Presenter

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Title
Sr. Lighting Artist, Crytek

Games
Plan

Introduction
Production
Lighting basics
Physics & Materials
Real-Time Lighting Features
Case Studies
  Outdoor Lighting
  Indoor Lighting
  Cinematics
Conclusion
Introduction
Crytek

Founded in 1999

Core pillars
- Technology (CryENGINE)
- Content creation (Crysis, Ryse, Homefront 2, etc.)
- Publishing (GFACE)

850 employees across 9 studios
- Frankfurt (Germany)
- Nottingham (UK)
- Kiev (Ukraine)
- Austin (USA)
- Budapest (Hungary)
- Seoul (South Korea)
- Sofia (Bulgaria)
- Shanghai (China)
- Istanbul (Turkey)
CryENGINE

Development time
+13 years

Motto since CryENGINE 2
“Real-time all the time”

Platforms
PC & mobile
Microsoft Xbox 360 & Xbox One
Sony PS3 & PS4

Licensees
Games
Military (simulation & training)
Architecture (visualization)
Etc.
## CryENGINE\Games and Licensees

### Games
- Ryse & Homefront 2 (Crytek)
- Sniper Ghost Warrior 2 (City Interactive)
- MechWarrior Online (Piranha Games)
- Monster Hunter Online (Tencent, Capcom)
- Star Citizen (Cloud Imperium Games Corporation)
- Civilization Online (2K, XLGAMES)
- Etc.

### Serious games licensees
- Enodo (Architecture)
- RealTime Immersive (Military)
- Thales Group (Military)
- Lockheed Martin (Military)
- Meggitt (Aerospace)
- Etc.
Crysis Franchise

Type
First Person Shooter

Character
Super soldier equipped with a Nanosuit

Focus
Sandbox gameplay
Visual experience
Crysis Franchise

Trilogy

Crysis 1 (2007): Awakening of an ancient alien civilization on an island
Crysis 2 (2011): Alien invasion in New York
Crysis 3 (2013): Awakening and destruction of the alien boss in New York
Production
Crysis 3 Focus

Improved graphics quality
  Push the visual quality even further
  Set a new benchmark for next generation games

Improved gameplay
  Bigger levels
  More variety
  Environments
  Weapons
  Enemies
Initial constraints

Smaller core team

~150 people on Crysis 2
~100 people on Crysis 3

Frankfurt team

Handful of graphics programmers
Dozen of environment artists
Couple of level artists
Couple of FX artists
1 lighting artist
Initial constraints

Shorter production time
- 38 months for Crysis 2
- 23 months for Crysis 3

Create a better game
- “Do better with less”

Art bottleneck
- Very little place for mistakes
Art Production Overview

Pre-production

Prototypes & concept arts

Art benchmark level

Implementation of the vision of the art direction
Improvement of the art pipeline and workflow
Creation of art guidelines for the full production

Full production

Iterations and finalization

From white-box to final art
Concept art

Manhattan + Rain forest + Dome
Art Direction

Crysis 1 meets Crysis 2

Natural settings
- Overgrown urban environment
- Extremely dense vegetation
- Grass fields, rivers, jungles, etc.

Lighting
- Dappled lighting
- Wet materials
Full production

Overview

All levels in the production pipeline at the same time
Sequential focus phases of 1 to 2 weeks for every level
  Design pit (Level design director)
  Art pit (Art director)
  Optimization pit (RND)
No post-production
  Lighting and FX „on time“

Post mortem

Tight production time
Smooth and straightforward production
Game delivered on time with a great art quality

NOT BAD
Lighting Basics
Lighting Basics

What makes lighting interesting?

- Intention
- Contrast
- Directionality
- Depth
Intention

Storytelling and emotions

Color temperature
- Warm tones: happiness, hope, security, etc.
- Cold tones: sadness, danger, darkness, etc.

