CRYENGINE LIGHTING HISTORY

10 years of evolution

3 generation of engines

4 games and visual benchmarks
CRYENGINE 1 – FAR CRY

Far Cry, PC, 2003
FAR CRY – LIGHTING

Baked lighting for terrain and static meshes

+ Higher performance for outdoor environments
- Low resolution
- Limited to static objects
- Fixed sun position
FAR CRY – SHADOWS

Outdoor baked shadows
FAR CRY – SHADOWS

Sun Shadow map for dynamic objects

+ Smooth shadows
- Limited view distance
FAR CRY – SHADOWS

Sun shadow map for dynamic objects
FAR CRY – SHADOWS

Stencil shadows for point lights

+ Raycast shadow volume
+ Very sharp shadows
- No smooth shadow
Stencil shadows for point lights
FAR CRY – SHADOWS

Indoor baked shadows
FAR CRY – HDR

High Dynamic Range Rendering

+ First iteration and one of first games in market using HDR
+ Much higher precision for the lighting information
+ Higher contrast/lighting ratio

- Levels and assets not tweaked for HDR
FAR CRY – HDR

HDR off

HDR on
FAR CRY - COLORGRADING

Highly saturated and cartoony color palette

User selected color theme
FAR CRY - COLORGRADING

Default
FAR CRY - COLORGRADING

Cold
FAR CRY - COLORGRADING

Cartoon
CRYENGINE 2 – CRYSIS

Crysis, PC, 2007
CRYENGINE 2 – CRYSIS

Crysis, PC, 2007
CRYISIS LIGHTING

Realtime lighting

+ HDR Rendering
+ Dynamic time of day
+ Cascaded sun shadow map
+ Ambient occlusion

- Very limited amount of light sources
- Flat ambient lighting
CRYYSIS - HDR

HDR Rendering

+ Better reproduction of luminance variations
+ Believable implementation of eye adaption
- Level mostly tweaked for HDR only
CRYYSIS - HDR

HDR off
CRYYSIS – TIME OF DAY

Dynamic time of day with procedural HDR skybox

+ Full control on sun, ambient, fog, skybox, etc.
+ 100 parameters

- Complex to handle (dawn and sunset transitions)
CRYSIS – TIME OF DAY

Dynamic Time of Day
CRYYSIS – SHADOWS

Sun Cascaded Shadow Map

- Large view distance for shadows
- Higher resolution near the player’s camera
- Lack of macro detail for self-shadowing (characters)
CRYSIS – SSAO

Screen Space Ambient Occlusion

+ Gray scaled approximation of indirect lighting
+ Light accessibility approximated in screen space
+ Replacement for Ambient Occlusion baking via vertex colors
- Limited number of samples - blocky artifacts
CRYSSIS – SSAO

SSAO off
CRYSIS – SSAO

SSAO on
CRYYSIS – TERRAIN AO

Terrain Ambient Occlusion

+ Simulate sky accessibility for terrain and vegetation
CRYYSIS – TERRAIN AO

Terrain Sky Accessibility off
CRYYSIS – TERRAIN AO

Terrain Sky Accessibility on
CRYSIS – LIGHTING PIPELINE

Ambient Lighting
CRYISIS – LIGHTING PIPELINE

+SSAO
CRYSSIS – LIGHTING PIPELINE

+Sun Light and Shadow Maps
CRYSSIS – LIGHTING PIPELINE

+Atmosphere (Fog and Clouds)
CRYSIS – LIGHTING PIPELINE

+Sunrays and Depth of Field
Final Picture with Colorgrading
CRYENGINE 3 – CRYSIS 2

Crysis 2, PC – Xbox 360 - PS3, 2011
CRYENGINE 3 – CRYSIS 2

Crysis 2, PC – Xbox 360 - PS3, 2011
CRYENGINE 3 – CRYSIS 2 [SOUZA 2011]

New challenges

+ Multi-platform
+ Urban environments

No Lead platform

+ Carefully picked changes

Scalable multi-platform technology

+ DX9, DX11, Xbox 360, PS3
+ Multithreaded, better streaming, etc.
TECHNOLOGICAL CHALLENGES

Jungle style environment
+ Single key light (sun)
+ Minimal asset variation
+ Mostly glossy reflections
- Alpha testing performance hit

