Integration of Hybrid Animation in a 360-degree Environment *

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Abstract

This paper addresses the lack of an existing pipeline for integrating Hybrid Animation in a 360-degree environment. While works like Google Spotlight's *Pearl* showcase the expressive potential of cinematic VR (Virtual Reality) animation using stylized NPR (Non-Photorealistic Rendering) techniques, they lack the integration of 2D visual elements. We propose a pipeline that leverages accessible tools, including Blender's Grease Pencil for 2D animation, NPR shading for stylized 3D rigs, and a 360-degree render using a metadata injector. Our framework makes hybrid 360-degree animation more accessible and adaptable, enabling future developments and creative applications.

Keywords

Virtual Reality, Hybrid Animation, 360-degree video, Blender, Non-photorealistic Rendering

1. Introduction

The evolution of animation and virtual reality has enabled new forms of immersive storytelling that combine artistic expression with technological sophistication. Hybrid animation, which merges 2D visual elements such as hand-drawn frames with 3D visual elements like computer-generated models, allows creators to achieve expressive, stylized visuals while leveraging modern rendering techniques [1]. Complementing this, non-photorealistic rendering (NPR) shaders enable 3D models to adopt 2D hand-drawn aesthetics, enhancing clarity, style, and narrative emphasis [2]. 360-degree cinematic VR provides immersive experiences through pre-rendered 3DOF content, often utilizing equirectangular projection mapping (EPM) to project spherical scenes onto a rectangular image for VR playback [3].

By exploring the intersection of hybrid animation, NPR shading, and cinematic VR, this paper examines how contemporary techniques can produce high-fidelity, stylized narratives that engage audiences beyond traditional media.

2. Theoretical Background

2.1. Hybrid Animation

Hybrid animation combines 2D visual elements, such as traditional hand-drawn animation, with 3D visual elements, including CGI models and environments, to create a visually rich and unique style [4]. This approach enables animators to retain the expressive qualities and fluidity of 2D hand-drawn techniques while leveraging the depth, perspective, and realism offered by 3D computer-generated elements to integrating these visual elements provides both creative flexibility and technical efficiency, enabling hybrid animation to achieve effects that are difficult to realize using only one medium [1]. Together, these methods demonstrate how the combination of 2D and

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3D visual elements enhances artistic storytelling and expands the possibilities of modern animation production.

2.2. Non-photorealistic rendering

Non-photorealistic rendering (NPR) shaders are techniques used in 3D computer graphics to produce 2D visual effects such as stylized lines, cel shading, and painterly textures on 3D visual elements, giving them the appearance of traditional 2D art By controlling color, lighting, and edges, NPR shaders allow 3D models to mimic hand-drawn or illustrative styles, bridging the gap between 2D hand-drawn aesthetics and 3D computer-generated elements[5]. This approach provides artists with creative flexibility, enabling the production of stylized animations, games, and simulations that emphasize artistic expression over photorealism. NPR shaders also enhance visual clarity and storytelling, particularly in hybrid animation, where 2D and 3D visual elements coexist.[6]

2.3. 360-degree Animation

360-degree Animation, often used in cinematic VR, provides an immersive viewing experience by allowing users to explore a scene in all directions. This format is widely used in virtual tours, animated short films, and immersive storytelling, where audience presence in the environment enhances engagement [7] To achieve seamless panoramic visuals, equirectangular projection mapping (EPM) is commonly employed, projecting the spherical environment onto a rectangular 2D image, which can then be wrapped onto a virtual sphere for VR playback [8]. This method ensures consistent image quality across the full 360-degree view and simplifies the rendering and compositing process. In many cinematic VR applications, content is pre-rendered rather than generated in real-time, allowing for high-fidelity graphics and complex visual effects that would be computationally expensive in interactive VR. Typically, this approach is paired with 3 Degrees of Freedom (3DOF) VR, enabling users to look around freely but not move through the scene, providing a controlled yet immersive narrative experience.

3. Case Study

3.1. A case study of Google Spotlight Stories: Pearl

Several immersive storytelling platforms have explored cinematic VR experiences. More specifically, Google Spotlight Stories allows users to experience 360-degree narratives with interaction and spatial audio. These experiences guide the viewer's attention within the environment, offering an engaging sense of presence.

Pearl is a VR short film created using non-photorealistic rendering (NPR) techniques and 360-degree cinematography [9] It provides an immersive narrative experience within a fully 3D environment.

The production of *Pearl* involved several innovative methods, developed by the research team using a custom in-house real-time rendering engine. Entire cinematic shots were animated in a 3D environment, which allowed the team to generate three distinct versions of the film:

1. An interactive VR version that enables users to manipulate and explore scenes.
2. A theatrical version rendered in real-time for standard viewing.
3. Pre-rendered 360-degree spherical video designed for standalone playback.

