Journal of Digital Media & Culture Technology Vol.5, No.2, December (2025), pp.139-149
ISSN 2983-0664(p) 2983-0850(e) *http://dx.doi.org/10.29056/jdmct.2025.12.05*

Theatrical Animation and Its Technological Evolution : Integrating 3D-2D Hybrid Rendering with New Directorial Practices

Eun Joung Kim[1]

Abstract

This study examines the evolving technological paradigm of contemporary theatrical animation by analyzing how advanced digital production methods are transforming the visual grammar, expressive capacity, and audience experience of feature-length animated films. Focusing on three representative works including The First Slam Dunk, Demon Slayer: Kimetsu no Yaiba-Infinity Castle, and Chainsaw Man: Reze Arc, the study investigates the integration of 3D-2D hybrid rendering, digital effects, virtual cinematography, and immersive exhibition technologies within recent animation production pipelines. The comparative analysis reveals a major transition in theatrical animation from a drawing-centered production model toward integrated digital pipelines in which technology, direction, and sensory exhibition operate as mutually reinforcing components. Ultimately, the study argues that technological innovation in animation production is reshaping competitive strategies in the global theatrical market.

Keyword : Theatrical Animation, 3D-2D Hybrid Rendering, Virtual Cinematography, Cinematic Direction, Audience Immersion

1. Introduction

In recent years, Japanese feature-length animated films have enjoyed a series of box-office successes in South Korean theaters [1]. Works such as The First Slam Dunk, Demon Slayer: Kimetsu no Yaiba-Infinity Castle, Jujutsu Kaisen: Shibuya Incident × Culling Game, and One Piece Film: Red have reshaped perceptions of theatrical animation to demonstrate that animation is no longer confined to a niche genre for specific fan communities but has become firmly established as mainstream theatrical content. This phenomenon cannot be attributed solely to the popularity of individual works or the strength of their original intellectual properties (IPs). Rather, it is the result of multiple cultural and industrial factors including the widespread diffusion of over-the-top (OTT) platforms that has broadened the audience base for animated series, the expansion of character-driven consumption culture, and

1 Department of Game Contents, Kyungil University, Gyeongsan, Korea [Professor]
e-mail: eunjoungkim@kiu.ac.kr

Received(October 22, 2025), Review Result(1st: November 19, 2025), Accepted(December 12, 2025), Published(December 31, 2025)

generational shifts in the composition of theatergoers.

Of particular note is that recent feature-length animated films have overcome the limitations of traditional 2D cel animation by actively integrating 3D computer graphics (CG) and digital production technologies to deliver visual experiences optimized for the theatrical environment. In order to fully leverage high-resolution screens and surround-sound theatrical systems, studios increasingly employ realistic motion, expanded camera work, lighting effects that resemble live-action cinematography, and multilayered compositing techniques. Recent developments in hybrid rendering, real-time visualization, and digitally integrated production pipelines have further accelerated this transition, which enables animation studios to combine the aesthetic sensibility of hand-drawn imagery with the spatial freedom and efficiency of contemporary CG workflows [2]. These technological advances constitute more than a change in drawing style but they have also driven a broader transformation in the visual language and representational framework of animation and function as key elements that enhance audience immersion. Against this backdrop, the evolution of digital animation pipelines has emerged as a critical area of scholarly and industrial attention, as recent studies emphasize the role of real-time rendering, pipeline integration, and cross-disciplinary production systems in redefining animation as a cinematic medium rather than a purely illustrative one [3].

This study aims to analyze the characteristics and evolutionary trajectories of new-generation production technologies employed in recent feature-length animated films by focusing on three representative cases: The First Slam Dunk, Demon Slayer: Kimetsu no Yaiba-Infinity Castle, and Chainsaw Man: Reze Arc. Through these animations, the paper examines how advanced production technologies such as 3D-2D hybrid rendering, digital effects, and cinematic camera work are integrated into contemporary feature-length animation from a technology-centered perspective and discusses the implications of these changes for future animation production paradigms.

