Sampling and Reconstruction of Visual Appearance: From Denoising to View Synthesis

CSE 274 [Fall 2022], Lecture 9

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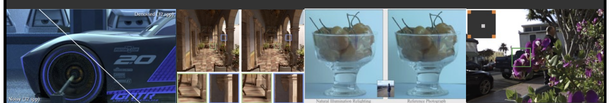


1

Applications

- Monte Carlo Rendering
- *Light Transport Acquisition / Many Light Rendering*
- Light Fields and Computational Photography
- View Synthesis
- Animation/Simulation (not covered in course)

- Introduce concepts of sparsity, coherence, compressive sensing for reconstruction

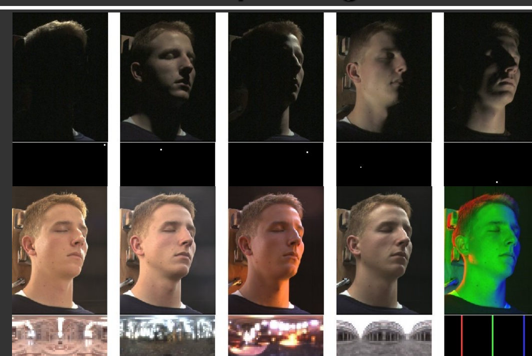
2

Acquiring Reflectance Field of Human Face [Debevec et al. SIGGRAPH 00]

Illuminate subject from many incident directions

3

Example Images



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Motivation: Image-based Relighting

Sample Lighting Directions

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Motivation: Image-based Relighting

Sample Lighting Directions

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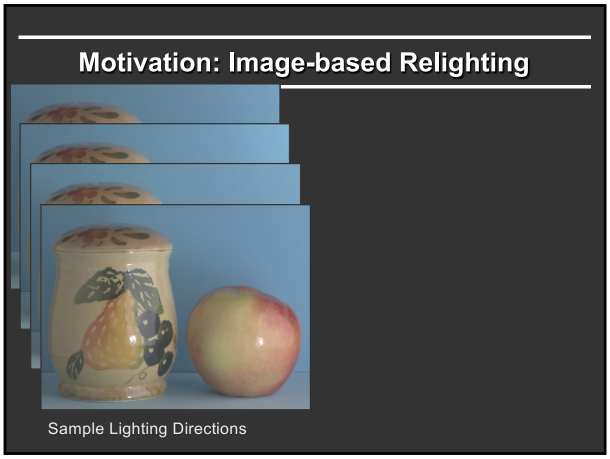
Motivation: Image-based Relighting
Sample Lighting Directions

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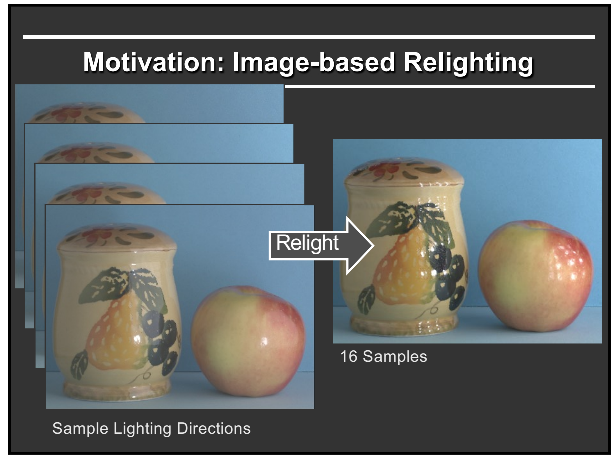
Motivation: Image-based Relighting
Relight
16 Samples
Sample Lighting Directions

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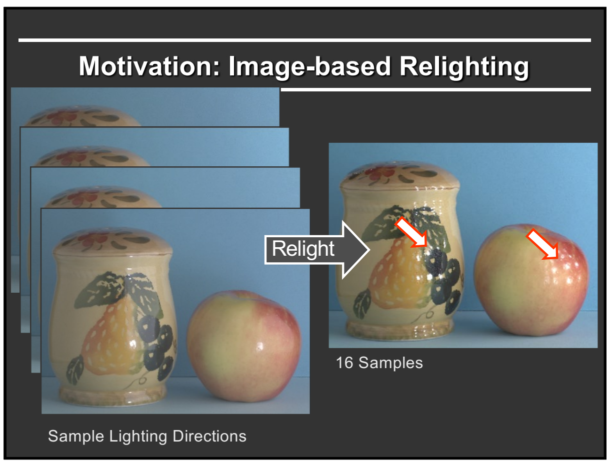
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Relight
16 Samples
Sample Lighting Directions

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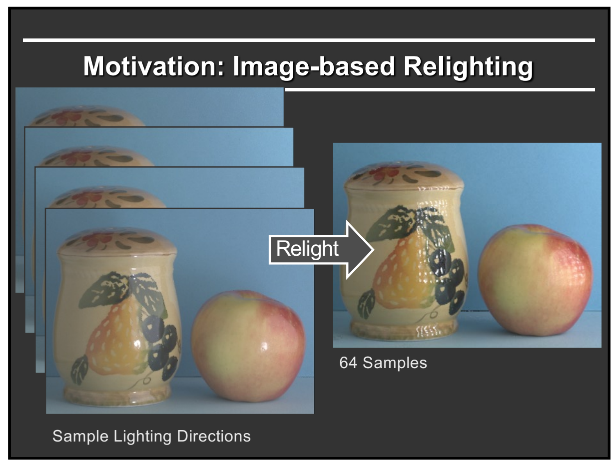
Motivation: Image-based Relighting
Relight
64 Samples
Sample Lighting Directions

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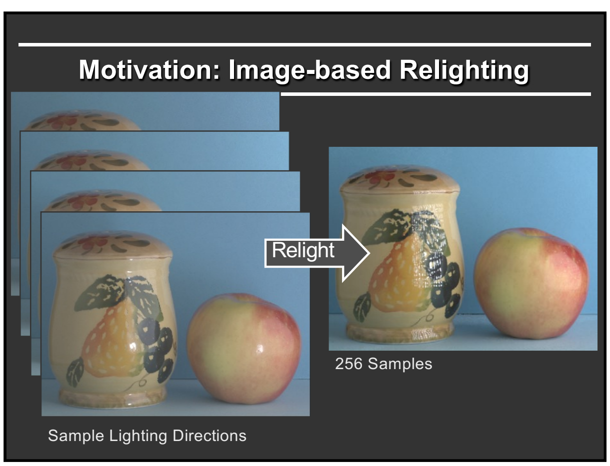
Motivation: Image-based Relighting
Relight
256 Samples
Sample Lighting Directions

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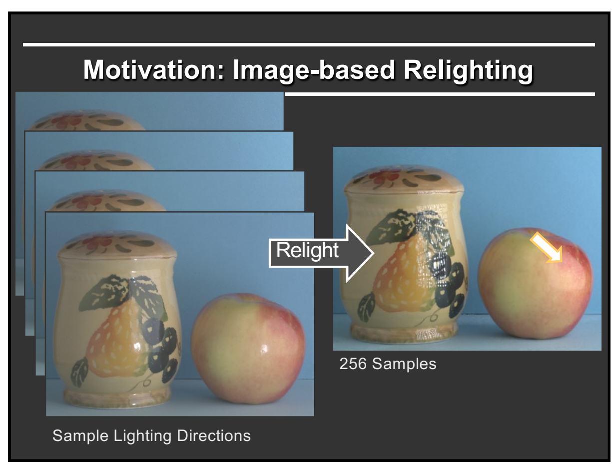
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Relight
256 Samples
Sample Lighting Directions

