

# Towards a Perceptual Quality Metric for Computer-Generated Images

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Daniel Meneveaux

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Electronic Imaging 2012

# Work Context

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### Computer-generated images (CGIs)

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- scientific visualisation;

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Geometrical/wave/quantum optics

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### Physically Based Rendering

Geometrical/wave/quantum optics, but:

- exhaustive simulation impossible;
- complexity reducing assumptions !

# Problematic

## Classical Assumptions

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$\frac{\text{Complexity reduction}}{\text{Quality reduction}}$  ratio of a given assumption.

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## Problem

No metric to quantify the perceptual quality of a CGI !

# Perceptual Quality Metric

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## Assessment of $Q$ and $C_1, \dots, C_n$

- psychovisual experiments;
- automated measurement (work in progress).

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- ① Color Bleeding
- ② Shadows
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- ④ Aliasing

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- 1 Color Bleeding
- 2 Shadows
- 3 Noise
- 4 Aliasing
- 5 Dynamic

# Perceptual Quality Criteria

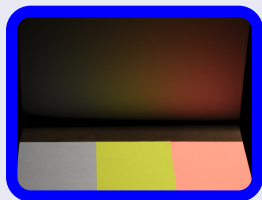
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## Color Bleeding








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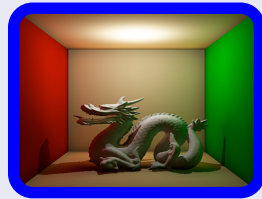
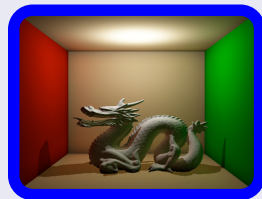
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## Shadows





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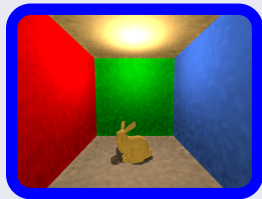
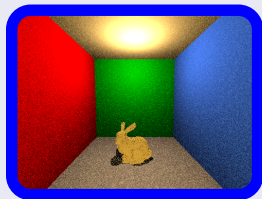
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## Noise










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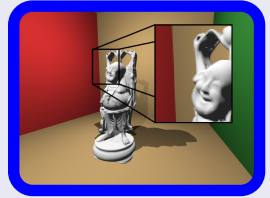
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## Aliasing












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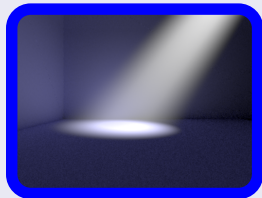
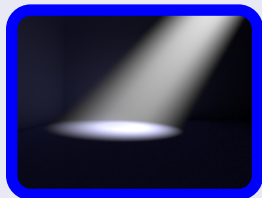
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## Dynamic



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## Seven Scenes



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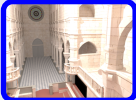
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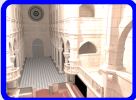
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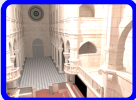
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## Seven Rendering Methods

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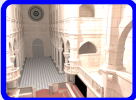


## Seven Rendering Methods

- 1 Ambient Term;

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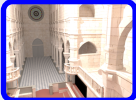
## Seven Rendering Methods

- 1 Ambient Term;
- 2 Ambient Occlusion;



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## Seven Rendering Methods

- 1 Ambient Term;
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- 3 Environment Gather;

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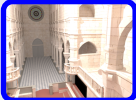


## Seven Rendering Methods

- 1 Ambient Term;
- 2 Ambient Occlusion;
- 3 Environment Gather;
- 4 Photon Streaming;

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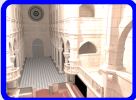


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- 1 Ambient Term;
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- 1 Ambient Term;
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- 1 Ambient Term;
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- 7 Metropolis Light Transport.

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## Test Set

7 Scenes  $\times$  7 Methods  $\rightarrow$  49 CGIs.

# Overall Test Procedure I

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Controlled Environment



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- Display [30" LCD/2,560 × 1,600/calibrated/ $d = 4h$ ];

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- Display [30" LCD/2,560 × 1,600/calibrated/ $d = 4h$ ];
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- Training [normalized speech/questions].



# Overall Test Procedure II

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Test *per se*



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- random order;

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- continuous scale  
(Poor & Excellent);

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- $\approx 1$  hour.

