

Surface Aging by Impacts

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Context

- Realistic rendering
- Synthetic objects look too perfect
- Aging effects



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Previous Work

- Specific effects
 - Dirt & dust [Miller94, Hsu95]
 - Sculpting & tracks [Wang95, Sumner98]
 - Weathering [Dorsey96b, Dorsey99]
 - Corrosion [Dorsey96a, Merillou01]
 - Cracks & fracture [Hirotा98, O'Brien99]
 - Scratches [Merillou01]



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Previous Work

- Imperfection systems [Becket90, Wong97]



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Impacts

- Impacts on surface
 - Scratches
 - Abrasion
 - Compaction



Compaction

- Surface compressed
- Many impacts
- Empirical simulation



Real Examples



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Motivation

- Empirical simulation
 - Simplicity
 - Efficiency
 - User interaction



Outline

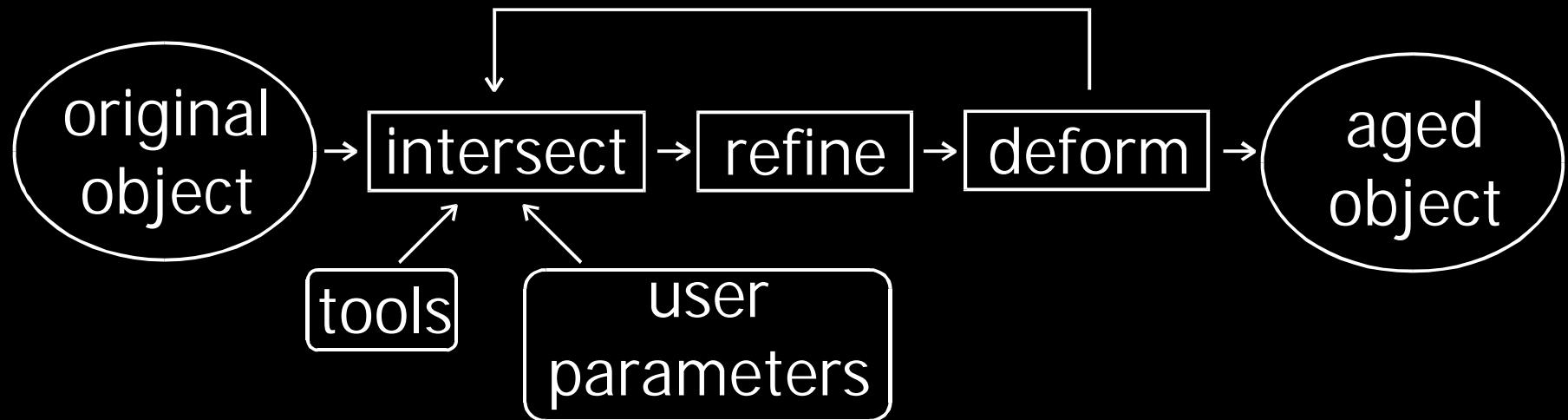
- Overview
- Inputs
- Simulation
- Results
- Conclusion



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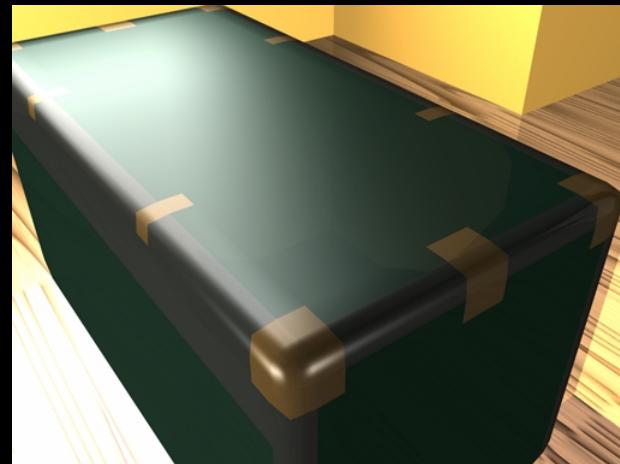
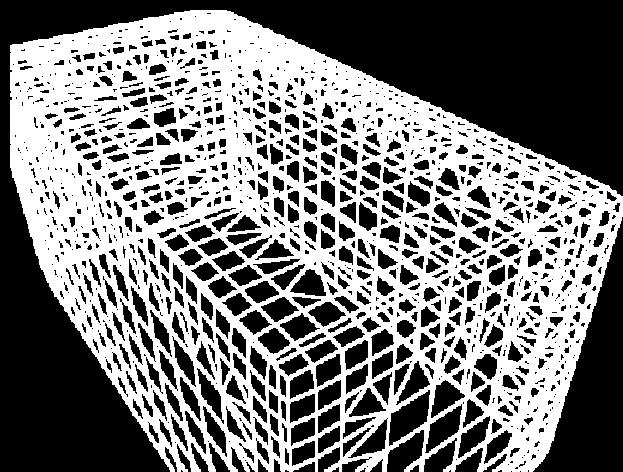
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Overview



Original Object

- Mesh
 - Common representation
 - Triangle mesh



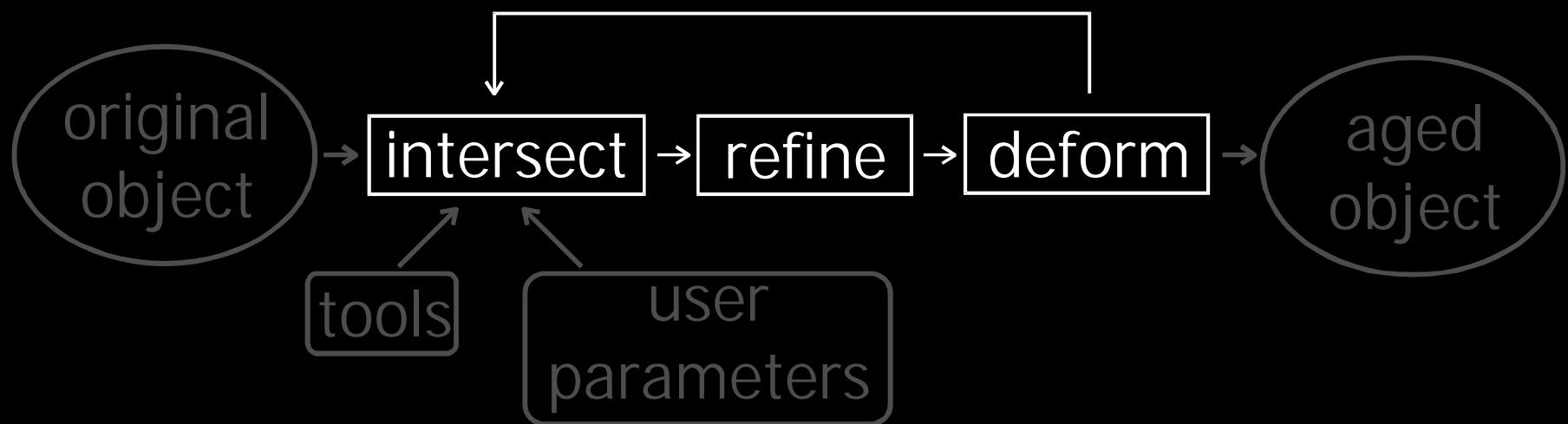
User Interface

- Tools
 - size
- Object deformation
 - compaction volume
- Impacts
 - location
 - direction

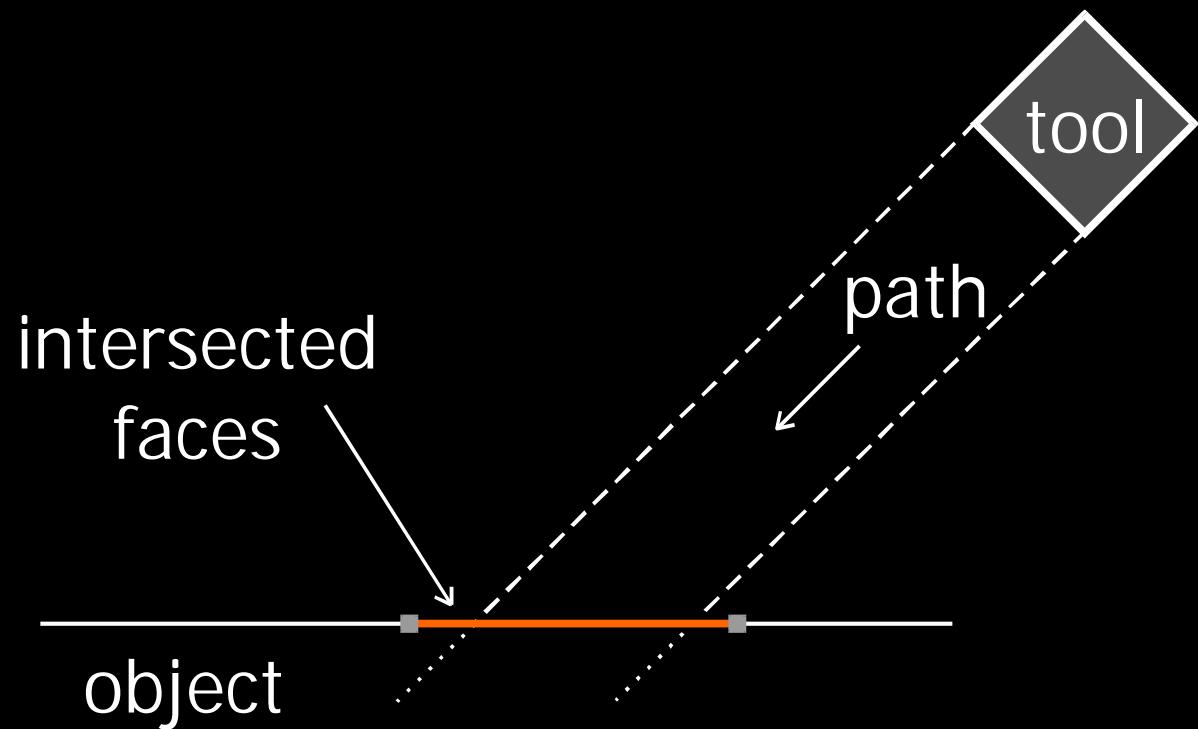


Simulation

- Intersection
- Refinement
- Deformation



Intersection



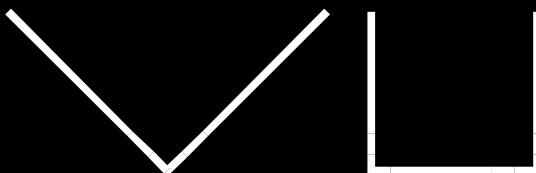
Tool Footprint

- Footprint of tool on object

- Sharp edges
(curvature)