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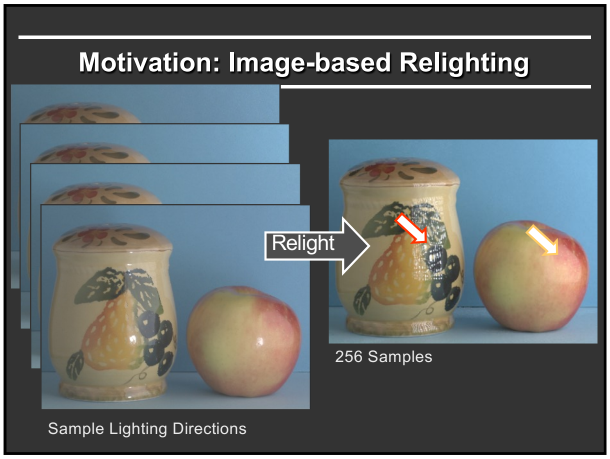

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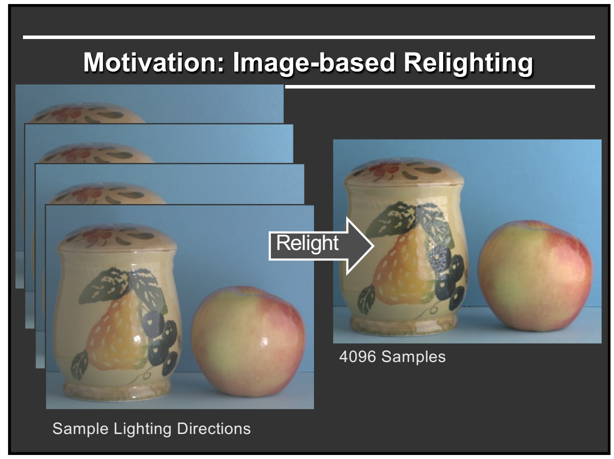

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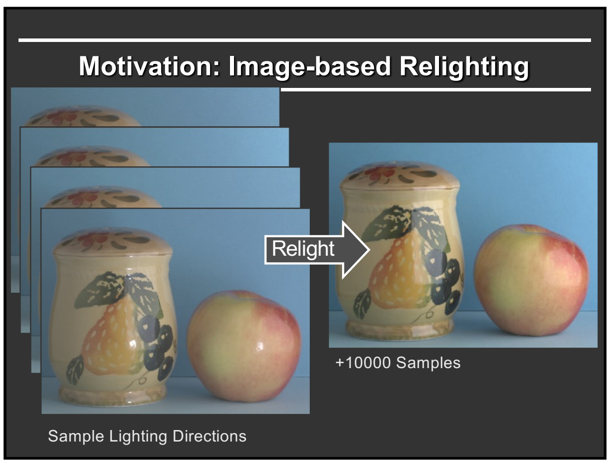

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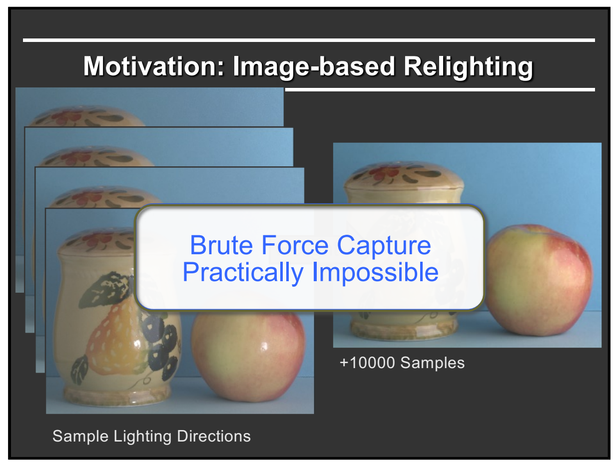

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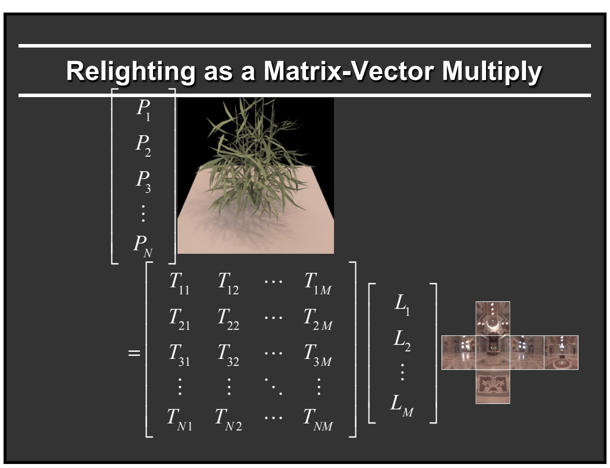

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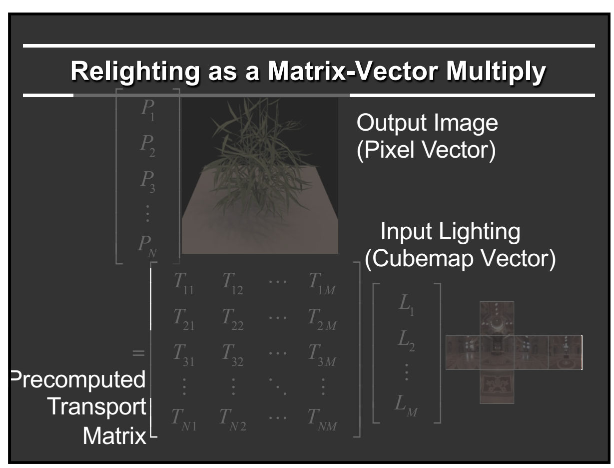

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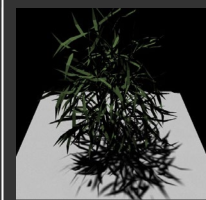
Matrix Columns (Images)

$$\begin{bmatrix} T_{11} & T_{12} & \cdots & T_{1M} \\ T_{21} & T_{22} & \cdots & T_{2M} \\ T_{31} & T_{32} & \cdots & T_{3M} \\ \vdots & \vdots & \ddots & \vdots \\ T_{N1} & T_{N2} & \cdots & T_{NM} \end{bmatrix}$$



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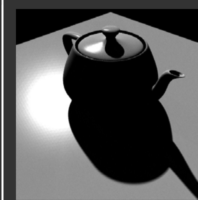
(Pre)compute: Ray-Trace Image Cols

$$\begin{bmatrix} T_{11} & T_{12} & \cdots & T_{1M} \\ T_{21} & T_{22} & \cdots & T_{2M} \\ T_{31} & T_{32} & \cdots & T_{3M} \\ \vdots & \vdots & \ddots & \vdots \\ T_{N1} & T_{N2} & \cdots & T_{NM} \end{bmatrix}$$



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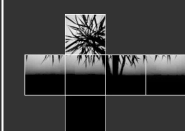
(Pre)compute 2: Rasterize Matrix Rows

$$\begin{bmatrix} T_{11} & T_{12} & \cdots & T_{1M} \\ T_{21} & T_{22} & \cdots & T_{2M} \\ T_{31} & T_{32} & \cdots & T_{3M} \\ \vdots & \vdots & \ddots & \vdots \\ T_{N1} & T_{N2} & \cdots & T_{NM} \end{bmatrix}$$