2. Theoretical Background

2.1 Traditional 2D Cel Animation Production

Traditional 2D cel animation developed through a process in which images drawn directly on paper or cel (celluloid) sheets were layered and photographed. The production workflow including (1) key animation that defines character outlines and motion, (2) in-betweening that interpolates movement, (3) background art, and (4) photography or compositing that requires highly skilled labor and a considerable amount of time. This method has the advantage of providing the distinctive texture and emotional

expressiveness associated with hand-drawn imagery [4]. However, as the scale of scenes expands, production costs and repetitive labor increase steeply so that it reveals structural limitations. Moreover, constraints on camera work and spatial movement restrict the degree of realism and dynamic visual experience that can be offered.

2.2 3D CG Technology and the Emergence of Hybrid Approaches

Since the 1990s, advances in computer graphics technology have fundamentally transformed animation production methods. The introduction of 3D modeling and rigging, motion capture, and physically based rendering (PBR) has made it possible to reproduce motion and lighting effects that closely resemble live-action cinematography, while also enabling flexible camera paths and frequent changes in point of view [4]. As a result, producers can achieve both greater production efficiency and higher visual quality, and hybrid production methods that combine 2D and 3D have become commonplace [5]. As shown in [Fig. 1], contemporary feature-length animated films employ 3D-based character construction as the underlying production structure, while selectively preserving 2D visual attributes such as cel-style outlines, simplified color planes, and hand-drawn surface textures through toon shading and line mapping. The two recent animations such as Arcane and Spider Man: Across the Spider-verse illustrates how these techniques function not merely as stylistic decoration but as deliberate technical strategies that mediate between computational realism and hand-drawn expressiveness.This technological convergence has gone beyond previous limitations of visual presentation and is regarded as a key foundation for realizing cinematic direction, dynamic action, and spatial depth from a quasi-live-action perspective.

[Fig. 1] Examples of animations tha combine 2D and 3D (Left: Arcane, Right: Spider Man: Across the Siper-verse)

2.3 Contemporary Animation Production Pipelines

Contemporary feature-length animation production is organized around a digital, multi-stage pipeline.

In general, the workflow consists of the following stages: Pre-Production, Layout, Modeling, Rigging, Animation, Rendering, and Compositing, each of which is interlinked in a complementary manner [6]. In the Pre-Production stage, activities such as scriptwriting, storyboarding, design development, and the establishment of a cinematographic concept are carried out. In the Layout stage, camera placement and spatial configurations are determined. The Modeling and Rigging stages construct the 3D structures of characters and objects as well as the joint-control systems. In the Animation stage, motion is generated using motion capture and/or key-frame animation. The Rendering stage applies lighting, materials, and particle effects, thereby determining the final visual quality of the images. Finally, in the Compositing stage, 2D effects, color grading, and multilayer compositing are performed to produce the theatrical release master. This digital pipeline not only enables the implementation of complex directorial effects but also plays an important role in managing the production process and maintaining consistency of quality.

3. Case Studies of Theatrical Animated Films

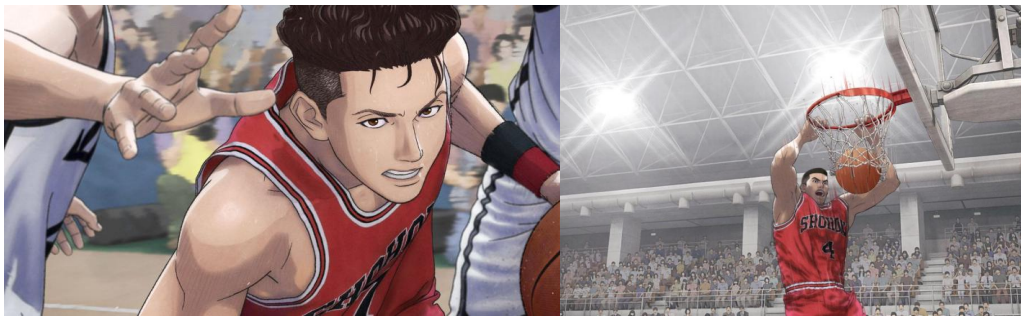
3.1 The First Slam Dunk

The First Slam Dunk is widely regarded as a work that breaks through the expressive limitations of conventional sports animation by centering its production on 3D and converting it into the visual texture of 2D cel animation through a hybrid rendering approach [7]. In particular, the film actively utilizes toon shading and line mapping techniques to achieve both the precise movements of 3D animation and the emotionally charged visuals associated with 2D hand-drawn imagery. In order to reproduce, within a digital environment, the line quality and tonal separation characteristic of traditional cel animation, the production team implemented variable line thickness along character contours, subtle fluctuations in texture, and brush-like stroke effects, thereby preserving the organic feel of hand-drawn animation.