- Perpendicular edges
(to the path)

Tools

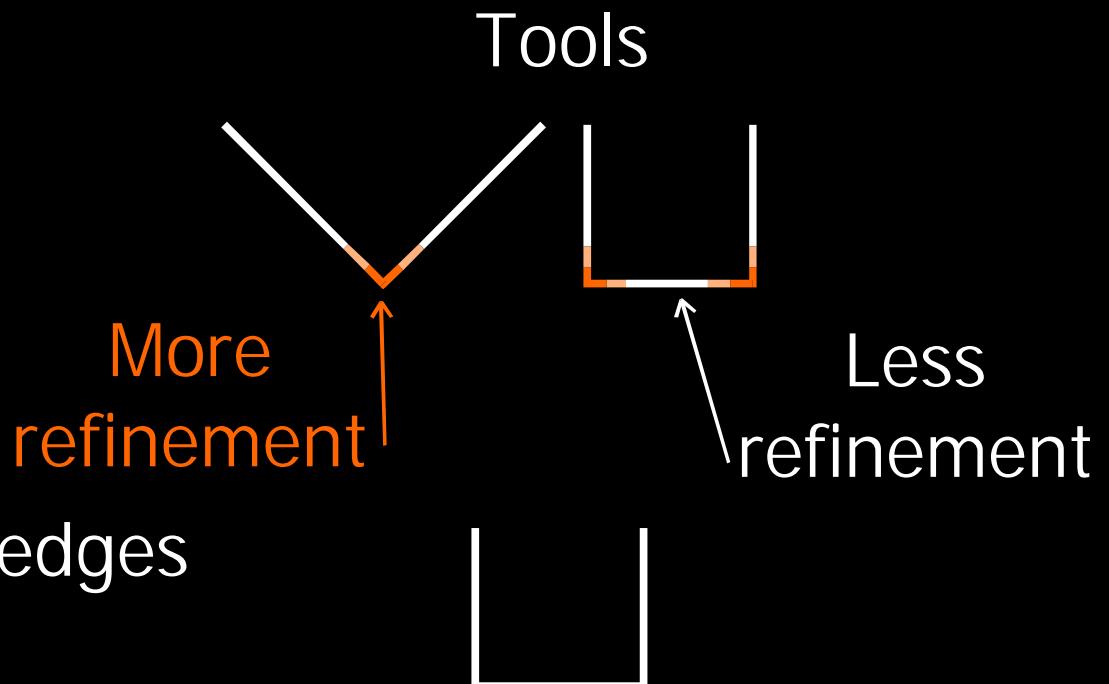


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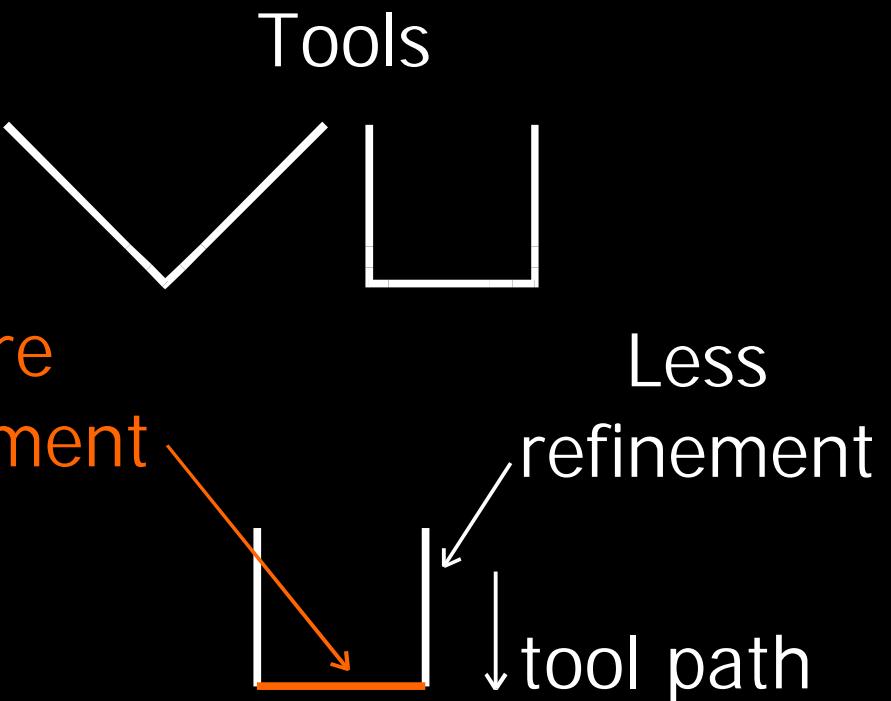


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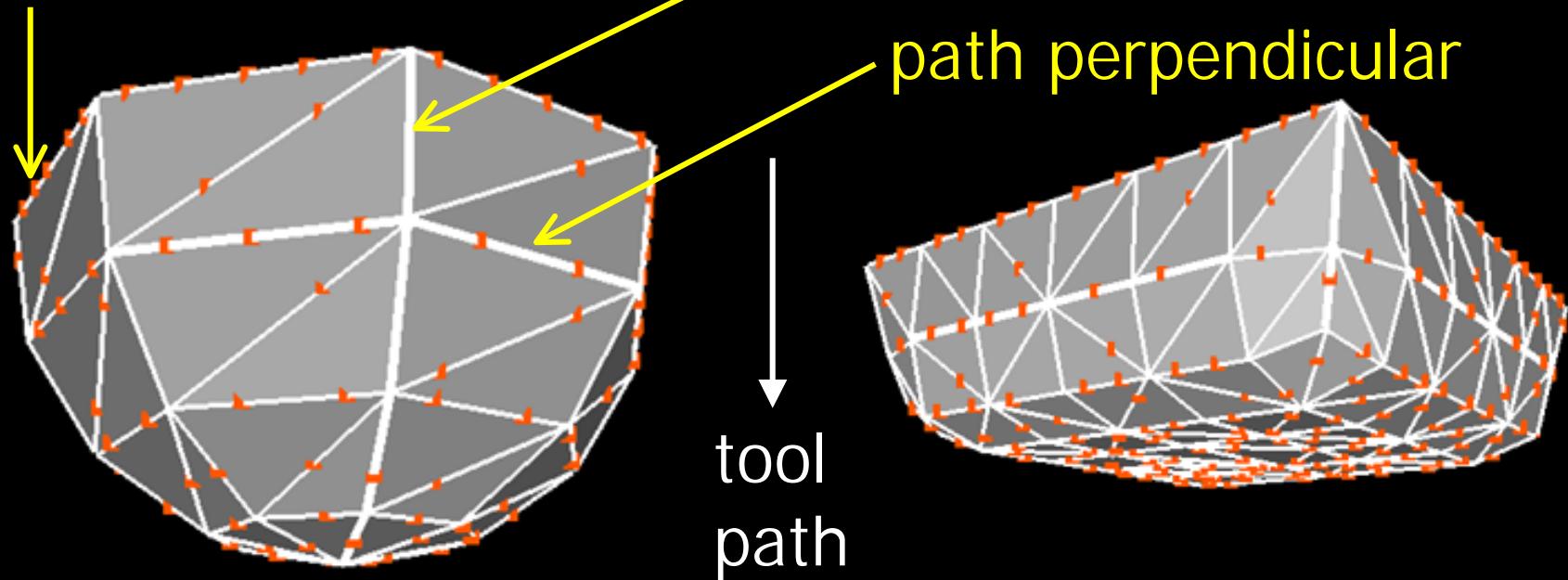
Feature Points

- Distribute feature points
- Tool edges
 - curvature (difference of normals)
 - perpendicular to path
 - length wrt user feature size
 - jittering



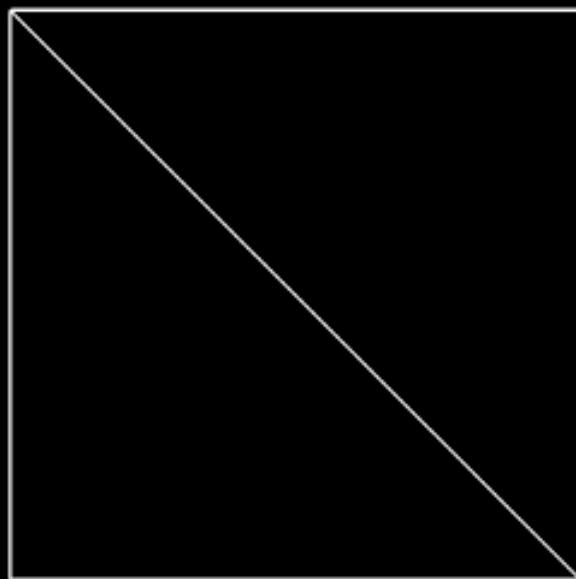
Feature Points

- Points representing required refinement border (curvature)

