Irradiance Caching in Pixar's RenderMan

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Overview

- Irradiance caching in Pixar's RenderMan:
  - simpler than the general case
  - more intuitive error control
- Ambient occlusion caching
- Use in movies

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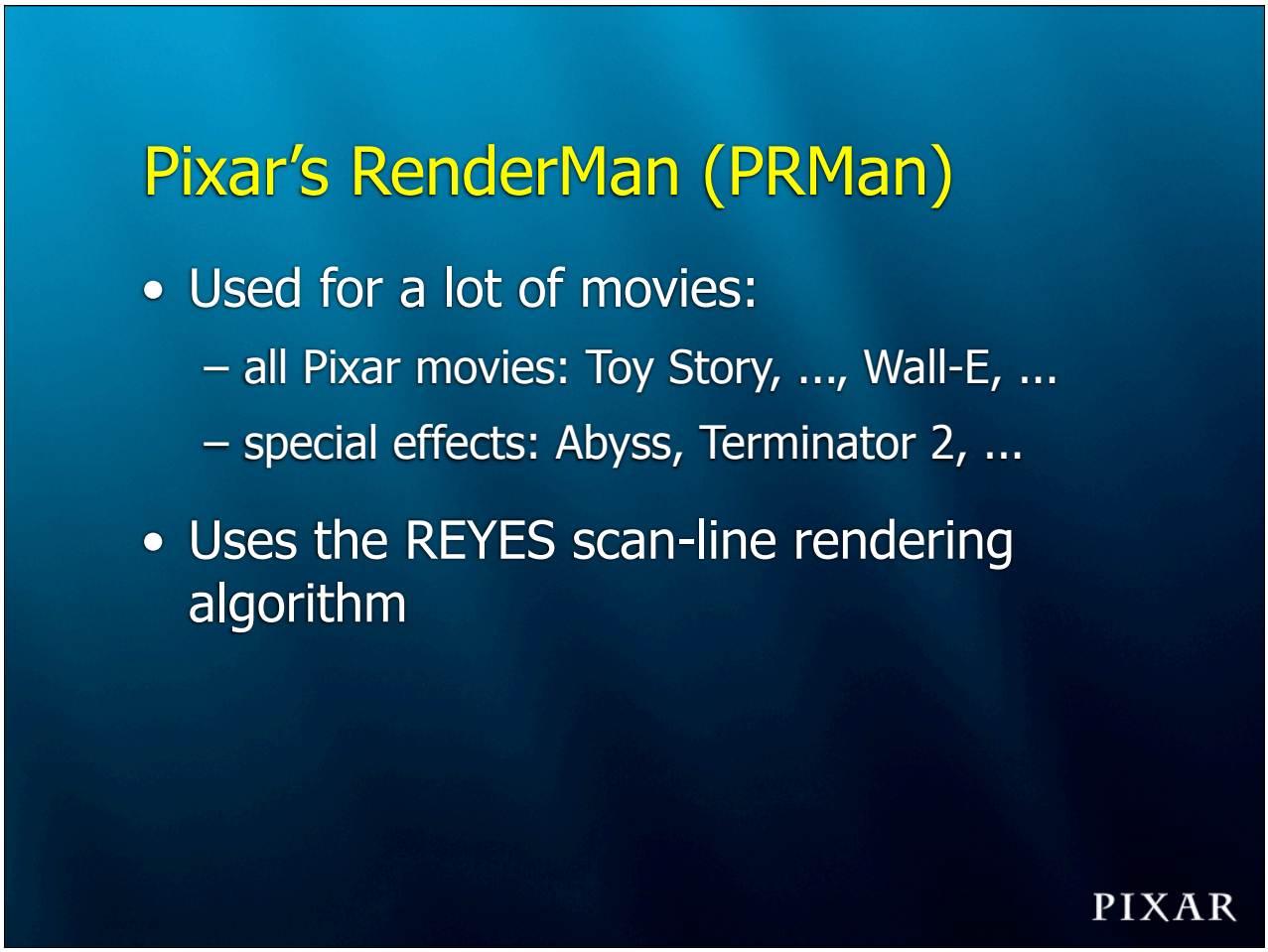
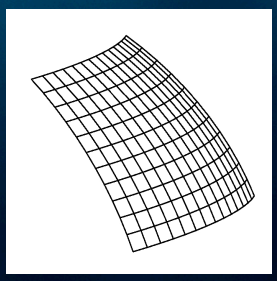


PRMan was also used for Star Wars episodes 1-3, Lord of the Rings 1-3, the Harry Potter movies, etc.
Every Visual Effects Oscar Winner of the past 15 years used PRMan.