Urban environment
- Complex lighting conditions
- A lot more assets and material variation
- Reflections everywhere
TECHNICAL HIGH LEVEL GOALS

Requirements

+ Improved lighting, particularly ambient lighting
+ Many lights
+ No limits on shadow casting lights
+ Reflections literally everywhere
+ Material variation flexibility
+ Minimal performance/memory footprint
PHYSICALLY BASED RENDERING

Linear Correct HDR Rendering

Minimal G-Buffer: Depth and Normals

Deferred Lighting

+ Ambient, Light Probes
+ GI, SSDO, RLR, Many lights
+ Physically Based Shading

HDR / LDR Post Processing
HDR & LINEAR CORRECTNESS

HDR [Reinhard 2010]
+ Precision, range
+ Physically based Post Processing

Linear Correctness [Gritz 2008]
+ All computations in same space
LIGHTING REQUIREMENTS

Urban environment

+ Physically based lighting and materials
+ Scriptable sun position for every action bubble
- Low sun not optimal for lighting ratio inside the city
- Moving sun not optimal for gameplay and player leading
+ Long range shadows
+ Large amount of lights for interiors and night settings
LIGHTING REQUIREMENTS

Windows reflections

Dappled lighting
MULTIPLATFORM LIGHTING

Similar shading quality on all platforms

+ Identical output range

+ Similar colorgrading and postFX (DoF and colorgrading)
MULTIPLATFORM LIGHTING

Differences between platforms

- Higher view distance and level of detail on PC
- Global Illumination on PC only
- Advanced DX9 and DX11 features on PC only
- Lights flagged as PC only in certain interiors
- Most projectors and key lights cast shadows on PC
MULTIPLATFORM LIGHTING

Xbox 360
MULTIPLATFORM LIGHTING

PC DX9 (High spec)
MULTIPLATFORM LIGHTING

Xbox 360
MULTIPLATFORM LIGHTING

PC DX9 (High spec)
MULTIPLATFORM LIGHTING

Xbox 360
MULTIPLATFORM LIGHTING

PC DX9 (High spec)
MULTIPLATFORM LIGHTING
MULTIPLATFORM LIGHTING

PC DX9 (High spec)
MULTIPLATFORM LIGHTING

PC DX9 (High spec)
DEFERRED LIGHTING

+ No need to re-render the geometry for every light
+ Higher performance
+ Higher amount of lights
- Forward pass still needed for shading
DEFERRED LIGHTS

Point lights with shadow casting abilities

+ Spherical volume

+ Projector lights with projection texture
LIGHT LEAKING

No occlusion available for deferred lights

- Occlusion volume manually placed by designers
- Box or arbitrary convex volumes
- Possible precision issues on console
LIGHT LEAKING

Light Clipping off
LIGHT LEAKING

Light Clipping on
LIGHT LEAKING

Light Clipping off
LIGHT LEAKING

Light Clipping off
LIGHT LEAKING

Light Clipping on
GLOBAL ILLUMINATION

Simulate several light bounces

+ Treat every lit surface as a possible secondary light source within a 3D light grid approach
+ Possible simulation of multiple bounces
GLOBAL ILLUMINATION

Limits of the current implementation

- Sun light dependant
- GI leaking and occlusion issues (Fix: light clipping volumes)
- PC only
- Lighting incoherence when using multiple bounces

Mostly visible with colored bounces

- Limited use in a dull urban environment
GLOBAL ILLUMINATION

PC DX11 GI off
GLOBAL ILLUMINATION

PC DX11 GI on
GLOBAL ILLUMINATION LEAKING

PC DX11 GI off
GLOBAL ILLUMINATION LEAKING

PC DX11 GI on
SHADOWS

Similar approach as in Crysis

+ Cascaded sun shadow map
+ Shadow map for point lights

- Possible shadow map acne, especially on console
SUN SHADOWS

PC DX9 High Spec
POINT LIGHT SHADOWS

PC DX9 High Spec
SHADOWS MAP ACNE

PC DX9 High Spec
SHADOWS MAP ACNE

Xbox 360
IMAGE-BASED LIGHTING

Environment HDR Light Probes

+ Accurate diffuse and specular lighting
- Hand-placed probes
+ HDR source, encoded into RGBM
+ G-Buffer material glossiness used for picking MIP level
+ Sphere volume, linearly blended into accumulation buffers
+ No more per-material environment map
- Problematic generation
IMAGE-BASED LIGHTING