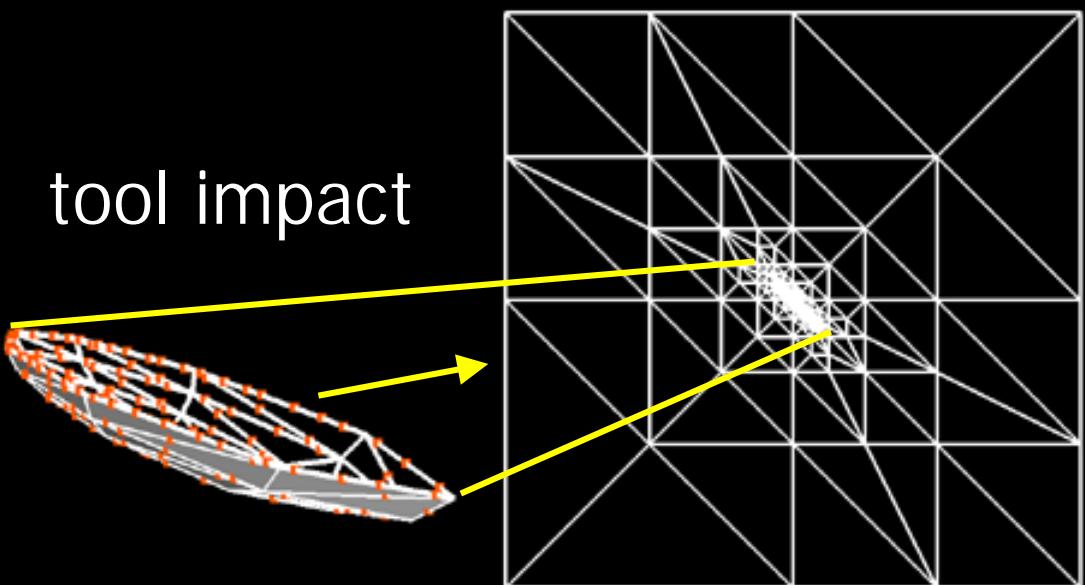


Mesh Refinement

- Project feature points
- Refine if $nb > \text{threshold}$

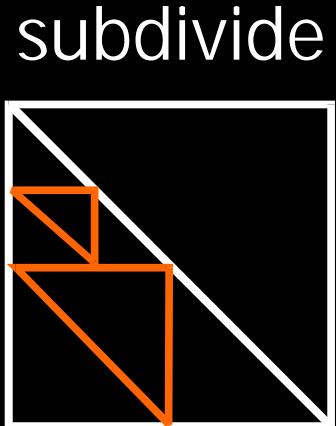
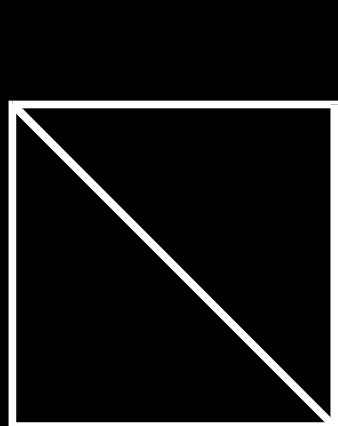


tool impact

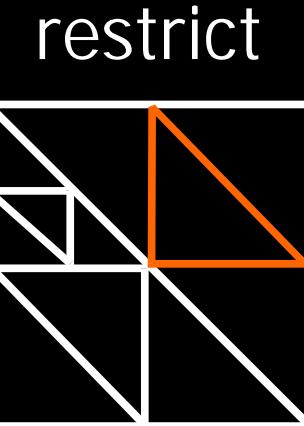


Mesh Refinement

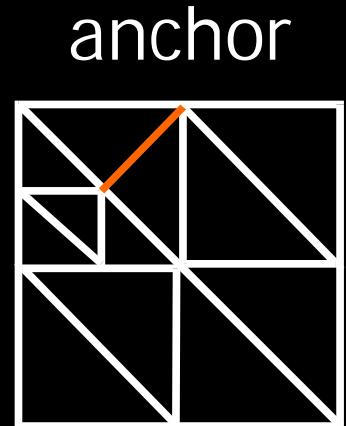
- Quaternary subdivision
- Restriction and anchoring
 - avoid T-vertices



subdivide



restrict

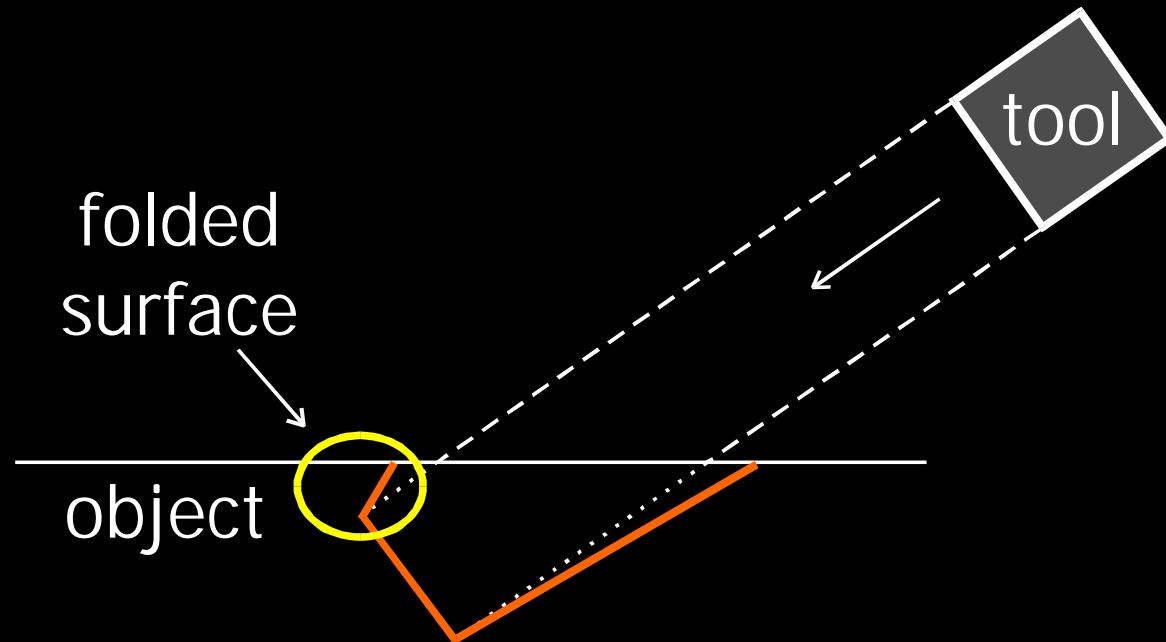


anchor



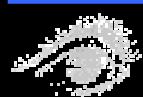
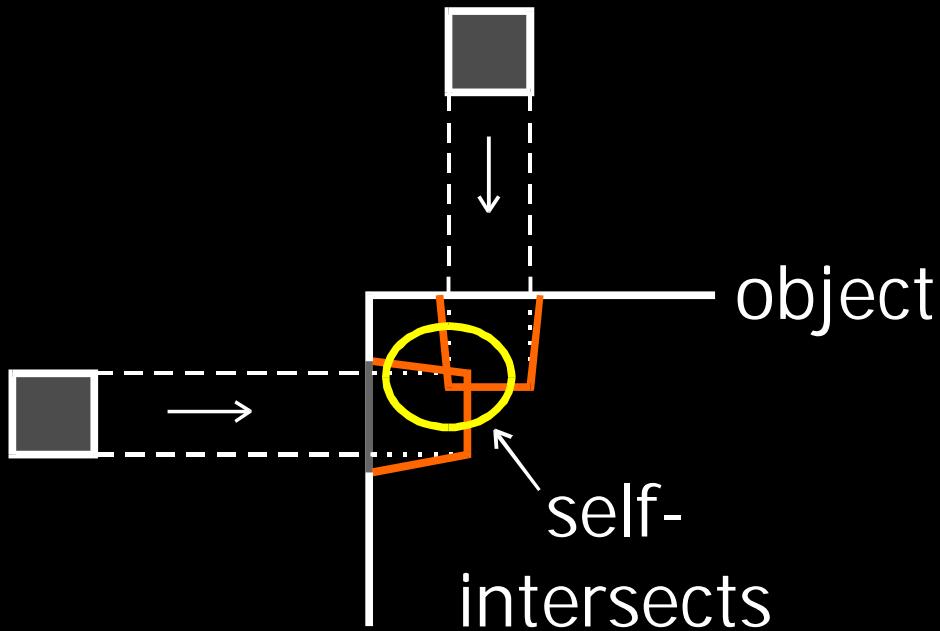
Problem: Folding

