Z-Buffer CSG Rendering

Use z-buffer hardware to solve visible surface problem for CSG trees.

Trickle Algorithm
- Subtract volumes from front to back.

Goldfeather Algorithm
- Clip one surface at a time in the z-buffer.
- Merge the result into second z-buffer.

A new approach to CSG Rendering

Sequenced Convex Subtraction (SCS)

- Use convex objects.
- Use two z-buffers.
- Minimise the number of z-buffers.
- Avoid sorting surfaces in the z-buffer.
- Use subtraction sequence that works for any viewing direction.

A Z-Buffer CSG Rendering Algorithm for Convex Objects

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Constructive Solid Geometry (CSG)

Leaf Nodes - objects
Parent Nodes - operations

- Boolean Union
- Boolean Intersection
- Boolean Difference
Sequence Abstraction
For n objects, use sequences embedding all n! permutations in volumes along a line.

SCS Subtraction Sequences
Subtraction Sequences are O(n^2)
With depth-compexity, O(kn)

SCS in Operation
Draw X
Subtract A
Subtract B
Subtract A

SCS Subtraction Sequence
- Z-buffer can store one surface only
- Z-buffer can not store holes behind the current surface
- Volumes may need to be subtracted more than once
- Sequence depends on the way volumes interact.

X - A - B

To avoid sorting, subtract in sequence ABA

Widget
n=4, k=4
abcd, abcd, dbca
k=2, SCS length 20
k=3, SCS length 39
k=5, SCS length 96
Conclusion
Sequenced Convex Subtraction Algorithm (SCS)
- No sorting.
- No z-buffer copying for CSG product.
- Two z-buffers required for CSG tree.
- Less z-buffer copying than other algorithms.
- Requires convex volumetric representation.
- Uses a sequence based on depth complexity.

Graphics Hardware Implications
- Higher rasterisation load, lower z-buffer load.
- Particularly advantageous on bandwidth limited hardware. (Nvidia TNT2, for example)

Further Work
Other algorithms make use of separability information.

How to generate sequences based on this information?

Optimal subtraction sequences.
(Better than $O(n^2)$?)

Fairer benchmark between SCS and Goldfeather.

Industrial Application.