4. Method

Our work focuses on developing a hybrid animation pipeline that integrates hand-drawn 2D visual elements, enabling immersive 360-degree VR storytelling. The entire production was carried out using open-source software, providing a standalone workflow from initial concept to final rendered 360° video. The pipeline was designed to maintain visual consistency across 2D and 3D components, ensuring a cohesive, illustrative aesthetic throughout the immersive environment.

4.1. Pipeline

The initial stage of the pipeline involved creating the visual style and look for the project, as shown in Figure 1. Once the conceptual sketches and visual development were completed, the focus shifted to shader development. A non-photorealistic rendering (NPR) shader was created using Blender's node editor as depicted in Figure 2. This step allowed for precise control over shading, outlines, and the overall visual tone of the scene. Through the combination of custom nodes, the shader replicated characteristics of traditional hand-drawn animation, while remaining compatible with real-time rendering requirements. Adjustments to lighting, color gradients, and edge detection were iteratively refined to achieve a stylized look that could be consistently applied to all 3D models in the environment.

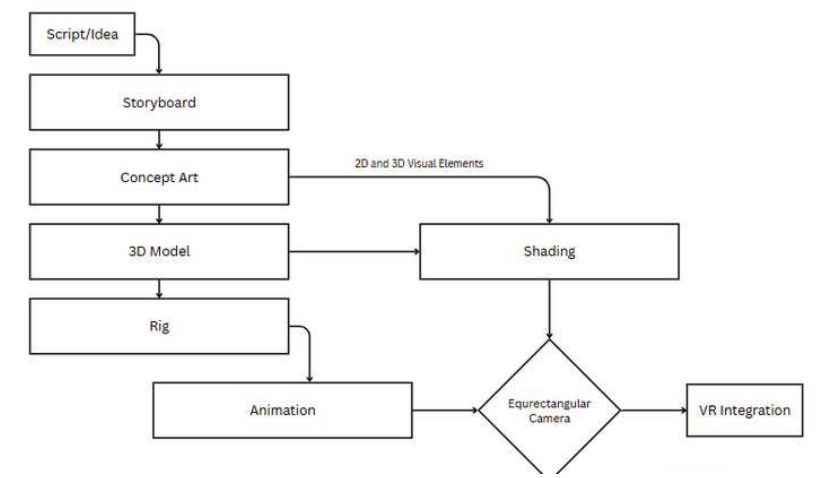

Figure 1: Production Pipeline. Diagram created by the Author (2025).

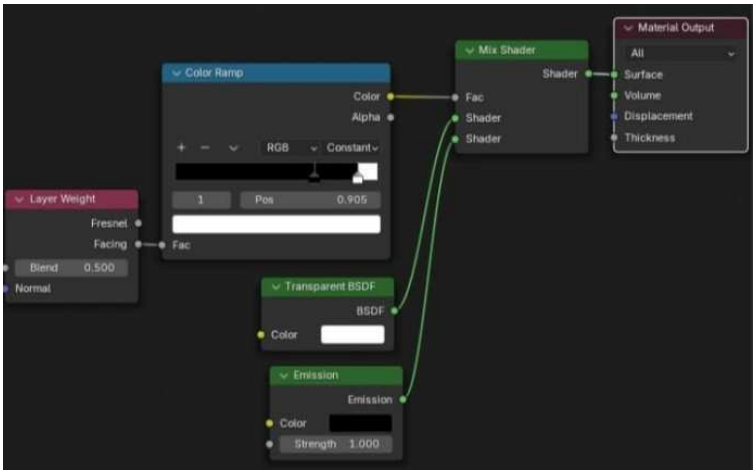

Figure 2: Node system. Created by the Author (2025).

5. Node Editor

Attention was directed toward matching the visual style between the 2D concept art and the 3D models. Concept planes were imported into the 3D scene to serve as reference, allowing for direct comparison and alignment. Textures, materials, and shading parameters were meticulously tuned to ensure that 3D objects maintained the illustrative qualities of the 2D designs. This stage was critical in creating a seamless visual integration, bridging the gap between hand-drawn aesthetics and three-dimensional depth.

5.1. 2D and 3D Matching

The style matching of the animation between the 3D models using the NPR shader, allowing for movement that visually resembled hand-drawn sequences. To further enhance the hybrid nature of the animation, Blender's Grease Pencil tool was employed to add frame-by-frame 2D animations and visual effects directly onto the 3D environment as demonstrated in Figure 3.

