

**Architectural and Performance Evolution of GPUs:**  
**A Comparative Study of GTX and RTX in Modern Gaming**

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## Introduction

Graphics Processing Units (GPUs) have undergone remarkable evolution over the years, profoundly shaping the landscape of gaming and digital visualization. NVIDIA's GTX and RTX series GPUs represent pivotal milestones in this journey, each offering distinct advancements in performance and rendering capabilities. This research examines the architectural innovations and performance benchmarks of these GPUs, emphasizing how real-time ray tracing introduced by the RTX series transforms visual realism in modern gaming.

GTX GPUs, lauded for their efficiency in traditional rasterization-based rendering, provided a strong foundation for mainstream gaming. RTX GPUs, however, bring to the table groundbreaking technologies like RT Cores for ray tracing and Tensor Cores for AI-enhanced rendering. These advancements enable lifelike graphics with improved lighting, reflections, and shadows, delivering unprecedented levels of immersion.

Using benchmark data from popular games like *Cyberpunk 2077*, *Minecraft*, and *Red Dead Redemption 2*, this paper compares the performance of the GTX 1070 and RTX 3070, highlighting significant gains in frames per second (FPS) and visual fidelity. The study also explores the implications of these innovations for game development, end-user experiences, and the future trajectory of GPU technology.

## Technological Advancements in RTX GPUs

The architectural evolution from GTX to RTX GPUs is characterized by three key advancements:

1. **RT Cores:** Dedicated hardware for real-time ray tracing, enabling realistic lighting and shadow effects. These cores simulate the physical behavior of light, enhancing visual realism with effects like reflections, refractions, and shadows that dynamically change based on in-game conditions.
2. **Tensor Cores:** AI-accelerated features like DLSS (Deep Learning Super Sampling), which boost frame rates without compromising visual quality. These cores apply machine learning algorithms to upscale lower-resolution images, reducing the computational load while maintaining image clarity.
3. **Enhanced Processing Power:** Significant improvements in shader and memory bandwidth, allowing for smoother performance in high-resolution settings, especially for games with high graphical fidelity.

Ray tracing, which simulates the behavior of light in a 3D environment, represents a paradigm shift in gaming visuals. This innovation enables dynamic and interactive lighting scenarios, setting RTX GPUs apart from their predecessors. As of recent releases, ray tracing has become one of the most notable features in enhancing gaming graphics, while AI enhancements like DLSS provide users with smooth performance even in graphically demanding games like *Cyberpunk 2077* and *Minecraft*.

## Detailed Breakdown of Key Innovations

### RT Cores

The RT Cores are specialized hardware units within RTX GPUs designed to accelerate ray tracing computations. By simulating the path of light in real-time, they enhance visual realism with reflections, shadows, and global illumination. Ray tracing in traditional GPUs

is done through software rendering, leading to high computational costs. However, the integration of RT Cores allows real-time rendering of these effects without compromising performance.

Tensor Cores and DLSS

Tensor Cores in RTX GPUs perform matrix operations that are integral to AI-driven rendering techniques. DLSS uses deep learning models to predict high-quality frames from lower resolution ones. This allows for a significant boost in frame rates, particularly in high-demand games like *Cyberpunk 2077* and *Control*. The technology upscales lower resolution images with minimal visual loss, making it particularly advantageous in 4K gaming.

Performance Analysis Across Popular Games

To analyze the performance differences, benchmark data for GTX 1070 and RTX 3070 GPUs across various games was collected. Table 1 summarizes the FPS results for both GPUs at 1080p resolution:

| Game                             | GTX 1070 (FPS) | RTX 3070 (FPS) | RTX 3070 (RTX ON) |
|----------------------------------|----------------|----------------|-------------------|
| <i>Cyberpunk 2077</i>            | 45             | 75             | 55                |
| <i>Minecraft</i>                 | 30             | 112            | 90                |
| <i>GTA V</i>                     | 87             | 132            | 105               |
| <i>PUBG</i>                      | 109            | 180            | 145               |
| <i>CS:GO</i>                     | 251            | 282            | 240               |
| <i>Far Cry 5</i>                 | 120            | 145            | 128               |
| <i>Assassin's Creed Odyssey</i>  | 58             | 80             | 70                |
| <i>Shadow of the Tomb Raider</i> | 62             | 100            | 85                |
| <i>Watch Dogs: Legion</i>        | 50             | 70             | 63                |

