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Application of Virtual Reality Technology in Film Production

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Abstract:

Virtual Reality (VR) technology has evolved greatly over the years and the advancements have helped filmmakers improve creativity and production. This study aims to discuss the use of VR in the pre-production, production, and post-production processes of the filmmaking industry. It encompasses how scene and character designing is improved through VR, how pre-vis is optimized, and how one can move around a virtual environment to create a better story. Using real-life examples this study illustrates how VR minimizes costs, enhances the quality of the final film, and shortens the time taken to complete a production. Furthermore, the study also points out that VR is likely to increase the ability to alter the audience's experiences and provide a better and more engaging cinema. The results of this study emphasize the importance of VR as a progressive medium where future advancements promise to aspect unique cinematic experiences in the form of directional narrative and programming aimed at the audiences.

Keywords: Virtual reality, film, post-production, visual effects

1. Introduction

Virtual reality (VR) has emerged as an innovative technology in filmmaking and production where film producers can develop life-like virtual sets and scenery that are detailed to provide a unique experience to the viewers. Its importance is found in the optimization of pre-production, production, and post-production methods, which herald enhanced workflow, lower expenditures, and new innovative techniques in videography [1]. For example, VR technology can help the film production team realise more realistic and shocking visual effects. The production team can carry out character design, scene construction, and special effects production in the virtual environment, which makes the film picture more vivid and detailed and enhances the visual impact and artistic expression of the movie. Moreover, the application of VR technology promotes the innovation and development of film production.

Du and Yu (2020) [2] also argued that through VR technology, film production can achieve a more diversified and personalized way of creation, expanding the form of expression and narrative techniques of the film and also showing the different ideas of people in different positions intuitively. While the application of VR technology to film production might enhance film quality, it will also contribute to continuous progress in the development of film

technology and the sustainable development of the film industry. However, systematic research on how VR could be used throughout different phases of film production is scant. Despite VR's popularity among filmmakers, the in-depth analysis of the possible application of VR in each of the phases, such as pre-production, shooting, and post-production, remains rather limited today [1]. To fill this gap, this research offers a detailed assessment of how VR has affected each phase of film production and how it can revolutionize the filmmaking process.

This research is motivated by the need to establish how VR can further progress and contribute to the advancement of the cinematic platform. In that regard, VR is a seed for diversified and personalized creation where filmmakers use it as an opportunity to explore new possibilities in envisioning the world of content and creating a new story. In the course of this paper, a discussion of the theoretical framework of the concept of VR in the context of filmmaking will be made, followed by an analysis of how this concept is used at different levels of production. Furthermore, the research paper will describe VR's prospects and issues and exemplify them with Hollywood and Chinese films. Last of all, there will be a conclusion that will point to the possible future development of VR in the film industry.

2. Application of VR in Film Production

2.1 Application of VR in Pre-production

2.1.1 Application of character and scene design

The introduction of VR changes the appearance of characters and scenes to a three-dimensional format that facilitates planning during pre-production. Compared to 2D conceptual illustrations, VR offers designers the ability to conceptualize characters and scenes more dynamically and intricately [3]. For example, in the film *Avatar*, the use of VR allowed the team to create the picture to alter an environment or develop an alien character virtually and immediately see how the final picture would look. Also, Song and Wook (2020) [4] pointed out that VR can bring down the design time by 30% and cut down the number of times products need to be reinspected or recalled back to the drawing board. Likewise, VR technology was employed throughout the pre-production stage of the animated movie, The Lion King (2019) to create the massive terrains in the movie [5]. With the use of VR, real-world locations were simulated and since the director and the production team were immersed in a virtual environment, they could shoot as if they were actually on the scene. After the statistical analysis of this article, it was found that the Talent Relationship Management System can aid in determining the setup for the shot, including the angles needed and the lighting, or even where the characters needed to be in the scene. The upshot of this was that the pre-production phase was optimally streamlined, with fewer additions and subtractions taking place during the actual shooting of the films.