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Outline

- *Matrix Row-Column Sampling (Many Lights)*

(clustering for matrix completion of light transport)

- Compressive Sensing for Light Transport
- Matrix Completion

Hasan, Pellacini, Bala SIGGRAPH 07

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Complex Illumination: A Challenge

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Conversion to Many Lights

- Area, indirect, sun/sky

Courtesy Walter et al., Lightcuts, SIGGRAPH 05/06

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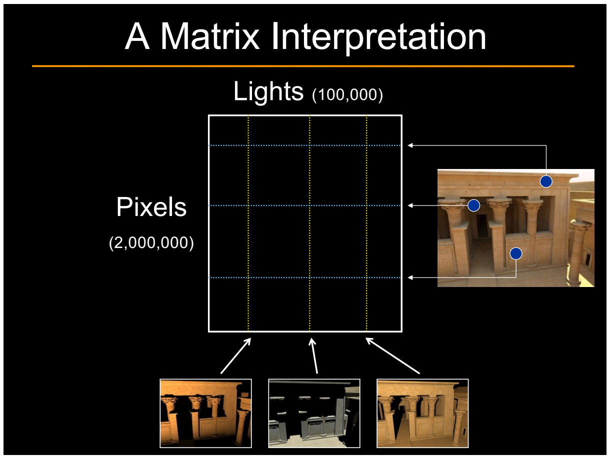

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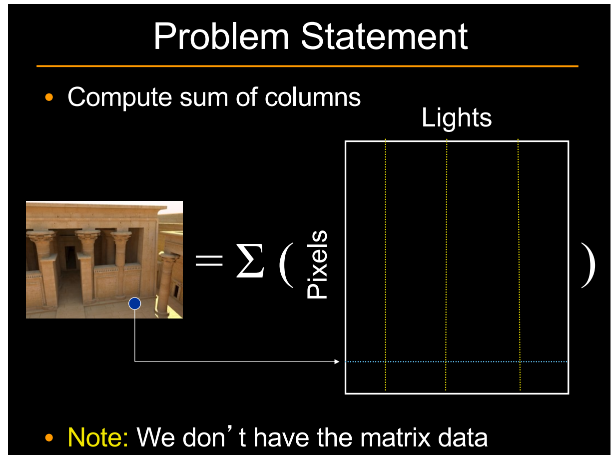

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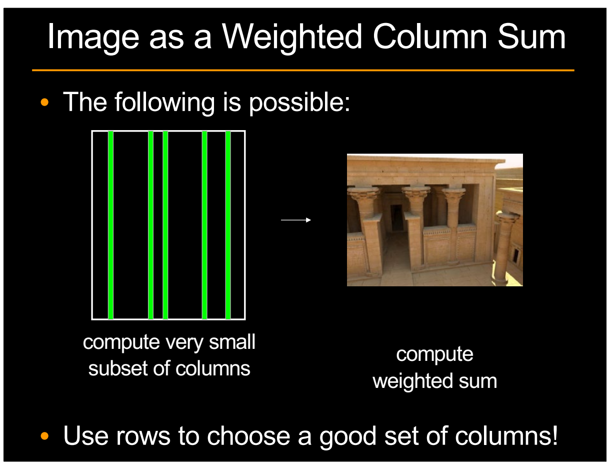

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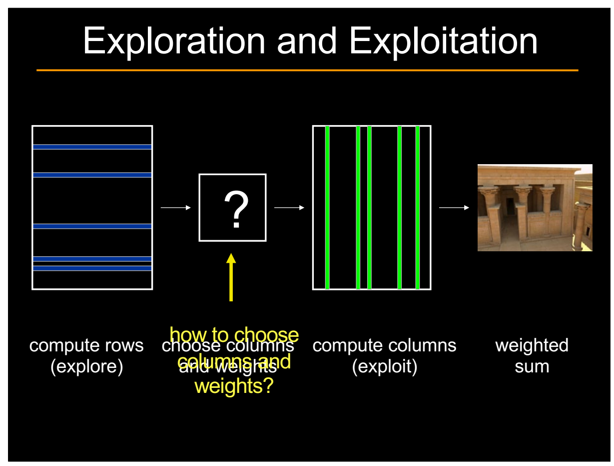

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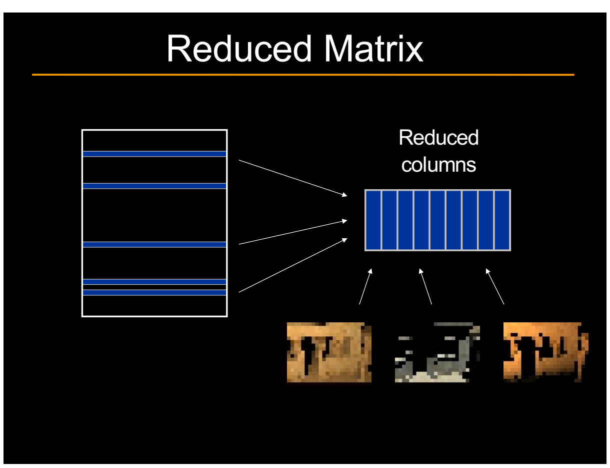

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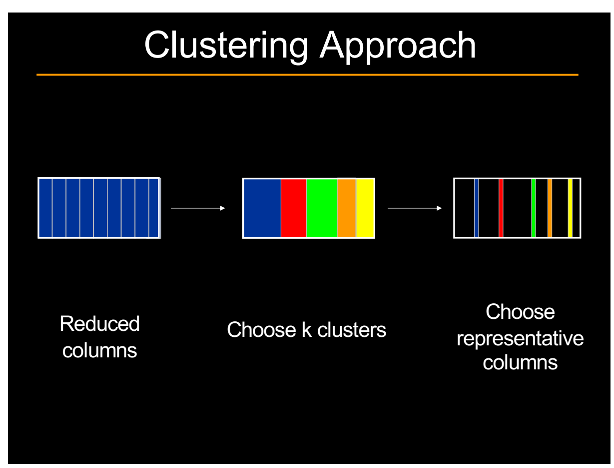

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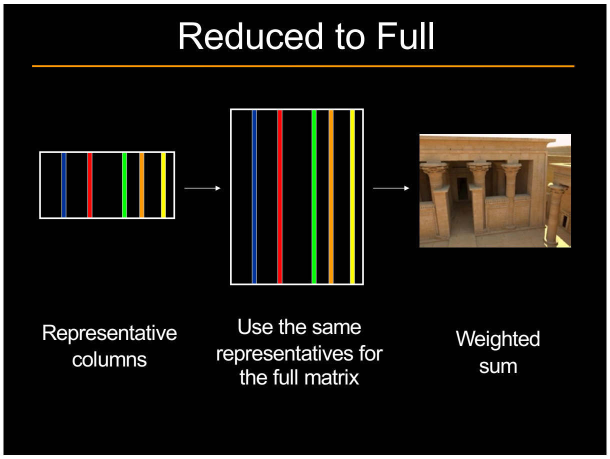