Environment probe off
IMAGE-BASED LIGHTING

Environment probe on
IMAGE-BASED LIGHTING

Environment probe off
IMAGE-BASED LIGHTING

Environment probe on
SHADING PASSES
SHADING PASSES

Read accumulated lighting and apply material properties

+ Diffuse, Specular, Emissive, Glow, Glossiness, Fresnel, etc

- Difficult maintenance of thousands of materials
DEFERRED LIGHTING BUDGET

Target framerate: 30 fps ⇔ 33.33 ms/frame

Entire Deferred lighting budget: 4-8 ms

+ Ambient: 1.5 ms
+ Cubemap: 0.5 - ... ms (art dependent)
+ SSAO – GI: 2 ms
+ Lights: 0 - ... ms (art dependent)

Light covering the entire screen: 1 ms

Light casting shadows: +3 ms
CENTRAL STATION LIGHTING

Blackout in Central Station

+ Dynamic lights in action
+ Gameplay affecting lighting
+ Material switching in realtime
CENTRAL STATION LIGHTING

More than 200 lights on PC

+ Most projectors casting shadows

More than 100 lights on console

+ Running at 30 fps on console

+ Deferred lighting cost of 7-9 ms on console

- Limited amount of shadow casting light on console, compensated by Ambient Occlusion
CENTRAL STATION LIGHTING

Ambient lighting
CENTRAL STATION LIGHTING

+SSAO
CENTRAL STATION LIGHTING

+Materials
CENTRAL STATION LIGHTING

+Key Lights
CENTRAL STATION LIGHTING

+Moon light
CENTRAL STATION LIGHTING

+ Deferred cubemaps
CENTRAL STATION LIGHTING

Final Picture on Xbox 360
CENTRAL STATION LIGHTING

Final Picture on PC DX9 High Spec
CENTRAL STATION LIGHTING

Deferred lighting coverage on Xbox 360
CENTRAL STATION LIGHTING

Deferred lighting coverage on PC
COLORGRADING

Colorgrading system based on color look up table

+ All static adjustment filters from PhotoShop available such as curves, color balance, hue/saturation, photofilter, etc.

+ Scripted colorgrading based on mission flow
COLORGRADING

Art Direction

+ No typical “next gen” colorgrading
+ Strong control over the color palette with textures and lighting
- Lack of visual identity?

Intelligent control over color and contrast

+ Tonemapping for contrast adjustment
+ Slight color balance for split toning and color harmony
ALIEN ATMOSPHERE
ULTRA UPGRADE [SOUSA 2011]

New DirectX 9 and 11 lighting features

+ Screen Space Directional Occlusion (DX9)
+ Real Time Local Reflection (DX9)
+ Shadows with variable penumbra (DX11)
+ Improved tone mapping (DX9)
SSDO

No AO
SSDO

SSAO
SSDO

No AO
SSDO

SSAO
RLR

Real Time Local Reflection off
RLR

Real Time Local Reflection on
RLR

Real Time Local Reflection off
RLR

Real Time Local Reflection on
SHADOWS PENUMBRA

Shadows with Variable Penumbra off
SHADOWS PENUMBRA

Shadows with Variable Penumbra on
TONE MAPPING

Improved tone mapping off
TONE MAPPING

Improved tone mapping on
FUTURE OF LIGHTING

Bigger, better, faster

+ Global Illumination

+ Realtime reflections

+ Volumetric effects
SPECIAL THANKS

Tiago Sousa, Carsten Wenzel, Nicolas Schulz
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REFERENCES

Gritz, L. “The Importance of being linear”, 2008

Debevec, P, “Recovering High Dynamic Range Radiance Maps from Photographs”, 1998

Reinhard, E. et al “High Dynamic Range Imaging”, 2010

Hoffman, N. “Physically based shading models in Film and Videogames”, 2010

Sousa, T. “CryENGINE 3 Rendering Techniques”, 2011

QUESTIONS

Pierre-Yves Donzallaz: pierre@crytek.com

Tiago Sousa: tiago@crytek.com, crytek_tiago (twitter)