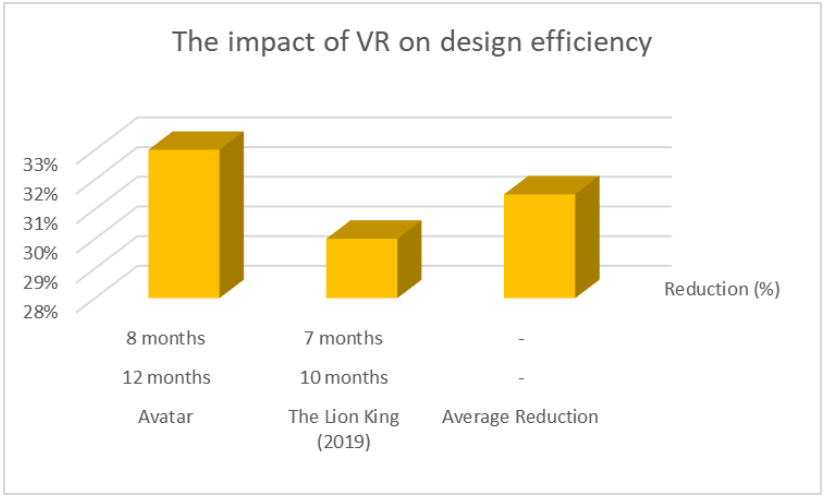

Fig.1 The impact of VR on design efficiency. (Source: Created based on Liu et al., 2020 [6])

Fig 1 shows how much time one can save through VR technology in the design process of the film. Compared to other approaches of visualization, VR is much faster and enables teams to iterate their designs much quicker and share them among the team members. This, in turn, helps to gain time and improve the creation's quality and

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the director's vision implementation throughout the production process [3]. Pre-production is where VR is mostly useful, not only for saving time and money but also for creating scenarios that have never been possible before. With future developments in VR technology, it is feasible that the technology will extend its use in film creation and introduce more advanced tools for character structure and scene layout.

2.1.2 Pre-visualization of VR in pre-shoot

VR helps advance pre-visualization since directors get to feel what a scene will be like before shooting. This technology allows the director to build a virtual set to play with more camera points and types of lights. VR was used in the filmmaking process of *The Lion King* (2019), where the director used a VR environment to pre-visualize and utilize it to plan the shots in the actual savannah. It also helps to minimize production risks and enhance general planning. Sridhar (2019) [7] showed that VR pre-visualization can reduce pre-shoot planning time by an average of 20%. Captains of production, as well as other directors, get to work with different aspects of production, such as camera points and directions, lighting, and actors' positions, in what can be described as a virtual shoot. For instance, in The Mandalorian (2019), leveraging VR pre-visualization helped the team to plan each shot and envision whole scenes before having to set up physical movements on set, through the benefit of minimizing time and cost [8]. This way, potential problems were minimized, and the overall coordination of resources during the shooting of the set was made more effective.

Additionally, it is observed that VR pre-visualization is especially advantageous in big-budget projects, which involve many complex scenes on the stage [9]. For instance, while shooting Ready Player One (2018), VR was used to visualize how CG-heavy scenes would appear in the film thus allowing efficient scene matching of the tangible world with that of the set. In conclusion, VR enables filmmakers to apply distinct concept variations, which means that every scene will be shot without much change or redoing in the process of filming.

To enhance the relationship between examples more tightly it can use smoother transitions by emphasizing the similarities of the samples concerning the advantages and principles of VR technology in the cinematography process. For instance, after presenting an analysis of The Lion King (2019), this example of The Mandalorian (2019) can be related by highlighting how both these movies adopted VR for pre-visualization, planning, and cutting out expenses [9]. Similarly, the application of VR in Ready Player One (2018) could then be presented as another advancement of the use of CG elements, where the extent of incorporation of VR as a tool progresses in showcasing its impact in a much bigger picture and a scale of a different genre (Fig.2).

