NVIDIA

Technical Brief

NVIDIA HPDR Technology

The Ultimate in High Dynamic-Range Imaging

Introduction

Traditional 8-bit, 10-bit, and 16-bit integer formats lack the dynamic range required to manipulate the high-contrast images typical of high-quality visual effects image processing. High dynamic-range (HDR) rendering utilizes floating point formats to represent color component in high-contrast images to capture the complete range of color values. Efficient use of HDR within an application requires a GPU with native support for floating point pixel formats. The floating point imaging capabilities of the NVIDA Quadro® FX 4000 GPU make it the ultimate GPU for NVIDIA High-Precision Dynamic-Range (HPDR) image rendering.

High Dynamic-Range (HDR) Imaging

To preserve the wide range of color values in an HDR image, color components must be manipulated using a logarithmic storage format. HDR rendering utilizes 16-bit and 32-bit floating point per color component to represent high-contrast images. This permits all original color data to be available for manipulation in the image processing pipeline. Traditional 8-bit and 16-bit integer color spaces—as well as sRGB, an 8-bit gamma colorspace—constrict color values to the range of 0 to 1. Color values in nature don't conform to this range. While sRGB, and e-sRGB (a 12-bit gamma color space) do provide a logarithmic representation of the image data, neither color space has the range and precision required to maintain color accuracy during image processing operations. Extending the range and utilizing floating point values to logarithmically express color components permits super whites (values greater than 1.0) and super blacks (values less than 0.0), as well as an almost infinite number of color gradients in between. As a result, HDR imaging allows extremely bright objects and rich dark objects to appear dark in the same image with increased visible detail, as demonstrated in Figure 1.

Image courtesy of ILM.

Figure 1. Example of HDR imaging

NVIDIA Quadro FX 4000 Features

The NVIDIA Quadro FX 4000 GPU provides numerous features for ultimate HDR imaging applications. These features include native support for 16-bit and 32-bit floating point color components, non-power-of-two textures, mip-mapping, and floating point blending combined with 1 GBps pixel readback performance.

Full FP16-Pixel and FP32-Pixel Buffer Support

Full support for 16-bit and 32-bit floating point pixel buffers combined with 128-bit floating point computations within the graphics pipeline, allowing simultaneous operation on four 32-bit floating point components, enables the complete manipulation of HDR image data on the GPU from acquisition to final render. Within an application, this permits image color components to be stored as 16-bit and 32-bit floating point values. Subsequently, common imaging operations such as color space conversion, filtering, and compositing operations can be moved from the CPU to the GPU with a dramatic increase in performance without compromising quality. The NVIDIA Quadro FX 4000 GPU has ten times the floating point processing of any ×86 CPU on the market today.

Non-Power-of-Two Textures

Typical post-production workflows manipulate film and video frames that are inherently not a power-of-two in dimension, while traditional graphics hardware has not been able to efficiently handle such images. To work around this, applications have been forced to encapsulate non-power-of-two images inside larger power-of-two textures, wasting both precious video memory and computation resources. For example, other GPUs require a 1920 × 1080 HD video frame to be stored as a 2048 × 2048 texture, wasting almost 50 percent more memory per frame in order to be efficiently rendered by the graphics hardware. The NVIDIA Quadro FX 4000 GPU, with native support for non-power-of-two textures, permits the full manipulation of such video and film resolution images without any additional memory overhead or performance impact.

Full-Featured Floating Point Textures

The NVIDIA Quadro FX 4000 GPU provides full-speed blending, filtering, and mipmapping of floating point textures to enable complex operations to be performed on HDR images within the graphics pipeline. One example of the power of this functionality is that multiple layers of full-resolution HDR images and mip-mapped graphic elements for titles and transitions can be composited within the NVIDIA Quadro FX 4000 GPU without the use of lower resolution or lower per-color-component bit-depth image proxies. The benefit of this functionality to the film and video post production workflow is a dramatic improvement in efficiency and resource utilization.

Another unique application, enabled by the floating point texture capabilities of the NVIDIA Quadro FX 4000 GPU, is the ability to utilize a floating point 3D texture as an HDR animation flipbook (Figure 2). In this case, an application renders each HDR image into an image plane of a 3D floating point texture. Then, by moving the eye point through the texture, individual frames can be viewed as an animation sequence in real time.