- Try to avoid surface folding



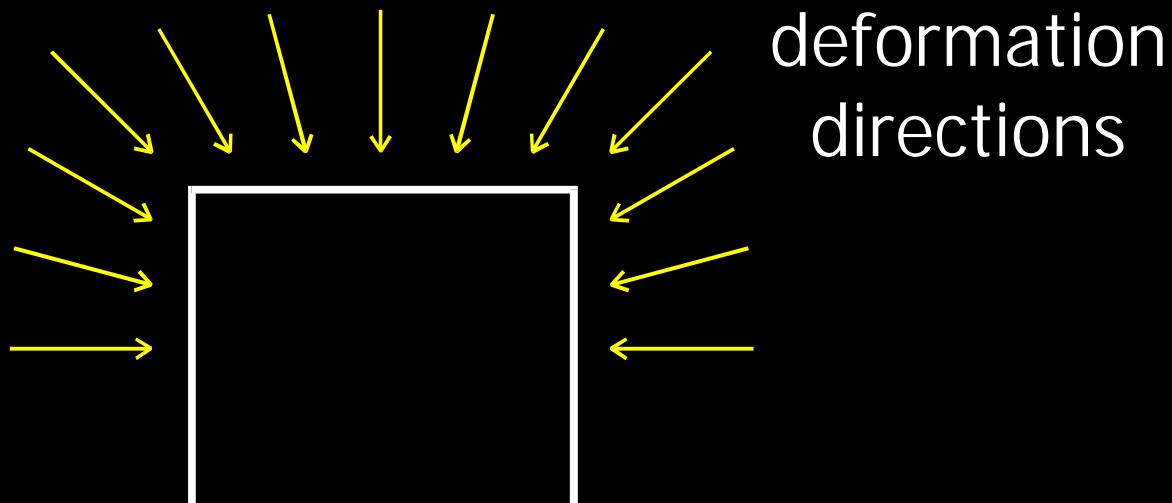
Problem: Self-intersection

- Try to avoid self-intersection



Deformation Direction

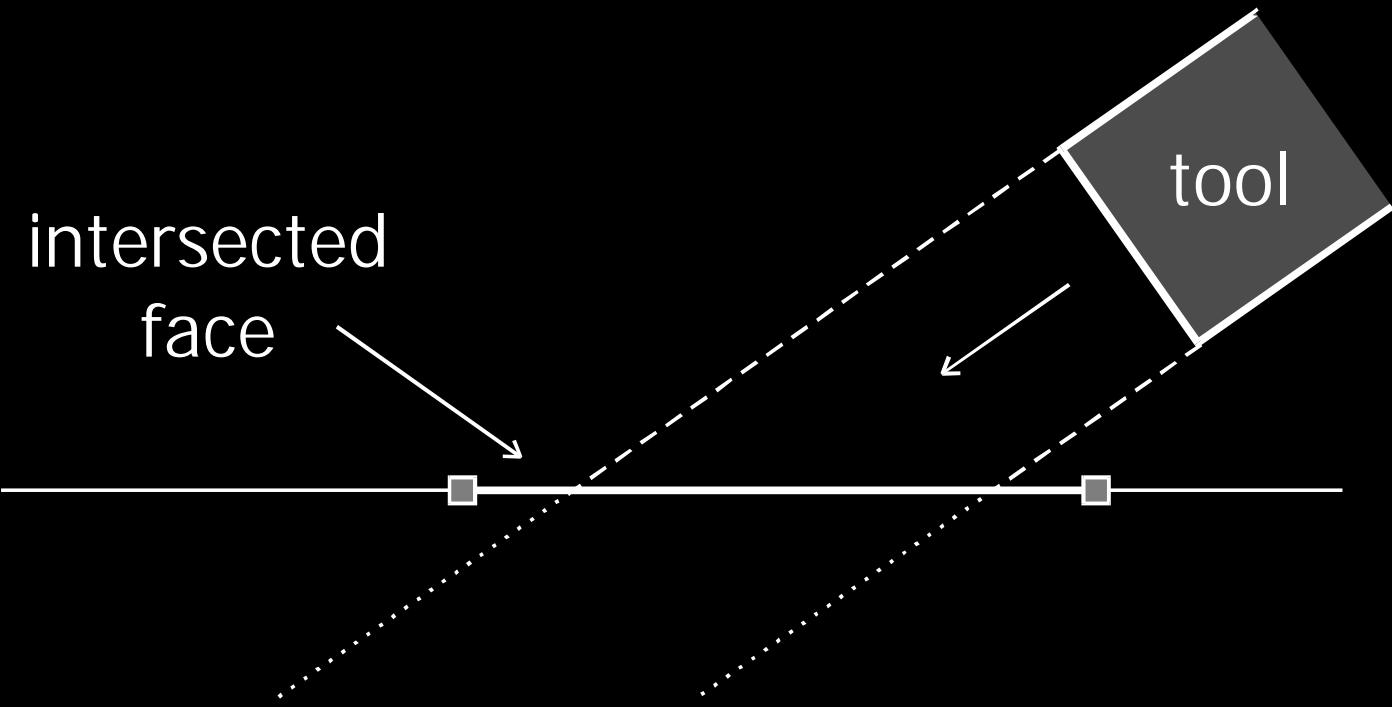
- Constrain surface movement
- Reduce self-intersections and folding