First, toon shading is a rendering technique that simplifies the shading of 3D models to produce stepwise gradations of light and dark similar to 2D cel animation [5]. Instead of detailed lighting values, it uses flat tonal separations to create clear volumetric forms. In The First Slam Dunk, this technique is combined with line mapping to fine-tune the strength of contour lines and facial expressions as shown in [Fig, 2]. Beyond automatically generated lines from the 3D models, additional digital drawing lines are selectively overlaid in cuts where emotional expression is critical, thereby reinforcing the dramatic impact associated with cel animation. Ultimately, the organic integration of line and tone functions as a core technology for preserving the sensibility of traditional hand-drawn animation in both static shots

and dynamic sequences.

The core technological approach of The First Slam Dunk lies in the combination of natural 3D skeleton-based motion and cel-style rendering. To accurately reproduce the mechanics of actual basketball movements, the film employs a hybrid of motion capture and key-frame animation, meticulously adjusting the sense of weight, acceleration, and physical contact. The rendered character surfaces are then refined with 2D-style textures and line corrections so that both the realism of 3D motion and the emotional expressiveness of line-centric drawing are retained. This approach plays a crucial role in maintaining the stability of lines and the individuality of characters even in fast-paced sports sequences and rapid frame transitions.



[Fig. 2] Control of character contour line intensity through toon shading and line mapping

The First Slam Dunk actively adopts camera configurations from live-action sports broadcasts so that it realizes a cinematic sense of shooting that earlier animation found difficult to achieve. In the basketball game sequences, techniques such as tracking shots, dolly moves, handheld-style motion, and depth-of-field shifts are applied through virtual 3D cameras. Camera paths are dynamically adjusted in response to changes in the speed and trajectory of the ball and players, thereby creating highly kinetic visual sequences. This method allows audiences to feel the energy and pace of the court and maximizes the realism of the sports scenes so that the animation moves beyond the relatively static camera compositions characteristic of traditional animation.

3.2 Demon Slayer: Kimetsu no Yaiba-Infinity Castle

Demon Slayer: Kimetsu no Yaiba-Infinity Castle represents a recent feature-length animated film in which Ufotable's integrated digital production pipeline is actively deployed to fuse the aesthetic qualities of 2D drawing with the visual strengths of 3D CG. Building on the technological foundation developed

through the TV series, the film uses complex 3D spatial compositions, live-action-inspired camera work, and high-density digital effects compositing to achieve visual depth and immersion optimized for theatrical exhibition. The structural representation of the Infinity Castle serves as a key element in this regard, as it is based on 3D spatial rendering that enables more advanced cinematic direction than was possible in the TV series.

Most of all, the most pronounced changes in the feature film lie in its approach to spatial composition and camera direction. Whereas the TV series relied primarily on 2D background art and relatively limited camera movement, as evidenced in [Fig. 3], the feature-length version employs 3D modeling to construct an 'infinite' spatial environment, thereby enabling free camera paths and visual direction that emphasizes perspective and depth. The Infinity Castle is organized as a volumetric 3D space rather than a layered 2D backdrop that allows the virtual camera to traverse vertically and laterally across multiple spatial planes.

In an interview, cinematographer Yuichi Terao stated that the goal of Infinity Castle was to make viewers feel as though they were physically located within an endlessly expanding space, and that 3D CG-based virtual camera technology allowed the team to achieve a degree of visual openness not attainable in the TV series [8]. This approach makes it possible to implement complex cinematographic techniques such as camera movement, rotation, and shifts in point of view so that it intensifies the rhythm of battle sequences and the emotional tension created by changes in scene tempo.

[Fig. 3] Spatial composition of the infinity castle using 3D CG-based virtual cameras

In the feature film, as shown in [Fig. 4], digital effects such as particles, smoke, explosions, and light reflections along with volumetric lighting and PBR techniques are employed on an expanded scale. These high-density effect elements are intricately integrated during the compositing stage, where they serve to enhance textural richness and depth. The multilayer compositing structure enables fine control of lighting, shadows, and scattered light, making the animated images appear less like flat illustrations and more like footage captured in a physical space. This process can be interpreted as a visual quality assurance strategy tailored to the high-resolution output required for large theatrical screens.

