Correlation-Aware Semi-Analytic Visibility for Antialiased Rendering

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Alpha-Blending

Correlation-aware
Beam rasterization pipeline

**Fragment shader:**
- Compute all visibility attributes
- Coverage: \( \alpha_A = \frac{\text{Area}(A)}{\text{Area}(\text{Pixel})} \)
- Shading at centroid

1 primitive at a time
Fixed compact per-pixel storage
Alpha-Composition

\[ \alpha_A \text{ OVER } \alpha_B = \frac{\text{Area}(A)}{\text{Area}(\text{Pixel})} \]

\[ \alpha_A = P(A) \text{ in } [0,1] \]

**Fractional coverage**

**Probability of coverage**

Assuming \( A, B \) statistically independent (uncorrelated):

\[ P(A \cap B) = P(A) \times P(B) \]

**Aggregate geometry**

**Uncorrelated coverages**

**Structured geometry**

**Correlated coverages**

\[ \alpha_A \text{ OVER } \alpha_B = P(A \cup B) = P(A) + P(B) - P(A \cap B) = P(A) + P(B) \times (1 - P(A)) \]

Visible contribution of \( B \)

\[ \alpha_A = \alpha_A + \alpha_B \times (1 - \alpha_A) \]

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\( \alpha_A \) OVER \( \alpha_B \)
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Decorrelation
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“Some”-correlation
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Full-correlation:
P(A | B) = 1,
P(A \cap B) = P(B) \times P(A)
\rightarrow P(A \cup B) = P(A)
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Anti-correlation:
P(A | B) = 0, P(B | A) = 0,
P(A \cap B) = 0
\rightarrow P(A \cup B) = P(A) + P(B)
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\text{Visible contribution of } B
```

```
\text{Fractional coverage}
```

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\text{Probability of coverage}
```

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\text{Uncorrelated coverages}
```

```
\text{Correlated coverages}
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Correlation tracking

*Localization* bitmasks:
Track the **spatial location** of coverage
NOT *Coverage* masks!

32-bit Mask
Jittered positions
(Hammersley sequence)

\( \alpha_0 \) ?

\( \alpha_A = 0.2 \)
\( |M_A| = 5 \)

\( \alpha_B = 0.13 \)
\( |M_B| = 3 \)
Generating *localization* masks

Lookup table fetches:
(2D Table \((\Theta, r)\), 16KB)

Tiny, zero-coverage triangles:

32-bit Mask Jittered positions
(Hammersley sequence)

[Waller et al. 2000, Sintorn et al. 2008…]
Correlation tracking

*Localization bitmasks:*
Track the **spatial location** of coverage

- $\alpha_O$?

\[ \alpha_A = 0.2 \]
\[ |M_A| = 5 \]
\[ \alpha_B = 0.13 \]
\[ |M_B| = 3 \]

\[ |M_O| = 1 \]
\[ \alpha^O_A = \frac{|M_O|}{|M_A|} \alpha_A \]
\[ \alpha^O_B = \frac{|M_O|}{|M_B|} \alpha_B \]
Correlation tracking

Localization bitmasks:
Track the spatial location of coverage

\[ \alpha_A = 0.2 \]
\[ |M_A| = 5 \]

\[ \alpha_B = 0.13 \]
\[ |M_B| = 3 \]

\[ \alpha'_A \]
\[ |M'_A| \]
Inside the *potential* overlap region $O$

- Assuming decorrelation $\rightarrow$ OVER blending (*multiplicative composition*)

- Use ad-hoc *fuzziness* heuristic $\rightarrow$ Transition ADD $\leftrightarrow$ OVER
  - $\frac{|M_A|}{\alpha_A} \times \text{sadp}(A, B)$
Semi-Analytic MSAA

1/4 Resolution

MSAA

- 256x
- 64x
- 32x

Semi-Analytic

~6x faster
256x MSAA

Semi-Analytic
Thank You !
Memory consumption

Without compression

- **Without color**:
  
  Our approach: 36 Bytes/pixel
  
  MSAA 8x: 24-32 Bytes/pixel
  
  MSAA 32x: 96-128 Bytes/pixel
  
- **With fp16 color**:
  
  Our approach: 42 Bytes/pixel
  
  MSAA 8x: 72-80 Bytes/pixel
  
  MSAA 32x: 288-320 Bytes/pixel

Aggregate / Fragment Visibility rep. (42 Bytes)

- **C**: Color (3x 2B)
- **α**: Coverage (4B)
- **M**: Localization Mask (4B)
- **S**: Depth Slab
  
  Plane equation (4x 4B) + thickness (4B)
- **Z_{min}, Z_{max}**: Depth range (2x 4B)