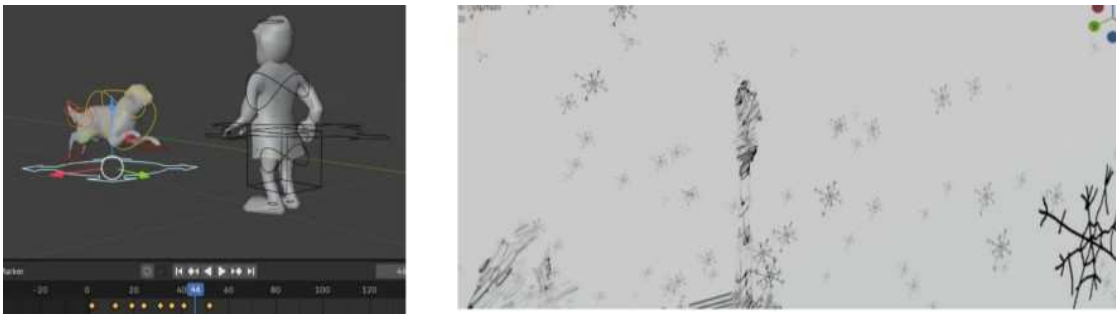

Figure 3: 2D and 3D Mixing. Created by the Author (2025)

This integration enabled the addition of secondary animations, such as dynamic effects of the snowflakes, while preserving the hand-drawn feel within a fully three-dimensional scene. The combination of rigged 3D animation and 2D frame-by-frame effects created a hybrid workflow, extending the expressive possibilities of the VR environment beyond traditional 3D animation.

5.2. Camera setup

The scene layout was then prepared for immersive 360-degree VR viewing. An equiangular camera setup was utilized to capture the entire environment, ensuring that the rendered video could be projected seamlessly onto a spherical surface as shown in Figure 4.

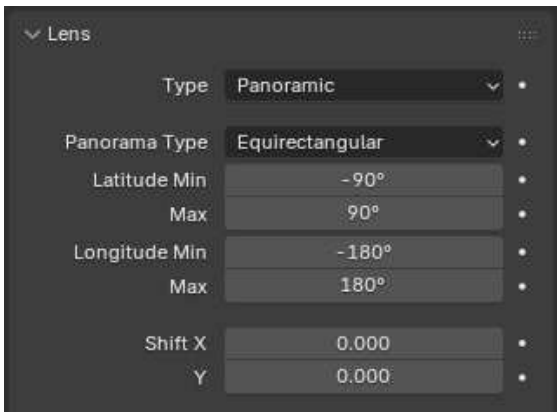

Figure 4: Equiangular: Camera Setup. Created by the Author (2025)

5.3. Equiangular Projection Mapping

To make the video compatible with 360-degree playback platforms, a metadata injector was employed. This tool encoded the equirectangular video with the necessary metadata for spherical projection, ensuring proper display in VR headsets and other immersive viewing devices. A demonstration of the hybrid animated scene into a fully immersive 360-degree VR experience can be seen in Figure 5.

Figure 5: Equirectangular Projection Mapping. Created by the Author (2025).

6. Conclusion

The methodology described above demonstrates how open-source tools can be leveraged to create hybrid animations that merge 2D hand-drawn artistry with 3D environments. The NPR shader development, 2D/3D style matching, Grease Pencil integration, equirectangular camera setup, and 360-degree metadata injection collectively establish a pipeline that supports both creative expression and technical precision. By combining these techniques, the project overcomes the limitations of traditional 3D-only immersive animation, providing a richer and more visually engaging VR storytelling experience.

The integration of hand-drawn animation within a 3D space not only enhances the visual expressiveness of the scene but also allows for greater flexibility in storytelling, enabling interactive and immersive narratives that retain the charm of traditional animation. The hybrid workflow presented here represents a practical solution for producing high-quality VR content with both aesthetic and interactive depth.

However, several limitations remain. Real-time rendering in VR still poses challenges, particularly in terms of maintaining high frame rates when combining complex NPR shaders with layered 2D animation.

Future work should address these limitations by exploring optimization strategies for real-time NPR shading, automation techniques created by a plugin for style transfer between 2D and 3D assets, and more efficient methods of integrating Grease Pencil animations into large-scale VR environments. Advancements in GPU processing and VR display technologies will further enable higher-quality hybrid content, paving the way for more interactive, adaptive, and visually rich immersive storytelling.

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Declaration on Generative AI

The author(s) have employed Generative AI tools such as ChatGPT and Grammarly for minimal improvement by structuring this research paper and checking grammar mistakes.

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Online Resources

360-degree Hybrid Animation Test