless, continuity may be applied to VR cinematic production, and the best approach to use here is using the 360° presentation environment. This will be discussed in more detail later.

2.7 Transportation and Presence in VR

The concept of presence is used to evaluate the degree of transportation achieved in VR and it may be defined as when "*our awareness of the medium disappears and we are pushed through the medium to sensations that approach direct experience*"[23]. Some more interesting interpretation acknowledge three types of presence that can partly determine the levels of immersion that a viewer has in a VR narrative.

"*The first is the **social presence**, which is the degree to which other beings, living or synthetic, also exist in the world and appear to resound to the viewer. Social presence is developed by engaging with others and in film, in interacting with others, even if they are animated characters.*

*On the other hand, **environmental presence** is the degree to which an environment seems to detect one's presence by means of interacting with, and responding to, the viewer in terms of physical objects or setting. If the environment knows that the viewer is present, it could contribute to that viewer's belief that, indeed, he or she is in that environment. Lastly, **personal presence** is grounded upon the simulation of real-world perceptions. A viewer knows that he or she is present through sounds and images in the virtual world*

[22] Mateer, John William, *Virtual Reality: how traditional film director's craft applies to immersive environments and notion of presence*. Journal of Media Practice, University of New York, 2017
[23] Biocca Frank A., *Opposite conceptions of the audience: the active and passive emispheres of mass communication theory*. University of North Carolina, US, 1988

that respond to the viewer as if in real-time, in the real world"[24]*.* Of these three sub-definitions, the third seems to be the most applicable to VR cinematography.

On the other hand, there is also general agreement on key considerations in the design of virtual experiences to maximize presence and by extension, transportation.

In a research paper of 1997 exploring again the concept of presence[25], there are concept which are still highly relevant to VR cinematography today:

- There should be clear rules on interaction and engagement, establishing how, where and when the viewer can move or change viewpoint;
- Navigation should be intuitive and straightforward so that movement is possible without distracting from visual or aural elements that facilitate transportation;
- The movement between points in the environment should be seamless, with consistent increases or decreases in speed in creating 360° video.
-

It must be emphasized that in contrast with films, interaction and navigation have not yet been fully mastered so that there are no existing standardized methods yet, so these aspects should be considered when making relevant decisions. *"As an example, 'Great Performers: LA Noir' relies on viewers' physical orientation of his or her head to change viewpoints between scenes. Doing so is the best chance for full transportation although there is the risk that the viewer misses key action if the viewpoint is in the wrong direction"*[26].

[24] Heeter, Carrie, *Being there: the subjective experience of presence*. MIT Press, 1992.
[25] Slater, Mel and Wilbur, Sylvia, *A Framework for Immersive Virtual Environment (FIVE): speculations on the role of presence in virtual environment.* Published in Presence: teleoperators and virtual environment, 1997.
[26] Mateer, John William, *Virtual Reality: how traditional film director's craft applies to immersive*

3. THE ROLE OF THE VR CINEMATOGRAPHER

As mentioned earlier, VR cinematography is very different from traditional cinematography where the cinematographer thinks within a specific frame, typically using a "planar, two-dimensional image in front of him or her". When framing in VR, the cinematographer positions the camera in a specific place, treating the camera as if it was a person[27]. It is important because the viewer would be using a headset to watch the film and scenes will be seen as if they were really present in them. Hence, by treating the camera as a person, the cinematographer acquires a more profound sense for what the camera can achieve and project. In the 360° environment, the role of the cinematographer changes: reduced creative freedom than before and significantly more outside-the-box thinking[28].

The following are the transformed tools of the cinematographer in VR films.

3 .1 Pre-production and Camera work

Generally, cinematographers initially collaborate with directors to understand the visual language and style, choose the technology best fitted for the concept, and then collaborate with various other departments besides gaffers and the lighting crew in order to execute it. In VR, the choice of technology becomes pertinent to many other factors.

Factors affecting selection are the size of cameras, number of cameras, camera movement and the time in post production stitching them together.

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environments and notion of presence. Journal of Media Practice, University of New York, 2017

[27] Speed VR - Virtual Reality Marketing, VR company, UK

[28] Ibidem

Camera size can be defined by how many cameras are needed to create a 360-degree video. There are multiple compact spherical cameras, that can shoot VR video using at least two built-in/native lenses with a viewing angle (FOV) of 180 ° to 220 °. It actually means that each lens is an axis in itself. Reflections regarding camera, rigs and lenses, are further discussed later.

These cameras are usually amateur devices based on easy user interface; and post-production manageability. 360-degree video with a resolution of up to 8K, which, on the basis of experience with classical film, may seem like an overkill, but in the context of virtual reality is quite an average standard. We have to imagine that a connected spherical 360-degree video that has 8K resolution will never be witnessed by the viewer as a complete picture. As the average person's viewing angle is 135 degrees, he/she witnesses at one angle of the entire video which would make it a resolution roughly around Full HD if not lower.

Deciding on the number of cameras also is determined by proxemics of the character. If a character is supposed to come really close to the viewer, more number of camera/sensors are needed next to each other. This would reduce the parallax error on portraits when stitching together. More number of cameras would also mean a higher resolution which would make the post production workflow quite heavy and cumbersome. Thus the choice of decisions of camera technology and coverage needs to be precisely addressed. Synchronizing videos from 12 different cameras for a 2-minute scene might be budgeted more than filming a 1 hour classical film. Having multiple sensors with a wide angle lens / FOV also helps in giving more levee in stitching in post production to remove barrel distortion and parallax error.

The deciding of the technology and the workflow also helps the respective departments to discuss VR tone and feel from the cinematographic perspective in a general manner rather than on specific shots and shot styles.

The role of a cinematographer, instead of focusing on *camera frame*, may pertain more to *camera placement* in a specific scene and its intended *impact on actors* in the scene as well as how to achieve intended or unintended *inclusion or exclusion* on the part of the viewer. Because of the level of engagement that a viewer has with the narrative and the environment in which it unfolds, it may be said that "VR is a far more intimate and involving format and only as cinematographers gain experience in the form will they understand what positions work best"[29].

Another consideration which is similar to traditional cinematographic choices is the *height of the camera*, with eye height preferable so that the viewer can be engaged in the conversation especially since lowering the camera could make the viewer feel small and thus vulnerable. On the other hand, if the camera is raised, the viewer may feel powerful and in control.

