Research on Animation Creation Based on 3D Graphics Engines: Postprint

Authors: Chang Jiaojiao, Zhang Guolong

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Abstract

Virtual reality is a high-tech frontier technology that has emerged in recent years, and 3D graphics engines serve as the software foundation for its implementation. By leveraging their inherent advantages, the integration of 3D graphics engines into the animation production pipeline can not only exponentially increase production efficiency by eliminating the substantial time spent waiting for traditional animation software to complete rendering, but also enable real-time modifications during production with exceptionally high editability. This paper classifies and compares current mainstream 3D graphics engines, introducing their basic architecture and production principles. It selects the popular Unreal Engine—Unreal Engine 4, describes its workflow for 3D animation production, analyzes its differences from traditional 3D animation production methods, and explores the future commercial development demands for animation production through Unreal Engine. The involvement of 3D graphics engines has significantly advanced the development process of 3D animation production.

Full Text

Media Industry · Media Practice: Research on Animation Creation Based on 3D Graphics Engines

Abstract: Virtual reality is an advanced frontier technology that has emerged in recent years, and 3D graphics engines serve as the software foundation for its implementation. By leveraging their inherent advantages, 3D graphics engines integrated into animation production workflows can not only exponentially increase production efficiency by eliminating the need to wait extensively for rendering in traditional animation software, but also enable real-time modifications during production with exceptionally high editability. This paper categorizes and compares current mainstream 3D graphics engines, introducing their basic architecture and production principles. Focusing on the popular Unreal Engine

4, it describes the workflow for producing 3D animations, analyzes its differences from traditional 3D animation methods, and explores future commercial development needs for animation production through game engines. The integration of 3D graphics engines has significantly advanced the development of 3D animation production.

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Authors: Chang Jiaojiao, Zhang Guolong

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1. 3D Graphics Engines

3D graphics engines have undergone more than 20 years of development and have become the most widely used commercial engines worldwide. They are employed in numerous works across PC games, console games, mobile platform games, VR games, real estate design, industrial simulation, military applications, and other fields. Consequently, an increasing number of developers are joining the ranks of 3D graphics engine development.

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2. Mainstream 3D Graphics Engines

Currently, a large number of game visual effects and film visual effects companies have begun focusing on 3D graphics engine research, independently developing various application software. The five mainstream engines are the OGRE engine, Unreal Engine 4, Unity engine, Gamebryo engine, and Bigworld engine. Among these, OGRE is a free, open-source engine, while the remaining four are commercial engines requiring licensing fees.

In terms of basic functionality, the OGRE engine features a fixed rendering pipeline, render-to-texture capabilities, font rendering, and graphical user interfaces. Its lighting system includes per-vertex and per-pixel shading with light mapping. Scene management employs ordinary methods, BSP trees, occlusion culling, LOD, and Octree structures. The texture system encompasses basic textures, multi-texturing, bump mapping, projective texturing, and volume textures. Its physics system provides collision detection and cylinder-based interactions. Unreal Engine 4 similarly offers a fixed rendering pipeline, render-to-texture, fonts, and GUI elements, with per-vertex and per-pixel shading plus light mapping. Its scene management uses ordinary methods, BSP trees, portal-based visibility determination, occlusion culling, PVS, and LOD. The texture system includes basic textures, multi-texturing, and projective textures, while its physics system handles collision detection, rigid bodies, and vehicle physics.

Unity engine provides comparable baseline features with a highly sophisticated lighting and shadow rendering system, built-in PhysX physics engine, and similar scene management and texturing capabilities. Gamebryo engine integrates PhysX physics and utilizes multi-threaded management systems with PVS for scene management. Bigworld engine employs a quadtree scene management system supporting seamless indoor-outdoor environments, with relatively simple physics implementation.

Regarding animation and interaction capabilities, OGRE' s animation system supports inverse kinematics, skeletal animation, skeletal animation blending, and motion blending, but lacks AI system support. Unreal Engine 4 supports keyframe animation, skeletal animation, and animation blending, with AI systems for pathfinding, decision-making, finite state machines, and scripting. Unity supports animations exported from DCC tools and script-controlled playback, but requires custom AI scripting as it lacks built-in AI systems. Gamebryo supports skeletal animation, facial animation, hierarchical animation, animation sequences, and blending between animations and physics simulation results, with AI support through the XaitmentAI middleware. Bigworld supports complex skeletal animations with more than four bones and includes AI capabilities.

