

# Technological Advancements on Filmmaking: A Case Study Analysis

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**Abstract.** This study investigates the impact of technological advancements on filmmaking, focusing on both the physical hardware used in film production and the software technologies employed in post-production. Using a comparative case study approach, the research examines *Avatar* (2009) and *District 9* (2009) to analyze the differences in post-production time, quality, and overall workflow efficiency. Additionally, a literature review explores various technical innovations in cinema, highlighting key developments such as digital cinematography, CGI, and virtual production. The findings reveal significant improvements in visual quality, creative possibilities, and the challenges posed by increased complexity and resource demands. This study contributes to understanding technology's role in modern filmmaking and offers practical insights for industry professionals.

**Keywords:** Filmmaking, Technology, Film Technology, Advancements, Software, Post-Production, AI, Virtual Reality, Augmented Reality, CGI, Budget, Film Gross, Avatar, District 9

## 1 Introduction

### 1.1 Motivation and Background

The motivation for this project stemmed from a passion for film and the pursuit of a minor in Video, Performance, and Social Practice at Rensselaer Polytechnic Institute. Upon considering a research topic, filmmaking technologies and their accessibility to the general public were immediately identified as areas of interest. Initially, the research aimed to explore new technologies that could make filmmaking more accessible. However, challenges in gathering sources and data soon became apparent. This led to a broadening of the research scope to examine advancements in filmmaking technology within the professional industry, focusing on how innovations have improved both the quality of films and production efficiency. The aim of this research hopes to highlight the bridge between the respective worlds of filmmaking and technology.

### 1.2 Research Problem and Contribution

The objective of this research is to **investigate** the role technology has in both the **physical filmmaking process** and **post-production software** in the **past**,

**present, and future** through the respective technological advancements made and their impacts on the filmmaking process. This is explored through the desire to answer the research question "How have technological advancements impacted the world of filmmaking, both in the **physical hardware** used to film motion pictures and the **software** technologies used in **post-production?**".

The research is structured into a literature review divided into three parts: physical filmmaking, animation/AI/Visual Effect, and VR/AR technologies. This structure allowed for a concise yet comprehensive reporting of technological advancements in various areas of filmmaking.

A comparative case study was deemed imperative to make a genuine contribution to this research process. What started with analyzing specific scenes from two films to demonstrate post-production advancements turned into the adoption of a comparative approach upon the discovery of such a case study. The films deduced best for the study were "Avatar" for its 3D motion capture success and "District 9" for its similar genre but lower-budget production. This approach allowed me to compare the impact of technological access on film production efficiency and quality, using behind-the-scenes footage and scholarly sources to support my analysis.

This comparative approach proved effective in concluding the influence of advanced technology on filmmaking, highlighting how "Avatar's" access to innovative post-production CGI and motion capture technology contributed to its efficiency and visual appeal, compared to "District 9," which relied on more traditional methods and innovative low-budget techniques.

## 2 Methods and Data

The motivation for this research stemmed from a passion for film and an interest in exploring how technological advancements in filmmaking have enhanced both the quality and efficiency of film production. The study focused on three main areas: physical filmmaking, animation/AI, and VR, structured through a comprehensive literature review and a comparative case study.

### 2.1 Literature Review

The literature review is divided into three parts to address specific aspects of technological advancements in filmmaking. The first part explores past physical hardware innovations in the filmmaking world focusing on Ang Lee's career arc as a director. The second part examines the present evolution of visual effects, animation, and AI technologies, focusing on how these innovations have revolutionized visual storytelling. The third part delves into the potential of future VR and AR in filmmaking, discussing how these technologies are used in production and post-production to create immersive environments and enhance editing workflows.

## 2.2 Comparative Case Study

To investigate the impact of technological advancements further, a comparative case study was designed, focusing on two films released in 2009: "Avatar" directed by James Cameron and "District 9" directed by Neill Blomkamp. "Avatar" was chosen for its pioneering use of 3D motion capture and CGI, while "District 9" was selected for its innovative low-budget approach combining practical effects and CGI. Both films, despite their technological and budgetary differences, were released in the same year and are of the same genre, making them ideal for comparison.