[29] Ibidem

Image 1 below shows various shot angels that are used for VR cinematography:

Image 1: Various Shot Angels in VR Cinematography

In VR, the effect is amplified when the camera is above the eye-line of the viewer because of orthoscopic tendencies. The reason why this effect feels more exaggerated in VR is that the viewers' eye-line is embodied in the viewing experience. The viewer physically pans or tilts the head around to look up or down at someone. Unlike in traditional cinema viewing, where the viewer looks at the centre of the screen irrespective of the camera angle or height, it has been shot in. Therefore, camera height becomes extremely important in setting the mood, tonality and the perspective of the viewers' indulgence while establishing the *spatial relationship of the characters with the perspective of the viewer*.

All these choices are decided based on the theme and drama of the story. If the 360 camera is placed on a drone, the viewer might feel as if flying whereas the viewers body might not catch up to the levitation. This might result in a disturbing viewing experience which can be creatively used according to the need of the project. Re-imagining the film '*Enter the void'* by *Gaspar Noe* in VR might help in understanding the visceral experience of the viewer psychology with the placement and height of the camera.

3.2 Lighting

With VR, natural lighting styles are much appreciated and they are elevated to greater importance as compared to traditional media. Notably, with VR, the cinematographer has nowhere to hide the equipment out of the frame, and during pre-production, discussions are made on how lighting may be left out of frame.

Options are hiding lights behind production-designed elements such as, sets or natural structures such as trees and posts, and, "built into the sets as natural on-screen elements such as lamps and mirrors" [30].

In Image 2 below, a scene is depicted showing an effective lighting setup. Lighting is done through street lights for a natural look, although lighting equipment has to be hidden behind and around the corner of a building. It becomes extremely important then to shoot on high dynamic range cameras to pull out details as well as direction to the lighting design.

[30] Ibidem

Image 2: VR Film Lighting Setup

Lighting manufacturers might eventually start creating 360° designed lighting that would spill from different directions. Which would benefit VR cinematographers because they will no longer have to deal with constraints in lighting intended for 2D filming[31].

When VR was first introduced, one of the technical challenges was to hide crew, lights and other pieces of equipment. That is not a problem anymore since the crew and equipment can be digitally removed. VR films go into production with this consideration already. The bigger creative problem is to design a lighting plan and stylistic choices which not only serves the story but also helps guide the viewer angle to viewing to the relevant story elements in the panorama. Smaller sources with higher outputs are preferred. The production designer works closely to build sets and tricks to hide the lighting sources. Battery operated lights are preferred to avoid using cables which might be cumbersome for the set architect as well as distracting for the viewer.

[31] Jaunt Studios, *The Cinematic VR Field Guide, A Guide to Best Practices for shooting 360°*, US 2017.

" […] *lighting constraints with VR to be the hardest part of the art form, as his goal in lighting design is always to direct the viewer's eye in a meaningful way. This becomes an added challenge when the viewer can see in all directions, and he's always using new ways to push the medium, so that everything is not always top-lit, common to VR film*"[32].

Andrew Shulkind, cinematographer with a great experience in VR, breaks lighting for virtual reality into two different approaches. *Shooting in a spherical way with a 360 degree camera*, like the Headcase camera that he designed, which uses seventeen Codex Action Cams to capture a RAW 360-degree field of vision at 12-bit color depth, far more than a typical GoPro system. That much dynamic range gives him a way to use practicals within a scene, which he will often enhance with lighting from above. "*The other way, is to shoot 'nodally', which gives everyone much more versatility. Basically, you back the camera up and shoot the scene in angles, like slices of a pie. It has its own challenges, but this makes for the cleanest, easiest stitch in post. When you shoot with a big camera ball, there's a perspective disparity between lenses, just like your eyes, which makes close objects more complicated to stitch. But by pulling the camera back to the same point in space, you can shoot successive slices of the pie separately, and it becomes much easier to reassemble as a complete viewing sphere. And from a lighting perspective, we can basically light from outside that slice, so it's much easier to shape for talent. Having soft light is the best way to light this kind of photography, because of the way that we have to manage shadows*"[33].

[32] Andrew Shulkind, VR cinematographer, interviewed from the blog Chimera Perfect Lighting (Chimeraperfectlighting.com), 2019.

[33] Ibidem

Shooting VR *nodally* gives the cinematographer the opportunity to include stylistic liberty and continuity to the scenes.

Traditionally, there are three primary purposes for lighting: *Illumination/Exposure*, *Stylization* and *Continuity*. Can cinematic and theatrical lighting principles be also used to guide the 'viewers' attention in VR?

Every light source has five main attributes: hardness or softness, intensity, direction, the colour of the light emitted and the pattern[34].

Contrast decision in lighting can help guide the viewer in their viewing experience. Contrast can be achieved by selectively lighting areas which the cinematographer wants the 'audience's attention. The areas which are not relevant are kept in relatively low levels of light intensity. The lighting ratio can be quite high, which further guides the viewer attention. It is expected that the viewer shall trace towards the brighter elements after having an understanding of the contrast.

Colour contrast and saturation have been traditionally known to guide the viewer. The colour tonality and saturation of an object is dependent on how that particular object reflects light. Employing colour tonality in VR also serves a similar purpose as colour contrast or the change in hue or saturation calls for viewer attention.

Moving lights are other tools to control and guide audience feedback. These may include pulsating or flickering lights and follow spotlights. Flickering lights can have dramatic effects of fear or curiosity for the viewer. If the

[34] Lowell, Ross, *A Matter of Light and Depth, Creating memorable images for Video, Film and Stills through Lighting*, 1992.

flickering is too rapid, that may instil fear in the viewer. If the flickering is subtle, the viewer might be drawn or feel invited to that area of flicker. Follow spots or torch lights can help the audience navigate and discover elements accordingly.

Another stage lighting technique which is used in VR is fading of the light. Much like theatre plays where the audience is guided to different areas of the stage by fading in and out of lights in those areas, VR similarly employs techniques of fading lights to not just direct attention but also transition to a different scene or space.