Beyond its digital visual presentation, Demon Slayer: Kimetsu no Yaiba-Infinity Castle also experiments with expanded exhibition technologies. The film actively supports immersive formats such as 4DX and ScreenX in order to enhance audience immersion through bodily sensory stimulation in addition to visual information. In 4DX screenings, the impact, vibration, and acceleration of battle scenes are conveyed through seat motion, wind, and vibration effects, while water-related scenes are synchronized with on-site water spray systems to match on-screen effects with physical sensation. ScreenX extends the field of view to 270 degrees in select scenes in order to amplify the sense of spatial expansion and highlighting the film's core concept of infinity as an embodied visual experience. The integration of these theatrical technologies differentiates the feature film from the TV series by transforming viewing into a form of sensory participation grounded in physical and spatial engagement.

[Fig. 4] Construction of a explosion scene using digital FX

3.3 Chainsaw Man: Reze Arc

Chainsaw Man: Reze Arc departs from traditional animation direction and is widely regarded as a recent example that actively adopts live-action cinematographic conventions and digital cinema aesthetics [9]. The film foregrounds visual-language elements such as shot composition, camera perspective, focus shifts, framing, and color grading as primary means of conveying emotion and narrative. In scenes that depict interpersonal relationships and emotional change, the film uses static compositions, restrained character movement, and lighting tones reminiscent of natural light to create a visual texture comparable to that of documentary or realist cinema.

By contrast, the action sequences employ handheld-style shaky camera work and extreme close-ups combined with jump-cut editing, thereby maximizing tempo and tension. As shown in [Fig. 5], this directorial strategy eschews the exaggerated stylistic devices typical of animation, instead seeking a balance between realism and emotional vitality, which distinguishes the film from earlier generations of animated works.

[Fig. 5] An explosive battle sequence in Chinsaw Man

From a technical standpoint, the film constructs spaces and objects on a 3D CG foundation and layers them with texture-based realistic surface rendering and color-grading-centered compositing. Skin tones, light reflections, and surface materials are adjusted using HDR-based color grading to achieve physical lighting effects comparable to those found in live-action cinematography. The muted-tone color palette used throughout the work can be interpreted as a strategy to convey dramatic emotions not through overt visual density but through low-key emotional energy. This technological configuration organizes the flow of narrative, character emotion, and viewer immersion primarily through the rhythm of cinematography, editing, and color rather than through overt visual devices. In doing so, it exemplifies the ongoing shift of animation from a medium centered on ‘drawn expression7’ to one grounded in cinematic visual language.

4. Discussion

This study has examined key trends in production technologies employed in recent feature-length animated films by focusing on The First Slam Dunk, Demon Slayer: Kimetsu no Yaiba-Infinity Castle, and Chainsaw Man: Reze Arc, and by analyzing their technical characteristics and differences in directorial approach. [Table 1] presents a comparative overview of the production technologies employed in each animation and summarizes their distinct technical strategies and industrial implications. The three animations demonstrate that contemporary feature-length animation shares a set of common technological directions: the integration of 3D-based production techniques with emotionally resonant 2D expression; the active adoption of live-action cinematographic conventions. In addition, the use of theatrical exhibition technologies that expand sensory experience for audiences. These changes are not limited to the advancement of visual effects, but they signal a broader transformation in the visual grammar and production paradigm of animation.

[Table 1] Comparison of production technologies used in each animation and their implications

Category	The First Slam Dunk	Demon Slayer: Infinity Castle	Chainsaw Man: Reze Arc
Production Based	3D skeleton motion + 2D cel-style rendering	3D-based spatial construction + 2D/3D compositing + high-density FX	Live-action-inspired direction + 3D spatial compositing
Style Implementation	-Toon shading -Line mapping -Emotion-driven line adjustment	-PBR -Volumetric lighting -Layered compositing	-Color grading -Texture-based surface representation -Handheld shots
Camera Work	-Sports broadcast-style shooting -Movement tracking -Dynamic tracking shots	-Free movement and rotation in 3D space -ScreenX expansion	-Real-cinema style -Close-ups -Jump cuts
Mode of Emotional Expression	Facial-expression-centered emotional lines and framing	Emotion enhancement through lighting and spatial distortion	Rhythmic contrast between static and explosive sequences
Implication	Completion of a 3D + 2D emotional hybrid	Cinematic expansion of animation and experimentation with immersive exhibition	Pursuit of realism and live-action-like visual grammar in animation