Data for the case study were gathered from a combination of behind-the-scenes footage, film timelines, and scholarly sources discussing the production processes of both films. The analysis focused on production efficiency, visual quality, storytelling, and budget innovation, aiming to conclude how access to advanced technologies can influence the filmmaking process and the final product.

## 2.3 Initial Results and Analysis

Initial results from the literature review and case study reveal several key findings:

"Avatar" benefited significantly from its larger budget, which allowed for the use of advanced motion capture and virtual camera systems, enhancing production efficiency and real-time visualization. The higher budget facilitated the integration of cutting-edge CGI, creating an immersive and visually stunning world that set a new standard for visual effects in cinema.

In contrast, "District 9" relied on a more traditional approach, utilizing a blend of practical effects and CGI to achieve its visual goals. Despite its lower budget, the film managed to produce high-quality visuals through innovative and efficient use of available technology. The documentary-style aesthetic, achieved through handheld camera work and practical effects, added a sense of realism and immersion that resonated with audiences.

The comparative analysis highlights that while "Avatar" showcased the advantages of a larger budget and access to the latest technology, "District 9" demonstrated that creative problem-solving and efficient use of technology can also result in compelling and visually impressive films. Both films utilized their respective technological resources effectively to enhance storytelling and achieve their artistic visions.

These findings suggest that while advanced technologies can significantly enhance film production and visual quality, innovative use of available resources can also produce compelling and high-quality films. Further research will continue to explore these dynamics and their implications for the future of filmmaking.

### **Timeline:**

- **Weeks 6-7:** Collect primary data from interviews, production notes, and documentaries of *Avatar* and *District 9*.

- **Weeks 7-8:** Analyze collected data and begin drafting comparative analysis sections.
- **Weeks 8-9:** Refine analysis, incorporate additional research findings, and finalize results.
- **Weeks 9-10:** Complete final draft, including discussion and conclusion sections.
- **Week 11:** Revise and edit the paper based on feedback.
- **Week 12:** Submit final research paper

### 3 Literature Review

This literature review investigates the role of technology in the filmmaking process, examining past, present, and future advancements. It is structured into three key sections: the transition from film cameras to digital cameras, the evolution and impact of CGI and animation, and the emerging role of VR and AR in filmmaking.

#### 3.1 Past - Evolutions in Physical Film Technology and its Impact on Ang Lee's Filmmaking

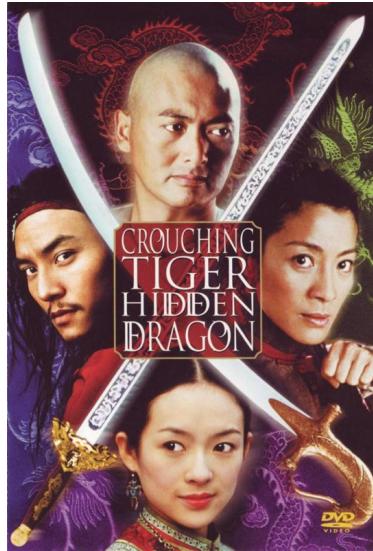
The transition from film cameras to digital cameras marked a significant technological shift in the filmmaking industry. Early film cameras, which dominated the industry for much of the 20th century, required physical film stock, which was expensive and limited the number of takes a filmmaker could afford to shoot. The process of developing and editing film was also time-consuming and labor-intensive.[28]

The advent of digital cameras in the late 20th and early 21st centuries revolutionized the industry. Digital cameras offered several advantages over traditional film cameras, including lower costs, greater flexibility, and the ability to shoot and review footage instantaneously. Pioneering works such as George Lucas's *Star Wars: Episode II – Attack of the Clones* (2002) and Michael Mann's *Collateral* (2004) demonstrated the potential of digital cinematography. Studies by Manovich (2001) and others have chronicled the shift towards digital filmmaking, highlighting how it democratized the filmmaking process by making it more accessible to independent filmmakers [16].