To conclude, traditional cinema and theatrical lighting principles are still useful in VR lighting design and language. The challenge generally lies in timing these lighting designs and light changes with the orientation and position of the viewer. For instance, if the scene has multiple areas of attention (beats) which has to be discovered one after the other, how does the following lighting design cater to that chronology? What if the viewer misses the fading lights because his/her orientation was at the area of the flickering lights? One of the elements from the scene can be the brightest element which would bring attention; the other element can have a pulsating light whereas there can also be a follow spot following the character, which is another element of the scene.

How does a cinematographer make sure the lighting design and changes are coherent with the viewers' position to navigate and do not serve as a distraction instead? One of the ways of tackling the timing of user control is to divide the scene into its multiple beats: study the sound language and the shot design for the scene with the various beats of how and when different elements should ideally be introduced. Once that has been established, different lighting

tools and light changes are planned according to the beats. What follows is also reading and predicting user/viewer feedback and inculcating that in the lighting design. For instance, if there is a subtle flickering light in one corner where the viewer is expected to look for some information, the light stops to flicker once the user gazes in the right direction and gets/reads the information. Alternatively, the light can switch off instead, if the viewer should rather be focusing on something else before. The viewer can after that follow the next lighting tool to discover the scene further. Lighting plan and transitions need to consider the audiences position and orientation. The lighting design should facilitate the tracking of the viewer movement and provide lighting feedbacks to aid the navigation.

3.3 Camera Movement

A VR cinematographer would have to be extremely skilled because camera movement is challenging considering that "all grip elements would be in the shot"[35].

Conventionally, a grip pushes the camera system atop a dolly; however, with VR, this will not be effective because they will be visible in the scenes except if there is a way to hide them or use remote-controlled equipment. The latter is a good option, especially since such equipment has become more affordable.

Nevertheless, the cinematographer would need the assistance of the lighting director in order to determine what needs to be hidden and how to hide it, likely through the help of lighting. Here, it must be emphasized that the VR

[35] Speed VR - Virtual Reality Marketing, VR company, UK

cinematographer has less control with lighting because the lighting director would be a more likely be a specialist crew member in VR filmmaking.

Since VR viewing is embodied and dependent to viewer interaction, it is generally advised to skip camera movement until or unless the viewer interaction would desire so. As camera movement independent of user orientation might simulate motion sickness and uneasiness for the viewer. Therefore, it is essential to understand why and when to move the camera; not just in the interest of the story but also predicting viewer interaction.

4. VR TECHNOLOGY AND TECHNIQUES FOR CINEMATOGRAPHY

VR cinematography entails new technologies and techniques, which are discussed in this section.

4.1 Technologies

Jaunt Studios is one of the companies that had originally specialized in cinematic VR. Its definition of VR cinema is more technical, stating that it is "360 video filmed using a panoramic video camera system and played back as an equirectangular video file which allows the user to look around the scene as it unfolds"[36]. Here, equirectangular refers to a "rectangular map projection which wraps accurately onto a sphere, and thus displays correctly in a panoramic view"[37].

Scenes in VR film can be either monoscopic (flat) or stereoscopic (3D), depending on the camera system and on the stitching process used. Typically, spatial sound microphones are used in capturing scenes to make the latter seem more real. However, in contrast with VR games, a viewer cannot move freely within the VR film environment. Only when the camera is moved during filming, does the viewer also gain "movement" in scenes. However, as technology evolves and improves, it would be eventually possible for free movement within scenes to be achieved by viewers.

[36] The Cinematic VR Field Guide - creator.oculus.com. https://creator.oculus.com/learn/cinematic-vr-field-guide/

[37] Ibidem

The following are examples of specific technologies used in VR cinematography:

Stereoscopic vs. Monoscopic VR.

Monoscopic (or mono) footage is flat, no depth, the viewer uses both eyes in viewing the same image, with the cinematographer projecting the same depth of the 360° viewing sphere. The viewer may look around the scene by swiveling the head but nothing seems closer, merely bigger. However, with 360° stereoscopic 3D, the viewer obtains 3D in every direction and objects may even seem to get nearer. "*The parallax is achieved when each eye sees a somewhat different image because of the gap between the eyes or cameras, thereby providing a sense of distance. These enhance the immersive experience in VR film as scenes are more natural and the viewer perceives it as occurring in real life*"[38].

Minimum VR Requirements

There are four minimum requirements for VR cinematography in order to maximize immersion and presence.

- ***360 Equirectangular Images***

These images are actually scenes in which the viewer can explore within a full 360° environments, as well as, up and down from pole to pole. There are cinematographers using camera rigs with front-only 180° field of view (FOV), but there are shortcomings in using these from the perspective of immersion and presence. For example, as the viewer looks behind, he or she gets pulled out of the scene. To address this, cinematographers usually insert graphics to provide backgrounds.

[38] Jaunt Studios, *The Cinematic VR Field Guide, A Guide to Best Practices for shooting 360°*, US 2017.

- ***Stereoscopic 3D***

According to Jaunt Studios is the most debated requirement because many who film using mono do so because it is cheaper, and it is easier to capture then stitch. However, to enhance immersion and presence, VR cinematographers have to shoot in stereoscopic 3D if possible. Moreover, stereo 3D vision enhances the real life feels in VR and is thus very important.

- ***Spatial 3D Sound***

Sound in VR is crucial because it helps in the immersive experience. Therefore, the VR cinematographer has to effectively combine this with several cues, such as, motion and light, so that viewers would be able to capture important moments and scenes rather than looking anywhere.

- ***Viewed in an HMD (Head Mounted Displays)***

Lastly, none of the aforementioned technologies would be useful at all if the viewer does not have an instrument with which to view the VR film. Albeit 360° video is usually made without a viewing instrument, a full VR cinematic experience requires one. The use of a head-mounted display (HMD) gadget is needed.

There are various types of HMD that differ in price, from the simple Google Cardboard to the Samsung Gear VR to the Oculus Rift and HTC Vive – the latter two being top of the line and costly gadgets. These high end HMDs permit full body tracking and some come equipped with hand controllers that allows the viewer greater control in moving within and interacting with the VR environment.

Cameras

There are different types of cameras used for shooting VR, with innovations occurring at a rapid pace. Each of these cameras has its respective strengths and weaknesses, as discussed below.

- ***Panoptic***

"*These camera systems emulate the visual system of flying insects and come in various "discrete camera modules arranged on a sphere, dome, or other shape"* [39].

