

Literature Review Paper:

Applications of Game Engine Technology in Animation and Other Fields

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With the onset of video games and consoles in the 1970's and 1980's, developers started from the ground up using basic programming languages including C and C++. As games started to sprout and grow further in complexity and scale, the development side of things got exponentially more difficult. As a result, it became increasingly clear that developing with pure code alone would not be feasible to be able to meet tighter release windows and the idea of game engines started to come into fruition. A game engine, by definition, is a framework that is specifically designed to assist in the development of video games, coming packed with a variety of useful libraries and helper codebases. An example of this includes the simple game engine designed by Nintendo during the development of the game *Excitebike* to be used during development of the first *Super Mario Bros* and, more recently, the game engine *Unreal Engine* used in development of popular games such as *Fortnite* and *Borderlands 3*. With *Unreal Engine* specifically, it was first released in 1998 with features and tools that allowed development studios to make a variety of different games ranging from RTS (Real-Time Strategy) games to FPS (First-Person Shooter) games, but in the past 2 decades, the game engine has grown into a much more powerful tool that can be used in many different applications other than video games. As the gaming industry grew to unimaginable proportions, requiring more funds than blockbuster film productions and more components for bigger Triple-A titles, including various in-depth simulation technologies, industry-leading animation tools, and hyper-detailed sound systems to allow for the best immersion quality in video games. In turn, with these tools being bundled into one neat package, studios and even research teams began to use *Unreal Engine* and even other game engines like *Unity* to develop movies, animations, and even simulations for comprehensive research. In this literature review, the ways in which game engine technology can be used in today's industries, including animation, simulation, education, and movie design, will be examined. Additionally, these applications will be compared to their industry-standard counterparts to see which aspects need improvement and if game engine technology can be the basis for productions going forward.

The first of many applications using game engine technology as a base that will be reviewed here is animation, and to investigate this field, starting off with an insight into the making of an animated trailer for a well-known video game will give a good impression as to how the animation development pipeline is shifted or affected by the usage of a well-established game engine in the industry. **Fortnite: Supercharging CG Animation Pipelines with Game Engine Technology**, written by Brian J. Pohl, Andrew Harris, Michael Balog, and more, investigates the process of developing an animated trailer for the game *Fortnite* using *Unreal Engine*, both created by Epic Games. Throughout the paper, one of the main advantages provided by working with *Unreal Engine* is the real-time interactivity. After explaining the development processes in the paper, Pohl et al. (2017) concludes:

In traditional 3D animation workflows, the final piece of the puzzle is achieving beautifully rendered results..., [and] its usually accomplished through a considerable investment in computer hardware... This is becoming more and more challenging with the increasing demands on studios to produce high quality content at a reasonable price and within a reduced timeframe. New workflows based on realtime technologies are becoming the next evolutionary step to addressing these concerns.

Using real-time rendering through *Unreal Engine*, the studio was able to have a streamlined animation development pipeline that made it more flexible to make changes to scenes. This included dynamic lighting and shadows, real-time effects such as volumetric fogs and shaders, and active fluid simulations that are all able to be played back without the need to create a separate render using considerable resources every time. This does make a good argument against the industry standard animation pipeline and methods used, particularly for saving production time traditionally used for rendering. However, this paper fails to give proper figures and experiments that compares the two pipelines. Due to this oversight, these remarks are merely hearsay that have no backing from any substantial research.

Unfortunately, a more substantial study of these animation pipelines must be done to make a proper argument in defense of the *Unreal Engine* animation pipeline.

Continuing from the previous paper, looking into the differences of the game engine pipeline and the traditional pipeline for animation will definitively show the advantages and disadvantages of either method or whether the game engine alternative is the better choice. To do this, it is also necessary to go deeper into computer graphics programming and the intricacies of how three-dimensional graphical engines can work with key-frame animations of today. **Application of Engine Technology and in 3D Animation Production**, written by Linye Teng, explores the two pipelines in detail and investigates the development of an animation engine using OpenGL. To start, the paper goes over the traditional animation pipeline and how rendering can severely slow down the development process depending on the number of changes that need to be made, like the last paper about the *Fortnite* animation. After explaining the different stages of animation production and going over the tasks of the early planning stage, Teng (2021) remarks:

Due to the lack of intuitive effect presentation, it often requires continuous Adjustment; if the engine's "real-time rendering" and other functional advantages are applied to the early stage of 3D animation production, the producer can realize the visualization of the lens effect without performing partial and key frame rendering as before, which helps the producer to understand the script Modification of the lens and optimization of other details.

