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Using Unreal Engine 5 to realistic rendering of scenes

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Abstract: This scientific paper discusses the Unreal Engine 5 (EU5) game engine and its tools in the field of realistic scene rendering. This real-time 3D image creation tool is used by developers to create photorealistic visuals and immersive experiences. Some of the main features of this graphics engine are presented, such as Nanite, Lumen and MetaHuman Creator, as well as the contributions that its use can bring to the industry of video games, film, architecture, virtual reality.

Keywords: Unreal Engine 5, 3D, Realistic Render Technologies, Nanite, Lumen, MetaHuman Creator, Live Link, ArchViz,Virtual Reality

1. Introduction

Realistic rendering is the computational process of creating virtual images that look extremely similar to reality, involving the calculation of light, shadows, reflections, and textures to accurately reproduce the visual details of digital objects, environments, or scenarios, providing a compelling and immersive visual experience.

To create an image, specific methodologies and special software and hardware are used. Traditionally, the rendering of 3D movies or scenes has been done using proprietary software. For example, Pixar used Renderman for all their movies, while IKEA used 3DS MAX and Vray to create their famous realistic furniture catalogs.

Realistic rendering is playing an increasingly crucial role in developing immersive user experiences, such as in video games, where users feel completely immersed in the narrative and environment. In the film industry, rendering is used to create incredible visual effects, allowing complex scenes to be previewed and dramatically reducing production costs.

Realizing the advantages that this powerful EU5 graphics engine can bring to these industries by making the most of its potential is one of the goals of this article.

Thus, after a brief reference to the history of the creation of this graphics engine since its first version, successive updates to the current version today, some of its main features are presented: Nanite, Lumen and the MetaHuman Creator, and the practical applications in the sectors of ArchViz (architectural visualization), Live Link and Virtual Reality.

The methodology used for data collection to write this scientific paper, was the document analysis of articles about realistic rendering in Unreal Engine 5 game engine, and selected studies through Google Scholar and Mendeley platforms, using keywords such as Realistic, Unreal Engine 5, Metahumans, Lumen and Nanite.

2. Unreal Engine 5 History

Before presenting the engines that employ UE5 it is interesting to talk a bit about its past. It is a game engine developed by the company Epic Games, initially released in 1998 and that has gone through several updates, with the EU5 version being released in 2021. Today there is already version 5.2

Its main goal is to provide a complete and powerful platform for developers to create high-quality games, offering a wide range of features, including advanced rendering, realistic physics, animation, artificial intelligence, and more. UE5 acts as an interface between developers and the hardware of the computer or console. It provides a scripting language called Blueprint, which allows the creation of game logic without the need to know how to program. In addition, it also provides support for programming languages such as C++ for more advanced customization. It uses a system of "components" to build objects into the game, allowing developers to easily combine and reuse functionality. This increases efficiency and speed in development.

Currently, the engine allows the creation of games for various platforms, such as PC, consoles, mobile devices, and even virtual and augmented reality. In addition, it is also used for creating interactive experiences in other areas, such as architecture, data visualization, and simulations.

EU5 has become one of the most popular and powerful engines in the games industry, driving the creation of titles featured in technology innovation magazines and events. Its tools empower artists to create scenes indistinguishable from real life. This software offers a very comprehensive set of tools that assist in the creation of scenes. With this set of tools this software pushes the limits of rendering, resulting in virtual environments that are very close to photorealism [11].

3. Main features of UE5

3.1. Lumen

Lumen is a real-time global lighting system introduced in EU5, and is designed to provide high-quality global lighting in 3D environments, thus offering realistic and efficient results. One of the main features of this technology is its ability to indirectly simulate global illumination without the need for time-consuming pre-calculations. It uses a technique called voxel cone tracing to calculate the indirect lighting in the scene, allowing developers to visualize the results in real time during environment creation [1], as illustrated in Figure 1.