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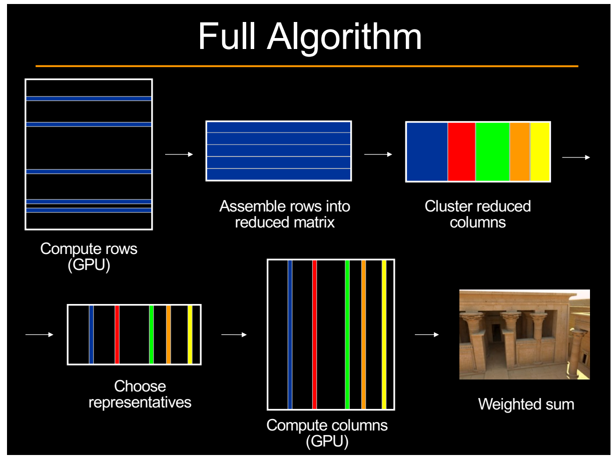

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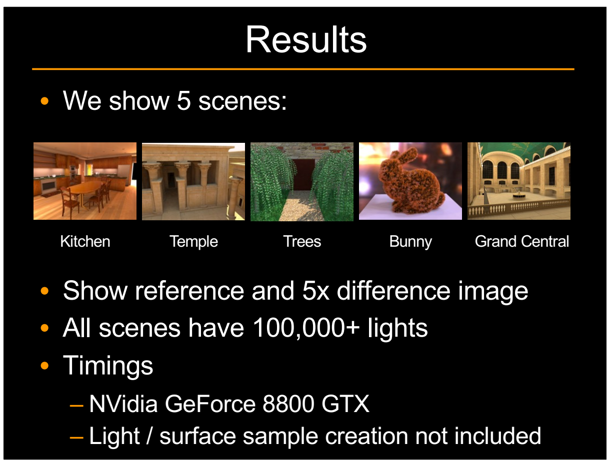

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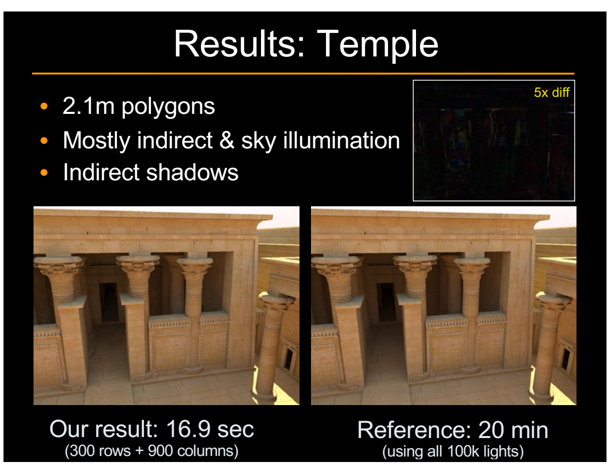

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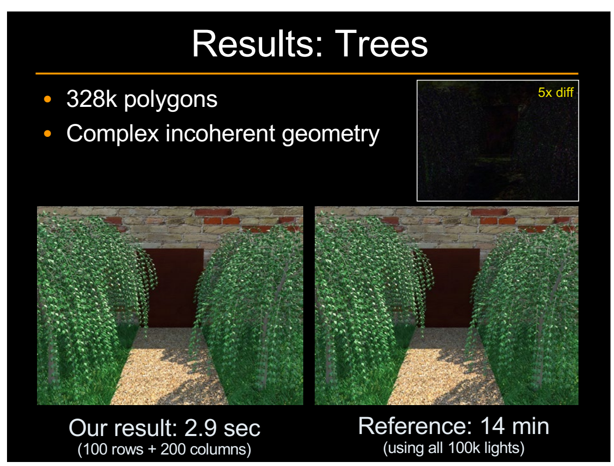

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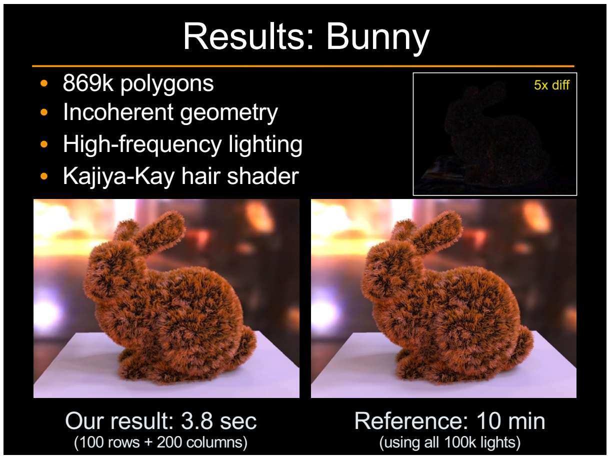

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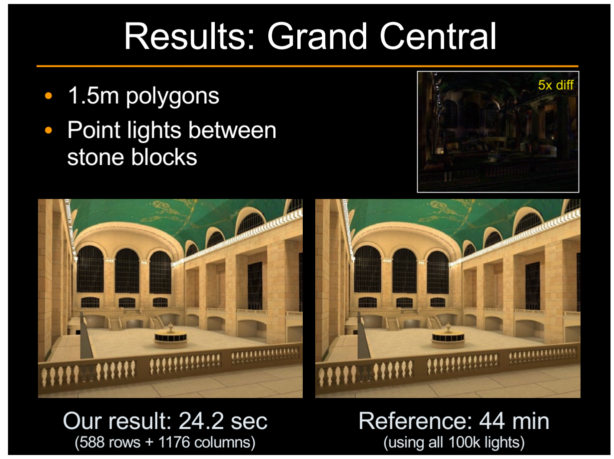

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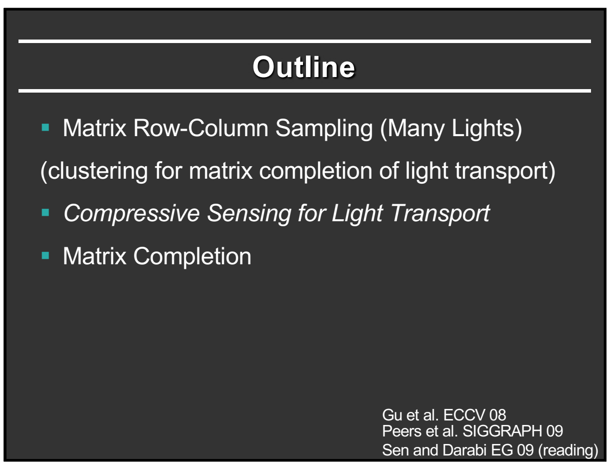

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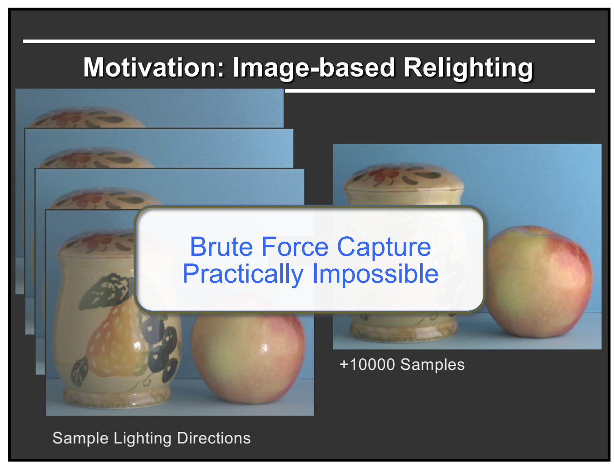