A list of movies produced with PRMan can be found at https://renderman.pixar.com/products/whatsrenderman/movies.html

The REYES rendering algorithm

- Object surfaces are split into parametrically square pieces ("grids")
- The square pieces are divided into micropolygons:



- The micropolygons are shaded; projected onto screen

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Irradiance caching and interpolation

- General case: cached data are from random points in space (may be from different surfaces)
- REYES: we know that a grid-full of shading points are all from the same surface
- Simpler!

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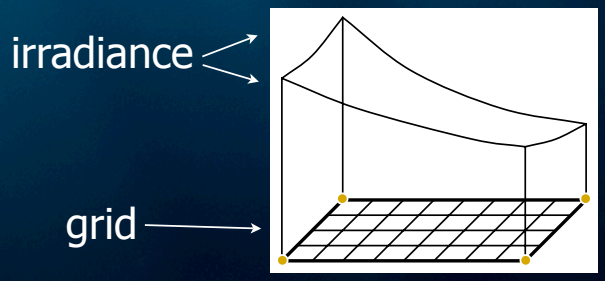
Irradiance caching and interpolation

- Compute irradiance and gradients at the 4 corners of grid
- Interpolate the irradiance to 5 points on grid using the values at the 4 corners



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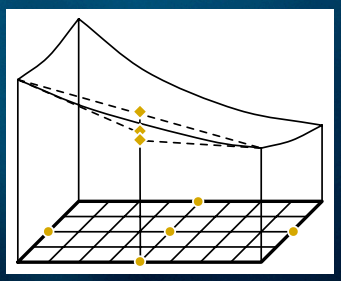
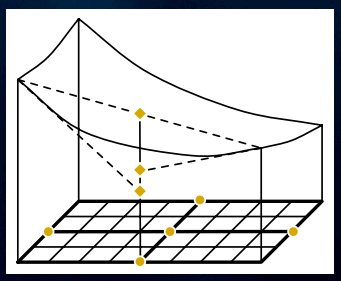
Irradiance caching and interpolation

- Close to bilinear?
- If all agree (within max allowed error) & min dist. large: use bi-quadratically interpolated values
- If not: compute irradiance & grad. at the 5 points and recurse (4 smaller subgrids)





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We assume that the irradiance on the patch has a bilinear variation. If not, we split the patch.

Error control

- Instead of 'a' in Radiance
- Specify max error (deviation from correct value)
  - for example 1% or 2%
- More intuitive