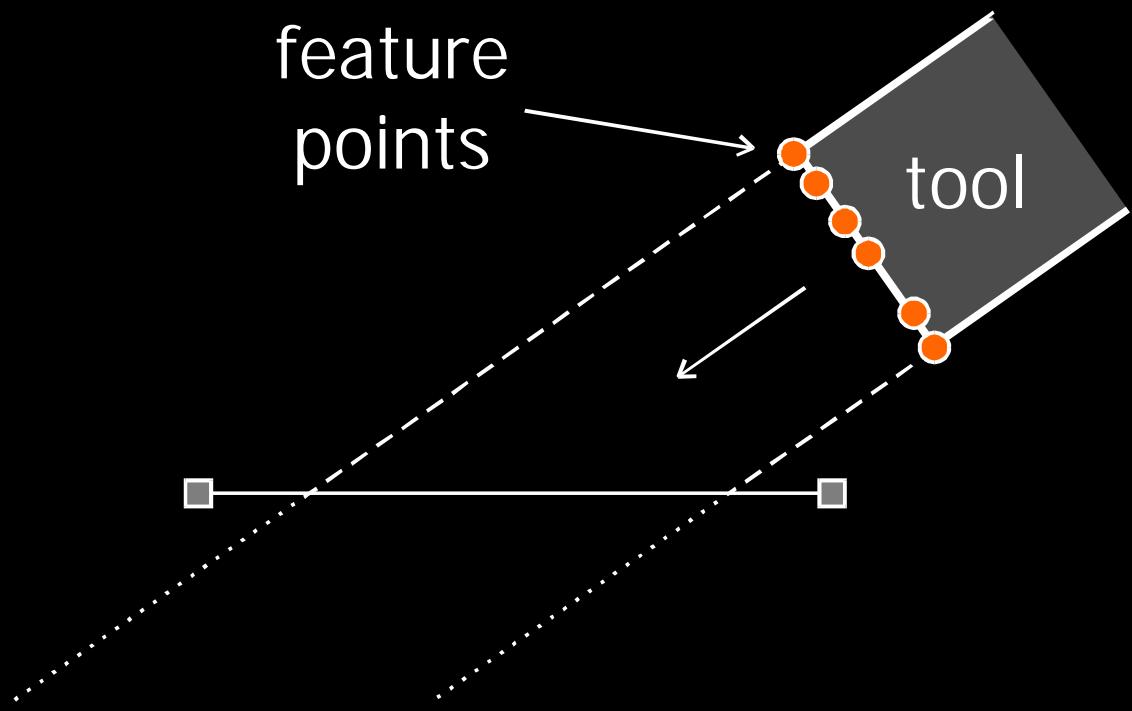
Deformation Steps



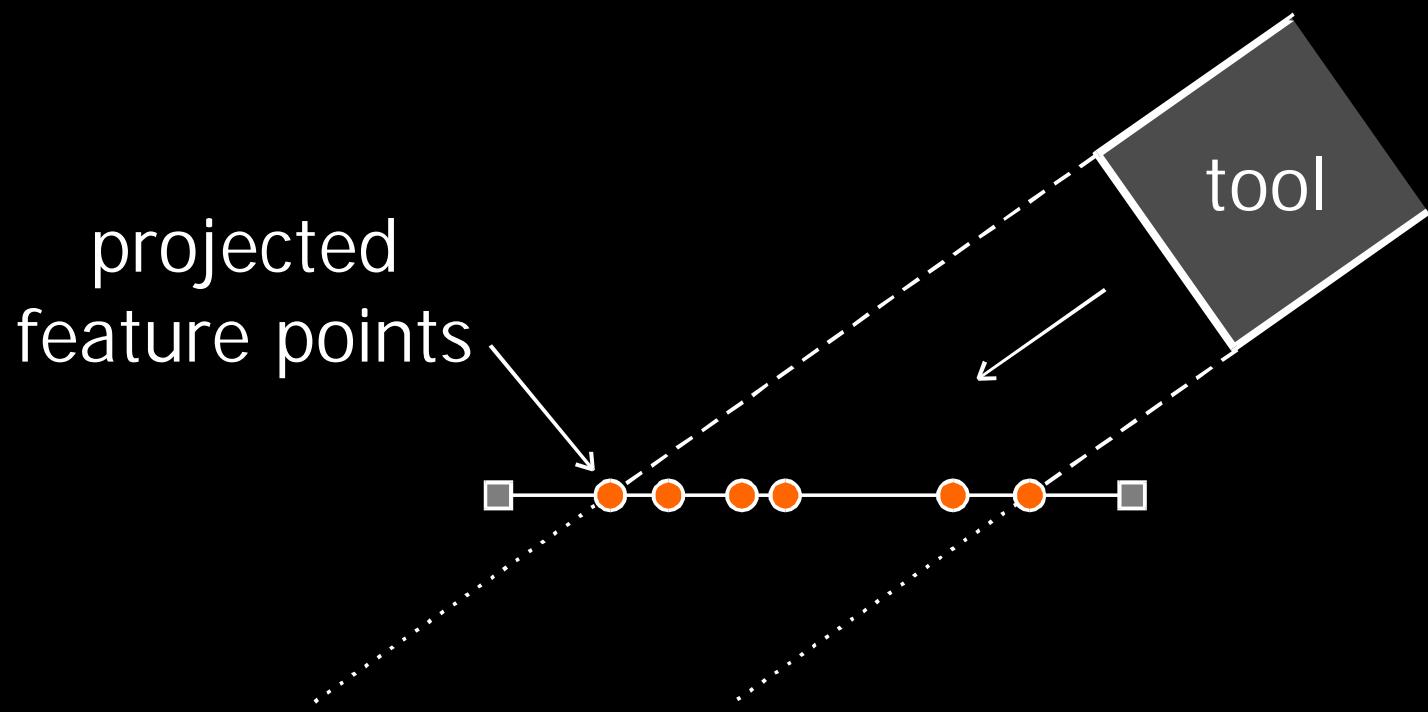
Deformation Steps



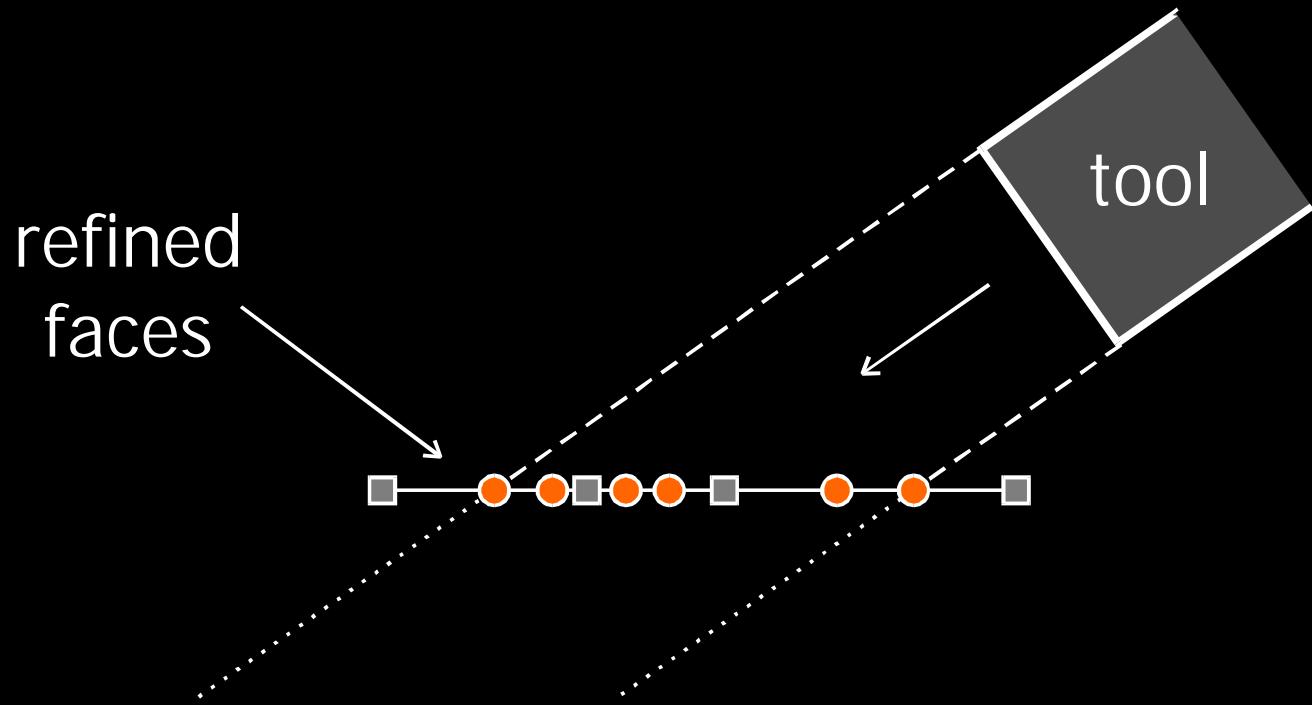
Deformation Steps



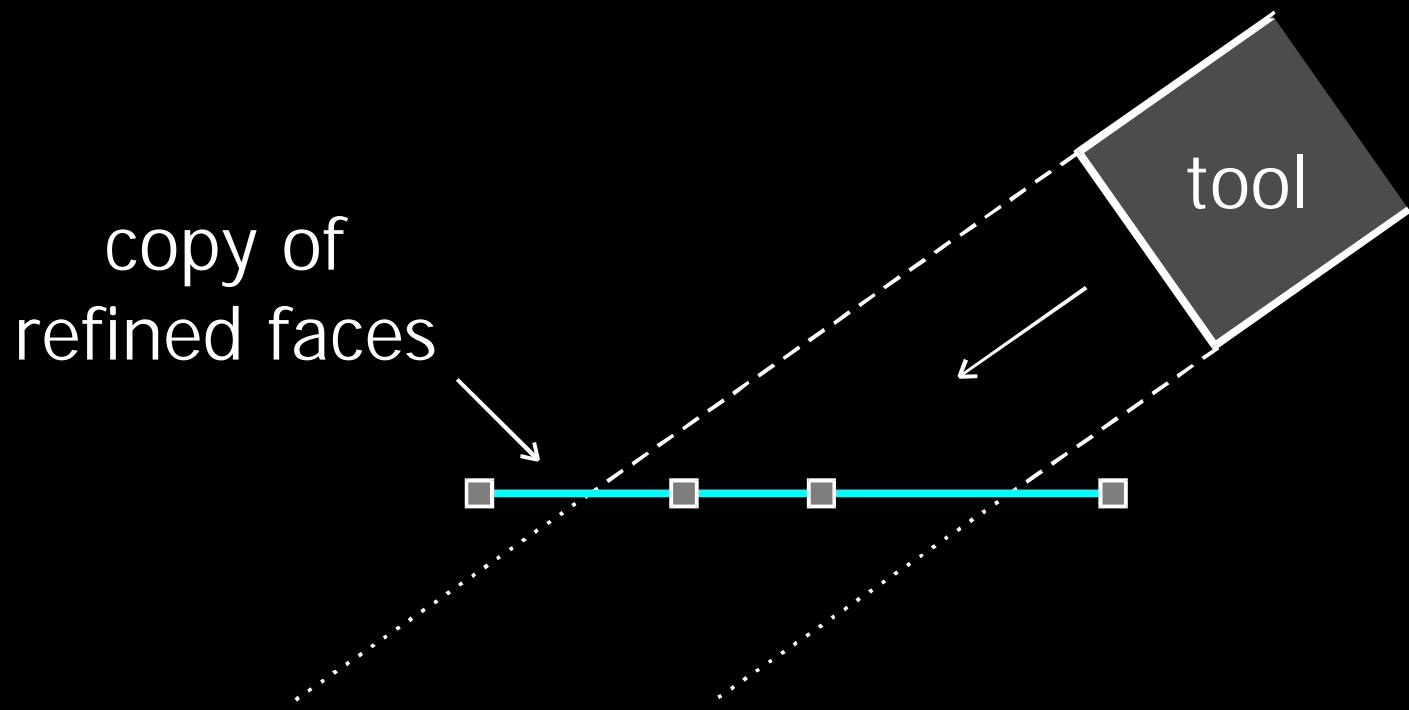
Deformation Steps



Deformation Steps

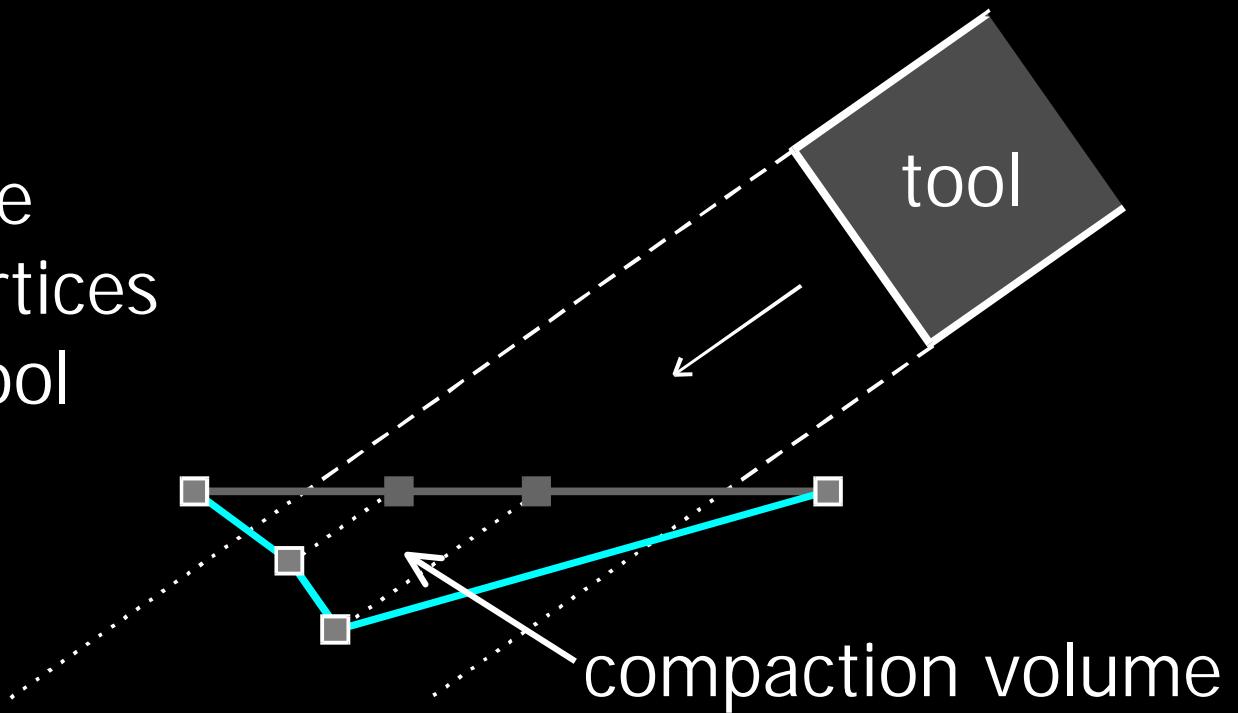


Deformation Steps



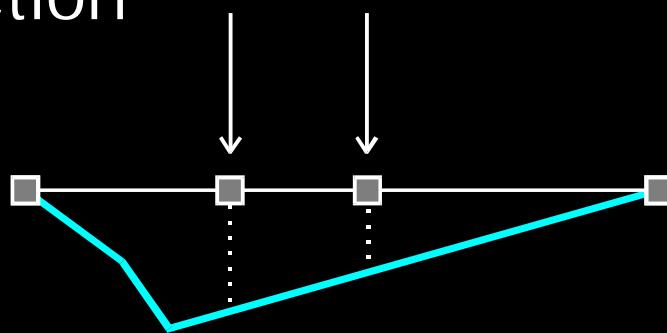
Deformation Steps

move
copy vertices
wrt tool



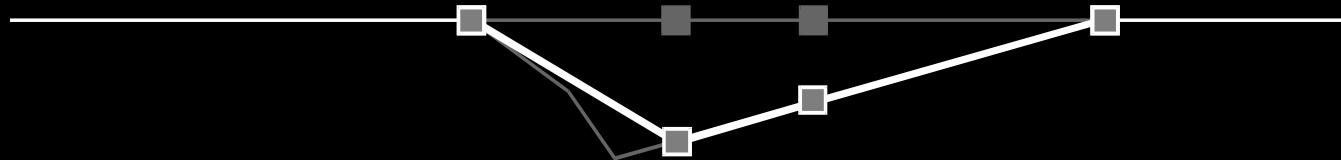
Deformation Steps

project along
deformation direction
on copy



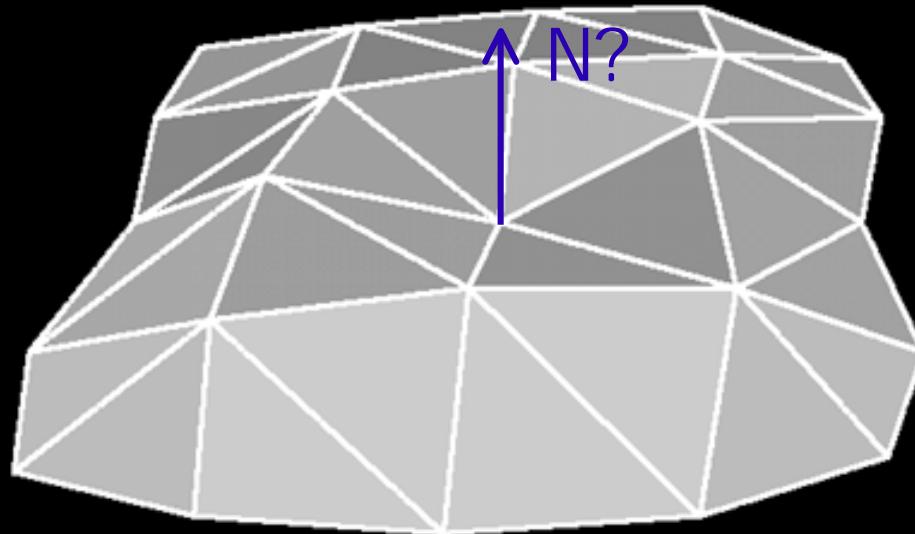
Deformation Steps

deformed
surface



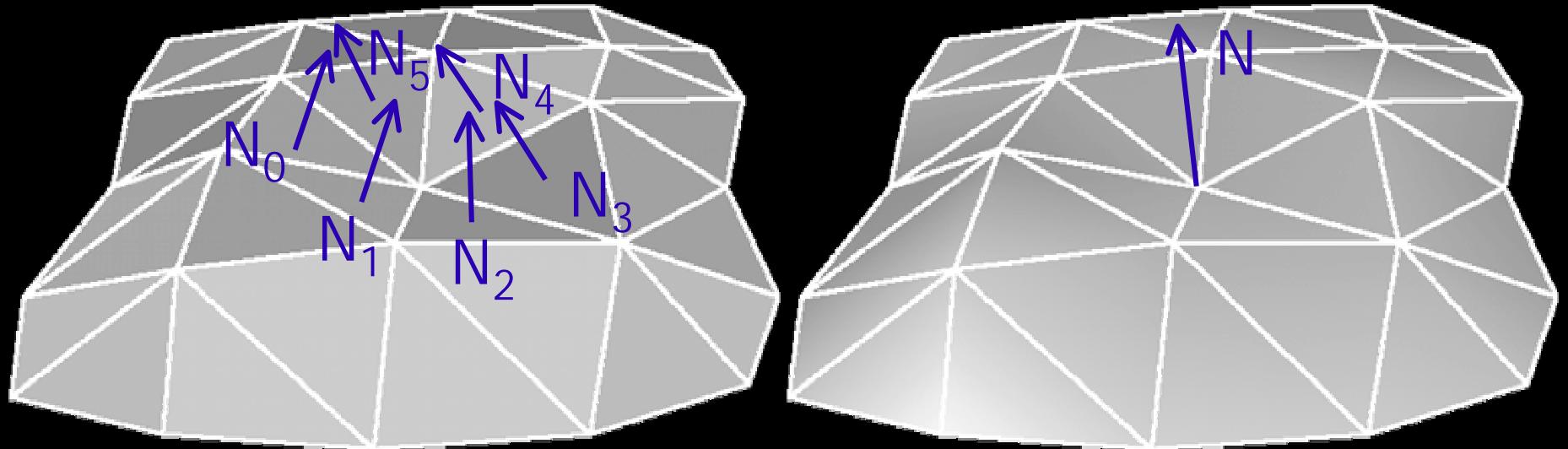
Output

- Aged object
- Recompute normals



Normals

- Weighted average
$$N = \sum w_i N_i$$
- weight \sim face subtended angle



Output

- 3D viewer
- Save
 - Render with any standard renderer
(we use Maya)