- ***Mirror Rigs***

This is a panoramic 360° camera "in a circular configuration shooting up into a collection of mirrors that are facing out into the scene at an angle".

An example of the mirror rig is the Fraunhofer OmniCam. These cameras may be mono or stereo, larger and heavier compared to other panorama rigs because of the mirrors that they carry. According to Jaunt Studios, the greatest advantage of using the mirror rig is that the cinematographer can shoot into a virtual nodal point within the mirrors with little or zero parallax in the scene thereby resulting in easy stitching. "*Due to the shared nodal point, such rigs usually permit real-time stitching and transmission of live 360° imagery"*[40]. The weaknesses of these cameras are their weight and size.

[39] creator.oculus.com. https://creator.oculus.com/learn/cinematic-vr-field-guide (accessed February 24, 2019).

[40] Ibidem

- ***Fisheye***

This is a commonly used camera for VR filmmaking because it is less costly, portable, and is easily stitched-usually in-camera. There are models and brands using only one lens to capture 180° images while there are also dual-lens models that capture full 360° images by stitching the two halves together.

- ***Light-field***

Light-field cameras are more complex to use and are considered as the future of VR making, although these still have little practical use, according to Jaunt Studios. "*Rather than concentrating light through a lens and onto a sensor, the light-field camera features different smaller lenses capturing light rays from every imaginable direction. Since this camera is so intricate, in order to snap even just a small section of the panorama, the array would have to shoot a section of the circle at a time. This makes filmmaking costly, time-intensive and computationally-intensive*"[41].

- ***Photogrammetry***

In order to effectively execute VR scene capture, it is necessary to sometimes "*move from the current inside-out methodology to an outside-in perspective*"[42]. This means to say that instead of filming scenes through the use of various cameras facing into the scene, *photogrammetry* allows the cinematographer to surround the scene using an array of cameras looking in. For example, Microsoft used its own photogrammetry technology, HoloLens, to produce holographic videos supported by a VR headset called Free Viewpoint Video. To execute this, an array of cameras was positioned around a green screen stage, capturing the

[41] Jaunt Studios, *The Cinematic VR Field Guide, A Guide to Best Practices for shooting 360°*, US 2017.
[42] Ibidem

video from different angles. The video processing used advanced photogrammetry techniques to produce "*a full 3D mesh with projection mapped textures of whatever is in the scene*. *This technology uses advanced mesh tessellation, smoothed mesh reduction, and compression to create scenes that you can actually walk around in VR*"[43].

Interestingly, advanced real-time photogrammetry techniques will be eventually used in filmmaking in the not too distant future to enrich the immersive experience that VR provides to viewers. It is likely that this technology will allow users to authentically connect in unprecedented ways using holographic video feeds and social environments.

4.2 Techniques

Having explored transportation in both traditional film and VR, the next step is to apply techniques from the traditional medium to enhance production of the newer one. The director and cinematographer need to collaborate in preparing for a VR project somehow differently from the traditional ways.

Here, current methods and techniques used in traditional filmmaking may be applied to VR films to produce an immersive presentation provided that the director and cinematographer considering the distinctive characteristics of the VR platform and ensuring consistency with the needs of supporting presence. For instance, issues with navigation in VR cinematography were identified above.

However, in the same way that it can improve a viewer's experience of a film, the effective use of drama and surprise can both facilitate *transportation* in VR cinematography by minimization of the impact of these issues on presence. As John William Mateer explains, "anxiety appears to have a direct impact on the

[43] Ibidem

subjective feeling of presence. Thus, a good approach in enhancing transportation would be to raise a certain degree of anxiety in the viewers through dramatic points in the narrative. For example, infusing a sense of jeopardy into the narrative can elicit empathy from viewers and at the same time, an effective way of diverting their attention from perceptions of artifice of the medium"[44].

Continuity has to be achieved and this depends on two key elements:

- the director's ability to predict and control the user's viewpoint within the virtual scene;
- the concept of organic direction.

VR directors and cinematographers need to not only compel viewers' attention but control it subtly so that *suspension of disbelief* is maintained.

Mateer suggests different techniques in doing this, including, highlighting contrasts in:

- *Grouping*, so that there is one element in the scene that dramatically differs from the rest, such as for instance, the distance between Juror 8 (Henry Fonda) from the rest of jury members in "*12 Angry Men*" by Sydney Lumet;
- *Colour*, so that an element in a scene stands out, such as the girl wearing the red coat in "*Schindler's List*" by Steven Spielberg;
- *Scale*, so that a specific element in a scene is sized differently than others;
- *Shape*, so that a specific element in a scene looks differently from the rest;

[44] Mateer, John William, *Virtual Reality: how traditional film director's craft applies to immersive environments and notion of presence*. Journal of Media Practice, University of New York, 2017

- *Visibility*, because one element in a scene is better lit compared to others;
- *Motion*, because one element in a scene has dramatically different movements compared to others.

John William Mateer, also highlights that techniques underpinned by psychology may also be applied in a VR context. For example, natural viewers' attention may be compelled by how there is a *propensity to look towards the direction where others are looking*, especially when empathy or identification is present in the said scene. In psychology, this is known as *passive cuing*. However, due to the challenges in framing in VR films, these psychologically-oriented techniques could be challenging to apply. Nevertheless, skilled cinematography and design as well as informed directorial choices may address these challenges. To achieve this, "*the director and cinematographer need to make production choices that are driven by the consistent interpretation of story elements, setting and character, enabled by in-depth script analysis. Every facet of production should reinforce others in order to produce a coherent virtual reality guided by clear rules so that transportation may be achieved*"[45].

If a particular sequence is intended for a 360° VR environment, considerations and choices would somewhat differ although transportation could still be achieved. For instance, if a scene to be shot with no any editing as is usually the case with VR, *blocking and positioning of action should be prioritized* and be the main drivers in controlling the viewers' specific angle of viewing. For example, in a war VR film, timing explosions will promote head movement to seek sound sources, subject movement to ascertain that some soldiers visually stand out, and, dead zones would be used to emphasize lack of activity and in

[45] Ibidem

the process, motivate the viewer to look elsewhere for something more interesting. These combined approaches can enhance immersion and transportation in manners that can control viewers' gaze.

