

Shape from Silhouette: Image Pixels for Marching Cubes

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Shape and Reflectance

Introduction

Overview

Used Methods

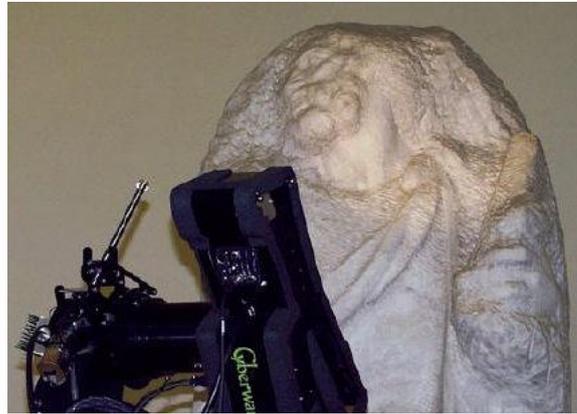
Refining

Normal

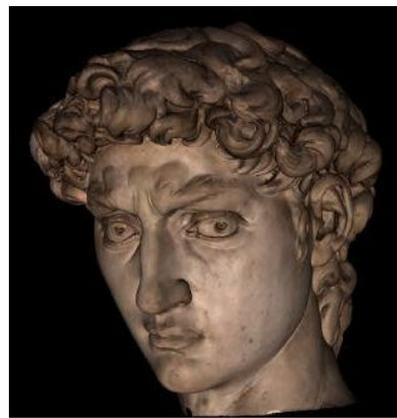
Results

Conclusion

The digital Michelangelo project



Laser scanner & Camera



Realistic rendering

Real-time reconstruction [Hasenfratz et al.]



4 Cameras



Real-time rendering

Goals and Contributions

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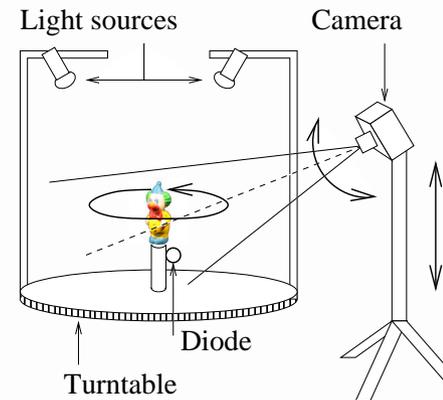
Normal

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Conclusion

● Goals

- Placing real objects into virtual environments
- Geometry estimation
- Relighting objects
- Shadows



● Using

- Acquisition system
- Series of photographs
- Objects without cavities



● Contributions

- Using image pixels for refining reconstruction process
- Estimating surface normal

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- Geometry reconstruction
 - Shape from silhouette approach
 - Marching cubes algorithm
 - Refining : image pixels
 - Normal from triangles or from voxels
- Results
- Conclusion

Used Methods

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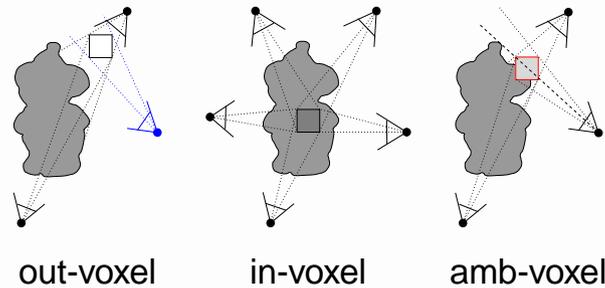
Normal

Results

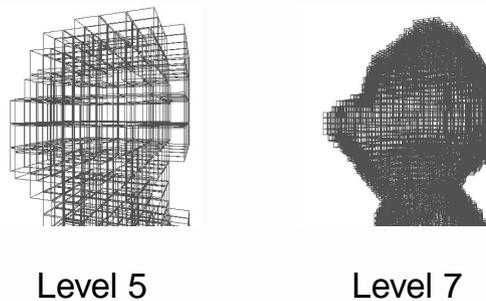
Conclusion

Shape from silhouette [Sze93]