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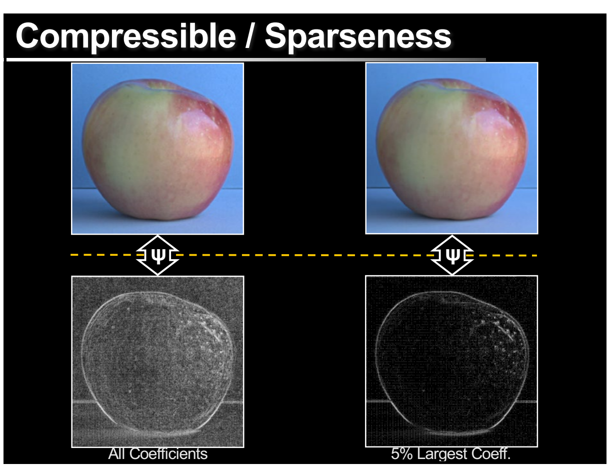

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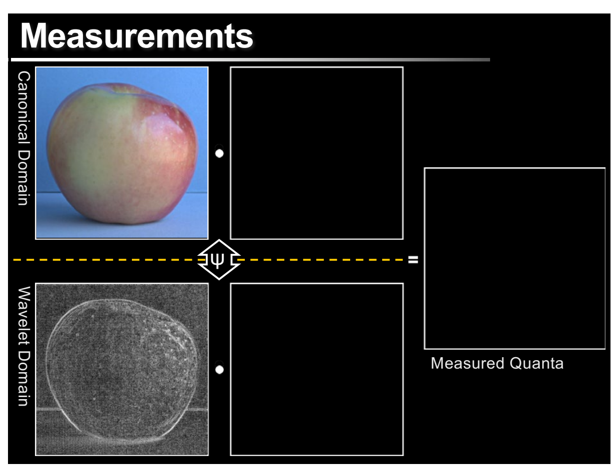

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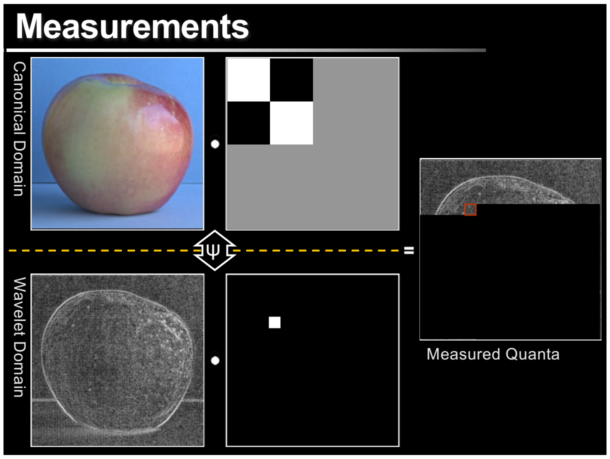

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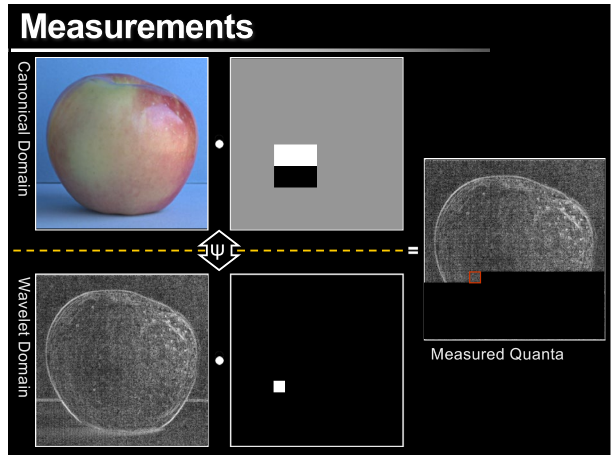

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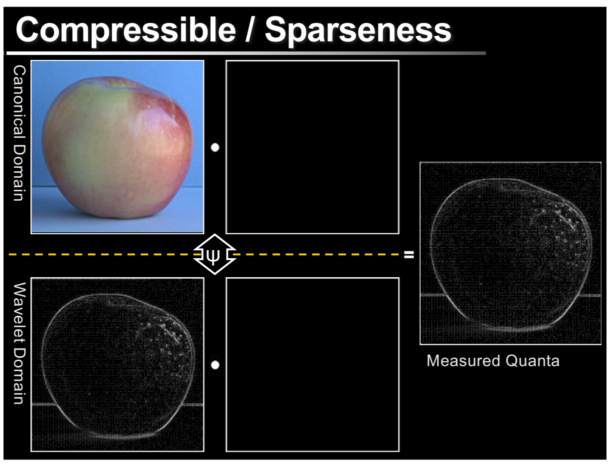

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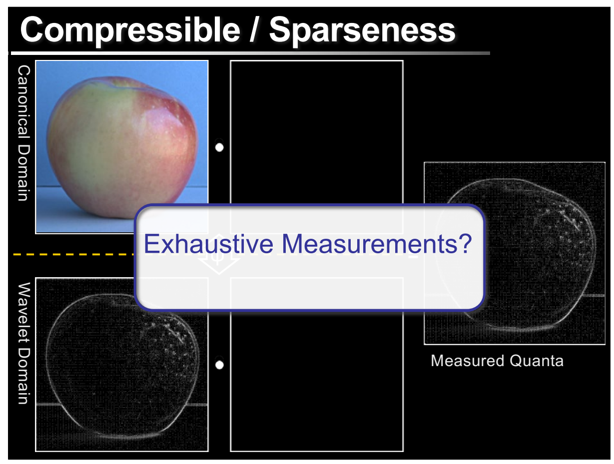

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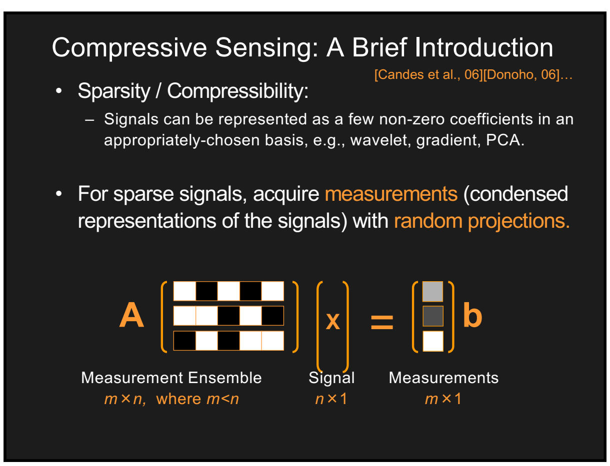

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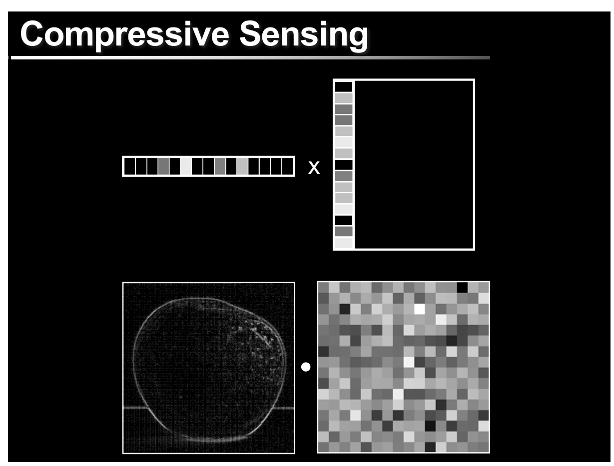