4.3 VR Opportunities

There is a big debate about opportunities in VR cinematography, with some saying that it is merely a trend while the rest say that it will transform cinema for the long haul. Probably VR will transform cinema in the next decade, provided that content can keep pace in technological advancements. "*Currently, tech giants such as Facebook and Microsoft are already promoting VR, launching new headsets in the event that VR film does cross over to mainstream. Film producers and studies are already preparing for investments into VR, and industry forecasts place potential revenues at $75 billion annually by 2021. Top film festivals, such as, Cannes, Venice, and Tribeca, have already established new categories on VR films*"[46].

In spite of arguments that VR film is poised to change public perception and expectations of cinema, more scholarly assessments indicate that revolutions in the area of cinema do not always lead to lasting changes.

For example, in spite of the hype surrounding its emergence, 3D films have historically struggled to compete with traditional film consumption. Therefore, IMAX has reduced its 3D screenings, while data on box office returns indicate decreasing audience interest.

Nonetheless, arguments among VR proponents must not be ignored. For instance, it has been argued that VR film will likely succeed and sustain that success because of audience appreciation on the opportunities to immerse within an imaginary environment. From the perspective of these VR film proponents,

[46] Lynch, Scott, Head of VR Development VOYRE in conversation with Pixvana.com

this format is considered as the future of cinema. Nonetheless, even if this were true, with VR films, the viewing experience as a social phenomenon will change because viewers will have to watch movies wearing headsets in order to fully immerse themselves with what is going on in the narrative. For film enthusiasts, there is a general anticipation that VR represents the opportunity to walk into one's own dreams or fantasies. This will significantly change not only how films are created but also how people are able to appreciate more the experience. Viewers would likely anticipate more watching certain films because they can truly feel part of them.

4.4 VR Challenges

It is undeniable that VR integration in film viewing is an exciting possibility because of how it can radically create new experiences for viewers. It may even lead to other developments that would transform how people would react to films. However, the application of this technology will not be easy. It is important to keep in mind all the inherent differences between virtual and real cinematography. For example, a virtual camera may be instantly teleported from one place to another, thereby producing a cutting effect that can only be achieved by means of editing in traditional cinematography. This means to say that a virtual camera needs to shoot and edit simultaneously. Moreover, a virtual camera may be used to freely move around narrative environments, at any speed – both of which are often difficult or impossible for a physical camera. In spite of these differences, both traditional and VR cinematography contend with the challenge of ensuring that movements of both camera and actors should be closely coordinated in order to deepen the reality that viewers expect from the narrative. For instance, Image 3 below depicts conventional shooting of a film scene. In a VR film scene, the tracks would be unnecessary, although the

movement of the avatar and camera would still have to be synchronized so that the shot may be captured as intended.

Image 3: Conventional Cinematography

Shooting and editing at the same time, combined with the ability to place the camera at discretion, are factors that make VR cinematography appropriate for interactive systems in which it is impossible to predict the movement of a user's attention. However, a challenge in this regard is that aesthetics might end up being sacrificed because controlling the viewer's attention and the camera is not always possible, at least at the current level of technological advancement. However, this is yet an early stage of VR integration and filmmakers may still be able to find ways to overcome this challenge.

In addition to these, "*VR cinematography is composed of pro-filmic performers with digital environments that can produce a sense of disturbance between the corporeality of the body and the symmetry and digitality of the rest of the image. In VR cinematography, data collected from pro-filmic reference points, whether spatial or bodily, are transformed into digital data that special effects technicians in a complex process. First, digital reproductions of spaces should be created and based on this. Camera movements are then plotted within this environment. VR cinematography is usually intercut with shots that use pro-*

filmic actors or locations, *with the goal to achieve a smooth, seamless transition. VR cinematography can accomplish this through camera movements or physical actions that would not be possible within real space. In addition to these, the camera and bodily movements would not have to be orchestrated at the time of the shooting; instead, an animated virtual space may be created through VR cinematography that enables camera movements to be plotted and shots to be composed and re-composed in post-production"*[47].

Another challenge is translating shot scenes into a VR film. With VR cinematography, instead of filming an actor executing a movement or scene in front of a screen and then incorporating this footage into another environment, performances are computerized by means of a process known as motion capture, or "mo-cap that in turn, generates manipulable digital doubles of performers, oftentimes referred to as digital stunt doubles or synthespians"[48].

With mo-cap, actors are made to perform in an empty set surrounded by cameras while wearing skin-tight suits fitted with highly visible markers. These markers establish a series of vertices in three-dimensional space, and the cameras capture only this vertex data. This information is then applied to a *virtual 3-D body*, which is then instantly mapped onto a kind of digital puppet. In turn, "*this puppet is manipulated as needed, the original captured data is retained, modified or discarded as necessary"*[49]*.* In addition to these, an actor's face may be filmed at various times using several dozen small cameras as it twists and contorts into different expressions, with the corresponding data then used to composite a programmable face that can be used for the digital double created by mo-cap. Again, executing this is challenging, although these would

[47] Jones, Nick, *Quantification and Substitution: the Abstract Space of Virtual Cinematography*, Sage Journals, 2013.
[48] Ibidem
[49] Ibidem

allow the actor's body to be reduced to a series of mapped points that are collected and subsequently manipulated through digital means. "*The VR cinematographer can then swap out, extend, adjust or transform the mo-cap data to create the kind of performance the shot demands*"[50].

Although these processes permit the capture of visual data of spaces and subjects photography or digital video recording, VR cinematography virtualizes this visual information, and in the process, interpolate a full space and a total body from fragments that can subsequently animated in a process that is different from the original period of shooting. Thus, the resulting VR cinematographed image does not engage with the physical world in the way that the film image does. VR cinematography would not be easy to execute not only because it is a relatively new endeavour and highly technical. It is different from image production in traditional cinematic media, and also different from computer graphics. Instead, it is created by pulling reality apart and then systematically re-assembling it in order to produce images and environments that possess cinematographic appearance, but the level of detail is structured differently.