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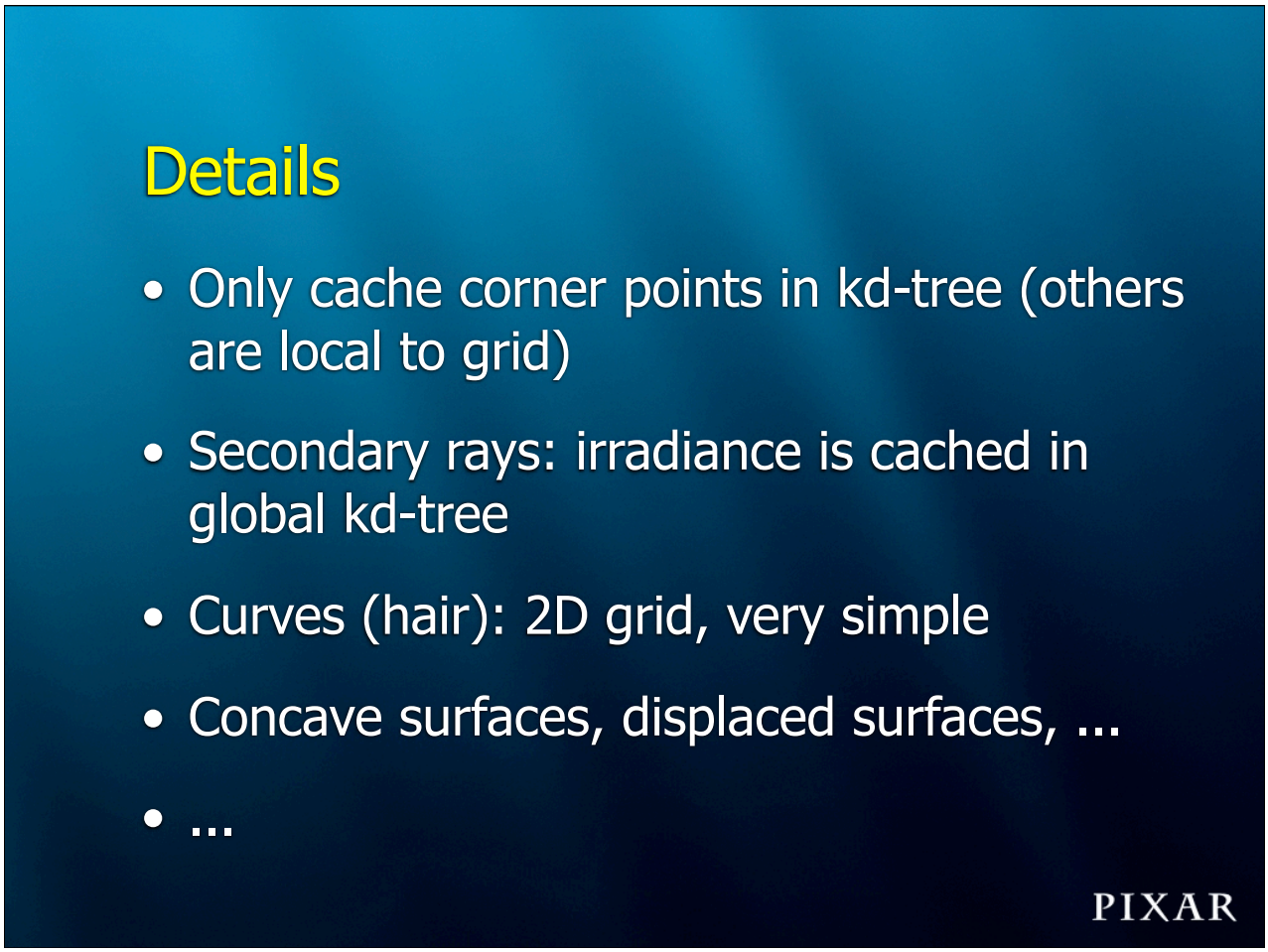
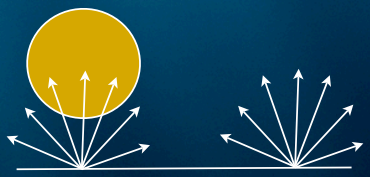


How to deal with concave and displaced surfaces has already been covered by the previous speaker

Ambient occlusion

- Fraction of hemisphere above a point that's covered



- Similar to shadows on overcast day
- Values between 0 and 1

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Ambient occlusion: examples

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Ambient occlusion: examples

... more cars

Luigi from `Cars'

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Use of ambient occlusion

- First used for movie production in 'Pearl Harbor' (ILM; mental ray)
- Used a lot in movie production
- Faster than global illumination: no need to evaluate the color at ray hit points

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Ambient occlusion gradients

- Ambient occlusion can be interpolated just like irradiance!
- Gradients computed as for irradiance (1 color band): just treat ray hit like irradiance 1, miss as irradiance 0
- Interpolation as irradiance (either Ward's formulas or ...)