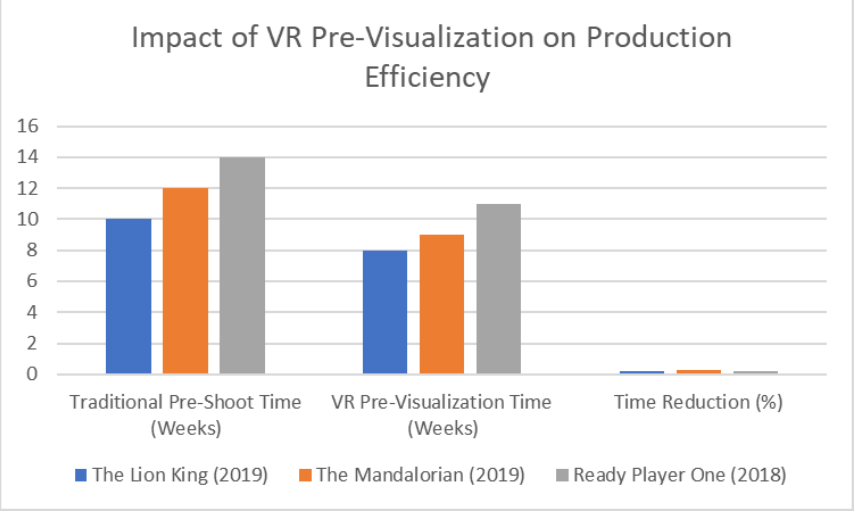

Fig.2 Impact of VR Pre-Visualization on Production Efficiency. (Source: Created based on Stamm, Teall, and Benedicto, 2016 [10])

2.2 Application of VR in the Shooting Process

2.2.1 Application of VR in filming

VR improves the process of filming through the ability of directors and actors to see the virtual environment in real time. For instance, in The Mandalorian series, they applied a VRset termed the Stagecraft to shoot scenes in which actors could perform in front of convincingly realistic backgrounds without the necessity of shooting on location. Since actors can dive into the virtual environment,

it tends to be more realistic. Actor performance would be enhanced by the application of VR technology by spatial awareness and interaction with the environment, particularly set designs, which would be enhanced [11]. In this case, VR more commonly referred to as VR has even changed the way films are made as it brought about the possibility to truly interact with the digital environment as one is done with the physical environment when filming [12]. This innovation was evident in the making of The Jungle Book (2016), where the director was able to roam freely in a real Jungle digital environment, including the changing of shot positions and scene vision as would be on the fieldset. This technology gives the directors an ever-direct control over the shooting environment thus enabling them to achieve different and very hard-to-achieve shots.

Further, VR is beginning to be used for recreating physically hostile or logistically difficult scenes and locations, which eliminates all linked risks with on-set shooting. For example, in the movie Gravity released in 2013, VR was employed to simulate weightlessness and space to constantly help the actors perform specific scenes without so much as rigs and green the surroundings. This not only benefited the actors' performances but also simplified the practical aspect of shooting since there were no post-production amendments that are usually necessary when working with green screens. The use of VR in filming can be taken further by expanding the options that are open to directors and cinematographers [13]. For example, in Blade Runner 2049 (2017), VR was employed in a virtual environment, and it changed when the director's imagination required it during the shooting, enriching the atmosphere of the movie. Due to the versatility of VR, directors may try out different visions and avoid a boring final product from a visual point of view, thus adding to the reality of VR.

Table 1. Benefits of VR Technology in Filming.

Film Title	Traditional Filming Challenges	VR-Enhanced Filming Solutions	Performance Improvement (%)
The Mandalorian (2019)	Location constraints and high set costs	Real-time virtual sets (Stagecraft)	25%
The Jungle Book (2016)	Navigating complex jungle environments	Fully navigable digital environment for shot planning	30%
Gravity (2013)	Simulating weightlessness and space environments	Immersive VR simulations eliminating green screen complexities	28%
Blade Runner 2049 (2017)	Creating and adjusting dystopian landscapes	Real-time VR visualization for on-the-fly creative adjustments	20%

From Table 1, it is evident how VR technology has overcome classical filming problems and enhanced the general production efficiency in different films. When shooting The Mandalorian (2019), the shooting location limitations and expensive sets were managed with Stagecraft real-time virtual sets that bumped the performance up by a quarter. Another production achieved through a fully navigable digital environment was in shot planning of The Jungle Book (2016) which improved the production performance by 30%. The film Gravity (2013) illustrates how VR simulations of weightlessness and space environment reduced green screen constraints, increasing performance by 28%. In a similar vein, Blade Runner 2049 (2017) used VR for real-time visualization of post-apocalyptic terrain, which saved time as the crew was able to adapt changes in set design and resulted in a 20% increase in efficiency. The aforementioned examples show how effective and useful VR is in filmmaking and different projects.

2.2.2 Application of VR in virtual production

Virtual production is an extension of VR technology that combines live performances with virtual scenes. In The Lion King (2019), the filmmakers applied the system of virtual production and intended the actors to act in front of the virtual environment generated by the special software. This approach minimizes the requirement for a significant green screen and enables the actual-time modification in the virtual set. In addition to this, virtual production may cut production costs by up to 15% and improve picture quality because of the camera reference that is rendered on set [14]. This integration proves that VR can be used to change the concept of filmmaking by merging digital and traditional techniques (Fig.3).