Some aspects of VR cinematography, as already discussed, need to be emphasized as challenges. For example, as mentioned earlier, there are various ways of compelling the viewer's attention to highlights in the VR narrative, including, passive cueing and highlighting differences in grouping, colour, scale, shape, visibility, and motion. However, because of technical differences presented by 360° video, it remains challenging to portray emotions. "*With traditional filmmaking, close-ups would be used to emphasize emotions. This is challenging with VR films because with 360° cameras, from the viewer's*

[50] Ibidem

perspective, it would seem like one's nose is pressed against the actor's face especially is a headset is being worn. Currently, the only way to deal with this challenge is to keep the actor further from the viewer's view so that the former appears smaller and more vulnerable"[51]. Nevertheless, although this could elicit empathy from the viewer, issues with immersion arise. For instance, if the actor is portrayed smaller on the screen to elicit an emotional response, it now becomes difficult discern whether the viewer's attention will be on that actor.

Another challenge that needs to be addressed is post-production. VR cinematography may be regarded as an exciting development not only in filmmaking but in visual technology, however, the cameras being used right now represent a challenge, in the context of post-production. "The current generation of cameras seems not to provide adequate control for cinematographers, even the most sophisticated ones. This means that more sophisticated ones need to be developed in order for VR to become commercially viable for producers. At this point, it may become more expensive for filmmakers to produce films in the VR environment, making them less attractive"[52].

As mentioned earlier, stitching is being executed, but doing so increases post-production time because it is highly time-intensive. An increase in post-production time means an increase in a film's budget. Production outlets may be hesitant to pour additional funding to films in VR. Aside from this, stitching also causes distortions. The problem here is that potential solutions may affect the quality of the VR film.

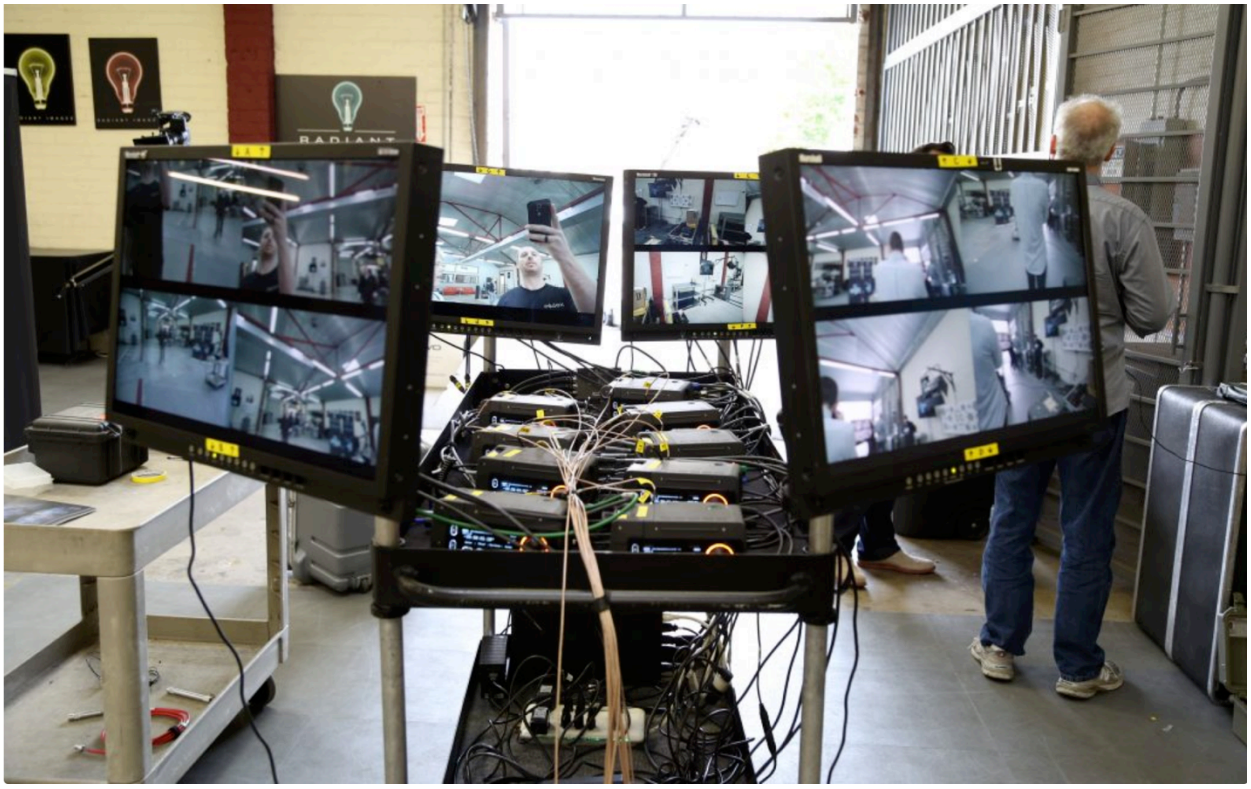
For example, a cinematographer may opt to use Kodak's sp360 4k camera rigs, which operate by having two cameras back to back. Although this could lead to the same issues of automation affecting more sophisticated cameras such as the

[51] Movidiam.com
[52] Ibidem

GoPro, there are only two stitch lines to deal with in crossing and provides "*creative opportunities to shoot one camera at one location and one camera at a separate location, and then stitch the two separate videos together. An option here is to shoot against an infinity curve or a full set split in two lit with traditional lighting, because one can shoot two separate 180 videos and stitch those together*" [53.]. However, the resulting images are not of high quality and thus not appropriate for professional use. At this point, finally, we need to wait and see what professional camera options become available, and we need to prove that 360 video is more than just a gimmick, it is a viable film format moving forward. Filming of VR projects also requires high level of on-set data management. Imagine a VR filming process using 36 cameras. Orientationmappings of each camera is very important. For each shot has one component, with a certain number of subfolders of each camera angle depending on how complex the rig will be. It will also include a preview composite, composite, tripod erase and retouching metadata at the bottom of the image, captions, audio files and final exports.