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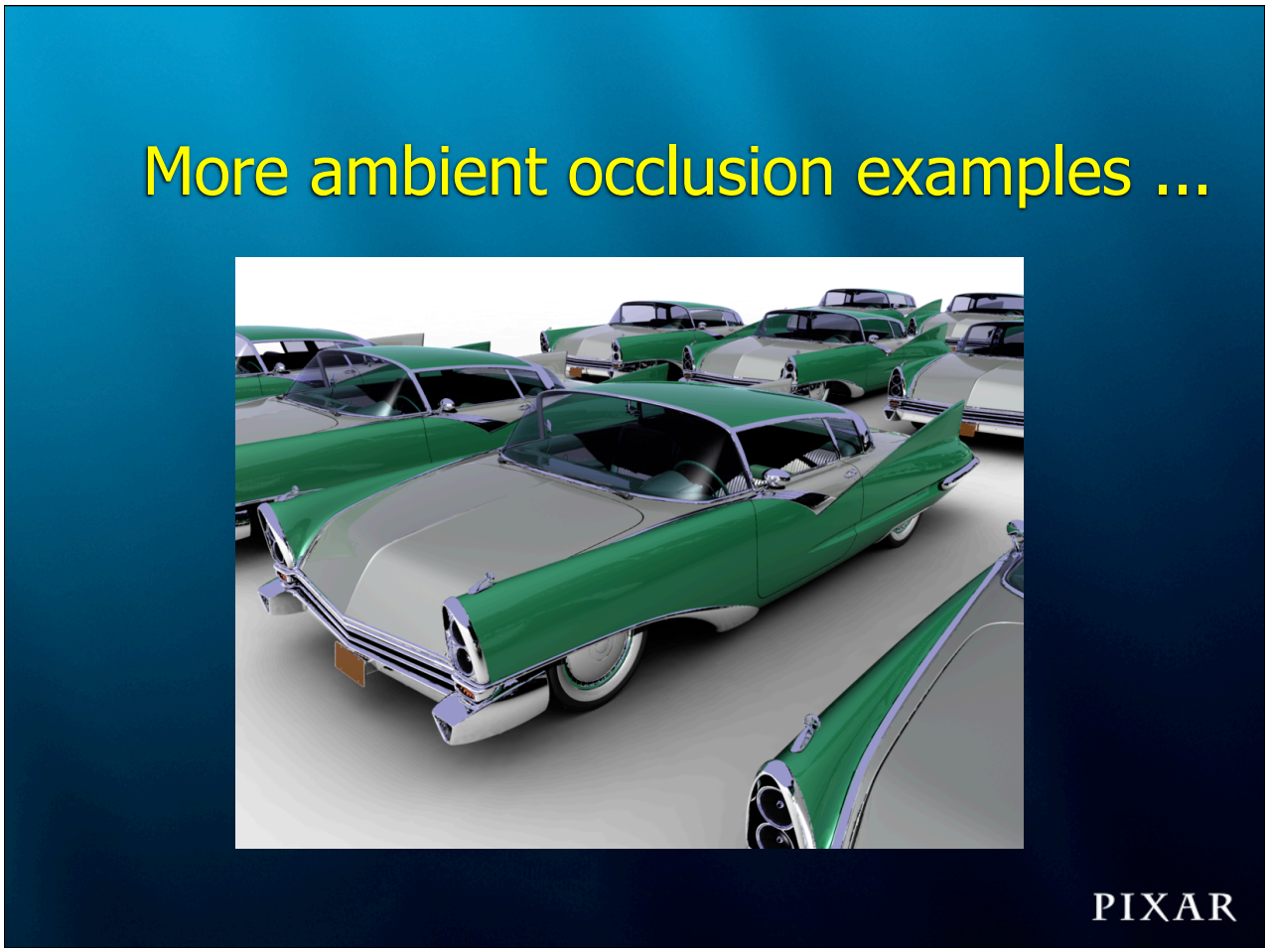
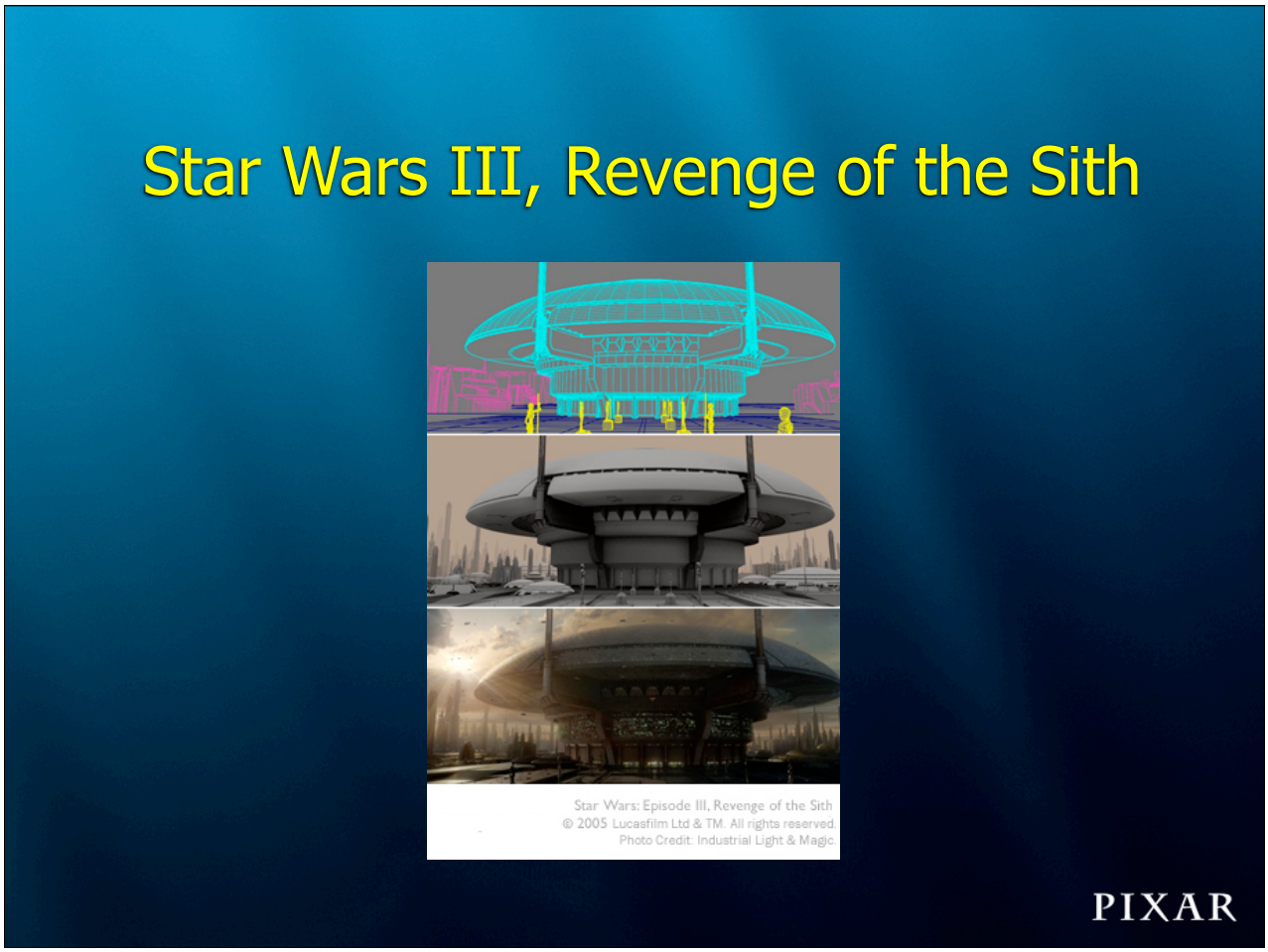


