Rendering | Render Farm

Render Optimization & Using the BK Renderfarm

Design Informatics

AR0771 – Week 6

Rendering (in CG)

The process of constructing a raster image from a 3D computer model

A description of a scene…
> geometry, visual properties of objects,
> lighting, atmospheric environment
> and simulation of a camera

… is processed to produce a picture

Rendering (in CG)

Direct and indirect illumination

Rendering involves a huge amount of calculations

Light from other points?

Light from everywhere? (!)

So optimization is key!

Rendering Process Overview

Simplified overview of phases in a typical render process:

1. Scene pre-processing
    Tessellate geometry (NURBs, displacement)
    Build BSP tree to optimize ray-tracing

2. Calculate light distribution
    Ray-trace Light map, Photon map and Final Gather points

3. Render into Framebuffer
    Combine light data, ray-tracing and shader properties into color values (samples)

4. Save image from Framebuffer
    Anti-aliasing, Color corrections, Lens shaders

Example of a 2D BSP tree

Notes on Pre-processing

NURBS geometry and displacement maps
need to be "tessellated" before rendering.
This is done on-the-fly each time you render.

- You determine the quality; default may be very poor
- Use the Approximation editor to change settings
- Verify the quality in a full resolution render

Window > Rendering Editors > mental ray > Approximation Editor

LTR: NURBS object, low-quality tessellation, medium

Notes on Final Gathering

Final Gathering is a technique used for indirect lighting
(also see the Light lecture)

- The 'right' settings vary heavily from scene to scene

- Simply cranking up all settings to the max will quickly grind your render to a near halt.

- Time spent on iteratively optimizing settings is time well spent: There's much to gain!

Top 3 Final Gathering Settings:
>   Secondary Diffuse Bounces
>   Accuracy
>   Point Density

Final Gathering (without secondary diffuse bounces)

Notes on Anti-Aliasing

Anti-Aliasing is the process of smoothing edges in a raster image

• It's an easy thing to get right, just don't forget it

Notes on Anti-Aliasing

Control the 'crispness' of the image by choosing the Sampling Filter that is used

| none | gaussian | mitchell | lanczos |
| Aliased | Quite soft | Sharper | Heavily Sharpened |

Color Management

- There's an issue with (linear) color values used in CG and how we perceive color

- Not getting it right leads to incorrect, awful colors

Incorrect color management (washed out)

Correct color management

Original textures

You have to change the defaults to get it right!

Color Management

Some background on this issue: Color values and representation

- Our eyes' sensitivity to light is non-linear
- Most computer image formats use this fact to translate linear color values into gamma corrected values

This yields more precise colors for values we are more sensitive to.
This means smaller image size, or more perceived precision within the same file size

gamma correction ½.2

0.5   0.5

0.218   0.218

CRT gamma 2.2

Gamma curve

Color Management

The problem:

- Maya expects textures to be in 'linear' color space
- Most file textures (images) are not. They are in sRGB space (gamma 2.2)

sRGB (gamma 2.2)　　　　　　　　　linear (gamma 1.0)

Because working with linear texture images is not practical we need to fix it through proper Color Management

Color Management and Lights

- The output of the rendering process can be in any color space: linear, sRGB or other.

- Without color management, renders are usually stored in sRGB: gamma 2.2.

- To get proper lighting behavior, it's recommended to render to linear output;
  The decay Rate of lights should be set to Quadratic

Quadratic Falloff

Linear Falloff

Quadratic Falloff
Gamma Correct

Color Managed Output

When rendering to linear color space,
the result will look too dark:

Uncorrected display in Render View (linear)

Corrected display in Render View (linear->sRGB)

Color Management - Maya

Enabling Color Management in Maya (<2016)

Color Management - Maya

When using mia_exposure_simple (or mia_exposure_photographic), for instance when you enable Physical Sun and Sky:

Set the mia_exposure gamma to 1.0 instead of 2.2 (default)!

Color Management - Photoshop

When you open a linear image in Photoshop, you need to apply gamma correction (2.2) manually.
Using an Adjustment Layer is the preferred method

Optimizing your Render Process

Recap:

- Modeling vs Textures (covered in modeling and textures lectures)
- Shaders: reflections, glossiness (covered in materials lecture)

New:

- Render View: Test resolution, Region rendering
- Clean your scene: history, unused geometry, curves
- Textures: appropriate resolution
- Render Settings: tweaking, presets for tests and production

Optimization: Render View

Region Rendering and snapshots

Optimization: Render View

Test Resolution

Optimization: Scene

- Remove geometry that is no longer needed
- Delete unused layers and render layers
- Delete history

Optional: File > Optimize Scene Size

Hypershade: delete Unused Nodes

Always make a backup of your Scene first!