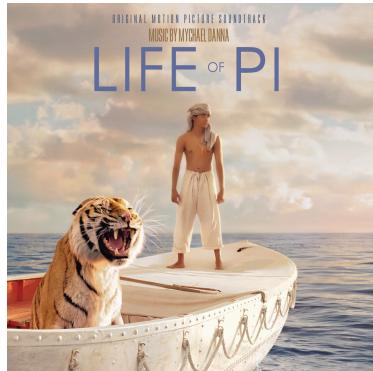
The impact of digital cameras extended beyond production. In post-production, digital footage could be edited and manipulated more easily and precisely using non-linear editing software. This technological shift also facilitated the integration of CGI, enhancing the overall quality and scope of visual effects [5].

Ang Lee's career exemplifies the impact of technological advancements on a director's artistic evolution. Over the years, Lee has embraced various technological innovations to enhance his storytelling. His film *Crouching Tiger, Hidden Dragon* (2000) utilized groundbreaking wirework and visual effects to create its signature fight scenes [28]. With *Life of Pi* (2012), Lee pushed the boundaries of

CGI to bring the story's fantastical elements to life, earning an Academy Award for Best Director [15].



**Fig. 1.** Crouching Tiger Hidden Dragon (2000) Movie Poster [3]



**Fig. 2.** Life of Pi (2011) Movie Poster [13]

Lee's exploration of technology reached new heights with *Billy Lynn's Long Halftime Walk* (2016), where he experimented with high frame rate (HFR) technology, shooting at 120 frames per second. This technological choice aimed to

create an immersive viewing experience, although it received mixed reviews regarding its impact on the storytelling [23].

In *Gemini Man* (2019), Lee used de-aging technology and HFR to tell a story involving a young and old version of the same character, portrayed by Will Smith. This film highlighted the potential and challenges of integrating advanced visual effects and new filming techniques [27].

Lee's journey illustrates how technological advancements can influence a director's approach to filmmaking, offering new tools for creative expression while also presenting unique challenges. His willingness to adopt and experiment with new technologies underscores the dynamic relationship between technological innovation and cinematic art [28].



**Fig. 3.** Portrait of Ang Lee [22]

### 3.2 Present: CGI, Animation, and AI

The integration of Computer-Generated Imagery (CGI) and animation has transformed modern filmmaking, enabling the creation of visually stunning and complex scenes that were previously impossible or impractical to achieve. CGI technology allows filmmakers to generate realistic environments, characters, and effects entirely within a computer, providing unparalleled creative freedom.

Key milestones in CGI include the groundbreaking effects in *Jurassic Park* (1993), which showcased the potential of CGI to create lifelike dinosaurs, and *The Matrix* (1999), which introduced innovative visual effects such as bullet time. In more recent years, films like *Avatar* (2009) have pushed the boundaries

of CGI and motion capture technology, creating immersive and visually spectacular worlds [26]. The Avatar Film had also put in place groundbreaking 3D motion capture technology that allows for clearer facial expressions and features to be mapped onto the bodies of the fictional characters in post-production [17]. Research by Whissel (2014) and others has explored the evolution of CGI and its impact on the filmmaking process, noting how it has expanded the possibilities for visual storytelling [26].



**Fig. 4.** Picture of the Motion Capture Technology in Use in Avatar (2009) [8]



**Fig. 5.** Continued Picture of how Motion Capture Would Map Onto CGI Characters [8]

Animation, closely related to CGI, has also seen significant advancements. Traditional hand-drawn animation has largely been replaced by computer-generated animation, allowing for more intricate and detailed visuals. Pixar's *Toy Story* (1995) was a landmark in this field, being the first feature-length film made entirely with CGI. The continued development of animation technology has enabled the creation of increasingly sophisticated and emotionally resonant films, as seen in works like *Inside Out* (2015) and *Spider-Man: Into the Spider-Verse* (2018) [6]. Spider-Man Specifically received many accolades for its innovation in animation, making its final product appear as a comic book come to life such as an Academy Award for Best Animated Feature Film [6].



**Fig. 6.** Spider-Man: Into the Spider-Verse (2018) Movie Poster [25]

In recent years, artificial intelligence (AI) has started to play a crucial role in both CGI and animation. AI is being used to streamline various aspects of the filmmaking process, including scene identification, facial recognition, and motion capture [21]. For instance, AI algorithms can analyze vast amounts of footage to identify and categorize scenes, significantly reducing the time needed for manual sorting and editing. This technology enhances efficiency in the post-production phase, allowing editors to focus on more creative tasks [4]. This is also demonstrated in the figure below from Reddy (2024).