This is 15 copies of Al's car from Toy Story 2. The floor has ambient occlusion computed using irradiance gradients.



More ambient occlusion ....

Global illumination in RenderMan

- Several methods:
  - photon mapping for full global illumination
  - baking direct illumination for single-bounce
    - ray tracing
    - point-based
- All (can) use irradiance caching and interpolation

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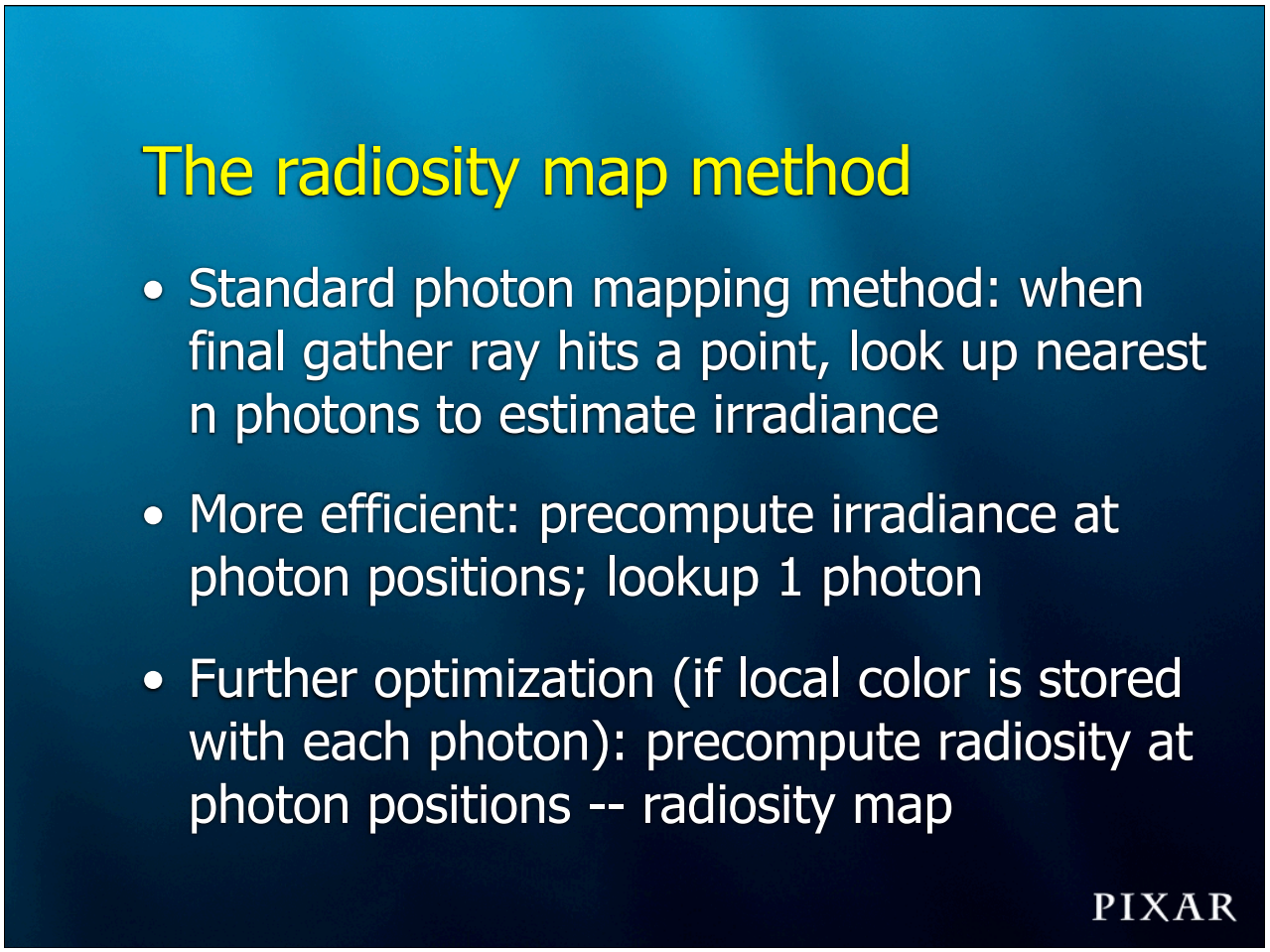

More information about the radiosity map method can be found in the SIGGRAPH 2007 Course Notes “High-quality rendering using ray tracing and photon mapping” (Henrik Wann Jensen and Per Christensen).

The radiosity map method

- Last step: distribution ray tracing using irradiance caching and interpolation

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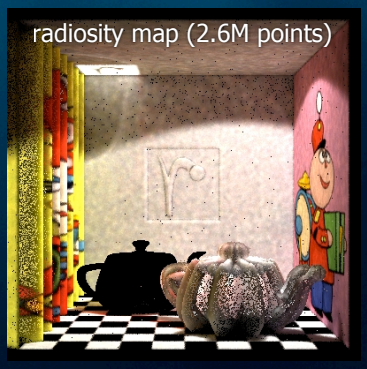
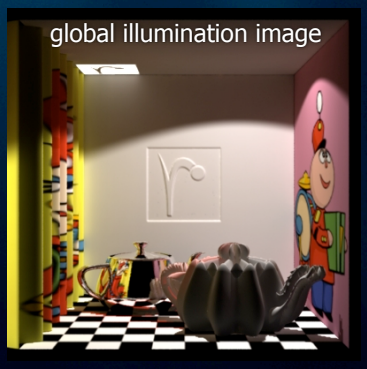
Example: box with teapots





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'Ratatouille' kitchen radiosity map

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Global illumination was actually not used on the Rat movie, but ambient occlusion was used a lot!
This is a global illumination example I rendered using the kitchen geometry and shaders from the Rat movie.
Notice the complex direct illumination and shading: ~200 light sources, ~150 surface shaders, ~1000 textures.