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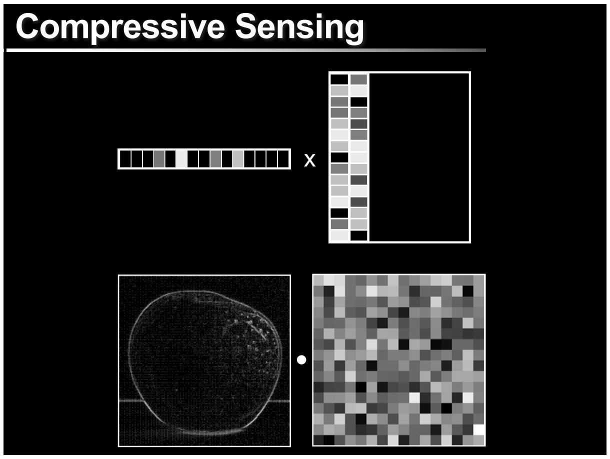

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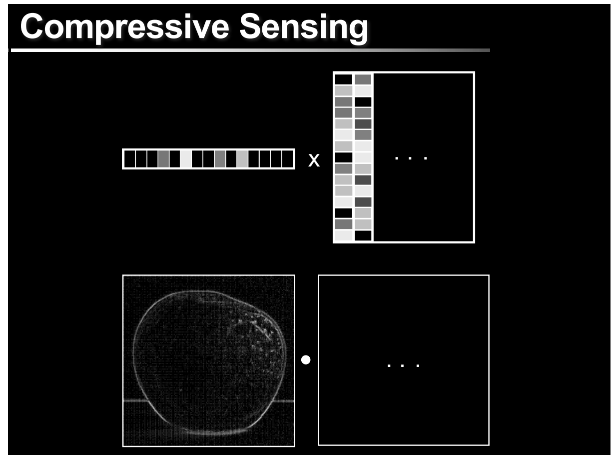

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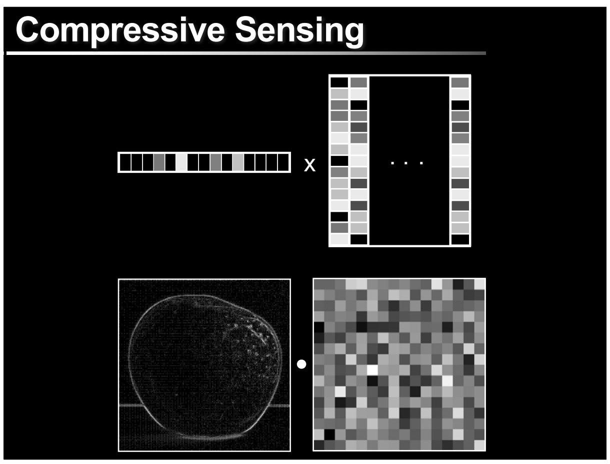

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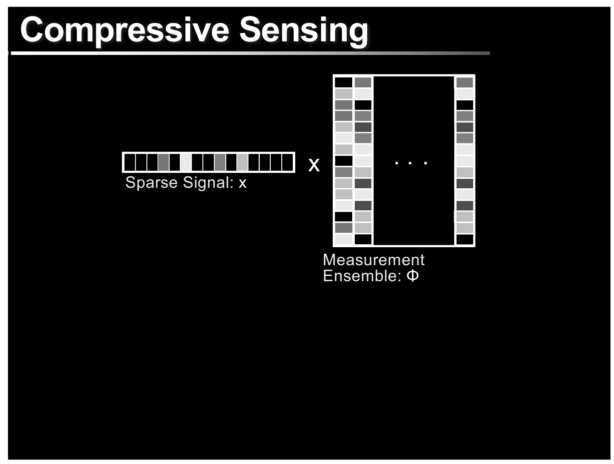

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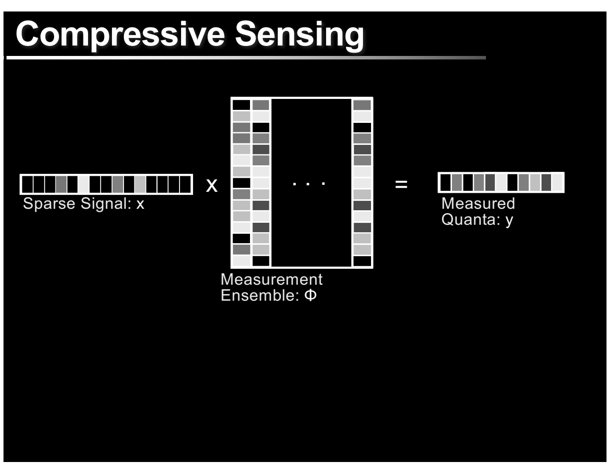

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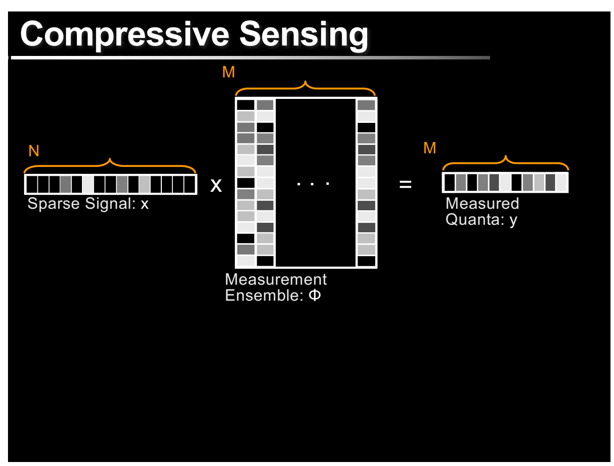

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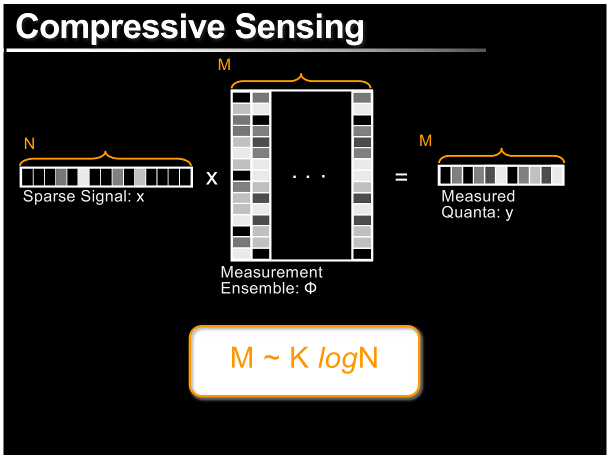

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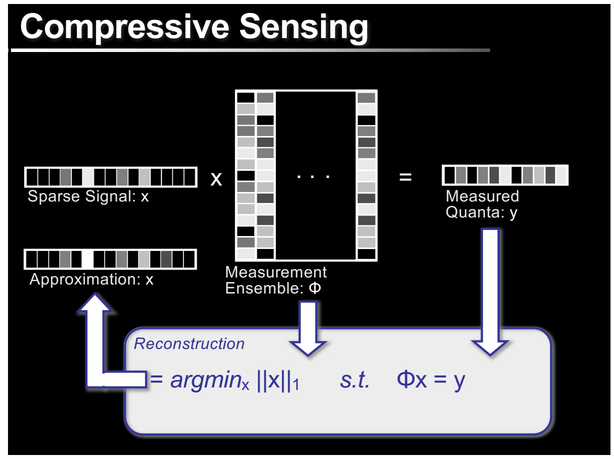

