“Ray tracing is the future and always will be”

SIGGRAPH 2013 – James A. McCombe
We Agree!

Thank you for attending

... unless
We must address the mass market
Desktop and mobile fill rates

<table>
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<th>Year</th>
<th>0Gpx/s</th>
<th>10Gpx/s</th>
<th>20Gpx/s</th>
<th>30Gpx/s</th>
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<tr>
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<table>
<thead>
<tr>
<th></th>
<th>Mobile (smartphone)</th>
<th>Desktop</th>
</tr>
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<tbody>
<tr>
<td>2006</td>
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</table>
# Desktop and mobile flops

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<tbody>
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<td>1,346</td>
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<tr>
<td>2012</td>
<td>22</td>
<td>3,100</td>
</tr>
</tbody>
</table>

Desktop: 0Gflops, 800Gflops, 1,600Gflops, 2,400Gflops, 3,200Gflops

Mobile (smartphone): 0Gflops
Mobile displays

727k pixels

2M pixels
Game animation requirements

Poly counts of RT characters

1999  1500  15 000  20 000  30 000


Source: Sony
Why bother with ray tracing?

<table>
<thead>
<tr>
<th>App Name</th>
<th>Category</th>
<th>Price</th>
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<tr>
<td>Sprinkle Islands</td>
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<tr>
<td>Walking Dead: The Game</td>
<td>Games</td>
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<tr>
<td>Tiny Thief</td>
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<td>$2.99</td>
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<tr>
<td>Wheel of Fortune: Cubed</td>
<td>Games</td>
<td>$0.99</td>
</tr>
<tr>
<td>Best Park In the Universe - Regular...</td>
<td>Games</td>
<td>$2.99</td>
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Why bother with ray tracing?

• For certain effects, ray tracing will be lower power than equivalent multi-pass rasterised effects.

• Unlikely to gain adoption unless this is true.
The Unified Shading Cluster
USC: An overview

![Diagram showing the relationship between PDS, USC, and Tex]

- PDS
- Tasks
- USC
- Tex
What is a task?

Task

Instances (x32)

• Vertex Shade
• Pixel Shade
• Ray Shade
• Compute Thread
Inside a USC
Why bother with fixed function?
Visualisation of the internal BVH
Ray:AABB Test

• “Fast Ray-Axis Aligned Bounding Box Overlap Tests with Plucker Coordinates.” – Jeffrey Mahovsky and Brian Wyvill
  • Slightly modified to test a ray interval
• 6 lines form the silhouette of the AABB
• 6 planes from the ray origin and each edge vector
• Dot product of plane normal and ray direction vector
• 6 signs must match and be negative.
Analysis: Ray:AABB Test

Ray distance setup

3 MUL

Translation

6 SUB

Box Plane Setup

6 ADD

Plane tests

12 MUL

Test Combine

6 bitwise OR
Instruction group packing

LD  MUL  ADD  MUL  OR
LD  MUL  ADD  MUL  –
LD  MUL  ADD  MUL  OR
LD  SUB  ADD  MUL  –
LD  SUB  ADD  MUL  OR
LD  SUB  ADD  MUL  –
LD  SUB  –    MUL  OR
LD  SUB  –    MUL  –
LD  SUB  –    MUL  OR
LD  SUB  –    MUL  –
LD  SUB  –    MUL  –

26 Instructions
(32 if using compressed data formats)
Analysis: Ray:AABB Test

USC USC USC USC USC USC USC USC
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63 mm²

1.42 mm²
Bandwidth problems ...

• 19.2G AABB tests per second peak

• 16 Bytes per AABB with lossless compressed formats.
Ray coherence: major bandwidth issue
Key points for a developer
Key points for a programmer

• Shading language has new built-in for emitting rays.
  • Ray emission doesn’t block
  • Self intersection guarding is automatically handled in hardware

• New shader type when rays intersect an object
  • Similar to fragment shaders resulting from triangle scan conversion.

• Keeping your per ray attachments small is critical.

• Ray tracing acceleration structure is opaque.

• Rasterisation and ray tracing can coexist cleanly.

• We solve the ray coherence problem in both traversal and shading.

• Main optimisation parameters will be ray count and shader complexity
Thank you