NULL-COLLISION ALGORITHMS—PART 2
TRANSMITTANCE ESTIMATION
DELTA TRACKING
DELTA TRACKING
DELTA TRACKING

- Distance Sampling

Distance
Extinction
Transmittance

3 samples

MONTE CARLO METHODS FOR PHYSICALLY BASED VOLUME RENDERING — DISTANCE SAMPLING
DELTA TRACKING

Distance
Extinction
Transmittance

4 samples

MONTE CARLO METHODS FOR PHYSICALLY BASED VOLUME RENDERING — DISTANCE SAMPLING
DELTA TRACKING

Each collision provides only binary information.

Distance

Extinction

Transmittance

A

B

Distance

A

B
RATIO TRACKING

[Cramer 1978, Novák et al. 2014]

\[
\prod_i \frac{\mu_n(x_i)}{\bar{\mu}}
\]
RATIO TRACKING

1) Remove termination
2) Compute weight

\[ \prod_i \frac{\mu_n(x_i)}{\bar{\mu}} \]
RATIO TRACKING

1) Remove termination
2) Compute weight

\[ \prod_{i} \frac{\mu_{n}(x_{i})}{\bar{\mu}} \]
RATIO TRACKING

Extra steps => higher cost than delta tracking

1) Remove termination
2) Compute weight

$$\prod_{i} \frac{\mu_n(x_i)}{\mu}$$
RATIO TRACKING

Probabilistic TERMINATION replaced by WEIGHTING

- Rational score instead of binary
- Requires more steps than a delta-tracking estimator (must reach $B$)
- Reduces the need for tight majorants
  - Loose majorants produce (more null collisions and therefore) finer estimates
RESIDUAL RATIO TRACKING

Compute part of the transmittance analytically

› [Novák et al. 2014]
RESIDUAL RATIO TRACKING

Residual transmittance estimated via ratio tracking

Control transmittance computed analytically
RESIDUAL RATIO TRACKING

\[ \langle T(t) \rangle = T_{\text{control}}(t) \langle T_{\text{residual}}(t) \rangle \]
RESIDUAL RATIO TRACKING

HOMOGENEOUS and RESIDUAL HETEROGENEOUS components

- Reduces noise by handling part of the transmittance analytically
- Requires a space-partitioning data structure (e.g. octree) to be practical
- Can handle negative residual extinctions
NEXT-FLIGHT ESTIMATORS

Score a weight at every tentative collision

- Cramer [1978] combines next-flight estimation with delta and ratio tracking

\[
\langle T(t) \rangle = T_{\bar{\mu}}(0, t) + \sum_{j=1}^{n} \frac{\mu_n(t_j)}{\bar{\mu}(t_j)} T_{\bar{\mu}}(t_j, t)
\]

Transmittance along the remaining segment through real + fictitious matter

Fraction of fictitious matter
SUMMARY

DELTA TRACKING estimator
  ▶ Relatively cheap but binary, inefficient w/ loose majorants

RATIO TRACKING estimator
  ▶ More expensive, but also more accurate especially w/ loose majorants

RESIDUAL TRACKING estimators
  ▶ Reduces variance by employing analytic computation for part of the transmittance function

NEXT-FLIGHT estimators
  ▶ Further improve performance by scoring a weight at each step
  ▶ Not fully explored yet in the context of rendering…
ACKNOWLEDGEMENTS

Peter Kutz for tracing down many of the early delta tracking papers
Maurizio Nitti for help w/ illustrations