AI-driven tools are also revolutionizing character animation and CGI by improving the realism and fluidity of movements. AI can assist in motion capture by refining the data captured from actors, ensuring that the digital characters' movements are smooth and lifelike. AI is also used in creating detailed facial animations, capturing subtle expressions and emotions that enhance the overall performance of digital characters [21].

There is also the existence of AI Scripting Algorithms in place to add to or refine the script creation of a project in the works. Though there have been

ethical debates on allowing the technology to perform this task, the positive outcomes it brings to the final product cannot be dismissed.[10]

These advancements not only improve the quality of visual effects and animations but also make the production process more efficient. AI's ability to automate repetitive tasks and enhance creative elements is pushing the boundaries of what can be achieved in modern filmmaking, offering filmmakers new tools to tell their stories in innovative ways [21].

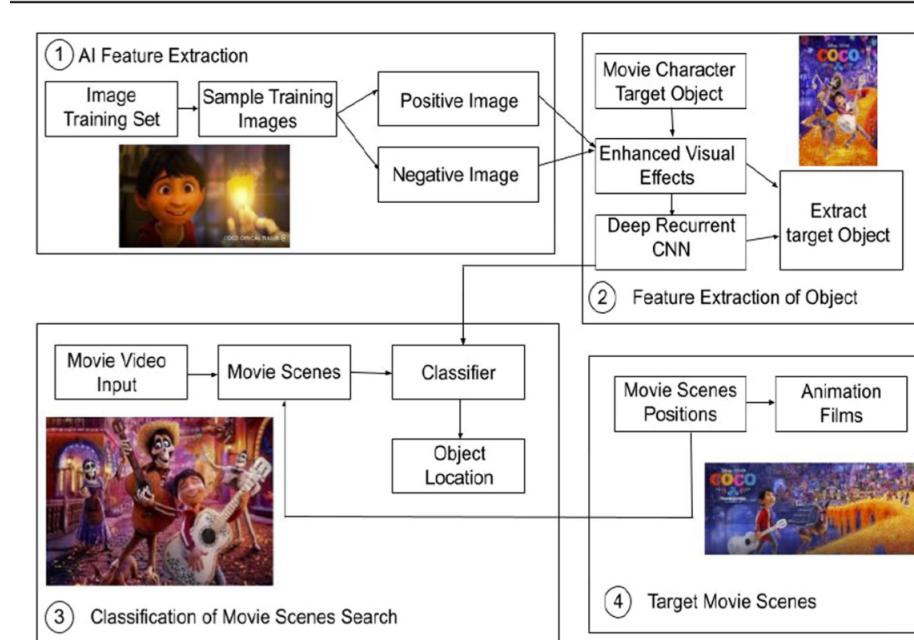


Fig. 7. "Visual Representation of AI in Animation Post-Production". Source [21]

### 3.3 Future: VR and AR in Filmmaking through New Innovations

Virtual Reality (VR) and Augmented Reality (AR) represent the future frontiers of filmmaking technology. VR immerses the viewer in a fully digital environment, while AR overlays digital elements onto the real world. Both technologies have the potential to fundamentally change the way films are produced, experienced, and consumed.

In production, VR and AR can be used to create virtual sets, allowing filmmakers to visualize and interact with digital environments in real time. This can streamline the production process, reduce costs, and offer greater creative flexibility. For example, the use of virtual production techniques in the making of *The Mandalorian* (2019) demonstrated how LED screens and real-time render-

ing could replace traditional green screen techniques, creating more immersive and interactive sets [4].