Figure 1: Cena realista com iluminação do Lumen

Source: https://vertexmode.com

Using Lumen allows for more accurate and realistic lighting than previous methods and better performance because it can be done in real time [2]. It is also compatible with other EU5 technologies, such as Nanite, which allows the rendering of objects with an extremely high level of detail, and the Chaos physics system (Chaos), which simulates destruction and realistic interaction of objects.

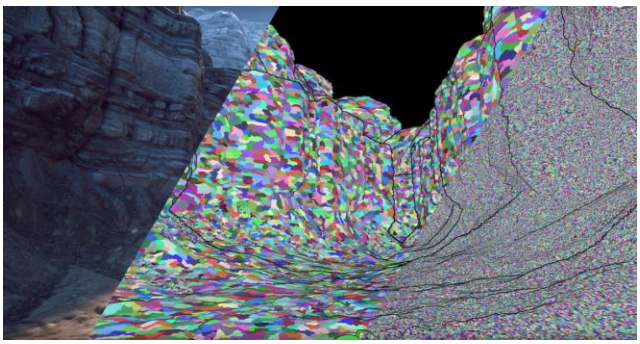
This tool also has advanced features, such as the ability to handle accurate reflections and refractions, smooth shadows, and the ability to adapt to changes in lighting in real time, allowing developers the ability to create highly immersive and realistic environments without compromising performance [1]

3.2. Nanite

Nanite is a virtualized geometry system in Unreal Engine 5 that uses a new internal mesh format and rendering technology designed to handle large amounts of geometry efficiently, allowing developers to create highly detailed, realistic environments in real time. Unlike traditional rendering methods, Nanite does not rely on the use of LODs (levels of detail) to optimize the rendering of complex objects. Instead, it uses a geometry data streaming system, where data is loaded in real time as needed. This means that all geometric details of an object are preserved, regardless of the object's distance from the camera [3].

The company Epic Games, drew on research done by Nvidia a few years ago on mesh clustering techniques to develop a new approach to optimize computations. Meshes are three-dimensional objects that make up the geometry of an environment or character within a game or application. It is a digital representation of an object or shape in three dimensions, composed of a collection of vertices, edges, and faces. Thus, instead of basing the calculations on the meshes themselves, the calculations are based on dividing the meshes into zones (clusters) to better understand the geometry and shape of the object and thus perform an appropriate calculation according to the visualization needs at a given time [4]. Each element is divided into clusters (groups of triangles) which, in turn, are divided into sub-clusters (128 at most), depending on the complexity of the shape. Nanite takes into account the number of pixels on the screen to calculate the complexity it must present to obtain the best quality of representation [4]. Figure 2 represents the changes of the clusters according to the distance from the camera.

Figure 2: Visualization of Nanite clusters



Source: https://80.lv/articles/discussing-the-possibilities-and-drawbacks-of-unreal-engine-5-s-nanite/

This can be considered a LOD approach, that is, developers create simplified versions of an object at different levels of detail. As the player

moves away from the object, the engine replaces the high quality version with a lower quality version, saving processing resources and memory. This is especially important in games with open worlds, where a large number of objects are visible at the same time. The main difference with Nanite is that it is not provided by an artist during the design of a game, but is generated automatically as a function of the topological complexity of the clusters, the geometry. The complexity of a scene is no longer based on the geometry, but on the topology of the objects [4].
It also uses advanced texture compression technology, which reduces the size of geometry data without significant loss of visual quality and also benefits from the processing power of modern GPUs, which can handle large volumes of geometry data efficiently. With Nanite, developers can create vast, detailed environments with highly complex objects such as rocks, vegetation, architectural details, and more.

3.3. MetaHumans

O MetaHuman Creator é um sistema avançado de criação de personagens humanos introduzido no EU5. Oferece uma solução completa para criar personagens 3D altamente realistas e expressivos de forma rápida e eficiente, onde os desenvolvedores têm acesso a uma biblioteca crescente de modelos de personagens pré-fabricados, que servem de base sólida para a criação de novas personagens. Esses modelos são altamente detalhados e incluem elementos como pele, cabelo, olhos e roupas, todos projetados para serem facilmente personalizáveis [5], como é possível observar na Figura 3.