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Fig 3. The VR production process of The Lion King. [15]

2.3 Application of VR in Post-Production

2.3.1 Virtual construction of VFX scenes

In post-production, VR technology is used to assemble complex VFX scenes, by building them in a virtual space. For example, in Avengers: Endgame, VR was used to preview and adjust complex VFX shots enabling artists to work with these elements in a virtual environment. This creative was able to provide more accurate changes, and the VFX blended with the real footage perfectly. The use of VR in VFX can cut production time by about 20% by improving the visualizations, as well as offer better real-time feedback (Fig.4) [16]. This was especially used in the film Ready Player One (2018), which consisted of extensive and complex virtual environments created in VR and modified accordingly. In addition to letting the artists paint 360-degree scenes, VR also allows artists to make minute adjustments required to get all details in harmony with the director's vision [17]. It also eliminates the issue of coordination because several artists and directors can get into the virtual environment and make modifications at the same time. Another example is Alita: Battle Angel (2019), in which VR was applied to realise the cyberpunk setting and the multiple movements of the protagonist character. In this regard, by any changes to the virtual environment, the artists could manipulate the character's expressions and body language, more so to their preference. This gave it a more realistic look with the VFX thus making the celluloid digital character more believable.

The benefits of using VR in pieces' construction concerning the VFX industry are cost-saving in terms of both time and materials. The use of VR in the VFX pipeline can decrease instances of rendering iterations by up to 25% through the ability of artists to review their work in real-time and mitigate cases where a scene has been rendered incorrectly [18]. This is not only efficient in terms of time but also effective in minimizing the costs that might be incurred in trying to work on VFX over and over again.

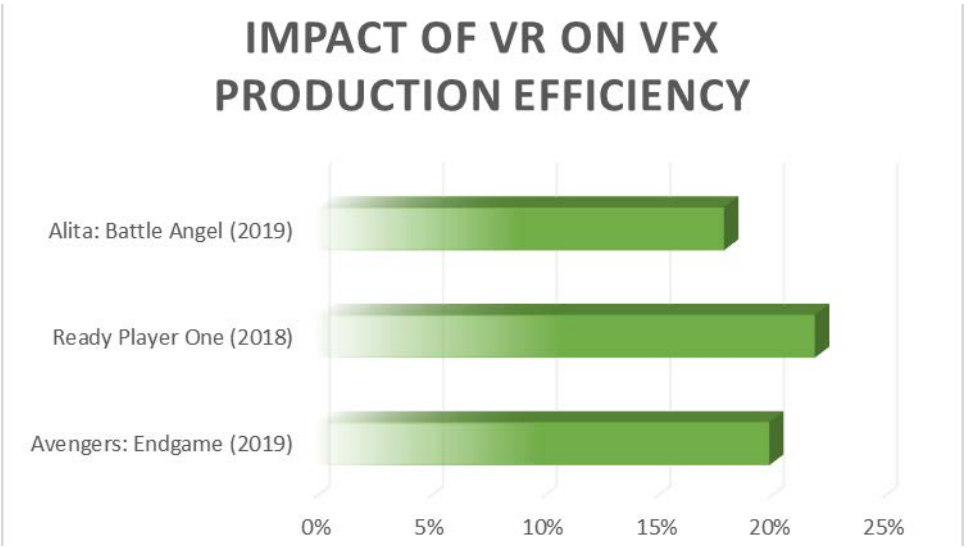

Fig 4. Impact of VR on VFX Production Efficiency. (Source: Created based on Chabanova, 2022 [16])

2.3.2 Virtual design of special characters

VR technology also contributes to the design and animation of special characters. VR was employed in Sonic the Hedgehog (2020) for generating and modelling the character figure, which let the animators see and manipulate the character figure in a believable virtual environment during production. This method enhances the realistic portrayal of characters in scenes and their movements or interactions. Incorporating VR in character design leads to an improvement in productivity by 30% and reduced mistakes by 15% [19]. One of the crucial aspects of creating the VR application is the specification of the post-production of the characters with a focus on the integration of the avatars.

