Gears of War 4: Custom high-end graphics features and performance techniques

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Figure 1: Screenshot from Gears of War 4 ©Microsoft

ABSTRACT

In this technical post mortem we talk about how The Coalition implemented new custom graphics features and optimized the rendering technology to achieve the performance needed for the high visual bar for Gears Of War 4[1].

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CCS CONCEPTS

• **Computing methodologies → Computer graphics**; *Rendering*;

KEYWORDS

HDR display, lighting, real time rendering, performance optimization

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1 OVERVIEW

We share information about custom high-end graphics features and key performance technology. Unreal Engine 4 offers full-featured

Physically Based Rendering, and a complete set of features supporting high quality lighting and shadowing. Our Art Direction and visual goals asked for additional high-end features to further enhance the overall presentation.

We developed a new Volumetric Lighting solution, that builds upon Epipolar raymarching, augmented with particle clouds modulation and dynamic shadows.

We developed fully Real time Global Illumination, that combines a general Virtual Point Lights solution for bounce lighting with Importance Sampling and environment sample-based heuristics to merge and optimize the bounce lighting solution for real time use.

We augmented Unreal Engine 4 with technology to efficiently play back massive destruction events, with efficient high quality real time shadowing.

We share inside information about how we transformed Unreal Engine 4 to deliver breathtaking graphics at full 1080p resolution at 30 fps for Campaign and at 60 fps for multiplayer.

We talk about our custom extensions to Temporal Anti Aliasing [Karis 2014] to combat blurriness and ghosting artifacts.

We briefly cover the technical side of our Material Masking System, fully detailed in another presentation, used to reach higher artistic levels of fidelity for materials as well as being a tool for compressing super dense materials consisting of many layers down to an ideal version that runs fast on the GPU

Finally, we go through some of our innovative key optimization techniques, both on GPU and on the CPU side for graphics - leading to both the performance levels we required but also allowed us to boost visual quality.

2 IMPLEMENTATION

Our Volumetric real time lighting technology builds upon epipolar ray marching, which is a technique to take samples and ray march rays where it matters the most, for performance and for quality. We extend the technique to support temporal upsampling for higher quality, and lowering the number of raymarch steps needed. We further extend the technique to take particle clouds placed in the 3D world into account, modulating light intensity along each ray by absorbing light as rays enter particle volumes.

Our Real time Global Illumination feature is implemented by Importance Sampling potential light bounces from the environment, combined with heuristics-based merging of samples to reduce the solution to achieve real time performance. The technique renders Reflective Shadow Maps (RSM) from the light's point of view. From these we generate Virtual Point Lights (VPLs) using importance sampling. We then use a heuristic to further examine the set of VPLs and based on distance and normals of the sample points, we merge the VPLs into a smaller more efficient set of final VPLs.

Our GeoCache real time playback feature decompresses the data stream entirely on the GPU, allowing for very low overhead playback.

3 OPTIMIZATIONS

Many of our key CPU optimizations were done early on, such as refactoring the constant buffer update mechanism to reduce overhead, adding a state cache to prevent re-issue of costly state changes on the GPU, shadowing caching and per-object shadow processing optimizations. We moved over to using D3D12 entirely on both PC and Xbox and this was a great win for us with significant gains on the API processing side.

Another efficient optimization was the implementation of parallel rendering in Unreal Engine 4, which was quite an effort and in the end made possible to process the high number of draw commands we needed.

We found that by taking advantage of a full pre-pass we could improve GPU throughput of masked geometry, for foliage for example, drastically.

Our shadow caching technology allows for both efficient caching of temporarily non-moving shadows cast by dynamic objects, and also for lowered update frequency processing which improved both CPU and GPU performance significantly.

We use Asynchronous Compute for overlapping some processing on the GPU with graphics processing, such as running the Reflection Capture Actor processing âĂŞ which is a key component of Physically Based Rendering âĂŞ in parallel with lighting and shadowing work on the GPU. We implemented Dynamic Resolution Scaling to absorb some of the most expensive scenes and events on the GPU, by rapidly responding to GPU demand outside of the available frame time by temporarily lowering output resolution. We only lower resolution on-demand, on the horizontal axis and never below 70%.

We implemented a number of custom techniques to optimize decals, fog and distortion rendering using GPU efficiency optimizations. We improved the quality and optimized the performance of Temporal Anti Aliasing as well as minimized ghosting artifacts.

4 RESULTS

We run Campaign and Cooperative play at 1080p resolution at 30 FPS and Multiplayer at 1080p at 60 FPS. All features are turned on for Campaign and some are disabled for higher framerate in Multiplayer. Our new graphics features were used throughout the game and aligned well with Art Direction's directives.

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REFERENCES

Brian Karis. 2014. High Quality Temporal Supersampling. http://advances.realtimerendering.com/s2014/. (2014).