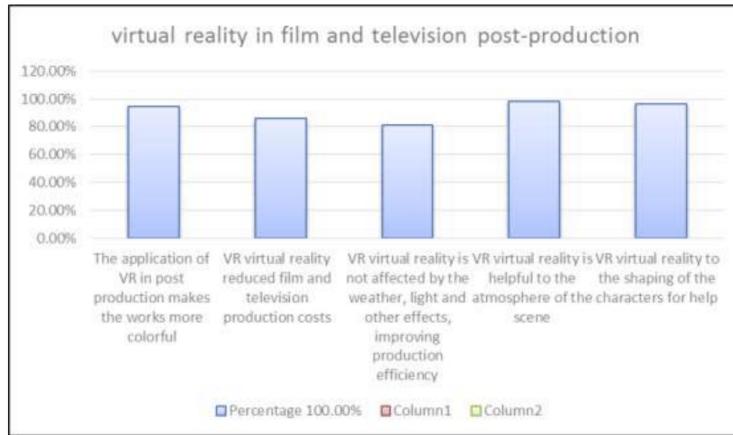
In post-production, VR and AR can enhance the editing and visual effects processes. VR tools can allow editors and visual effects artists to work within a 3D space, providing a more intuitive and immersive workflow. AR can be used to preview effects and adjustments in real-world contexts, enhancing the accuracy and effectiveness of post-production work [20].

VR can also be used to enhance the post production process of a motion picture. One of the more specific VR tools to mention is VPET, which stands for Virtual Production Edition Tool which allows directors to come into a virtual space and edit films. [24]

The potential of VR and AR in filmmaking is vast, offering new ways to engage audiences and tell stories. As these technologies continue to develop, they are likely to play an increasingly prominent role in the industry. Research by scholars such as Anderson (2018) and Rainie (2019) highlight the emerging trends and potential applications of VR and AR in filmmaking, suggesting a future where these technologies are integral to the creative process [4] [20]. Figures below by Ming (2021) also prove that VR is agreed to have the potential to make significant positive changes on the film industry as a whole [17].

Content	Identify	Disagree	Percentage
VR virtual reality to the shaping of the characters for help	109	4	96.46%
VR virtual reality is helpful to the atmosphere of the scene	111	2	98.23%
VR virtual reality is not affected by the weather, light and other effects, improving production efficiency	92	21	81.42%
VR virtual reality reduced film and television production costs	97	16	85.84%
The application of VR in post-production makes the works more colorful	107	6	94.69%

**Fig. 8.** Survey Chart from Post Production Personnel on How Virtual Reality Could Aid the Creative Process. Source: [17].



**Fig. 9.** Survey Bar Graph from Post Production Personnel on How Virtual Reality Could Aid the Creative Process. Source: [17].

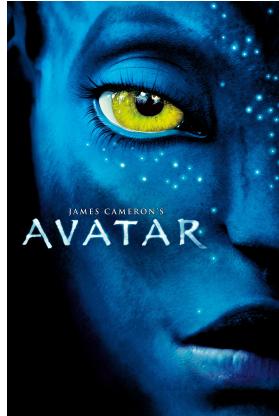
Audience Statistics on VR Film and Television Audience Evaluation	ratio
Very rubbish	2.11%
general	8.23%
Very fresh form	37.61%
Very good	52.08%

**Fig. 10.** Audience Evaluation Results on Opinion of Virtual Reality Film and Television. Source: [17]

#### 4 Case Study: Comparative Analysis of *Avatar* (2009) and *District 9* (2009)

This case study explores the impact of technological advancements on the production processes and quality of two seminal films released in 2009: *Avatar*, directed by James Cameron, and *District 9*, directed by Neill Blomkamp. Both films utilized advanced technologies of their time, but in distinct ways, offering a comparative perspective on how different technological approaches can influence filmmaking.

#### 4.1 *Avatar* (2009)



**Fig. 11.** *Avatar* (2009) Movie Poster [1]

*Avatar* is widely recognized for its groundbreaking use of 3D motion capture technology and CGI. James Cameron invested significant time and resources into developing new technologies to realize his vision of Pandora, an alien world teeming with life. The film's production process highlights several key technological advancements. The sophisticated 3D motion capture system allowed for the detailed capture of actors' performances, which were then translated into the digital characters of the Na'vi. This technology significantly enhanced the realism and emotional depth of the characters, setting a new benchmark for visual effects [7].