● Octree construction

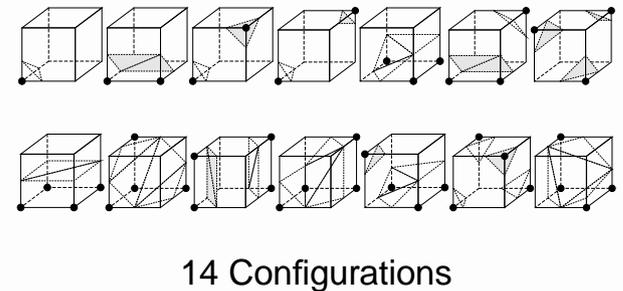


● Discrete surface

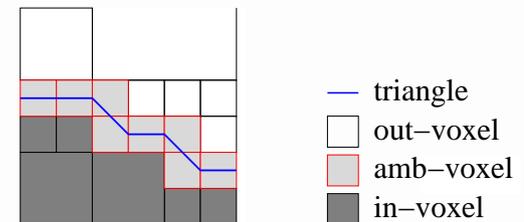


Marching cubes [LC87]

● Possible configurations



● Triangular mesh



Refining with Pixels

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6-connected surface

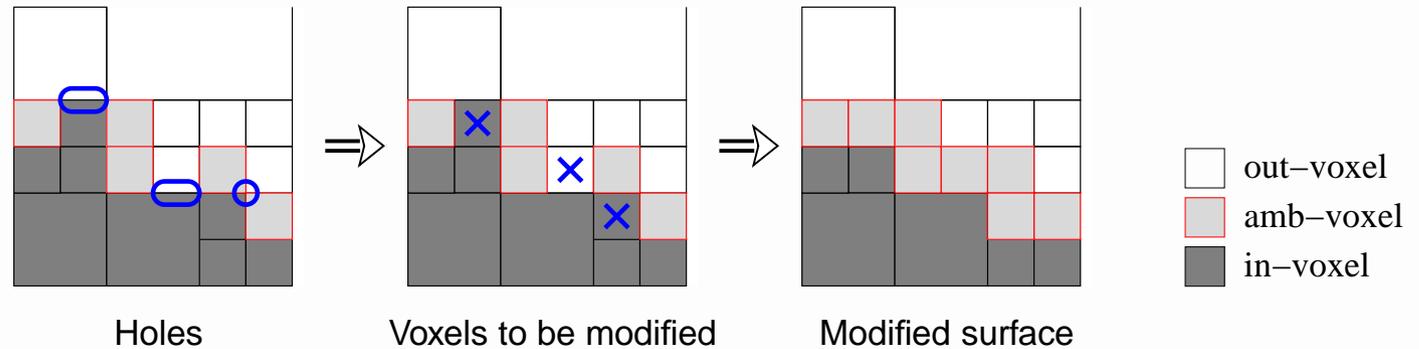
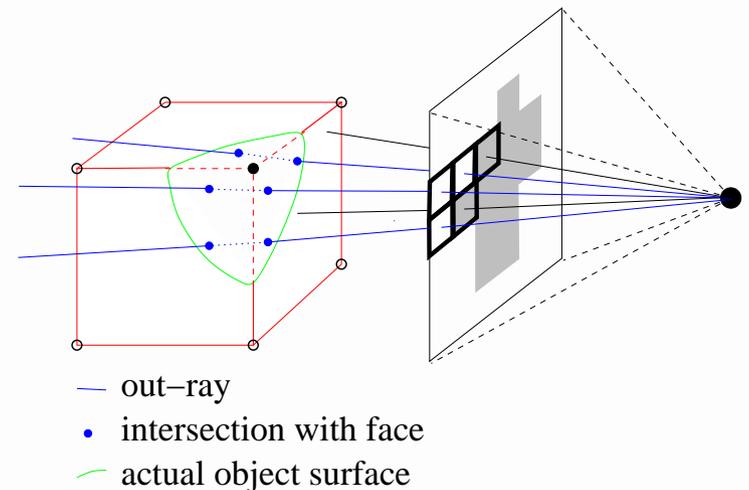
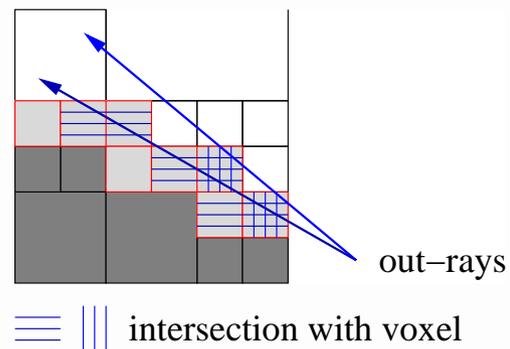