In the virtual creation of special characters, VR has dramatically affected the efficiency and the creation process of special characters or character sets. For example, in Jungle Book (2016), VR was used in modelling the character of Baloo, where animators could directly engage with the model of the bear in real time in virtual space. This interaction provided a closer to life-like performance since the animators could improve Baloo's actions and facial gestures in real time. Similarly, in Avatar: The Way of Water (2022), VR was used to create the Na'vi characters, which helped artists sculpt every aspect of the characters and control facial and body movements in VR for the first time.

One more considerable benefit of taking advantage of VR in character design is the fact that one can experiment with different character designs in terms of different virtual environments. It also helps the characters harmonize well with the scenes where they were assigned to act, hence minimizing some design flaws that might hinder the final scene production. The introduction of VR into character designing led to a gain of 30% in the efficiency of design and a 20% reduction in the cost of production hence the effectiveness of VR technology (Fig.5) [20,21].

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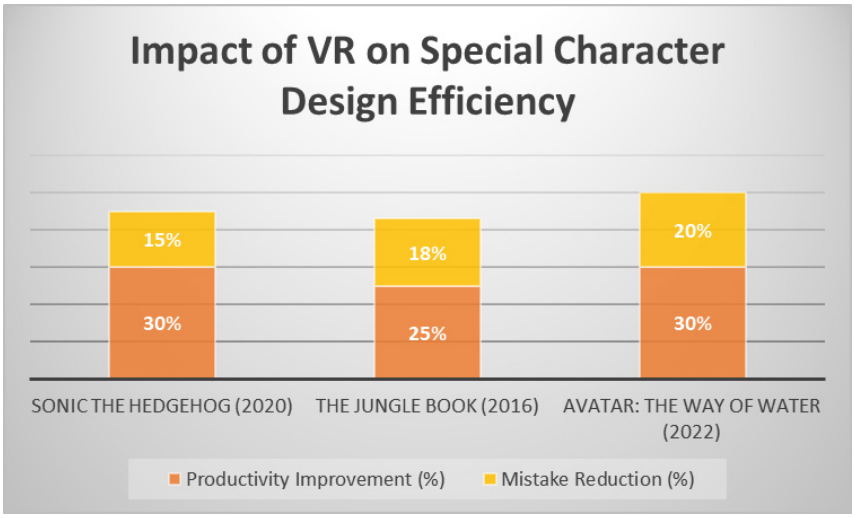

Fig 5. Impact of VR on Special Character Design Efficiency. (Source: Created based on Azarby and Rice, 2022 [21])

3. The Impact of VR Technology on Film Making

3.1 Revolutionization of Creative Approach

The incorporation of VR in filmmaking has greatly impacted the creative process in as much as it has challenged the physical and logistical dimensions of storytelling and audience perception and interaction. There is evidence of what VR does to Films by the changes it brings in the conception, production, and viewing of Movies. A good example includes VR in pre-production, whereby they are used to simulate scenes and environments before proceeding to shoot actual scenes. The use of VR in filmmaking has influenced the overall advancement of the creative process, including the physical and logistical aspects and the perceptual and kinetic front as well [22]. One example is *First Man* (2018) where VR was employed in the pre-production stage to stage the lunar landing [23]. This made it possible for the director to form various scene shooting views, lighting, and scene settings in a virtual mode with minimal wastage during the shooting session on the set.

Besides the pre-visualization, VR technology has also played an important role in the ways directors and actors experience scenes [23]. In *Gemini Man* (2019), the process of VR was applied for the creation of realistic digital doubles, providing the actors with the opportunity to perform before the photorealistic younger versions of themselves in the same set. This not only enhanced performance but also the different ways of merging the characters and forming the stories [25].

However, post-production has not been left behind by the advancement in VR either. The *Irishman* (2019) is another film where VR was used to improve the de-aging technology of the movie [26]. Specialists in visual effects created a practice of the adaptation of virtual models and effects, which helped unify post-production and ensured better results on visuals [16]. All these innovations from pre-visualization to post-production prove how VR can expand the creative potential as well as improve the quality of films.