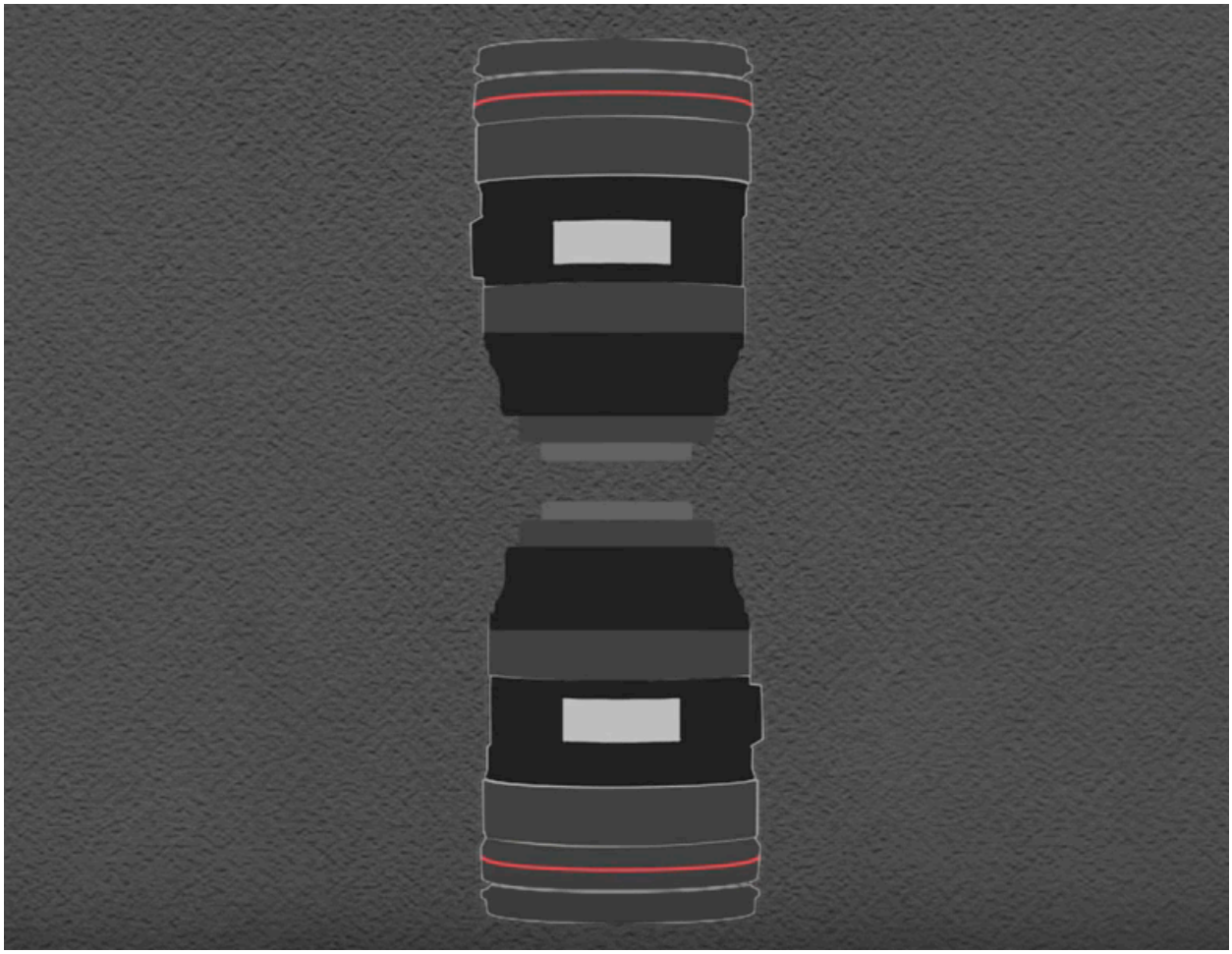
Adhering to the right data management, which we determine in advance, is very important because VR processes far more data than traditional filming. A badly organized file structure might result in extreme repercussions to VR workflow.

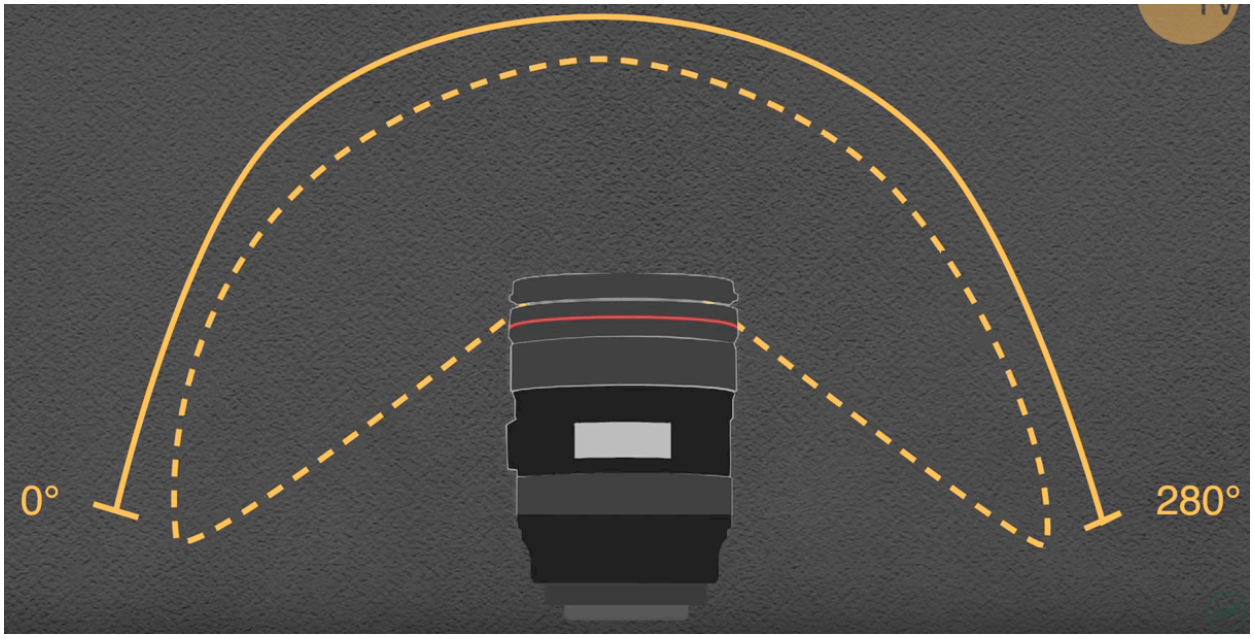
[53] Movidia.com



The reason why go-pros and smaller cameras are still a preferred choice than using cine lenses is that one needs to have sensor chips at really close distances from each other to register interactive differences and to avoid barrel distortion from the edges.