Image pixels



Refining with Pixels

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6-connected surface

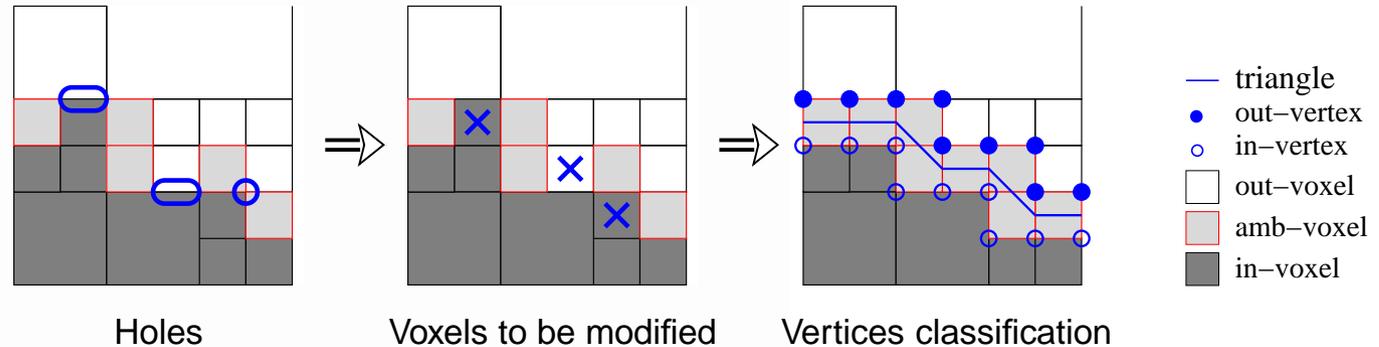
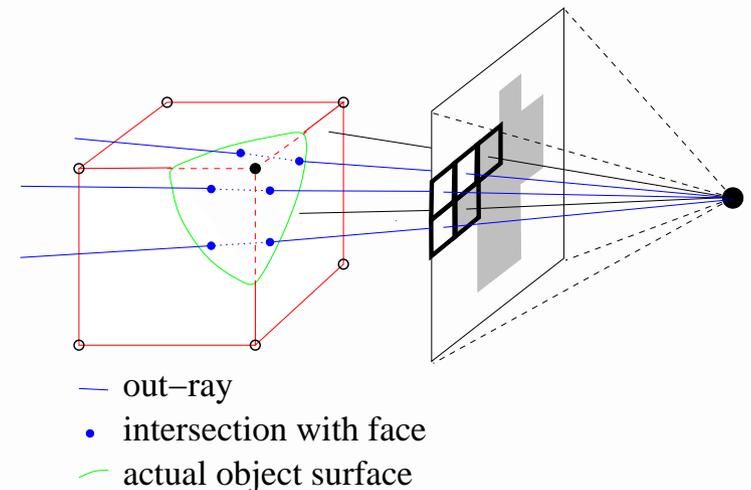
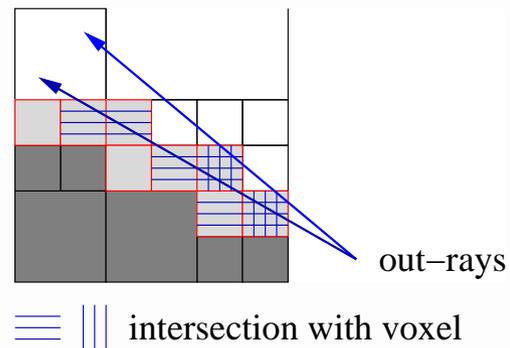