5. Conclusion

The technological development of feature-length animated films is shifting the competitive landscape

from a focus on drawing quality alone to one centered on innovation in production technology systems and the design of audience experience. The advancement of 3D-2D hybrid rendering technologies creates an environment in which dependence on large-scale human labor can be reduced while maintaining consistent quality. At the same time, the adoption of live-action-based directorial methods extends the expressive scope of animation to a level comparable with that of the live-action film industry. Furthermore, the integration of immersive exhibition formats such as 4DX and ScreenX provides differentiated value-added structures for the theatrical sector and functions as a driver for the expansion of animation IP markets.

The future of the feature-length animation industry is likely to evolve toward production strategies centered on technological integration, expanded exhibition technologies grounded in audience experience, and the strengthening of IP-based global theatrical competitiveness. The findings of this study suggest that the core of these transformations lies in the integrated development of technology, direction, and exhibition platforms. This integrated structure should be regarded as a key topic in future research on animation production and in the formulation of market and industry strategies.

With regard to future research, further empirical studies are needed to examine how audiences perceive and physically experience these technologically mediated cinematic environments, particularly in immersive formats such as 4DX and ScreenX. In addition, comparative research across national or industrial contexts would provide deeper insight into how integrated digital production strategies are adopted and localized within different animation ecosystems.

References

[1] W. B. Lee, “[Focus] Japanese Anime That Has Become Mainstream Cinema: ‘Chainsaw Man the Movie: Re ze Arc’ and the Significance of Its 2.3 Million Admissions”, cine21.com, https://cine21.com/news/view/?mag_ id=108700, (accessed October 6, 2025).

[2] W. Li, Y. Wang, H. Yang, Z. Ye, P. Li, Y. A. Liu, L. Wang, “Development of a mixed reality method for underground pipelines in digital mechanics experiments”, Tunnelling and Underground Space Technology, vol. 132, February 2023, pp. 104833, doi: 10.1016/j.tust.2022.104833.

[3] Animost Team, “What is an Animation production pipeline in real-time?, animost.com, https://animost.com/tut orials/what-is-an-animation-production-pipeline-in-real-time/, (accessed October 6, 2025)

[4] S. Choi, “An Aesthectic Study on 3D Digital Animation by <Coco>”, Cartoon & Animation Studies, no. 52, September 2018, pp. 133-157, doi: 10.7230/KOSCAS.1338.52.133.

[5] M. S. Kim, “A Study on the Visual Direction of 3D Animation through Case Analysis of <Spider-Man: Across the Universe> Focusing on Comparisons with Disney·Pixar”, The Korean Journal of Animation, vol.

19, no. 3, September 2023, pp. 184-205, doi: 10.51467/ASKO.2023.09.19.3.184.

[6] C. W. Lim, D. H. Kwon, “A Study on the Rework Process to Make Effective 3D Animation - With a Focus on Cases of Previz layout Processes”, Cartoon & Animation Studies, no. 59, September 2020, pp. 203-229, doi: 10.7230/KOSCAS.2020.59.203.

[7] I. Wang, “The First Slam Dunk: Inoue Takehiko's scintillating basketball anime captures the thrill of competitive sport”, bfi.org.uk, https://www.bfi.org.uk/sight-and-sound/reviews/first-slam-dunk-inoue-takehikos-scintillating-basketball-anime-captures-thrill-competitive-sport?utm_source=chatgpt.com, (accessed October 6, 2025)

[8] E. Esterella, “Inside the tech innovations made for the new Demon Slayer movie to make that Infinity Castle more infinity”, thepopverse.com, https://www.thepopverse.com/movies-demon-slayer-kimetsu-no-yaiba-yuichi-terao-interview-making-the-infinity-castle-feel-infinite, (accessed October 6, 2025)

[9] W. Champman, “‘Chainsaw Man - The Movie: Reze Arc' Review: The Popular Anime Bloodfest Gets a Sweet and Sad Movie Sequel”, Indiwire.com, https://www.indiewire.com/criticism/movies/chainsaw-man-the-movie-reze-arc-review-1235156950/?utm_source=chatgpt.com, (accessed October 6, 2025)