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Video



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Target Real Images

- Real photographs as goals



trunk



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Target Real Images



stairs



door



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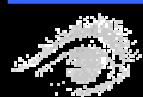
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Target Real Images

door
&
frame



metal
plate



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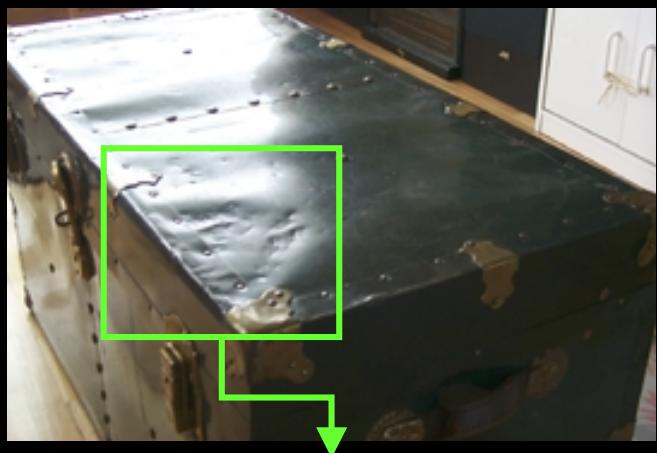
User Interaction

- Trial and error
 - tools
 - tool size
 - compaction volume
 - impact location and direction
- 30 minutes to 2 hours user time per object

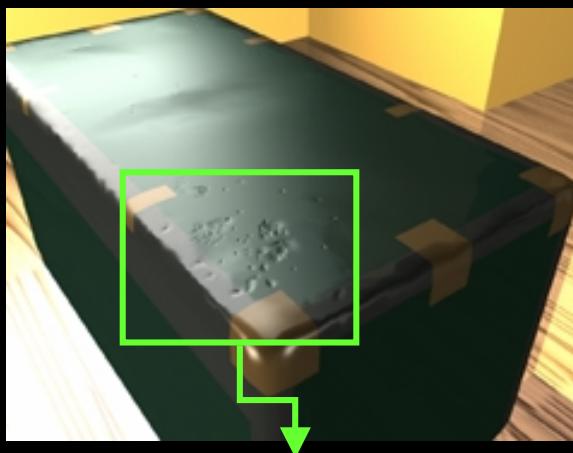


Synthetic Aged Trunk

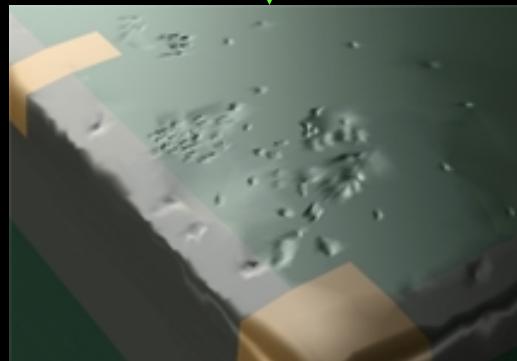
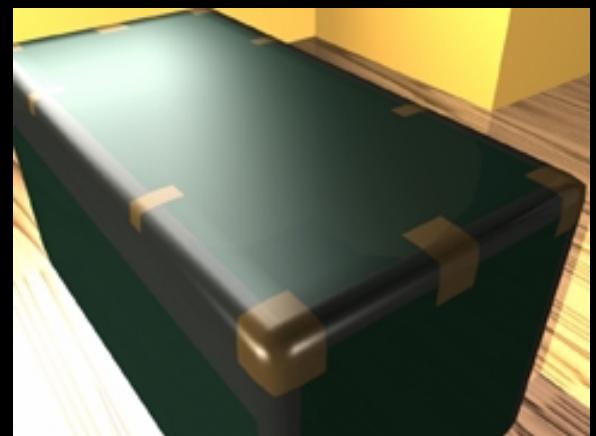
real