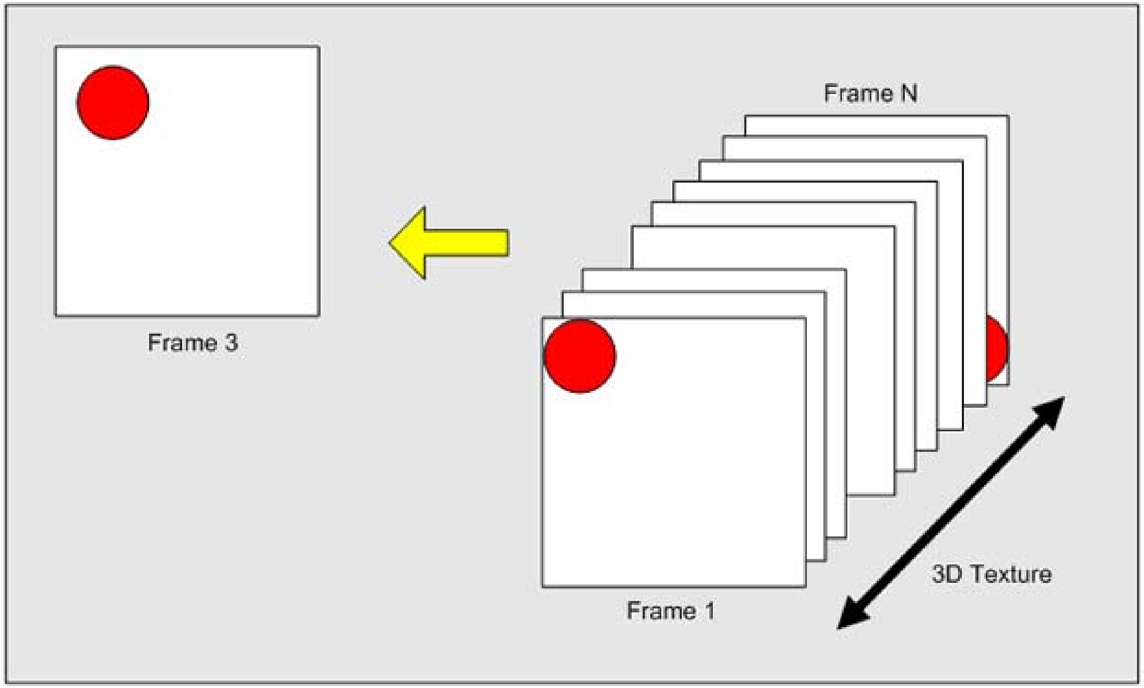

Figure 2. 3D Texture as HDR animation flipbook

Fast Pixel Readback

Fast pixel readback from video memory at up to 1 GBps on the NVIDIA Quadro FX 4000 allows HDR images rendered on the GPU to be quickly transferred back to host memory. This capability makes the NVIDIA Quadro FX 4000 ideal for HDR image compositing applications that reutilize render images for subsequent composite operations. Final frames can also be efficiently copied back from the floating point frame buffer to system memory for later streaming to a flipbook animation review application or other post-production process.

OpenEXR Encoding

One example of an HDR imaging infrastructure that takes full advantage of the floating point imaging capabilities of the NVIDIA Quadro FX 4000 GPU is OpenEXR, developed by ILM.

OpenEXR is 16-bit floating point SM10e5 encoding (one sign bit, five exponent bits, and ten mantissa bits) that provides 1024 (2^{10}) values per color component per f-stop and 30 f-stops ($2^5 - 2$). With full support for 16-bit floating point pixel formats and texture operations, the NVIDIA Quadro FX 4000 GPU provides native support for OpenEXR. Figure 3 demonstrates how the additional data available within an OpenEXR image allows f-stop adjustment to reveal additional details hidden in the shadows.

Images courtesy of ILM.

Figure 3. Adjusting an OpenEXR image to high f-stops, details emerge from the shadows.

Conclusion

The NVIDIA Quadro FX 4000 GPU combines support for 16-bit and 32-bit floating point non-power-of-two pixel buffers and textures with full-speed floating point filtering, blending and mipmapping capabilities, and fast pixel readback to create the ultimate platform for high dynamic-range imaging. This functionality permits traditional visual effects image processing operations to be moved from the CPU to the GPU with a dramatic increase in performance and workflow productivity.

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