This is like the conclusions from the first paper: how real-time rendering in the animation pipeline can drastically lower the amount of time used up in the rendering stages of production. After this remark, he goes through the basic engine functions and optimizations and how they can be implemented into fledgling game/animation engines. His findings on the specific implementations of features such as HDR, the halo effect, and the usage of helper libraries are in-depth and very thorough. However, when

looking specifically on what is said regarding the two different animation pipelines, it is a similar story as the previous paper where there isn't much research done on the comparison of the two on any metric, making the claims about real-time rendering technologies, again, merely hearsay without substantial research for backing. Hopefully for future studies, these two pipelines will be looked at more in-depth.

Moving away from specifically animation production, movie production pipelines can also be drastically changed with the use of game engine technology. While the previous two papers mention the benefits a game engine can provide in the rendering stage of animation, both fail to offer evidence and figures to back those claims. However, **Interactive movie design based on the game engine technology**, written by Zhixin Fang, Libai Cai, Guo Juan, and Gang Wang, looks over the two different pipelines and compares the two in detail to determine if using game engine technology and, by extension, real-time rendering is the future of interactive movie production. After beginning with the background of mass media and how video games and film have become staples in today's media-obsessed society, Fang et al. (2020) mentions how *Unreal Engine 4* supported the VFX implementation in Steven Spielberg's *Ready Player One* and *Blade Runner 2049*:

This approach is gradually replacing the usual sketchbook-like approach to storyboarding. Movie creators can call the preset model, action, lighting and other material library, quickly complete the role and scene scheduling, and watch the picture effects with the support of the real-time rendering engine.

Continuing, Fang et al. (2020) explains, "In today's production quality requirements continue to improve and the production cycle gradually shorten the situation, efficient real-time rendering ability has become a strong core competitiveness." After this, the paper remarks on another famous producer's work and how game engine technology supported another recent hit, Jon Favreau with his *The Mandalorian*. At SIGGRAPH 2019, Jon Favreau explained how using game engine technology, the team

was able to shoot *The Mandalorian* using virtual sets and LED walls to have a dynamic green screen and to be able to shoot the final shots with all the CG effect implemented into the scene, allowing for more flexibility in adjustment and tweaks of all aspects of the final shots. After reading the first two papers discussed earlier, this paper investigates the usage of game engine technology in films today by looking at recent hits and how directors and producers used game engine technology to support the filming and visual effects. Additionally, it delved deeper into interactive movies and how interactivity is becoming increasingly more sought out in popular media, and how game engine technology supported that niche by offering a platform to plan out the story paths and different endings. Overall, this paper has succeeded in presenting game engine technology as the new frontier for visual effects, animation, and film artists while supporting this claim with strong examples and pipeline diagrams.

Next, looking into some of the specific components of movie design and animation and how they are influenced by the onset of game engine technology. One of the most important aspects of animation is character design, and the processing of those designs can be crucial to the success of an animation production. In the paper **Development of Character Design Frameworks using Game Engine: Unreal Engine**, written by Kongdee Nop, Jintapitak Manissaward, and Tangto Oattarapon, explains how using game engine technology improved the frameworks of character design in a more efficient, expedient, and useful manner. Like the other papers discussed, the problem of the rendering stage when completing the character model in Autodesk Maya was addressed. Simply put, due to the computer power and time that is required, rendering can severely hamper the progress of production and lead to various roadblocks like hardware limitations not being able to finish a render. To remedy this issue, the team here switched over to *Unreal Engine 4*, and immediately felt the difference with the real-time rendering, blueprint system, and VFX, animation, and material toolsets that were available for use. After doing research comparing the Unreal pipeline and traditional pipeline, Nop et al. (2019) states:

The impact results of this study which have been found are a new pattern of new workflows by changing software and illuminated some unnecessary process without decreasing a quality... Somehow, any software in this digital society might cross each other unbounded which is very helpful to evolve a concept of frameworks more and more.

Compared to the traditional pipeline using the industry-standard Autodesk Maya for modeling, animation, and rendering, the alternative Unreal pipeline proved to fair just as well if not better in terms of time and resources. Not only did the alternative pipeline streamline the production as *Unreal Engine 4* had tools for VFX, animation, and materials/textures, but it also made the workflow more flexible as all the tasks were able to be completed in the game engine itself. As mentioned, many times earlier, having the benefit of real-time rendering while designing, staging, and animating characters in production allows for more control over scenes and gets rid of one of most time-consuming phases without any drawbacks. As such, game engine technology has advanced enough to the point where its tools can provide to productions other than game development, and this paper, with its workflow experiments and findings, adamantly defends that claim and suggests that other fields should investigate alternative programs for the possibility of finding potentially better production workflows.