Cameron also employed a virtual camera system known as the **SIMUL-CAM**. This enabled him to navigate the 3D environment of Pandora as if filming on a physical set [8]. This system offered unprecedented creative freedom, allowing for dynamic and immersive shots that would have been unachievable with traditional cameras [19]. It also minimized the need for much back-and-forth between the physical filmmaking process and the post-production stage[8]. The extensive use of CGI in *Avatar* created a fully realized world with photo-realistic flora and fauna. The seamless integration of CGI with live-action footage resulted in a visually stunning and immersive experience for audiences [14].

The technological advancements utilized in *Avatar* not only improved production efficiency by enabling real-time visualization of digital environments but also elevated the film's visual quality, contributing to its critical and commercial success [7].



**Fig. 12.** SIMULCAM in Action Filming on a Set for Avatar (2009) [18]



**Fig. 13.** Screen Showing What SIMULCAM Sees With the CGI World Mapped Onto In Real-Time From The Prior Image [18]



**Fig. 14.** James Cameron, the director of Avatar (2009) using the SIMULCAM On Set [8]

#### 4.2 *District 9* (2009)



**Fig. 15.** District 9 (2009) Movie Poster[2]

*District 9* adopted a different approach to technology in filmmaking. Directed by Neill Blomkamp, the film combined traditional techniques with innovative use of CGI to create a gritty, documentary-style narrative about alien refugees in South Africa. Blomkamp used a blend of practical effects and CGI to create the alien characters known as "prawns." Practical effects added tangible realism,

while CGI enhanced the aliens' appearance and seamlessly integrated them into live-action footage [6].

The film's documentary style was achieved through extensive use of handheld cameras, which added to the sense of realism and immersion with the more grainy and unstabilized footage. This approach contrasted sharply with the highly controlled and polished visual style of *Avatar* [5]. Produced on a relatively modest budget compared to *Avatar*, *District 9* demonstrated that innovative use of available technology could achieve high-quality visual effects. The film's success highlighted that effective use of technology does not necessarily require massive budgets but rather creative and efficient application [4].

The CGI methods used were more mainstream Hollywood approaches. Such as have an actor in what is coined as a "ping-pong ball suit" pantomime the actions of whatever creature needs to be CGIed into the movie, as it would then be edited onto them in post. The only slight downfall to this approach in this project was the need to return to production after realizing that one of the alien actors was moving in a certain way that breaks the continuity of the film after trying to CGI the figure of the alien onto the actor's body.[9]

The technological choices in *District 9* emphasized storytelling and realism, creating a unique and compelling narrative that resonated with audiences. The film's success illustrated the potential for lower-budget productions to leverage technology effectively [4].



**Fig. 16.** Photo of District 9 (2009) Live Location Set CGI work with traditional CGI methods [9]



**Fig. 17.** Photo of Prosthetic work to create Alien Figures in District 9 (2009) [9]



**Fig. 18.** Shot of prosthetic alien in District 9 (2009) [9]

#### 4.3 Comparative Analysis

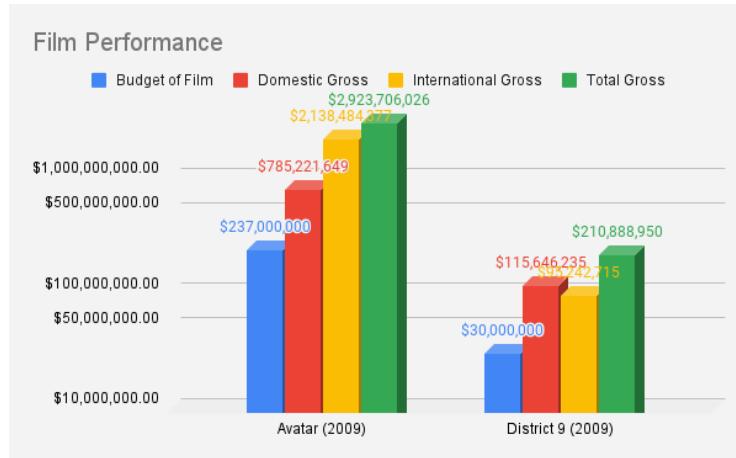
Comparing *Avatar* and *District 9* reveals several insights into the impact of technological advancements on filmmaking. *Avatar* benefitted from advanced motion capture and virtual camera systems, which streamlined the production process, allowing for real-time visualization and adjustment. In contrast, *District 9* relied on a blend of practical effects and CGI, which required a different workflow but still achieved impressive results [7] [14] [6].