Image pixels



Refining with Pixels

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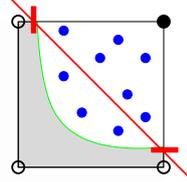
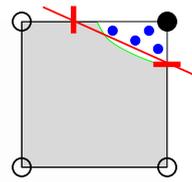
Refining

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● Surface line



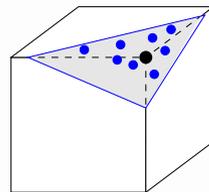
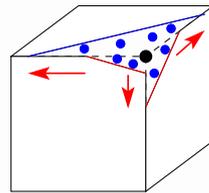
- in-vertex
 - out-vertex
 - out-ray intersection
 - mc-vertex
- } P_i
- ← surface line L_k

Minimize

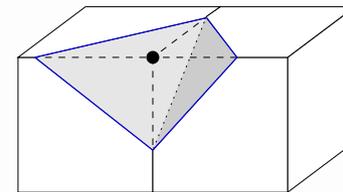
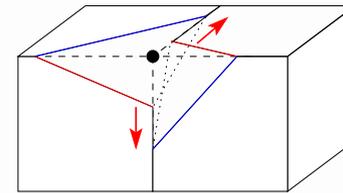
$$dist_k = \sum_i dist(P_i, L_k)^2$$

Vertices for MC triangles

● Surface continuity



Between adjacent faces



Between adjacent voxels

Surface Normal

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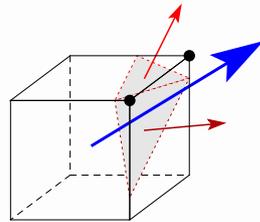
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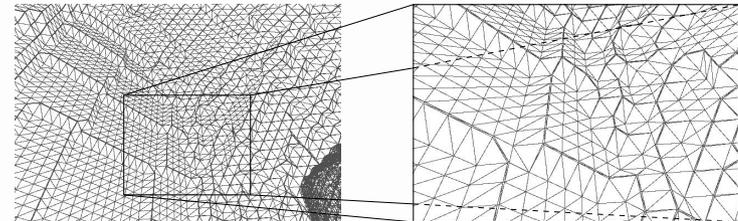
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● From triangles



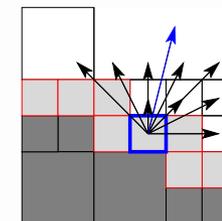
Average of triangles normals
weighted by areas



Smoothing is necessary

● From voxels

- Given neighborhood
- Surface mesh not needed
- Less precise estimation



Using out-voxels directions

Results for Shape Estimation

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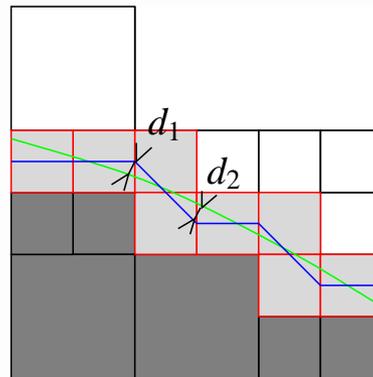
Normal

Results

Conclusion

- With a 1-meter diameter sphere (object with known geometry)

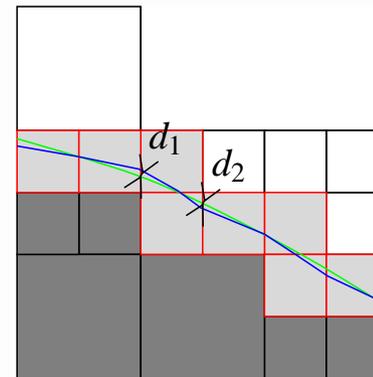
$$\text{Average distance } AD = \frac{\sum_{i=1}^n d_i}{n}$$