Summary

- Two special cases of irradiance caching:
  - REYES algorithm
  - ambient occlusion
- Irradiance and occlusion caching are ubiquitous in production rendering !

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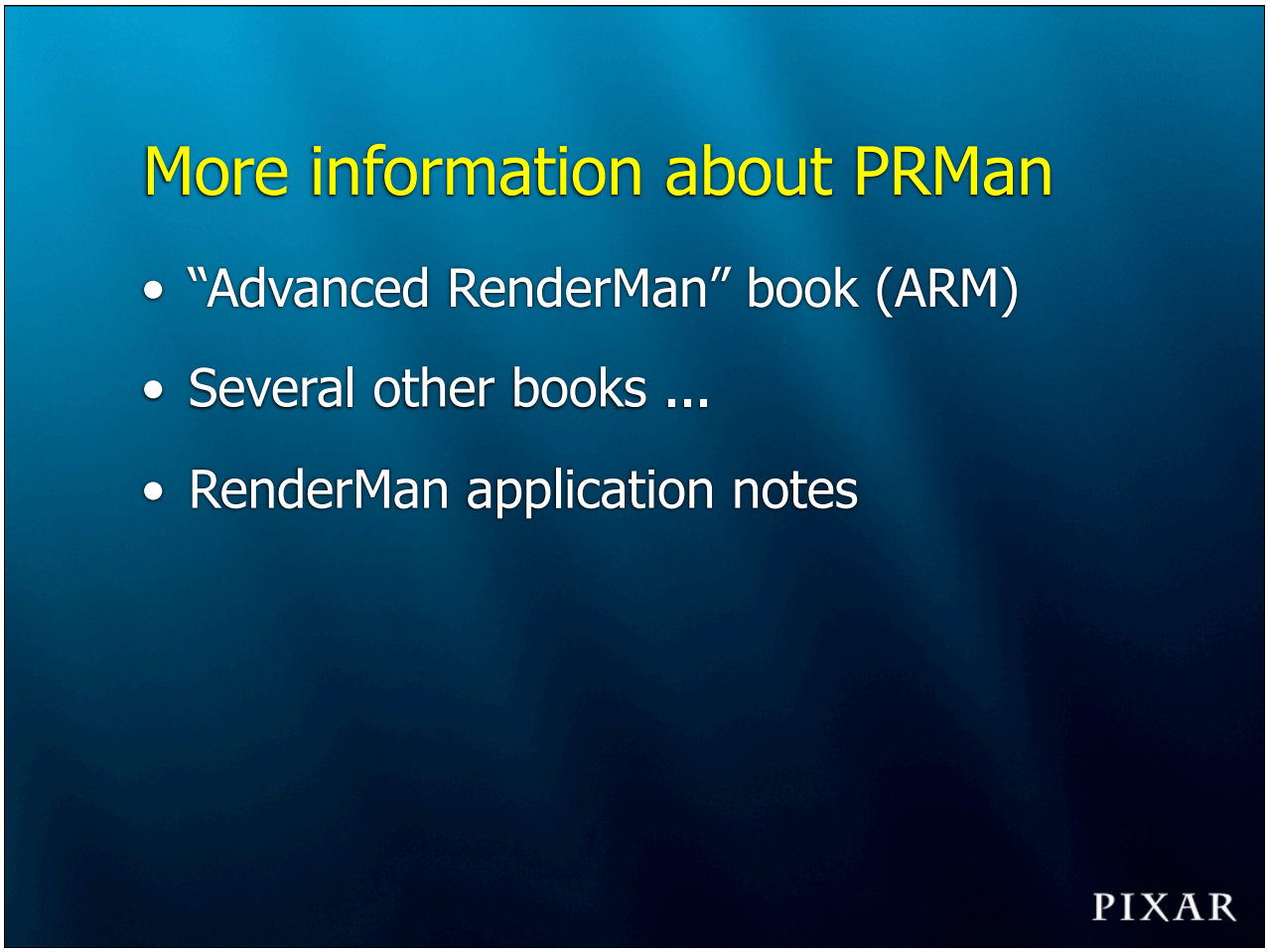
More information about PRMan
• "Advanced RenderMan" book (ARM)