aged



clean



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Synthetic Aged Door

real



aged



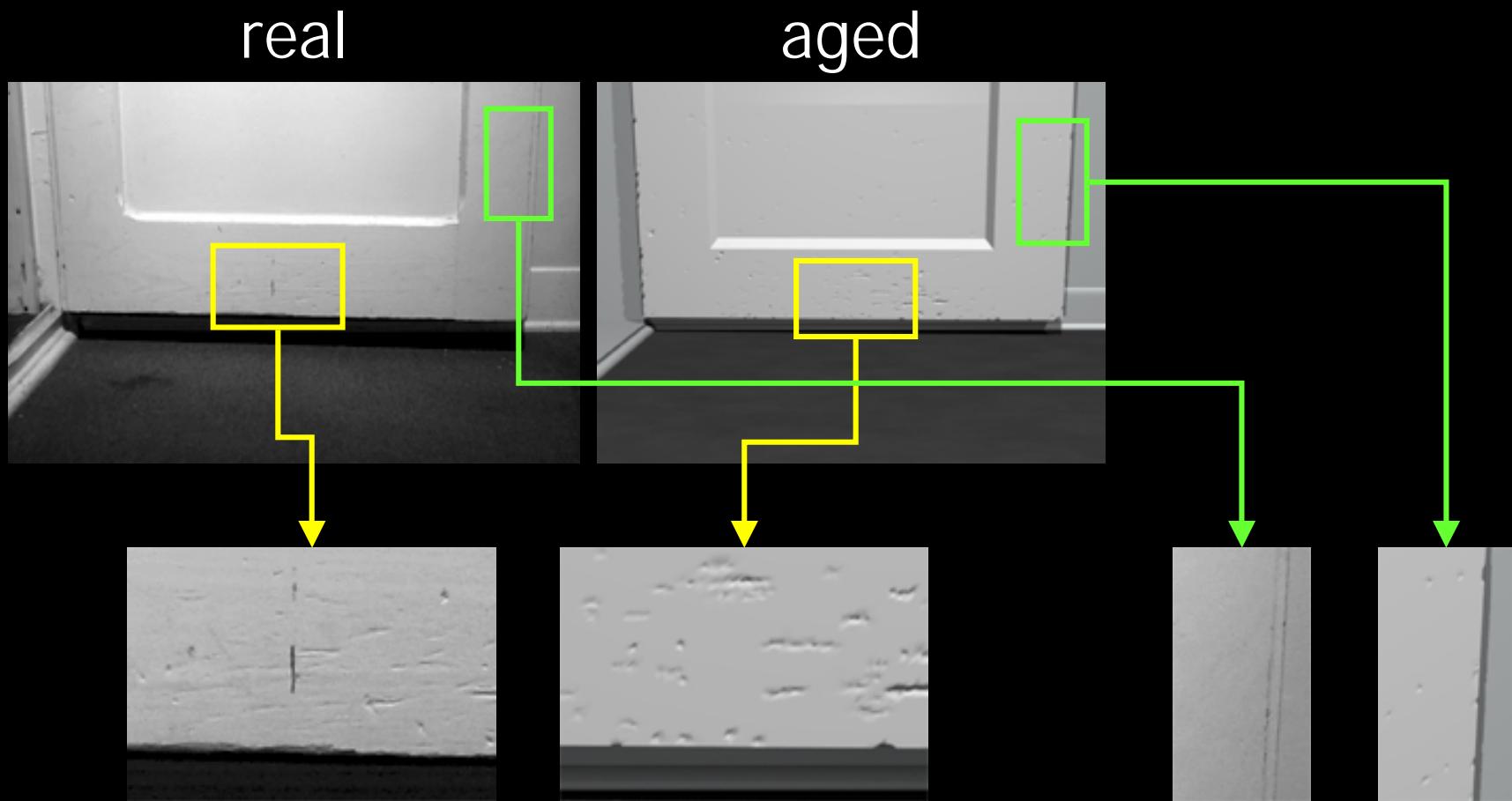
clean



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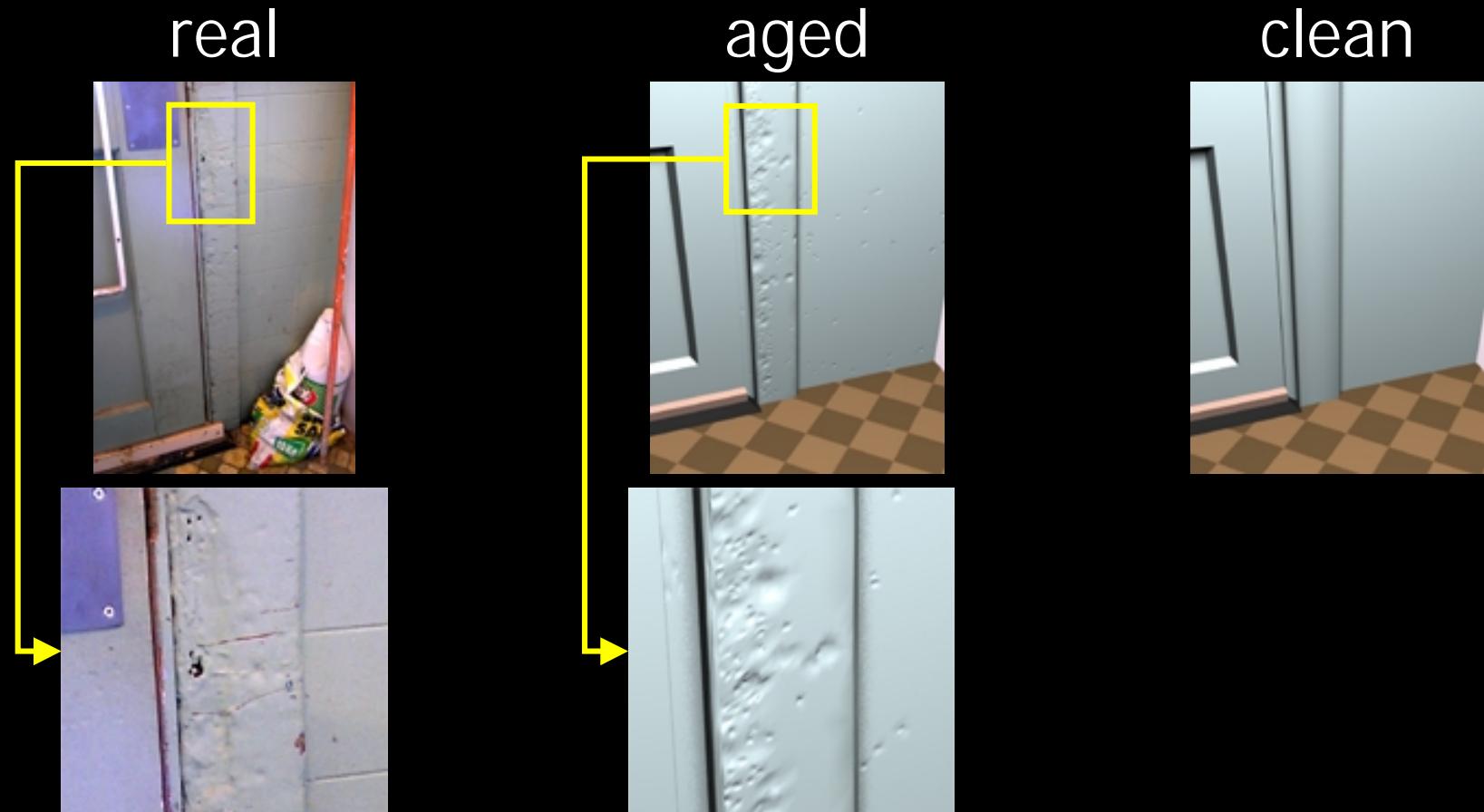
Synthetic Aged Door