Fog
- Low density: exploration, security, etc.
- High density: unknown, danger, etc.
Contrast & Range

Definitions
- Contrast: Difference of luminance or color in a picture
- Range: Absolute difference between the darkest and brightest tones in a picture

Usual objective
- Obtain a wide range and high contrasted picture
Contrast

Low contrast

High contrast
Contrast

Low contrast

High contrast
Color Contrast

High contrast from complementary colors

Commonly emphasized tones

Cold tones
- Sky
- Shadows

Warm tones
- Skin
- Fires & explosions
Color Contrast\Movie Posters

Image credits: Universal, Warner Bros, Disney & Sony
Color Contrast
Lighting Ratio

Relationship between light and darkness

- Studio: key light and fill light
- Outdoor: sun light and shadows

Very low lighting ratio

Very high lighting ratio
Directionality

Position of the key light sources
- Ensure proper lighting ratio
- Improvement of the player leading

Side (too high lighting ratio)
Back (too high lighting ratio)
Front left (optimal lighting ratio)
Directionality and player leading
Depth

Layers with different values or “steps”

Increased dimension factor

- Separation
- Readability

Very low depth

High depth
Fog Ramp 2000m
Fog Ramp 500m (final)
Fog Ramp 250m
Fog Ramp 125m (final)
Physics & Materials
Non-Metals Overview

- Specular reflection
- Diffuse reflection
- Incident light
- Refraction & Absorption
- Scattering
Metals Overview

Specular reflection

No diffuse reflection

Incident light

Absorption

No scattering
Surface Roughness

**Sharp reflections**

**Blurry reflections**

Polished surface

Rough surface
Materials

Diffuse texture

Specular texture

Glossiness/roughness texture
Specular Textures

Common mistakes

- Total lack of consistency between the specular textures
- Specular texture created from a diffuse texture (grey-scale & high contrast)

Solution

Physically-based approach
Augustin-Jean Fresnel

(1788–1827)

“The stronger the angle of incidence of the light, the stronger the reflection.”

Fresnel Effect

\[ n_1 = 1, \quad n_2 = 1.5 \]

Reflection coefficient of a non-metal

Black plastic spheres
Reflection Coefficients

Metals

Non-metals
Physically-Based Specular Color

Specular luminance [0:255]
- Most non-metals: 20-70
- Metals: +180

Specular color
- Non-metals: grey-scaled
- Metals: slightly colored (gold, copper, nickel)
Physically-Based Specular Texture

Diffuse-based specular texture

Physically-based specular texture

Physically-based specular color
Glossiness\Roughness

Roughness defined by a value (0:255)

Uniform roughness

Roughness defined by a glossiness texture

Very important for material definition

More artistic freedom for painting details

Scratches
Specles
Wet areas

Glossiness range
Specular texture
Glossiness texture
Diffuse Textures

Common mistakes
- Visible light & shadows
- Too strong ambient occlusion
- Too high contrast

Work done by the engine
- Lighting & shadows
- Ambient occlusion
- Postprocessing

Solution
- Lighting control during capture
- Calibration during and after capture
Diffuse Textures\Capture

Minimize lighting information in the textures

- Prevent strong direct light
- Ensure neutral color balance
- Ensure flat consistent lighting

Bright daylight

Low sun settings

Overcast

Image credits: Richard Yot, www.itchy-animation.co.uk
Diffuse Textures \ Calibration

Shoot reference with color checker

Hold the color checker perpendicular to camera
(Minimize Fresnel effect)

Automated or manual software correction

Adjust white balance, levels and colors

Image credits: X-Rite, xritephoto.com
Diffuse Textures/Reference Library

Calibrated reference textures for proof checking
- Based on the most representative textures of the game world
- New textures consistently tweaked to fit the reference textures
- Lighting calibration based on the reference textures

Calibrate key textures only
- No need to calibrate 10,000 textures
- Trust your eyes for the rest
Art Production Guidelines
Asset Zoo Level

Test level for proof checking assets

- Level based on the Art Benchmark level
- Check assets consistency at a glimpse with multiple lighting debug modes
- Store all assets in one single level
Asset Zoo Level Flat shading

Pure flat indirect lighting

Control the consistency of the diffuse textures

No post processing, no reflection, no ambient occlusion, no fog

Standard lighting mode

Flat shading mode
Asset Zoo Level\Clipping Control

Visualize blacks and whites clipping

Good estimation of clipping on TVs with limited color space (16-235)

Flat shading mode

Clipping control mode
Asset Zoo Level\Clipping Control

Black: RGB 0-15
White: RGB 240-255
Lighting calibration

Gamma chart and color gradient chart

- Control lighting influence on the textures
- Control Post FX influence on the colors and white balance
- Prevent clipping of the blacks and whites
Lighting calibration
Monitors

Ensure all artists work with proper monitors (IPS, *VA or PLS panels)

View angles of low end monitors (TN panels)

View angles of higher end monitors (IPS panel)

Calibrate all monitors to industry standards to ensure consistency across workstations
sRGB, Gamma 2.2, 6500K and ~100cd/m2
Monitors & TVs

Most gamer monitors
- TN panel technology
- Terrible vertical view angles
  - Overall Gamma depending on sitting height & screen inclination
+ Very low reaction time (~2ms)

Most televisions
- Terrible color settings with dynamic contrast & sharpening
- Reduced output range (16-240 or 16-235)
- HDMI mess in consoles settings (Standard, Extended, etc.)
+ Acceptable “Cinema” settings

Lack of standardization for visual equipment
  - For sound systems: THX certification
  - For displays: ?