Without image pixels

$$AD = 10.8mm$$

$$AD = 8.9mm$$



With image pixels

$$AD = 6.7mm$$

$$AD = 6.4mm$$

- reconstructed surface
- actual surface
- out-voxel
- amb-voxel
- in-voxel

with octree depth = 5

with octree depth = 7



Precise even with a low octree depth

Results for Shape Estimation

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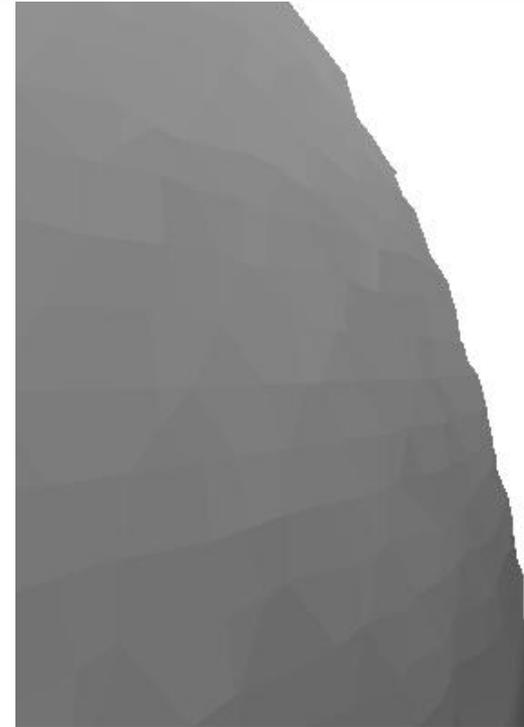
Results

Conclusion

- With a 1-meter diameter sphere (object with known geometry)



Without image pixels



With image pixels



Outline more regular

Results for Normal Estimation

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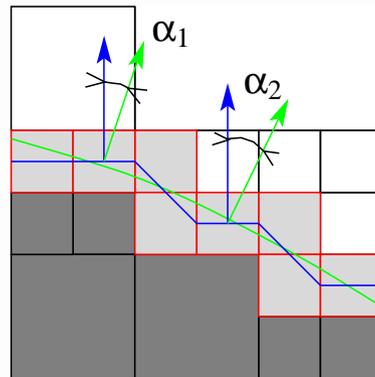
Normal

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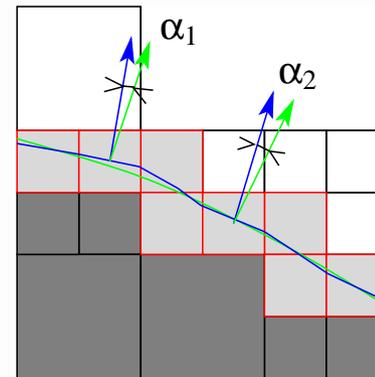
$$\text{Average angle difference } AAD = \frac{\sum_{i=1}^n \alpha_i}{n}$$



Without image pixels

$$AAD = 5.7^\circ$$

$$AAD = 2.1^\circ$$



With image pixels

$$AAD = 3.3^\circ$$

$$AAD = 1.8^\circ$$



Surface less bumpy

- reconstructed surface
- actual surface
- out-voxel
- amb-voxel
- in-voxel

with octree depth = 5
(any smoothing)

with octree depth = 7
(smoothing with 3 voxels)

Results for Normal Estimation

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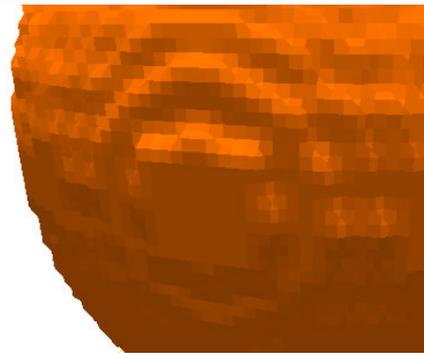
Normal