Optimization: textures

Resolution
- Don't create large textures just because you can
- Relate the size to the size of the texture in the final image

Final poster
A1
841 x 594 mm
33.1 x 23.4 inch

Texture

@100 pixels per inch: 3310 x 2340 pixels
@120 pixels per inch: 3972 x 2808 pixels
@150 pixels per inch: 4965 x 3510 pixel

Example: the texture is roughly 1/4th of the image.
If the image is 3310 pixels wide, the texture would roughly take up 830 pixels in width.

Double this value and round up for some margin and 2048x2048 should be sufficient for your texture.

Each 4096 x 4096 pixel texture takes up 64MB of memory during rendering

Project and Texture Problems

If *at any point in time* you've opened your scene
without setting your Project properly,
your scene will contain texture location errors

Use the Texture Tools
from the TOI shelf in Maya
to remedy this

TOI Texture Tools

- Make sure you've Set your Project in Maya

- Conform texture locations to project':

    Fix problems with texture locations in your entire scene

- Test:

    Perform a dry-run of above. Outputs in log, but doesn't actually do anything yet

- Conform textures and delete orphaned:

    … and also delete file nodes from hypershade that are no longer used

Optimization: Render Settings

Most important for quality and speed:

- Sampling (Anti Aliasing)

- Ray Tracing

- Final Gathering | Global Illumination

Sampling

To get good anti-aliasing quality, you need multiple samples per pixel

Dots are pixel centers, but not sample locations.

min/max samples 0
Dots are sample locations.

samples 0 (min) 2 (max)

Sampling

- Samples for Unified Sampling

- Test render: 0.25 – 0.8
- Final Render: 0.8 – 2.0

Raytracing

Raytracing settings are split into:

- Reflections

- Refractions

- Shadows

Raytracing is also commonly used to determine what the camera is looking at (primary ray), for ambient occlusion and more

SHADOW RAYS

REFLECTION RAY

NORMAL

REFRACTION RAYS

PRIMARY RAY

Raytracing

Reflections:

Maximum number of times a ray will reflect when calculating

0 reflections

1 reflections

2 reflections

Images courtesy of Mental Images

Raytracing

Refractions:

Maximum number of times a ray will refract when calculating refractions

Refractions occur when a ray goes through a (semi-) transparent surface.

Image courtesy of Mental Images

Raytracing

Max Trace Depth

    Maximum allowed
       reflections + refractions

    for a single ray

It's just an additional setting to allow for more fine-tuned optimization

You can simply use:

      mtr = reflection + refraction

Or choose a value less than the exact sum

Raytracing

Shadows

- Maximum number of times a ray will reflect when calculating shadows

- This setting determines whether a shadow appears in a reflection (of a reflection of a ...)

Shadows 1

Shadows 2

Raytracing

Guidelines:

- Reflections/refractions: 4 – 10

- Max Trace Depth 50 – 75% of sum (2 – 6)

- Shadows: 2 – 4

Disclaimer: these are very general guidelines. If your scene contains a lot of glass or reflective materials, more refractions reflections or shadow depth *may* be necessary

Image courtesy of marczych

Final Gather

Accuracy:

The number of rays cast per FG point

- Determines quality in the most direct way

- Subtle light effects demand a high accuracy

direct light

eye ray

direct light

finalgather ray

Accuracy: number of these guys per FG point

Final Gather

Accuracy:

- Start with 20
- Increase when image is full of spots
- Use steps of 10

Range for production:

Simple lighting: can be as low as 50

Complex lighting, high quality: 1000+

Example of result of low Accuracy, full of 'FG spottiness'

Final Gather

Point Density:

How many places and where Mental Ray will do a full FG calculation in the final image

- Determines overall quality
- 1.0 (100%) means everywhere where MR would initial plan to do a FG calculation
- 0.5 means at 50%, so roughly twice as coarse

FG point visualized. MR intelligently determines where the density needs to be higher

Image courtesy of Digital Tutors

Final Gather

Point Density:

- ## Start with 0.6 for test renderings
  Use 0.8 for test rendering when results are very poor with low Accuracy

- ## Set to around 1.0 for final renderings

- ## > 1.2 should normally not be needed

Final Gather

Point Interpolation:

Mental Ray can interpolate values from different FG points
This sets how many values to average/weigh.

- Higher values create a smoother image

- Results are less accurate: light gets 'smeared out'

- It's faster than increasing the accuracy

Point camera's looking at and is currently considered

Light value at a FG point

Final Gather

Point Interpolation:

- Set to about half of the Accuracy

- Increase to 1x or 2x the Accuracy
  as desired
  (if more accurate results aren't required)

- Keep in sync with Accuracy

Final Gather

Secondary Diffuse Bounces:

Indirect light can 'bounce' even further than the default one indirect bounce, using Secondary Diffuse Bounces.