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Synthetic Aged Door Frame

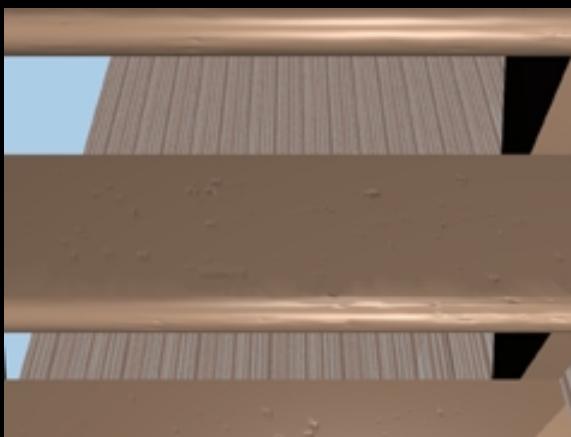


Synthetic Aged Stairs

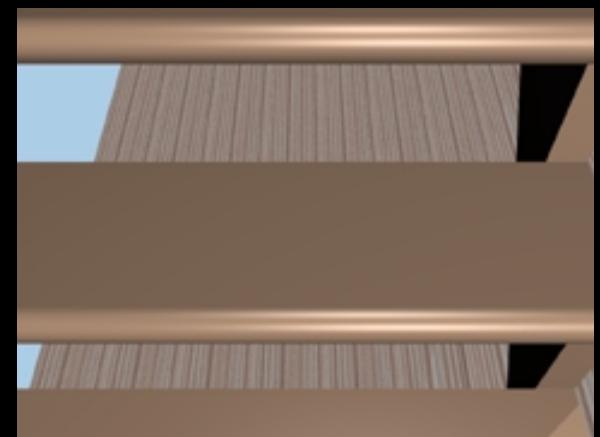
real



aged



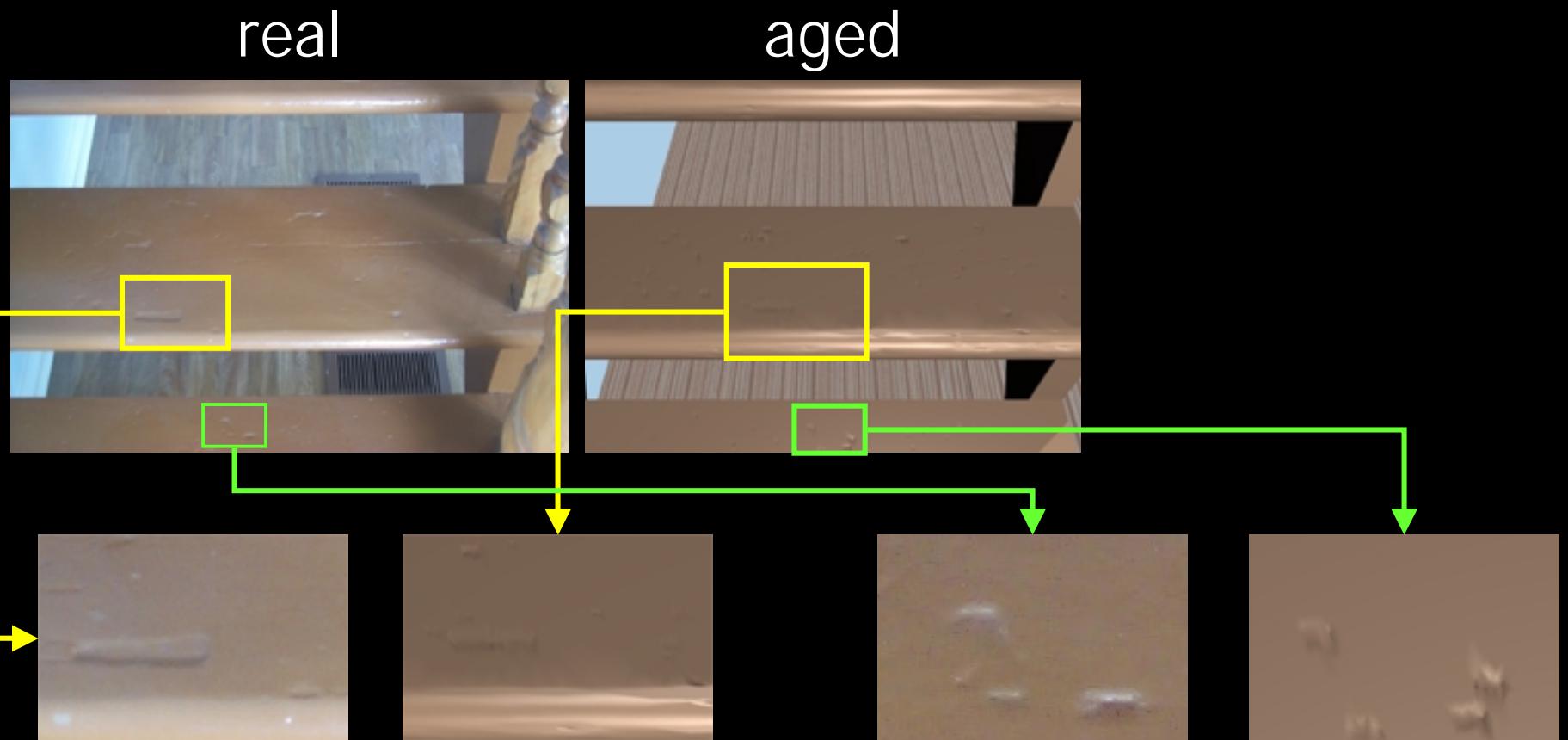
clean



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Synthetic Aged Stairs

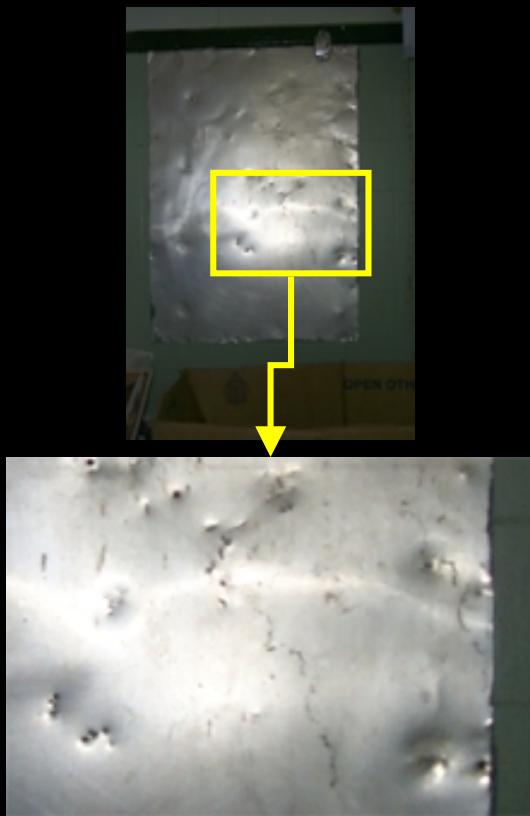


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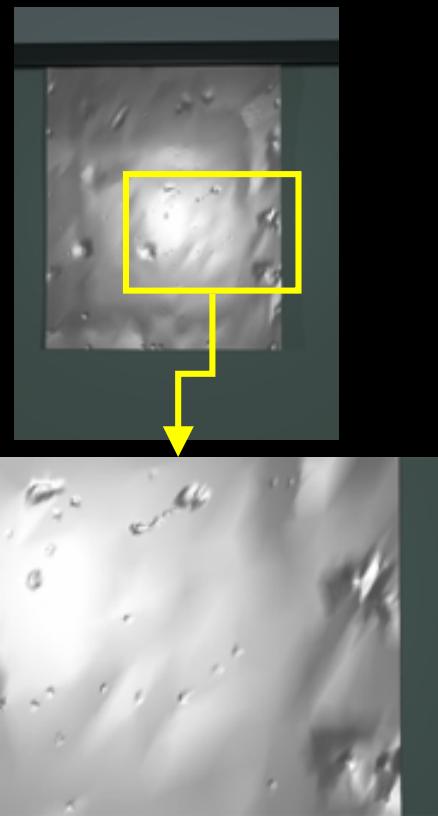
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Synthetic Aged Metal Plate

real



aged



clean



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Simulation Statistics

	Stairs	Trunk	Frame	Plate	Door
Impacts	128	149	300	234	276
Total (seconds)	4.13s	4.78s	7.59s	6.17s	8.54s
Average (milliseconds)	32ms	32ms	25ms	26ms	31ms

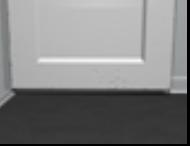
Athlon 600 MHz Linux PC



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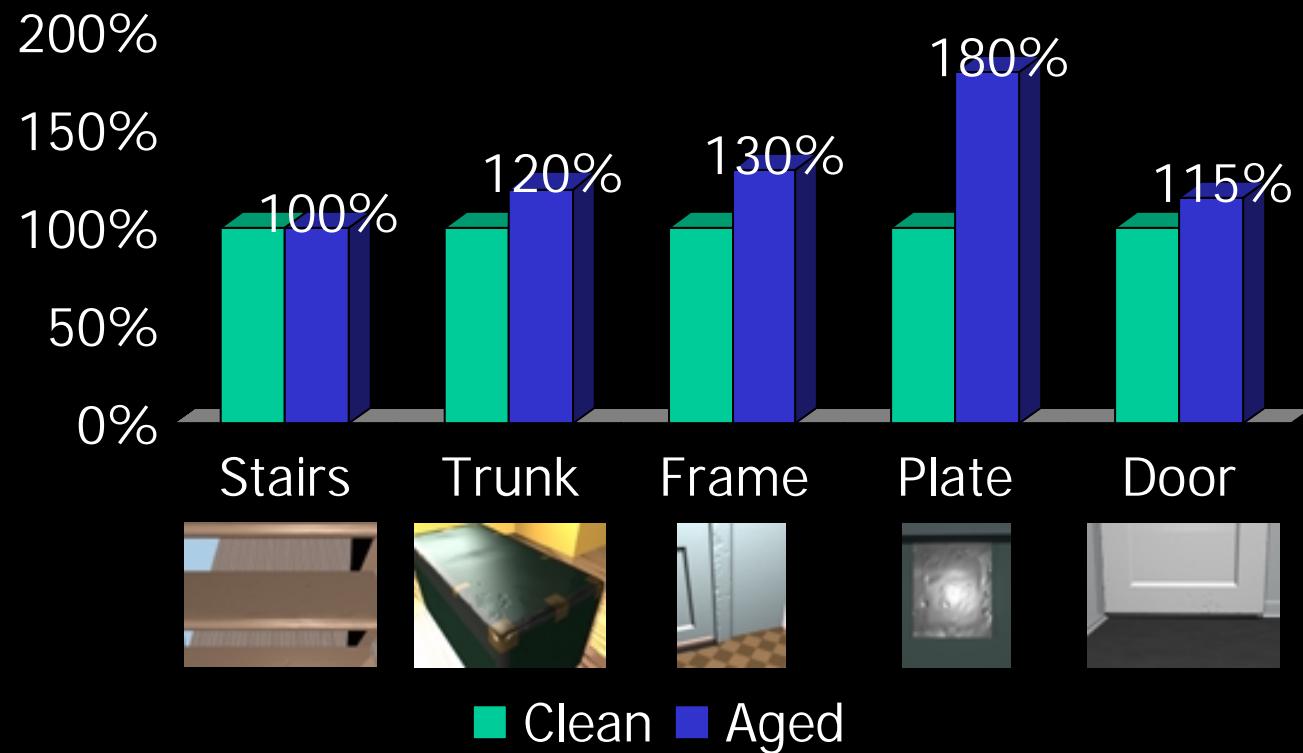
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Simulation Statistics

	Stairs	Trunk	Frame	Plate	Door
Mesh size					
original	6 k	2 k	352	2	1 k
final	22 k	18 k	23 k	20 k	25 k
regular	232000 k	80000 k	11000 k	16000 k	32000 k



Rendering Time



SGI Onyx 4 x R4400, 200 MHz



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Conclusion

- Increased realism
- Adaptive refinement
- Reduced
 - folding
 - self-intersection
- Simple & Efficient
- Intuitive & easy to use



Future Work

- Surface
 - refinement, representation
- Impacts specification
 - from possible results
 - extraction from images
- Other effects
 - pealing, abrasion, scratches, dirt



Acknowledgments

- Grants & scholarships
 - FCAR, NSERC, MRI-MEQ
- Rendering software
 - Alias|Wavefront
- iMAGIS is a joint project of CNRS/INRIA/UJF/INPG



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