Both films set new standards for visual effects in their respective styles. *Avatar* demonstrated the potential of high-budget, cutting-edge technology to

create immersive worlds, while *District 9* showed that innovative use of technology on a lower budget could still produce high-quality visuals [19] [4]. The technological choices in both films were driven by their respective storytelling needs. *Avatar*'s technology facilitated the creation of an expansive and visually rich world, while *District 9*'s approach enhanced the film's gritty, realistic aesthetic [5] [4].

Looking at the figure below depicting each of the film's performances at the Box Office in comparison to each film's respective budget, we can see how much of what *Avatar* was able to do can be accounted for by the starkly larger budget. By having the money given to them by then *Twentieth Century Fox*, they were able to invest in their inventions to propel the filmmaking process further to reduce production time and create a more efficient final product which skyrocketed their ability to make a profit. In contrast, *District 9* was still able to use its creative techniques to work around its lower budget to obtain a final product that grossed high in its own right based on its lower starting point. The comparative analysis highlights how budget constraints can drive innovation. *District 9*'s success on a lower budget underscores the importance of creative problem-solving and efficient use of technology in filmmaking [4].

These numbers were attained by IMDbPro's Box office Database for each respective film [11] [12].



**Fig. 19.** Figure Comparing how each film grossed at the Box Office compared to its budget

## 5 Conclusion

The evolution from physical film to digital cameras, alongside the integration of CGI, animation, and AI, has profoundly revolutionized filmmaking, enhancing both creative possibilities and production efficiency. Furthermore, emerging

technologies such as VR and AR hold the promise of further transforming the industry, opening new avenues for innovative storytelling. The comparative analysis of *Avatar* and *District 9* serves as a testament to the diverse ways in which technology can amplify the filmmaking process, providing invaluable insights and guiding principles for future cinematic endeavors. This study not only underscores the transformative impact of these technologies but also highlights the ever-expanding horizons of what can be achieved in modern cinema.

## 6 Evaluation

This work was aimed to answer the question "How have technological advancements impacted the world of filmmaking, both in the **physical hardware** used to film motion pictures and the **software** technologies used in **post-production?**" by investigating the role technology has in both the physical filmmaking process and post-production software in the past, present, and future through the respective technological advancements made and their impacts on the filmmaking process. Therefore, this work can potentially be evaluated by how well the question was answered through the literature review findings in addition to the analysis and conclusions drawn from the comparative case study. As this research lacks true quantitative and experimental data, there is little to evaluate numerically.

## 7 Limitations

There are two notable limitations that I have with this research:

- **Scope is genre-specific:** the comparative case study only compares two Sci-Fi genre movies that were released in the same year due to the need for extra visual effects and physical hardware to create a scientific and fictional world. Should the study be broadened to include other genres such as a drama or a comedy, conclusions may change as the technology used to create those films is more basic.
- **Lack of First-Hand Account Material:** The research is comprised of found behind-the-scenes footage and other material from secondary sources as there is difficulty in the ability to connect with the successful and famous Hollywood directors that created the major films mentioned throughout this research. A true first hand account of these directors on their experience using these technologies and how they believe it transformed their filmmaking process would strengthen the research in tenfold.

## 8 Future Work

To combat some of the limitations in the research, some future work to further this research is to open the comparative case study to account for films that are comparable in other genres to see if the conclusions drawn from the Sci-Fi films

of investing in technologies to propel the filmmaking process if you have the funds to do so or using creative workarounds to hide the shortcomings of a given budget. The research could also benefit from true first-hand account material that is specific to this topic, so reaching out to directors such as Ang Lee, James Cameron, and Neill Blomkamp to answer questions related to this work would also be a great future task.

## 9 GitHub Repository

To see all work related to this project comprised and organized into one space, please visit <https://github.com/TheGoodKevin/IntroductiontoResearch>.

## 10 Acknowledgements

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