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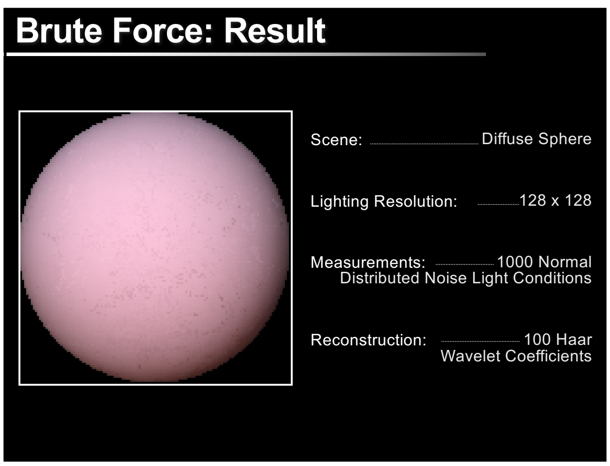

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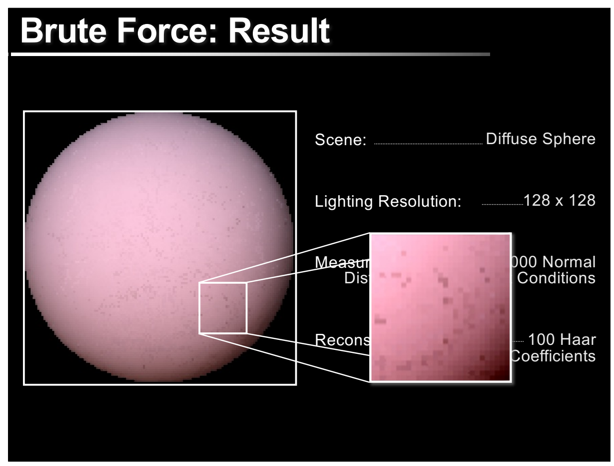

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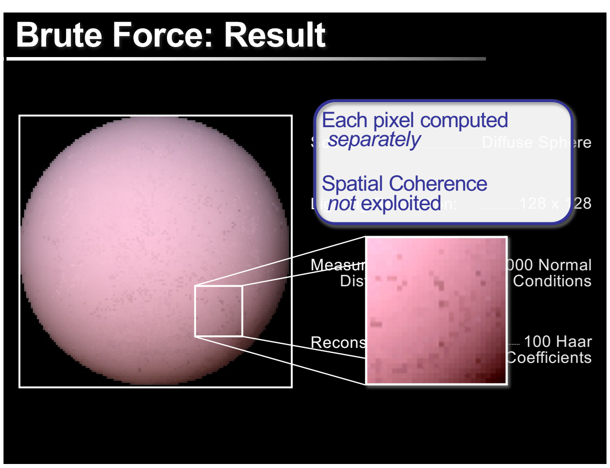

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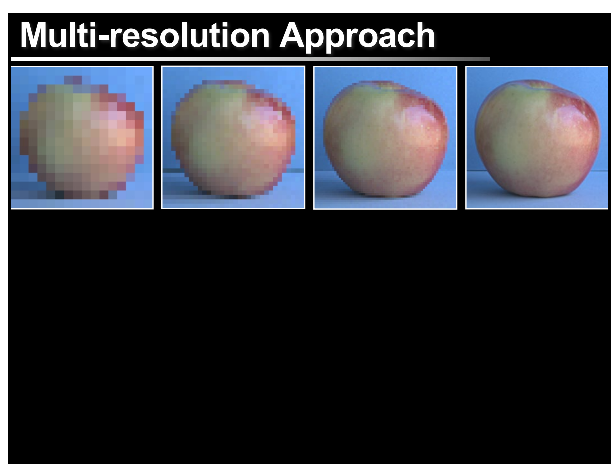

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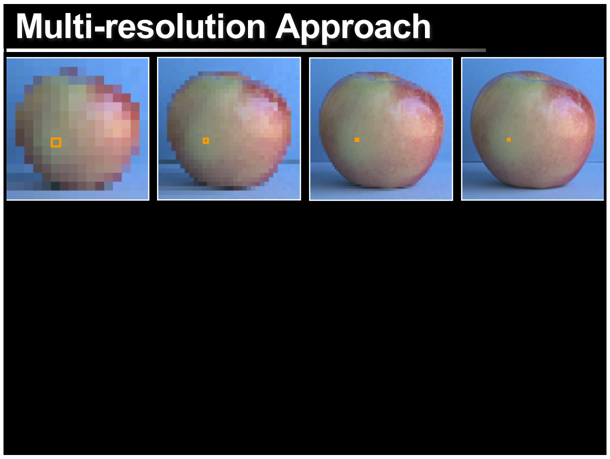

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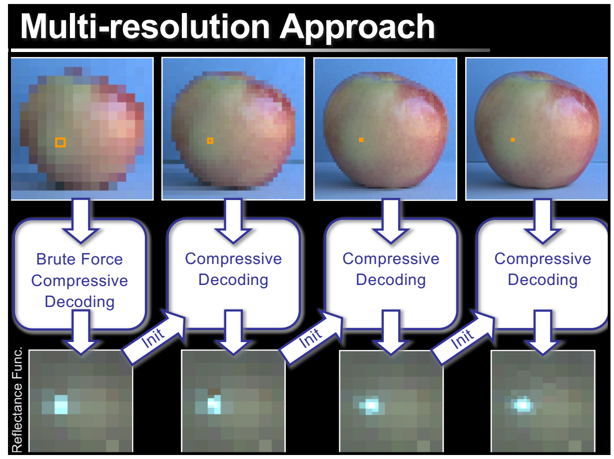

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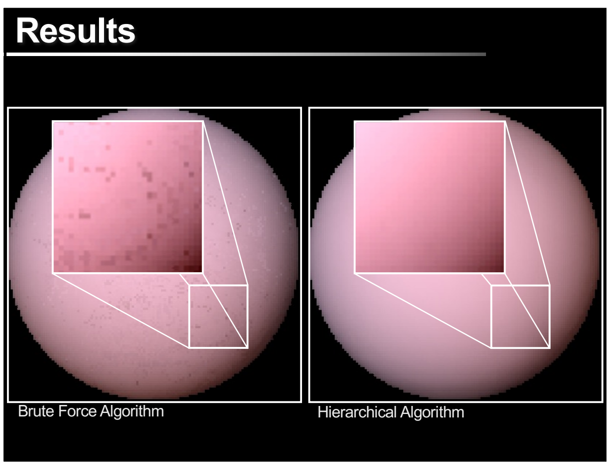

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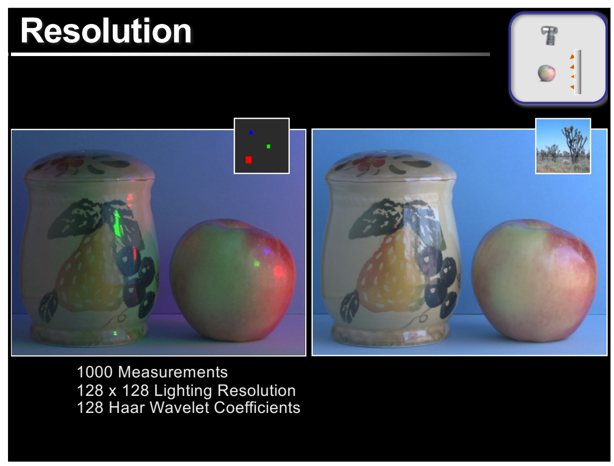