- Expensive calculation (exponential!)
- Make test renderings to see whether is actually contributes enough to be noticeable

Secondary Diffuse Bounce
Notice the exponentiality

Final Gather

Secondary Diffuse Bounces:

- Leave at 0 if you can
- Increase in steps of one
- Values > 5 should generally not be necessary

Temporarily decrease for test rendering if you don't need the additional bounces: for quicker rendering and a streamlined process

Final Gather Troubleshooting

Final Gathering Quality Filter

- Set to 1 if you have some very distinctive bright spots in your image

- Caused by reflections (and low accuracy)

Distinct spots caused by FG artefacts

FG Examples

Accuracy: 20

Point Density: 0.6

Point Interpolation: 10

Render time: 0m47

FG Examples

Accuracy: 40

Point Density: 0.6

Point Interpolation: 20

Render time: 1m09

Increased Accuracy
(and Interpolation accordingly)
for higher quality (less 'spotiness')

FG Examples

Accuracy: 40

Point Density: 1.0

Point Interpolation: 20

Render time: 1m27

Increased Point Density
for a bit higher quality, but beacuse point interpolation and accuracy is still quite low, the effect is hardly noticeable: this scene clearly requires higher accuracy.

FG Examples

Accuracy: 40

Point Density: 0.8

Point Interpolation: 40

Render time: 1m26

Changing back the Point Density and just increasing the Interpolation quickly yields smoother results
(albeit not too accurate)

FG Examples

Accuracy: 60

Point Density: 0.8

Point Interpolation: 40

Render time: 1m48

Increasing the Accuracy makes the render a bit better, but still not perfect.

Render Settings Presets

- You can create and load Presets

- Switch back and forth between test and production quickly

- Re-use settings that you commonly use: less fiddling, less mistakes

Preset Caveats

When you use Presets:

- Some settings can be set quite high
- Double-check your Ray Tracing, Sampling and FG Seetings after loading a preset
- Make adjustments and save the preset

The BK Renderfarm

- A stack of dedicated servers for rendering
- Available 24x7
- Total capacity:
  - Over 350 GHz of CPU power (in ~140 threads)
  - Over 320 Gigabyte of memory
  - ~17 tasks executed in parallel (20GHz, 18GB per task)

2013 Q4 addition to our farm:
    20 cores (E5-2680v2)
    2.80 GHz, 40 threads: 112 GHz
    64 Gigabyte DDR3 memory
2015 Q1: in 2 servers
    48 cores (E5-2680v3)
    2.50 GHz, 96 threads: 240GHz
    256 Gigabyte DDR4 memory

Th BK Renderfarm

Comparison

	Renderfarm per task	TU Laptop 2014-2015 HP Elitebook	Macbook Pro 15" 2015	Renderfarm Total
Processor # Cores	4 8 threads	4 8 threads	4 8 threads	68 136 threads
Processor Speed Combined	20 - 22,4 2,5-2,8Ghz * 8	19,2 2,4 GHz * 8	17,6 – 22,4 2,2 - 2,8 GHz * 8	352
# machines for equivalent of renderfarm		18	16 - 20	1
Memory	18 GB	8 GB	16 GB	320 GB

Using the Renderfarm

Workflow:

- Prepare your project and scene
- Configure your job
- Publish your scene
- Submit the job
- Wait…
- Get the results

Using the Renderfarm

- Your Maya Project **must** be set properly
  otherwise your textures won't work

- Copying your entire project to the renderfarm
  file server may take a while:
  - use a wired network connection
  - Upload from the campus network

- Outside TU network: VPN is required
  » http://vpn.tudelft.nl

Using the Renderfarm

- The queue works on a first in first out basis
- But it can be managed otherwise to allow for a more fair allocation of resources
- If you your task to be incorrect, please remove it asap

BK Renderfarm

More information: renderfarm.bk.tudelft.nl. Note: The data on this page is not real-time. The data is at most 1 minute old.

Server status ⟳

Job Queue ⟳

ID	job name	owner	status	progress	started	#working	#frames
14	AR0771_test	remove job	Started	0%	2014-10-06 13:13	1	1

You can follow and manage your jobs on:

http://renderfarm.bk.tudelft.nl

Renderfarm Troubleshooting

If there's any problem with your job:

- Determine what's wrong: quality setting, textures, crash/error

- Use the Log file that's placed in the renderfam_logs folder within your folder on the renderfram file server

Each render produces a log file which is made available to you for inspection to troubleshoot any problems

Renderfarm Help

Documentation: http://wiki.bk.tudelft.nl/toi-pedia/Renderfarm

For any additional assistance, please refer to @Hok

Some Final Notes

- Make sure your polygons are detailed enough
- Check NURBs tessellation quality
- Texture resolution and filtering (esp. bump)
- Use lossless format (such as PNG, Tiff or TGA) instead of JPEG for textures, especially for bump and displacement