Moving away from film and animation pipelines, looking to the educational applications of game engine technology can provide a new insight as to how the tools of certain game engines can be used to help further educational projects. **Development of laparoscopic cholecystectomy simulator based on unity game engine**, written by Jinglu Zhang, Yao Lyu, Yukun Wang, and more, describes the process in which a Laparoscopic Cholecystectomy VR surgery simulator was created for educational purposes. After going through the several simulation components that had to be developed for the simulator and commenting on the feedback that was received, Zhang et al. (2018) reflected on the benefits and detriments of using a game engine, and one point reflected on smaller timeframe needed for development:

For the self-developed simulators, reinventing essential functional blocks (rendering, physics and event handling components) for a simulator is time-consuming and leads to huge development expenditure. In our case, we spent about four months for the whole development cycle, but it took one year or more for a simulator like [Qian et al. 2015] to achieve the similar function.

After using the Unity Engine in this case extensively to implement features including Haptic Rendering and Volumetric Soft Body Simulation, all made possible with the NVIDIA Flex simulation library, the first version of the VR simulator was completed and used in testing for evaluation and feedback. While the technology being tailored for game design did lead to limitations regarding physical simulation and precise animation, the Unity engine employed here allowed the team to complete their objective of making a simulator in a timely and smooth manner without sacrificing any major components. This paper offers a new insight into how a simulator is developed through a widely used game engine without proprietary equipment, and the result, after looking at the figures, ended up better than expected. However, the evaluation and research testing done after the simulator was developed was lacking as with only 10 participants in the study, the results are fairly limited in its potential for application. Putting that aside, the development process described here gives valuable information on the modularity and flexibility of a game engine.

Lastly, looking at another application with a primary role in education made with game engine technology can round out the information that has already been established in the last paper. **Using Game Technology to Automate Neuropsychological Tests and Research in Active Aging**, written by Dan C. Rotaru, Sara Garcia-Herranz, Manuel Freire Moran, and more, investigates the usage of game engine technology to implement a computerized version of the 15 Objects Tests to compare against the paper version and support research. In the conclusion section of the paper, after explaining the results of the study and what it implies, Rotaru et al. (2018) mentions the many areas that game engine technology is being applied in:

Instances of games or applications for non-entertainment purposes using game technology have been successfully applied in education, medicine and other fields, and are collectively called “serious games”. We are developing multiple serious games for testing cognitive impairment that focus on different cognitive skills. The future work of this study is to be validated with further game-like applications. The subjects will be presented with different situations that require quick reaction and focus on the details of the situation.

After completing the computerized version of the 15-OT and comparing it to the paper version in the study, the results came out to be almost equivalent in some metrics and in favor of the paper version in other metrics. However, in terms of automation and research into aging, the computerized version offers valuable real-time data into identifying cognitive issues and catering to individualized tests. Since this was the first test performed with this kind of application, the study was limited in its sample size, only focusing on 18 healthy old participants for the initial tests. While the authors have stated that they intend to expand their testing to include more demographics, this paper is rather limited in its research backing, like the previous paper.

In this literature review, the applications of game engine technology in other industries such as animation, simulation, education, and movie design were examined through several studies conducted in the past few years. On top of this, these studies noted how game engine technology would eventually improve and become more practical and time-efficient than the industry standards in certain scenarios, and from looking at these studies, the real-time rendering technologies incorporated into these game engines have made the biggest difference in the workflows in all the fields discussed in the paper. Especially with animation, rendering can take up a considerable amount of time, and when a long film or simulation is being rendered, it can hamper development and put it to a standstill, which is not ideal for making release windows. However, with the use of real-time rendering, developer studios in many fields can see the outcome on the spot and apply feedback faster than the normal pipeline. While the

technology isn't perfect and sometimes the picture of regular rendering looks better than the real-time render, as the technology improves, the public will start to see the gap closing, and soon, I believe that real-time rendering will overtake the classic rendering method in the industry standard pipeline. Other than this important aspect, game engines offer a slew of useful features and tool that allow simulation developers and film makers to plan out their products in a concise and organized manner. In this sense, the game engines are the jack-of-all-trades software that have all the tools necessary for multiple applications available and ready for use, without the need for secondary applications. This also cuts down on planning and development time, and this is sure to make its way into the mainstream due to how convoluted and difficult the traditional animation pipeline can be. With all of this in mind, I believe that more studies with bigger sample sizes need to be done to really show proof that this technology can make a noticeable difference in development because as it is now, the research being done currently doesn't have proper sample sizes to make the studies and experiments worthwhile. However, if those bigger tests and experiments are conducted over a significant period of development, then many companies and industries will start to recognize the virtual gold mine that game engine technology actually is.

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