Why care about colors then?
  - Consistency within the company between work and review stations
Real-Time Lighting Features
Real-Time lighting

“Real-time, all the time”

- HDR Lighting, shadows & atmosphere
- HDR Image-based lighting
- Ambient occlusion
- Global illumination
Rendering Techniques

Forward rendering

Every object shaded sequentially
Multiple passes required for multiple light sources

Issues
Waste of resources on pixels covered by multiple objects
Waste of resources complex scenes (many objects and lights)

Complexity
Amount of geometries * amount of lights

Typical usage
World with low light sources usage (sun)
Older hardware (no MRTs support)

Deferred rendering

Geometry and lighting data extracted from the scene
G-Buffer (geometry) and L-Buffer (lighting)

Every pixel shaded in one pass

Issues
Forward passes required for complex shaders and transparency
Difficulty to exclude lights from certain objects or areas

Complexity
Amount of pixels * amount of lights

Typical usage
Lighting heavy scenes (interior)
Deferred rendering

Hybrid deferred rendering in CryENGINE

Most of the shading processed in one single pass (opaque geometry)
Forward pass still required for transparency & complex shaders (hair & skin)
Deferred rendering\G-Buffer

Albedo YCbCr (RG)
Specular (B)
Depth
Normals (RG)
Glossiness (B)
Translucency (A)
HDR Lighting

High precision
PC/PS3: FP16
Xbox 360: FP10

Large range
Many F-stops
Nearly zero banding
Light Entities\Omni Light

Point light
Spherical light volume
Shadow mapping
Light Entities\Projector Light

Point light
Conical light volume
Projection texture
Shadow mapping
Light Entities\Projector Light FOV
Light entities\Area Light

Surface light (rectangle)
Shadow mapping with penumbra approximation
Projection texture (optional)

Narrow light source & sharper shadows
Wide light source & blurrier shadows
Environment probe

Capture of the lighting in an HDR image

- Reflections (specular component)
- Ambient (diffuse component)

Workflow

1. Placement of the probe in a key location
   - Center of rooms and outdoor areas
   - Corners and edges of large areas
   - Areas with strong light variations
   - Area with sensitive materials (strong specular luminance & glossiness)

2. In-editor generation of an HDR cubemap texture (6 faces)

3. Rendering using a spherical or parallelepiped volume
Environment Probes/Cubemap

HDR cubemap (tone mapped)

HDR cubemap (tone mapped)
Sun Shadows

Cascades shadowmapping

- 6 sun cascades
- Closer cascades to the camera have higher resolutions
- Possible shadow map acne on higher cascades

Vegetation on

Vegetation off
Ambient Occlusion

Simulation of light accessibility

Screen Space Ambient Occlusion
- Compute the occlusion amount of “random” pixels on the screen
- Developed for Crysis 1 (2007)
- Improved for Crysis 2 (2011)
- Low performance cost (consoles)

Screen Space Directional Occlusion
- Improved SSAO based on light source direction
- Contact shadows
- Developed for Crysis 2 DirectX11 upgrade (2011)
- Improved for Crysis 3 (2013)
- Higher performance cost but higher quality (PC)
Screen Space Directional Occlusion (PC)
No Ambient Occlusion
Screen Space Ambient Occlusion
Screen Space Directional Occlusion
Ambient Occlusion

Screen space techniques

“Dumb” occlusion

Total ignorance about objects outside the screen or behind the camera

Simulation of light occlusion for micro details (< 2 m)

Macro Ambient Occlusion (> 2 m)

Vertex colors (baked)

Good quality when baking an entire scene
Not recommended in the player area for diffuse consistency
Low flexibility

Darkening lights (dynamic)

Hand-made ambient occlusion
High flexibility
Manual Ambient Occlusion

Subtractive approach

Bright global ambient

Dark local ambient
  Negative lights (ambient lights)
  Environment probes
Manual Ambient Occlusion
Global Illumination (GI)

