

Approximate Boolean Operations on Free-form Solids

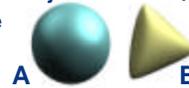
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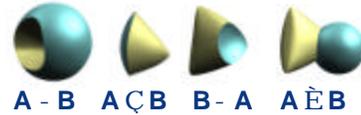
Boolean operations

Construct objects from parts

- combine



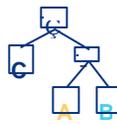
- difference, intersection, union



Surfaces and CSG

Constructive solid geometry

- solids: boolean expressions
combine solids naturally
not efficient for rendering,
collisions, ...



Parametric surfaces

- efficient representation for
rendering, multiresolution, ...
- patches, subdivision, hierarchical



Approach

Approximate Boolean ops

- input: free-form solids as
multires subdivision surfaces
- output: multires subdivision
surface approximating the result

Want

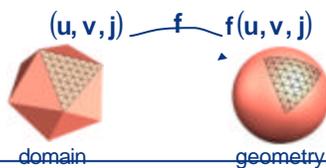
- good approximation
- coarse control meshes
- user controlled precision



Background

Multires subdivision surfaces

- recursive
refinement
- parameterization



Related work

- solid modeling: too many to enumerate
- surface-surface intersection: too many...
- reparameterization: Eck et al. 95,
Krishnamurthy 96, Lee et al. 98,...
- mesh optimization: Freitag et al.
- merging control meshes: Linsen97



Overview

4 main steps

- approximate intersection
- cut and merge meshes
- parameterization
- fitting

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Surface intersection

Find intersection

- world-space location
- parametric location

world-space parameter domain

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Intersections

Surface-surface intersection is difficult

- complex intersection curves
- singularities, robustness

Instead...

- robust mesh intersection
- symbolic perturbation for topological consistency

intersection of identical solids

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Cut meshes

Cut meshes along straight edges

- refine to resolve curve topology
- control valence and aspect ratio

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Resolve topology

Avoid refinement if possible

do not refine refine

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Resolve topology

Avoid refinement if possible

do not refine refine

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Resolve topology

Snap heuristic

- short curve segments may require many refinement steps
- snap mesh to curve to simplify intersection

Algorithm

- snap mesh & refine
- repeat until topology resolved

unresolved

snap ↓

resolved

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Merge meshes

Match vertices intersection curve

- one-dimensional problem
- refine to create vertices

refine

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Overview again

4 main steps

- approximate intersection
- cut and merge meshes
- parameterization
- fitting

} topology

} geometry

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