Results

Conclusion

- With a 1-meter diameter sphere (object with known geometry)

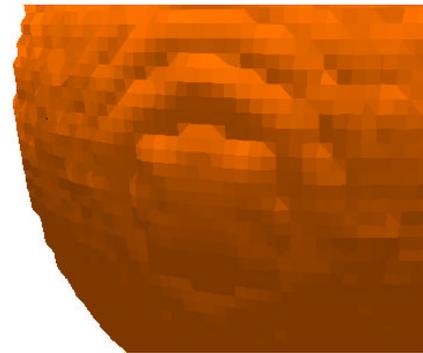
$$\text{Average angle difference } AAD = \frac{\sum_{i=1}^n \alpha_i}{n}$$



Without image pixels

$$AAD = 5.7^\circ$$

$$AAD = 2.1^\circ$$



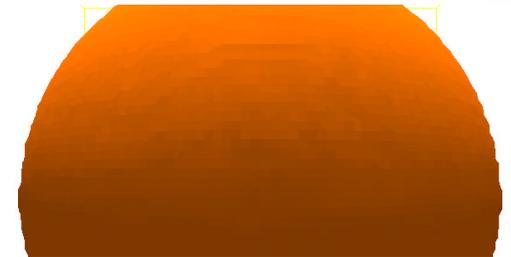
With image pixels

$$AAD = 3.3^\circ$$

$$AAD = 1.8^\circ$$



Surface less bumpy



Smoothing with 3 voxels

with octree depth = 5
(any smoothing)

with octree depth = 7
(smoothing with 3 voxels)

Conclusion

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- Acquisition system
 - A camera and a turntable
- Reconstruction process
 - Discrete surface
 - Triangular mesh
- Contributions
 - Refining object shape
 - Recovering surface normal
- Application
 - Light sources and object reflectance estimation [MM04]
- In the future
 - Real objects integration
 - Objects realistic relighting



Photographs

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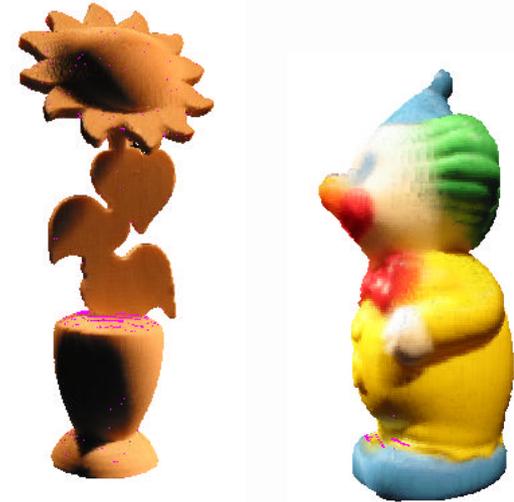
Refining

Normal

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Rendering of the mesh
using voxel radiance

Conclusion

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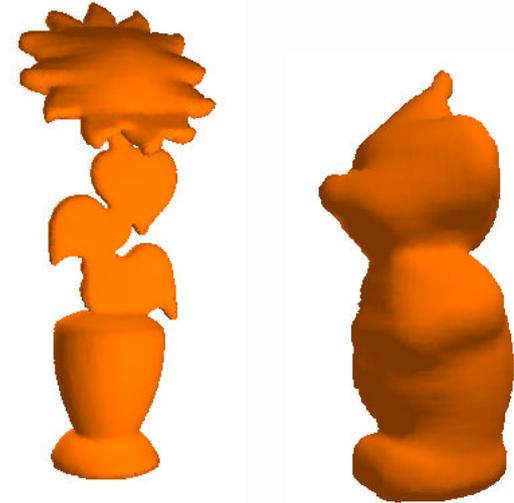
Refining

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Relighting of the mesh
using smooth normals

Image Pixels for Marching Cubes