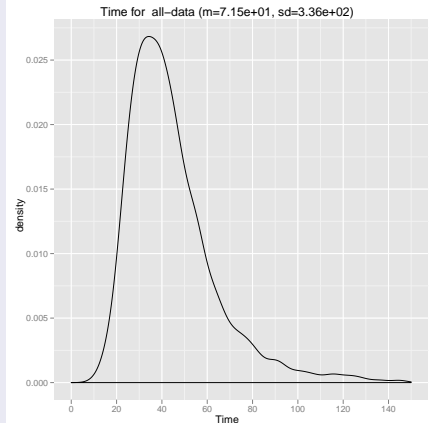


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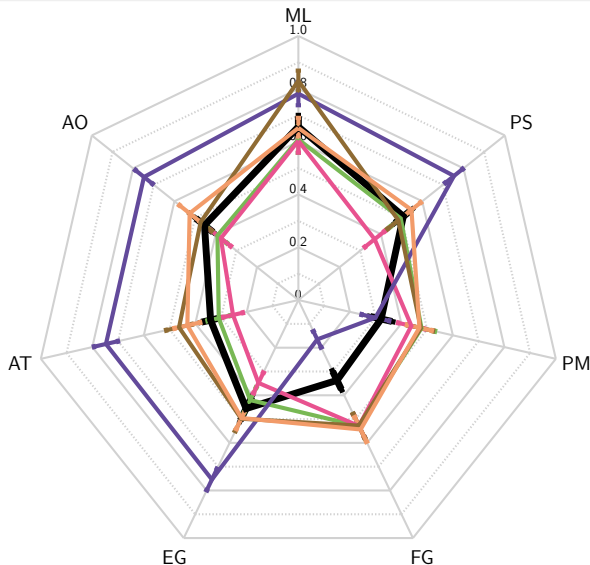
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## Assessment Time



# Radar plot with confidence intervals



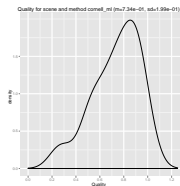
- Color bleeding;
- Shadows;
- Noise;
- Aliasing;
- Dynamic;
- Overall quality  $Q$ .

- ML Metropolis Light Transport;
- PS Photon Streaming;
- PM Photon Mapping;
- FG PM + Final Gather;
- EG Environment Gather;
- AT Ambient Term;
- AO Ambient Occlusion.

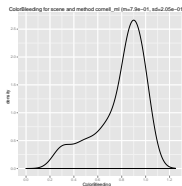
# Criteria/quality vs Methods (distributions)

ML

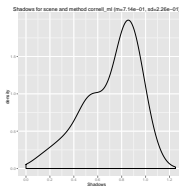
Quality



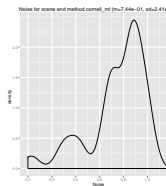
ColorBleeding



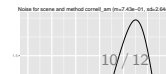
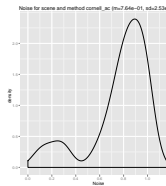
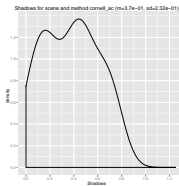
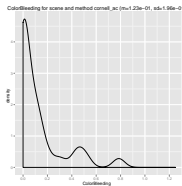
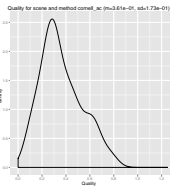
Shadows



Noise



AC



# Statistical Modeling

# Statistical Modeling

## Linear regression of $\mathcal{M}$

$$Q = 0.40 C_{\text{dynamic}} + 0.27 C_{\text{shadows}} + 0.18 C_{\text{noise}} \\ + 0.07 C_{\text{color ble}} + 0.03 C_{\text{aliasing}} - 0.06$$

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## Discussion

- Overall quality mostly dependant on:
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## Discussion

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  - + Dynamic, Shadows, Noise,
  - Color Bleeding, Aliasing;
- Similar results with three criteria.

## Synthesis and future works

### Synthesis



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- Perceptual Quality Metric Adapted to CGIs;

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- (Dynamic, Shadows, Noise) / (Color Bleeding, Aliasing).

### Future work

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### Synthesis

- Perceptual Quality Metric Adapted to CGIs;
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### Future work

- Automated Measurement of the Criteria;

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### Future work

- Automated Measurement of the Criteria;
- Perceptual Quality Metric Assessment Tool.