Table 1. Performance Comparison: GTX 1070 vs. RTX 3070 at 1080p, with RTX ON

The RTX 3070 demonstrates a significant performance advantage across all titles, particularly in graphically intensive games like *Cyberpunk 2077*, *Assassin's Creed Odyssey*,

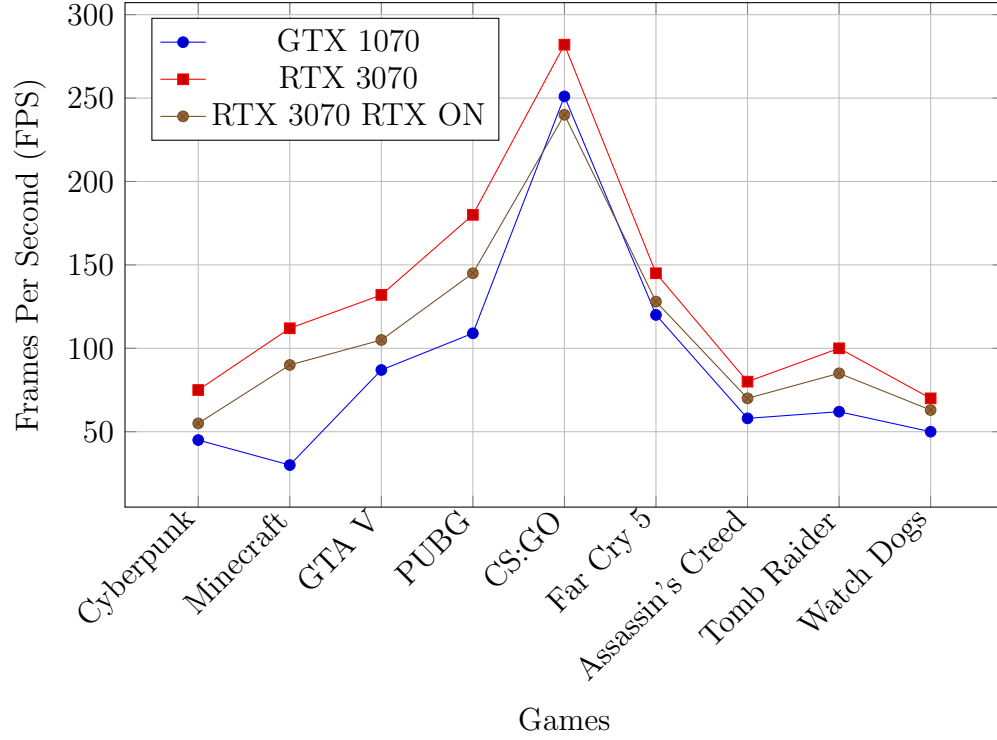


Figure 1. FPS Comparison: GTX 1070 vs. RTX 3070 Across Games with Ray Tracing On

and *Shadow of the Tomb Raider*. The addition of ray tracing further boosts performance in visually demanding scenes, as shown in the *Cyberpunk 2077* and *Minecraft* benchmarks.

### Implications for Gaming and Development

The architectural innovations in RTX GPUs not only enhance gameplay but also redefine game development paradigms. Developers can now create highly detailed and realistic environments without sacrificing performance. For gamers, these advancements translate to smoother gameplay, reduced latency, and an overall immersive experience. AI-driven techniques like DLSS further enhance game performance, offering a seamless experience even at 4K resolutions.

## Conclusion

The transition from GTX to RTX GPUs marks a transformative phase in GPU technology. The integration of real-time ray tracing, AI-driven optimizations, and increased computational power has redefined gaming visuals and performance benchmarks. RTX GPUs pave the way for a future where photorealistic gaming becomes the standard, offering unprecedented opportunities for developers and gamers alike.

## References

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