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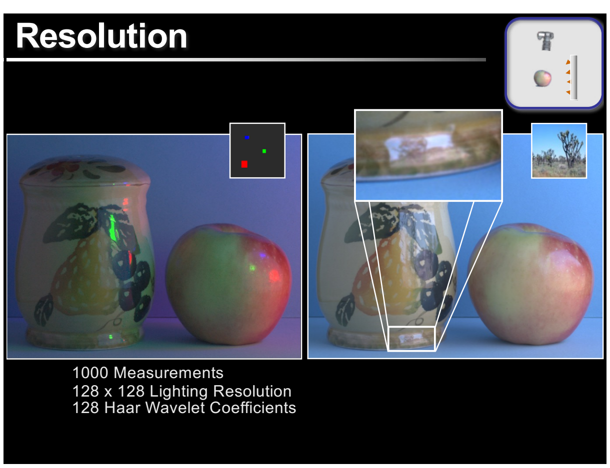

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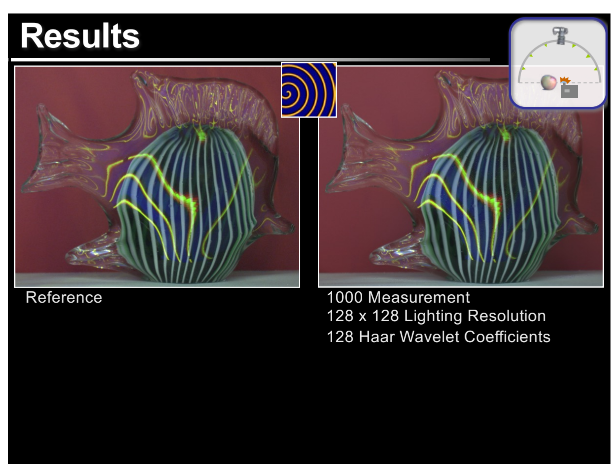

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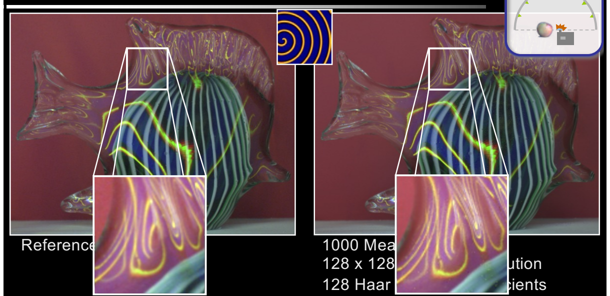
Results



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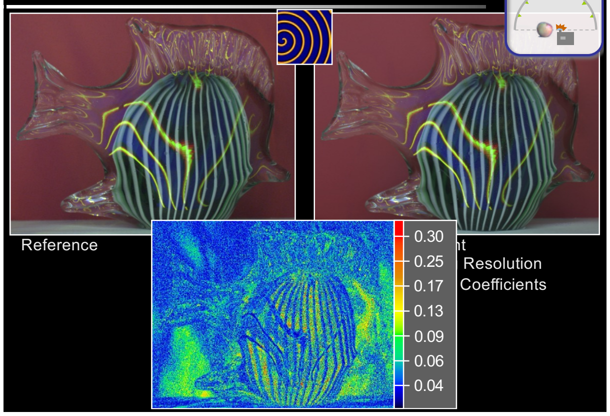
Results



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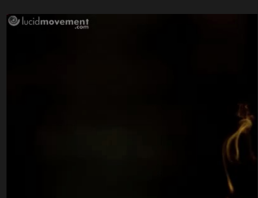
Inhomogeneous Participating Media

Volume densities rather than boundary surfaces.
Efficiency in acquisition is critical, especially for time-varying participating media.



Drifting Smoke of Incense
(532fps Camera)

Mixing a Pink Drink with Water
(1000fps Camera)

Video clips are from http://www.lucidmovement.com

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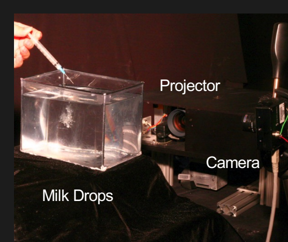
Compressive Structured Light

- Projector: DLP, 1024x768, 360 fps
- Camera: Dragonfly Express 8bit, 320x140 at 360 fps
- 24 measurements per time instance, and thus recover dynamic volumes up to 360/24 = 15 fps.



Gu, Nayar, Grinspun, Belhumeur, Ramamoorthi 08, 13

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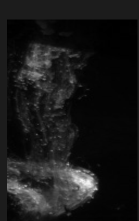
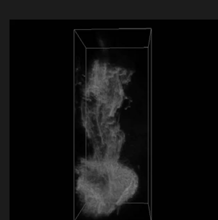
Milk Dissolving: One Instance of time

- Milk drops dissolving in a water tank.



Photograph

Measurements
(24 images of size 128x250)



Reconstructed Volume
(128x128x250)

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Milk Dissolving: Time-varying Volume

- Milk drops dissolving in a water tank.

Video (15fps)

Reconstructed Volume
(128x128x250)

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Outline

- Matrix Row-Column Sampling (Many Lights)

(clustering for matrix completion of light transport)

- Compressive Sensing for Light Transport
- *Matrix Completion*
  - *Extension to compressive sensing: Low rank matrices*
  - *Minimize matrix norm (rank), given some entries*
  - *Combine many ideas seen previously*

Huo et al. SIGGRAPH Asia 16

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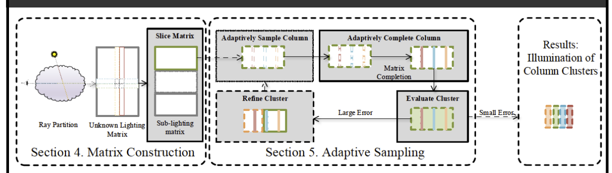
Outline

- *Matrix Completion*
  - *Extension to compressive sensing: Low rank matrices*
  - *Minimize matrix norm (rank), given some entries*
  - *Combine many ideas seen previously*



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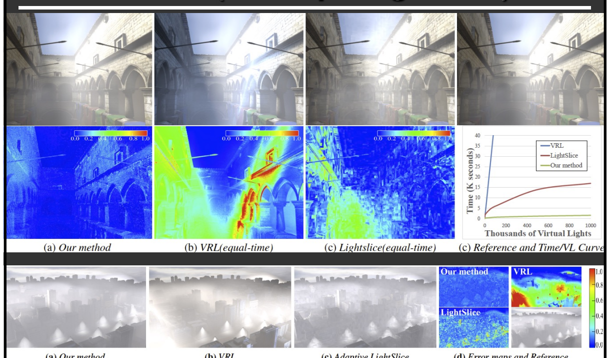
Results (Participating Media)



(a) Our method (b) VRL(equal-time) (c) Lightslice(equal-time) (c) Reference and Time/VL Curve

(a) Our method (b) VRL (c) Adaptive LightSlice (d) Error maps and Reference.

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Summary

- Light Transport for Acquisition, Many Light Rendering
- Compressive Sensing for projected patterns
- Matrix Completion for many light rendering

- Leverages popular ideas in applied math
- Consider all forms of coherence
- Think about modern extensions with deep learning

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