Figura 3: MetaHuman Creator

Fonte: https://www.popsci.com/story/technology/pic-games-new-metahuman-digital-creator/

This System allows you to adjust various character attributes, such as face shape, body structure, age, ethnicity, and more. It offers full control over facial expressions, allowing highly realistic and expressive facial animations. One of MetaHuman's main advantages is its efficiency. With the use of optimization algorithms, character creation can be accomplished in a matter of minutes, compared to traditional methods that can take hours or even days, allowing developers to save valuable time and resources in character production [5].

MetaHuman Creator is fully compatible with the other advanced features of EU5, such as Lumen and Nanite, meaning that characters created with MetaHuman can benefit from these technologies, resulting in exceptional visual quality in real time.

4. Performance

EU5 performance is a key focus area for developers and users of this platform. While performance can vary depending on the hardware used and the complexity of the scenes and resources applied, it is still designed to deliver a high-performance experience.

As described earlier, the innovative tools introduced in EU5, are very optimized for those

developing on this graphics engine and represent a great advantage.

\The main advantages are:

- **High-fidelity graphics:** the engine uses advanced technologies, such as Lumen and Nanite, to produce highly detailed and realistic graphics. This enables the creation of immersive and visually stunning environments.

- **Production efficiency:** By reducing the need for intermediate work required in previous EU versions such as creating LODs or Low Poly models, EU5 helps developers save time and effort during the design process. This results in more efficient and faster production.

- **Compatibility:** the engine offers support for a wide range of platforms, from console computers, virtual reality and even mobile devices. This allows developers to reach a wider audience and explore different markets.

- **Compatibility with emerging technologies:** UE5 is designed to adapt to the latest technological innovations, such as ray tracing, virtual reality, and augmented reality. This allows developers to explore new immersive experiences and take advantage of the most advanced technologies available.

- **Robust community and support:** the engine has an active developer community as well as comprehensive support provided by Epic Games. This makes it easy to share knowledge, solve problems, and access additional resources, helping developers maximize their creative potential.

In addition, EU5 offers optimization features such as auto-scaling, which automatically adjusts visual quality and performance according to the capabilities of the user's hardware, thus allowing games and applications to run smoothly and optimally on a wide range of devices. However, it is important to note that the performance of EU5 also depends on proper optimization of code, efficient use of resources, and consideration of the limitations of the target hardware. Developers are encouraged to follow recommended optimization practices and perform regular testing to ensure optimal performance in their projects.

5. Practical applications in various industry sectors

5.1. Architecture

UE5 redefines the way architecture and design professionals visualize and present their projects. Combining creativity and technical precision, the UE5 offers an interactive visual experience, real-time rendering, natural light simulation, and many other features that enhance the ArchViz (architectural visualization) process. It is then possible to create highly realistic and interactive architectural visualizations. Clients can explore the virtual spaces in real time, walk through the environments, interact with objects, and experiment with different designs and materials. This immersive approach allows users to have a more accurate and engaging perception of projects, aiding in decision making and visual communication.

Lumen provides dynamic global lighting in real-time, allowing shadows and reflections to adjust instantly as the environment changes. Daylight simulation is an important feature for architects, as it allows them to analyze the lighting in the space at different times of the day or under different weather conditions.

Collaboration and design review is also made easier. The platform offers features that allow multiple people to work together on an architectural project. Team members can make changes in real time, share comments, and conduct interactive reviews. This streamlines the design process, improves communication between those involved, and reduces the need for physical prototypes [6].

Integration with virtual reality (VR) and augmented reality (AR) devices is another powerful feature for ArchViz. The platform allows users to experience spaces at an immersive scale, offering a more accurate perspective and the feeling of actually being present in the environment. VR and AR are also valuable tools for presenting and selling projects to potential clients, allowing them to visualize and interact with the space even before the physical construction [6]. Figure 4 demonstrates a possible result achieved in UE5.