For special effects functionality, OGRE supports environment mapping, lens flares, billboards, particle systems, motion blur, skyboxes, and water fog effects, but lacks audio and networking support. Unreal Engine 4 supports lens flares, billboards, particle systems, skyboxes, water, explosion effects, decals, fog, and lens effects, along with 2D and 3D audio and client-server networking. Unity features particle systems, tessellation technology, bump mapping, polygon surface lighting, environmental effects, and water effects, with support for real-time 3D graphics mixed audio/video streams and networking from single-player to real-time multiplayer. Gamebryo supports particle systems, HDR, DOF, and common effects, utilizing Audiokinetic' s Wwise audio middleware and a modular, extensible networking library. Bigworld supports extensive depth-of-field local contrast, gain, explosion, and smoke effects, with Doppler-effect-based audio processing and client-server networking using RedHat Linux servers.

Each engine possesses distinct advantages and disadvantages, making it difficult to evaluate performance using uniform standards. Nevertheless, after years of development, numerous successful cases have been produced using 3D engine technology.

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3. Traditional 3D Animation Production Methods

The evolution of traditional animation production technology has progressed from single-machine rendering to network rendering, with various cities establishing their own software park rendering farms for enterprise use. Traditional 3D animation workflows typically utilize Maya as the primary platform, supplemented by other DCC tools and renderers. This pipeline, adopted by most animation studios, follows a sequential process: modeling, rigging, animation, texturing, lighting, and rendering. Centered on Maya with other DCC tools providing support, this represents a linear, non-destructive workflow.

The advantages of this approach include mature craftsmanship, high controllability, abundant talent reserves, smooth operation within existing talent structures, and strong team cohesion. However, the disadvantages are equally significant: the technical requirements necessitate numerous pipeline stages and large team sizes. Post-rendering modifications require repeating previous stages, resulting in high revision costs and substantial team 磨合 expenses.

Contemporary 3D graphics engines enable more rapid evaluation of modified models, scenes, and lighting. With real-time rendering technology, engines facilitate immediate adjustments to lighting effects, material textures, and special effects, saving substantial rendering time costs. This increases the time available for lighting and material evaluation, making it easier to achieve superior results.

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4. Animation Production Based on Unreal Engine 4

Unreal Engine 4, developed by Epic Games, represents the latest version of the premier Unreal Engine. As a game development platform, it provides developers with extensive core technologies, data generation tools, and foundational support. While widely recognized for game development, its exceptional visual quality has increasingly attracted applications in film, television, advertising, and other fields. Animation produced with game engines is termed "engine animation." Leveraging the real-time rendering and modification capabilities of game engines presents an effective solution for improving 3D animation production efficiency.

As a relatively new animation production platform, Unreal Engine 4' s standardized workflows and talent pool remain under development, differing significantly from Maya-based pipelines. The typical workflow involves creating assets (models, textures, rigs, animations, simulations) in DCC tools, potentially using digital sculpting techniques (ZBrush) for character models. After texturing and rigging characters with skeletons or motion capture systems, skeletal animations are imported into Unreal Engine 4, where scenes are constructed, materials authored, lighting established, sequences created, and footage edited for final output.

Compared to Maya' s linear pipeline, the Unreal workflow is non-linear. In this system, every node can be modified during production with exceptional editability and minimal impact on other stages. Most notably, lighting can be adjusted and output at any time. Through the engine' s lighting system, scenes receive illumination that brings architectural environments to life. Unreal

Engine 4' s light source types allow adjustment of color, intensity, position, size, and direction to simulate light sources and effects in animated scenes. By combining static and dynamic light sources with scene objects, each shadow type compensates for the other's weaknesses, enabling rapid rendering of impressively lifelike visual art.

Furthermore, Unreal Engine 4' s material system is highly modifiable, constructed through networks of visual script nodes. This visual editor comprises material visual script nodes, meshes, colors, texture maps, material properties, and material inputs. Each node contains HLSL code snippets to achieve the visual effects required by artists. After importing models, materials are assigned individually, with parameters such as specular highlights, reflectivity, refraction, reflection, and bump mapping adjusted to achieve the most realistic object appearance possible. This process unleashes tremendous creative potential, as traditional pipelines often prevent teams from seeing the final result until late stages, whereas Unreal Engine 4' s workflow imposes no such limitations—a capability officially described as enabling directors to oversee the entire project.

Case Study 1: *Zafari*

Zafari, the world' s first animation produced entirely with Unreal Engine 4, was directed by David Dozoretz and produced by Digital Dimension. Given the exceptionally high number of shots, the production team initially feared insufficient rendering time and followed traditional workflows for the first half. Characters and animations were created in Maya, while lighting, effects, and rendering were completed in UE4. Later, the technical team recommended real-time production in UE4. From a workflow perspective, their lighting and rendering pipeline progressively moved forward and shortened production time. Lighting development occurred simultaneously with layout and set dressing, and once animation was approved, a complete segment could be viewed within an hour.