The problem with using cine lenses is that we would need to stick the sensors right next to each other. Moreover, each lens has to provide an angle of 280 degrees, which would cover 360 with stitching. Which only leaves fish-eye cine lenses as an option. The problem with using fish-eye is the barrel distortion. Even though it is going to be projected in a sphere, but except the centre, the rest would have a distortion. That is why having multiple cameras in a tight rig avoids that distortion. As of today, it is viable to have cine camera sensors right next to each other. Sony Venice extension tethering system might be the smallest sensor optical cine element in the market today. The camera allows foe the sensor to be removed from the body with the optics and controlled. This results in a smaller size professional camera. The Sony Venice extension system is fairly new and has only been tested and used in the filming of the 3d sequels of AVATAR.




0°
280°

"High-quality spatial sound can also be a challenge especially since it is as important as image in VR films. When a cinematographer shoots VR scenes using panoramic camera rigs, he or she usually uses default recording with panoramic microphone rigs"[54].. The set up is an omnidirectional microphone on top of the camera, and this could lead to compromised sound recording. An option to this problem would be to use human sound recorders through shotgun microphones or boom microphones, but then again, this presents a problem in that they could be visible in scenes. Both the human recorders and the equipment would have to be hidden from the scene being shot.

Lastly, there is the challenge of filling and un-filling of the panoramic sphere: the VR cinematographer and director need to fill the full 360° view with exciting material to capture the interest of viewers. However, to compel the viewers' attention to the important scenes, *specific spaces have to be un-filled* so that they do not compete with the scenes that have to be highlighted. "*It is common for camera-based VR cinematographers to feel compelled to digitally-fill in the 'nadir hole', or the region at the bottom of the panoramic sphere, where the camera rig would not see the tripod"*[55]. Again, this approach can affect the quality and authenticity of the VR film. Color grading in VR is another challenging tool for a cinematographer. The panoramic picture after being stitched can be edited in traditional film software's such as Baselight and Davinci Resolve but can only be previewed using a HMD or a headset. This makes secondary corrections or power window adjustments or tracking quite challenging in a VR image. Although just like in traditional films, colorgrading is another important tool for directing the viewers' angle in the panoramic sphere.

[54] Naimark, Michael, *Capturing People in VR Cinema. A look into the future with VR pioneer*.

[55] Lawrence, D. & McKee, J. *VR Cinematography Studies for Google*, 2016.

But just like traditional films, one cannot use vignette masks or tracking adjustments to direct the audience's attention.

5. Conclusion

VR is an emerging technology that is continuously used for filmmaking. Formerly used mainly in gaming, filmmakers have been tapping upon VR as a means of enriching the viewing experience. Indeed, through VR, viewers engage more deeply in a narrative, which VR films are, too. When used in filmmaking, VR has the opportunity to experience a film narrative just as if they were in the author's intended environment. This experience is made possible by VR technology, such as the HMD and headphones that viewers use to experience the synthetic environment just as if they were present in it. In other words, VR cinematography enables an immersive VR experience in which the viewer feels he or she is present within a 360° world, hear spatialised audio that deepens the sense of viewer presence in the film's environment. One of the challenges in VR cinematography is in framing, and in this paper, this conundrum was addressed through a combination of theories and practical examples. For example, VR films are explained as a form of narrative depicted in real-time that no other traditional media offers. By using VR, a cinematographer is transported to the filmmaker's intended narrative setting to experience the narrative seemingly in real-time. Here, the concept of suspension of belief is essential for the viewer to appreciate the VR-enriched narrative and is achieved when viewers are not distracted by technical matters to the point that they believe they are in the narrative's environment itself. VR enables the production of sights and sounds to which the viewer responds as if these were features of the real world. It is important to note that the use of VR in filmmaking changes the role of the cinematographer not just in terms of camera work, lighting and camera movements but also post production. When it comes to lighting, the

cinematographer needs to closely coordinate with the set architects and lighting specialists in order to achieve the look of the intended environment of the narrative. However, as technology develops, lighting design is expected to be developed in the inception stage with the production designer at a higher level, who works with the director and DOP to integrate practicals as lighting sources which become more natural and economical for the space being filmed. Possibly, the VR cinematographer might have to redefine their control in their expertise of composition and lighting. Since VR films are so spatially driven, it is to be observed whether the position of a VR DoP is as relevant as to the role of a production designer in the future years of VR filmmaking. VR cinematography is enabled by a range of high tech equipment, including, cameras and HMDs. At this point in time, opportunities for VR film are being debated upon, with some saying that it is merely a passing trend and novelty, while some assert that it is the future of cinema.

Regardless of which opportunities would come into fruition, current challenges have to be resolved, including, costs of producing high-quality VR-enriched narratives and the complexities of VR cinematography. With the current access to technology, it is easy to shoot in VR, but we are still far away from producing quality VR. A high production, content-driven VR film is still dependent on evolving creative practices and choices using the developing technology. The role of a cinematographer might change in its process and language, but the fundamentals and the philosophies of the practice cannot be ignored. Hence the cinematographer cannot be absent from the holistic process of filmmaking. In a direct comparison of film cinematography techniques with the possibilities of VR cinematography, the challenges of VR filmmaking are still evident. However, there is a plethora of various techniques and possibilities to narrate stories in

VR. VR does not provide a replacement for any other established film technique. It is not a substitute for classical films or tools of fiction storytelling. As the audience is used to having complete films narrated to them, than having autonomy by being actively involved. VR documentaries are still quite a successful medium since they provide the closest to reality immersion to the viewer. VR also is a successful medium in pornography not just due to its realistic immersion but also interactivity. Similar to why sex dolls are being replaced to robots with AI. Perhaps the future generations might prefer having more interactivity and user agency to VR fiction storytelling. Meanwhile, a VR cinematographer should aim to discover a radically fresh approach to storytelling in 360 films. Ultimately, the actual challenge of every cinematographer whether classical or VR, is not to find an alternate way of lighting, framing, editing or other established film techniques but is in creating a memorable experience for the viewers which allows them to immerse and engage in a story and its virtual world. This storytelling medium of technology is still at the brink of a vast journey of exploration. 'The one thing that we know of VR is that we do not know anything about VR'.

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