Advancing Dynamic Lighting on Mobile

Sam Martin
Geomerics
Cambridge, UK
sam.martin@geomerics.com

Matt Wash
Geomerics
Cambridge, UK
matt.wash@geomerics.com

1. Introduction

Dynamic lighting is common place for PC and console graphics, but until recently was too expensive for mobile devices. Many of the rendering techniques that work well on desktop architectures are inherently energy inefficient and perform poorly.

In this talk, we explore what can be achieved on current mobile devices, and ways to advance the state of the art. We focus on a dynamically lit scene with time-of-day lighting, including real time radiosity. We describe how this result was obtained and which additional hardware and graphics API features would have significant impact.

2. Approach

For each frame in our test application, we render the scene in a single pass as follows:

1. Generate a HDR lightmap on the CPU containing all indirect lighting and low frequency direct lights, using Enlighten, a real time radiosity SDK
2. Generate a shadow map to provide visibility for the sun
3. Render the scene geometry in a single pass, combining the sun and lightmap in high precision, and tonemap the result before writing to the framebuffer.

The sun and distant environment can be animated by the user to change the time of day. The Enlighten lightmap generation pipeline is described in [Martin and Einarsson 2010] and is summarized in this talk. We ported the application to a wide range of mobile GPUs to compare performance and determine the level of support.

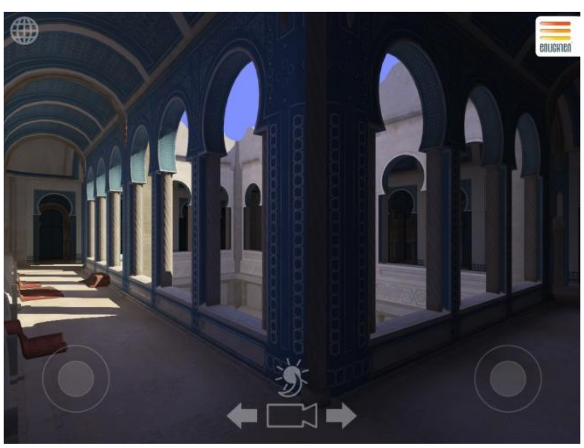

Figure 1. *"Palace" scene with fully dynamic lighting on iPad2*

3. Analysis

We focus on rendering with a single pass. OpenGL ES 2.0 lacks support for multiple render targets which deferred lighting would require to avoid additional passes. Light pre-pass rendering has been demonstrated at real time rates [Jeung 2012], and can extend our work, but requires a low resolution backbuffer to maintain the frame rate. We limit our test application to a single directional light and discuss how the exposure of tiles and on-chip memory may allow for more efficient rendering of multiple lights.

Similar to the findings of previous work [Pranckevičius and Zioma 2011], we find performance is limited by pixel processing. We show how the radiosity system can be used to add additional low frequency illumination, including environment lighting and local area lights. By handling all bounce lighting and low frequency light sources on the CPU we reduce the per-pixel workload by minimizing the number of GPU light sources.

Efficient generation of shadow maps requires the extension GL_OES_depth_texture. Support for hardware PCF filtering is not widely available, and we show that manual filtering is unlikely to be affordable on most hardware. We compare the available options and discuss the feasibility of cascades and sample distribution shadow maps [Laurizen et al. 2011].

Mobile devices have limited support for HDR textures. We show a method for efficiently encoding HDR lightmaps through a simple 4-byte RGBA format, but only on devices that support high precision texture interpolation. The precision of interpolation is not currently prescribed by OpenGL ES, and we show how doing so would have a practical application.

We discuss general techniques to improve performance, including a fast tonemapping approximation and simplifications for specular materials, and report performance on all hardware tested.

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