As the first fully game-engine-rendered animation, the director initially harbored numerous concerns about meeting production quality standards. The project required rendering subsurface scattering, ambient occlusion (AO), vector-based motion blur, and realistic-looking water—all challenges that Unreal Engine 4 accelerated significantly. For a large-scale project like *Zafari* with 10,000 shots, requiring weekly episode delivery with minimal errors, rendering has always been the greatest pressure point. While traditional pipelines might complete one test render per day, UE4 enabled 20 iterations within hours. Each episode required approximately 20 nodes, compared to over 120 in traditional workflows. This allowed artists to see rendered shots ten minutes after completing animation. With all work conducted in Unreal Engine 4, effects became nearly real-time, and lighting, effects, rendering, and compositing were completed within the engine, enabling real-time preview of final results and delivering substantial advantages to the studio. Traditional workflows for such projects typically required three to eight lighting artists; the new pipeline reduced lighting and rendering team size by approximately 75% while increasing artist efficiency and productivity by hundreds of times. This truly empowers designers to work in real time, reducing costs while simultaneously improving quality.

Case Study 2: *The Land of Spirits*

The Land of Spirits (*Diling Qu*), a Chinese animation produced by Shenzhen Zhuohua Interactive Entertainment using Unreal Engine 4, employs a drama-game 联动 (interactive drama-game) format with cinematic quality that has attracted growing attention. Notably, this animation blending Chinese cultural elements features exquisite visuals, with outstanding backgrounds, lighting, character designs, color tones, and linework—achievements largely attributable to its distinctive production methodology.

Using Unreal Engine 4 for domestic animation production represents an innovative and bold attempt. The real-time computation capability enables preview during production, allowing direct adjustments within the engine when content requires modification. This approach not only delivers exceptionally high image quality but also provides significant time-cost advantages. For series animation requiring high quality without 承受 ing massive revision workloads, Unreal Engine 4 participation dramatically improves production efficiency and editability, enabling more creative possibilities. The production team employed bold camera work—including pushes, pulls, pans, and tilts—to create an engaging viewing experience. While traditional animation locks every shot during the storyboard stage with no opportunity for later modification, Unreal Engine 4' s involvement allows extensive experimentation and adjustment, granting creators greater expressive freedom and delivering richer audience experiences.

Shenzhen Zhuohua Interactive Entertainment' s successful use of Unreal Engine 4 to improve animation production efficiency represents a pioneering attempt in Chinese animation. Domestic animation companies are advancing at the forefront of technological innovation and progress. As Unreal Engine 4 continues to optimize and improve, an increasing number of exquisite "engine animation" works will undoubtedly appear in the market.

Production Advantages and Future Prospects

Based on domestic and international applications of 3D engines in animation, using engine technology to optimize production workflows offers advantages across all stages. During initial development, scripts, story structures, styles, character and scene design, and background music require repeated revisions to properly breakdown shots. Traditional animation production demands substantial preparation and manpower for these early modifications. Engine animation enables "real-time modification" and "real-time rendering," leveraging WYSIWYG advantages to present animation segments and shot combinations instantly.

In mid-production, character actions, facial expressions, lip-syncing, atmospheric rendering, and scene transitions involve massive workloads requiring high efficiency. Engine technology provides better control over frame content through executable code. For instance, crowd animation in shots—such as battle scenes with thousands of soldiers—cannot simply copy-paste characters with identical actions. Traditional animation requires individual adjustment of each character; adjusting 500 characters at 10 minutes per character would demand nearly four days. In contrast, engines can control crowd animation through scripts, adjusting walking, running, attacking, and evading actions via script controls within hours.

Post-production requires extensive editing and effects work. In traditional animation, effects demand specialized personnel for repeated revision and refinement, consuming substantial manpower, resources, time, and creativity at high cost. Engine technology enables real-time modification and rendering of effects through particle system parameter adjustments, achieving diverse visual presentations. Numerous effects plugins can also create dynamic atmospheres with versatile controls.

Moving forward, further promotion of 3D engine technology in film and animation production will strive to satisfy consumers' high-quality audio-visual enjoyment and promote common development in the industry economy. Given China' s current situation, engine-based animation production remains in its initial development stage, requiring technicians to further research engine internal structures. At present, using 3D engines for animation production is entirely feasible with clear advantages, though it has not yet completely surpassed offline rendering technically. This transition will require a development period of several years or even a decade—time for both technological maturation and talent growth. Real-time rendering for animation production will undoubtedly become the industry mainstream.

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(Author Affiliation: School of Art and Design, Lanzhou Jiaotong University)