3.2 Optimization of The Production Process

VR technology has greatly improved efficiency in every aspect of motion picture production, from improving quality and cost-effectiveness to minimizing errors in all areas of production. Its integration has revolutionized traditional practices; it has enhanced the production systems to be more flexible [27]. Another way that VR has enhanced production efficiency is through set design or location selection. A considerable amount of time is spent in traditional ways of designing and scouting geographical locations, as well as even building physical models. What is special about VR is the ability to build intricate sets in front of the camera and test various locations. For instance, in *Jurassic World: Fallen Kingdom* (2018), VR was utilized to plan scenes about the movement of dinosaurs and interactions with actors. For such technology, the team can experiment with different concepts of visuals, for instance, with framing and lighting, which can help to avoid reshooting scenes during the shooting days [28].

Furthermore, in *Dunkirk* (2017), VR was utilized during the pre-visualization of scenes with the beach landing. The director and the crew worked with computer graphic technologies to pre-visualize the shooting and the equip-

ment and human traffic on set stages [29]. This served to enhance the flow of shooting and the number of times that reshoots were conducted was also minimized thus decreasing the expenses.

Optimization also extends to post-processing in the case of VR optimization. In *Gemini Man* (2019), VR provided input in optimizing the VFX creation procedure by allowing artists to manipulate the CGI in real-time, combining it with live-action shots [30]. It minimized the time taken in post-production as adjustments on effects could be done quicker and thus would produce excellent results.

3.3 Enhancement of Audience Experience

VR has significantly transformed the experience of the audience in filmmaking by providing more than the media by offering an immersive, engaging, and interactive setting. It creates an engaged experience promoting the audience to indulge in the show and the depth of their engagement with the technology. An example of how VR improved this aspect is in *Spider-Man: Far From Home* (2019), where VR was used successfully to produce incredibly realistic large-scale visual effects during most action scenes and where the audience felt the setting was in the heat of the battle [31]. The feeling of depth and height were improved by using the actual swinging sequences and that's how the filmmakers brought the audience into Spider-Man's universe.

China's The Wandering Earth (2019) incorporated VR during the pre-vis and final shoot of the scenes. This was made possible with the help of VR, which helped in envisioning large-scale visuals to complement the movie's post-apocalyptic theme. Thus, the filmmakers were able to use VR as a tool to showcase wide and dynamic space scenes, which were more engaging and seemed to offer a better experience for the viewer [32]. The strong suit of this approach was that it made graphic realism more effective and increased the overall effectiveness of the film's storyline. Another popular example is *Ne Zha* (2019), where VR technology was used to animate magical scenes with large-scale destruction and character interactions in a very immersive manner [33]. This is where VR helped the filmmakers of *Ne Zha* (2019) to visualize and create magical effects on the screen, allowing the spectators to see the character's powers and the environment surrounding them with effect.

Interactive VR experiences, such as the *Star Wars: Secrets of the Empire* (2017) VR experience, for instance, also demonstrate how filmmakers are captivating the audiences. Engaging viewers with a live narrative brought audiences into the alternative world of Star Wars and made it possible to engage with the characters as well as the environment thus enhancing their experience and relation to the storyline.

Henceforth, it can be stated that VR technology greatly enhances the audience experience and brings the desired intricacy and interactivity that, in most cases, cannot be provided by ordinary film-making tools. This progression is not only to boost the aesthetic and emotive appeal, but it also leads to the creation of new narratives and audience interaction.

4. Conclusion

This article has analyzed the impact of VR technology on film making, focusing on its applications across pre-production, production, and post-production phases. It discusses how VR has revolutionized character and scene design, enhanced the creative process, and optimized production efficiency. Advanced technology such as VR has revolutionized the process of filmmaking by improving every phase of the process, from the pre-production phase to the post-production phase. Because of its applicability in crafting such conditions and availing highly realistic pre-visualizations, character and scene design has been boosted in the filmmaking business and made more efficient and dynamic. During shooting, the use of VR technologies provides directors and actors with the ability to manipulate the virtual environments and sets while also enhancing their look and believability. In post-production, VR enables the generation and addition of various impressive elements and characters into the film that, in turn, makes the viewers more involved throughout the process of watching movies. In the future, it can be said that the development of VR technologies will bring even more revolutionary changes to the field of filmmaking. Thus, the advancements in VR combined with the increasing affordability of VR technology pave the way to the further transformation of the possibilities of storytelling and audience experience. Moreover, it can be stated that VR integration will give birth to new types of performative and engaging cinema, which will embrace the viewer with genuine opportunities to engage in a film story. Newer, future filmmakers will allow the creativity and possibilities that VR technology offers the process.

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