• Several other books ...
• RenderMan application notes
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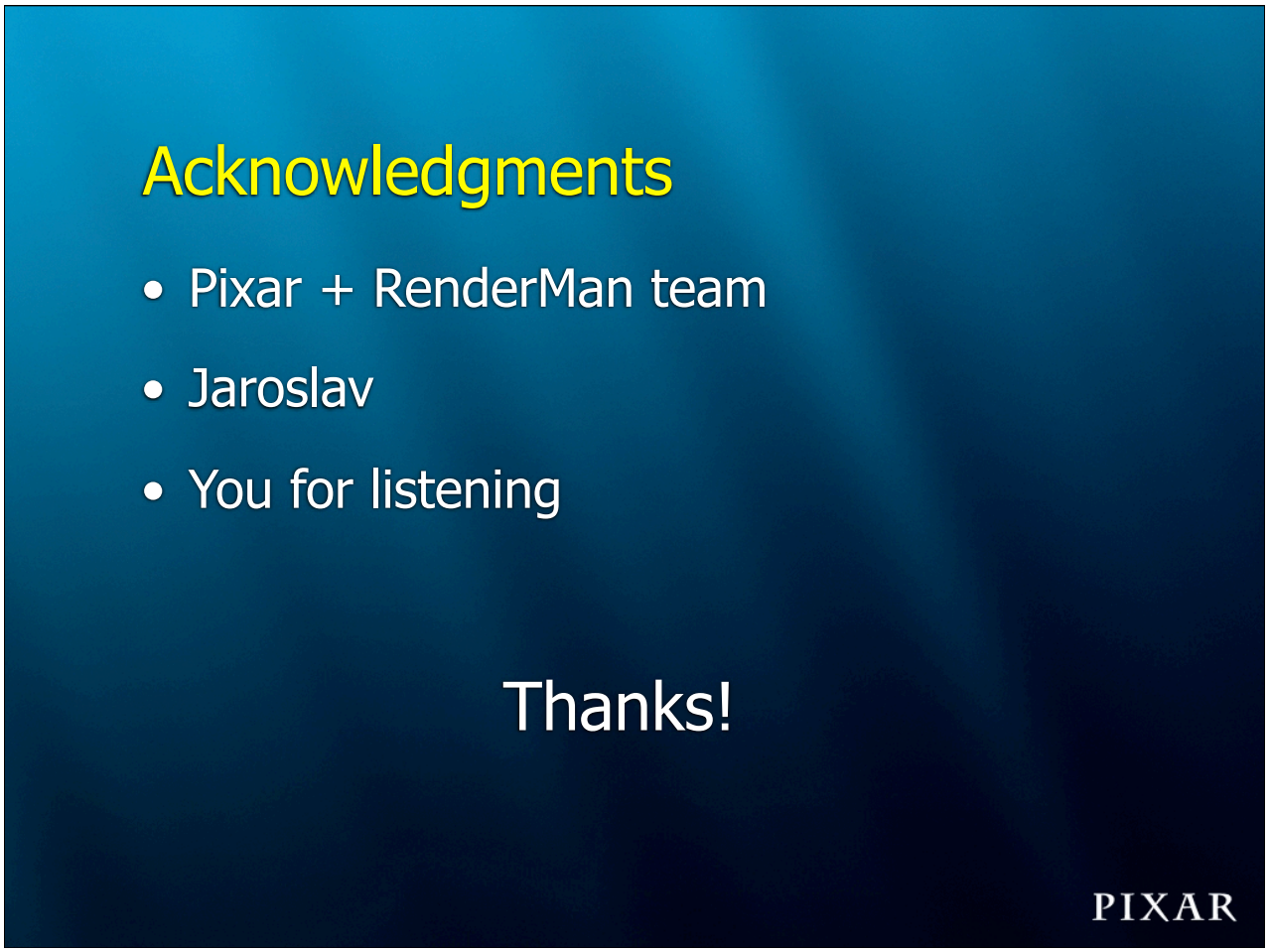
Acknowledgments
• Pixar + RenderMan team
• Jaroslav
• You for listening
Thanks!
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Questions?

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