Procedural 3D grid of lights

- Every surface considered as a potential light caster
- Sun support only

Pros

- Dynamic GI for outdoor environment
- Decent results in noisy environment

Cons

- Unusable for interior lighting
- Low precision and highly inconsistent
- No automated occlusion (leaking)
No global illumination
Manual bounce lights (helpers)
No global illumination
Global illumination
Manual bounce lights (helpers)
Time of Day

Outdoor lighting tool

- Keyframe-based
- 24 hours cycle
- Moving sun
- ~100 parameters

Sun & sky light

Fog & HDR skybox

Post-processing

- Tone mapping & eye adaption
- Color balance
- Photo filter
Sun position

Crysis 1

Mix of static and moving sun
Ideal for semi-open world environment

Crysis 2 & 3

Scripted sun position
  Up to 10 static sun positions per level
  Sun coordinates changed in “streaming tunnels”

Ideal for contained environments with large scale assets
  Ensure optimal lighting ratio in every area
  Prevent areas from being totally in the shade
Sky Techniques Evaluation

Painted skybox
- More dramatic
- Old school
- Low flexibility
- Difficult authoring
- Often looking fake (shading)

Photo-based hemispheres
- Best visual result
- Compatible with procedural skybox
- Sun shading

Cloud billboards/decals
- High flexibility for cloud placement
- Compatible with procedural skybox
- Alpha-blending overhead
Sky System

Technologies

- Procedural HDR skybox
- Alpha-blended HDR clouds hemispheres
- Tileable cloud shadows

Dynamism

- Moving clouds
- Moving cloud shadows
- No more old gen static painted skyboxes!
Sky Domes

Main sky dome
- Detailed clouds
- Limited rotation angle
  - Preservation of sun shading
- Visible on all platforms

Secondary sky dome
- Low opacity mist
- Constant rotation
- Visible on PC only
- Alpha-blending cost
Cloud Shadows

Revived technology from Crysis 1

- Scrolling tileable texture
- High tiling to maximize shadows variation on the ground
- Black clamped to grey to prevent too dark shadows

Pros

- Give more life to the environment
- Leading the player in the right direction

Cons

- Inconsistent with the actual clouds hemispheres
Real-Time Lighting Analysis

Pros

- Very fast lighting rendering times
  - A few milliseconds per frame only
- Instant visualization of the final results
- Moving and dynamic lighting

Cons

- Strong limitation for low end platforms
  - Amount of lights
  - Radius
  - Shadow casting
  - Overlapping
- Waste of resources on non-dynamic scenes
  - Static sun lighting
  - Static interior lighting
- Huge amount of manual work
  - Time-consuming interior lighting
  - Manual light bounces
  - Manual light occlusion
Case study

Outdoor Lighting
Canyon Case Study

Deep canyon
- Dark & cold
- Dappled lighting
- Light beams

Technique used
- Light subtraction
Height-based ambient
Darkening (helpers)
Wet lights (helpers)
Dappled lighting (helpers)
Light bounces (helpers)
Global environment probe
Light shafts (helpers)
Canyon Case Study

**PC (670 GTX)**

- 60 lights @ 2 ms

**Console**

- 20 lights @ 6 ms
Case study
Indoor Lighting
Interior Case Study

Additive approach

- Dark global ambient
- Addition of lights & probes

Intensive usage of lighting modules (prefabs)

- Copy by reference (instancing)
- Light a large interior only with a few prefabs
Local light setup I
Local light setup II
Prefab creation
Prefab duplication (instancing)
Prefab editing
Prefab editing
Reference materials
Local probe
Interior Case Study

PC (670 GTX)
150 lights @ 4 ms

Console
90 lights @ 10 ms
Case study
Cinematics
Cinematic in Crysis

First person perspective only

Very limited player camera control

Long takes only

Harder to hide lighting tricks

Off-screen lights

Depth helpers
Character Cinematic Lighting

Main Focuses

- Ensure characters emotions visibility
- Ensure proper skin shading
- Separate characters from the background

3 point lights setup for faces

- Key light
- Fill light(s)
- Back light

Face lights attached to characters

- Torso or head joint
Rash
3 point lights setup
3 point lights setup problems
No character lighting
No character lighting
Back light (sun)
Conclusion
# Lighting Statistics

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Next Gen Lighting

More physically-based pipelines

High quality lighting approximation in real-time

Large scale ambient occlusion in real-time

True volumetric effects

...
Special Thanks

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Carsten Wenzel, Technical Director
Magnus Larbrant, Senior Art Director
Entire Crytek team
We are hiring!

http://www.crytek.com/career
Questions?

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