Figure 4: Archviz

Fonte: https://www.unrealengine.com/en-US/blog/unreal-engine-5-opens-new-doors-for-architectural-visualization?sessionInvalidated=true

5.2. Cinema

An innovative tool that may eventually replace animation capture for theaters through specialized suits is Live Link. This plug-in provides a common interface for transferring animation data into Unreal Engine 5 from external sources, such as Autodesk Maya 3D development software, Motionbuilder or motion capture systems [7].

With Live Link, the user can import keyframe-based animations or else a character that moves identically to a mocap actor, in real time.

After installing the plug-in, the Live Link client can be accessed through the EU5 menu. This way the source (external software), the object (camera, character, etc. in the external software) and other external) and other settings can be modified. Then the character that needs to be animated is defined as a mesh Actor Blueprint component, and also an Animation Blueprint. The node connections required in these projects vary depending on the source software used. The actor is then placed in the level and, if everything is set up correctly, the character should start moving according to the game mode. This movement can be recorded and turned into an animation sequence [8].

Recent models of Apple's iPhone and iPad offer sophisticated facial recognition and motion tracking capabilities that distinguish the position, topology and movements of over 50 specific muscles on a user's face. If your iOS device has a depth camera and ARKit capabilities, you can use Epic Games' free Live Link Face application to perform complex facial animations on 3D characters in Unreal Engine 5, recording them live on your phone and in the engine [9]. This link can be made directly with a MetaHuman, as can be seen in Figure 5.

Figure 5: Real-time capture of a MetaHuman (Live Link)

Source:
https://www.youtube.com/watch?v=pnaKyc3mQVk

5.3. Virtual Reality

Virtual reality has been widely adopted as an effective team training tool in a variety of industries because it offers an immersive and interactive experience, allowing participants to simulate real work situations in a controlled and safe virtual environment. It can also facilitate collaboration between team members, even if they are physically far apart. Participants can share the same virtual environment and work together to solve problems, practice communication skills, and improve coordination and teamwork. It allows you to provide immediate and personalized feedback to training participants, through real-time analytics and metrics, you can assess individual and collective performance, identify areas for improvement, and offer specific guidance to enhance skills and competencies, it also allows you to create highly flexible and adaptable training scenarios.

A wide range of situations and contexts can be simulated, from emergency and rescue training to sales and customer service simulations. Scenarios can be adjusted according to the team's specific needs and objectives [10].

6. Conclusion

In summary, this scientific state-of-the-art review article on the topic "The use of Unreal Engine 5 for realistic scene rendering" explored the use of EU5 for realistic rendering of 3D scenes in the architecture, film, and virtual reality industries. Based on the analysis and discussion of the advanced features provided by the EU5 graphics engine, it became clear that this platform offers a set of powerful tools for creating highly realistic 3D environments and its performance is highly beneficial to the developer community.

EU5 introduces features such as Lumen, a real-time global lighting system that allows you to accurately simulate light and produce high-quality visual results. Nanite, a rendering technology system, features a new micropolygon-based geometry system that allows real frame-per-second rates to be maintained without any loss of fidelity and the efficient manipulation of large amounts of geometry without compromising performance, enabling the creation of detailed and immersive environments. MetaHuman Creator, an advanced character creation system, which offers the ability to develop highly realistic and expressive human characters with ease and efficiency, adding even more quality and immersion to rendered scenes. These combined technologies give developers and artists a powerful platform for creating cutting-edge visual experiences, whether for games, film, architecture, or other applications. Realistic rendering of scenes is made possible by the visual fidelity and flexibility provided by EU5. While this study has focused only on the use of EU5, it is important to recognize that realistic scene rendering is a constantly evolving area. New techniques, algorithms, and tools are continually being developed to further improve the visual quality and efficiency of rendering, so academic research must keep up with evolving technology.

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