# Anti-aliasing Anatomic Surfaces

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# Anti-aliasing: problem defintion

- Given a voxelized representation, find a surface within the voxel boundaries that represents the input image.
- The problem is ill-posed – there are several possible surfaces; we select the smooth one.

# Previous attempts

Constrained mean curvature flow [Whitaker 2000]

- Cons
  - Shrinks volumes.
  - Constraints make the result piecewise smooth.

Filtering methods

- Cons
  - Shrink volume
  - Change topology: holes

# Flow of Laplacian of curvature

- Flow of Laplacian of curvature has been shown to produce smooth surfaces. [Chopp 1999]
- Constraining it doesn't have any ill-effects.

# Data representation

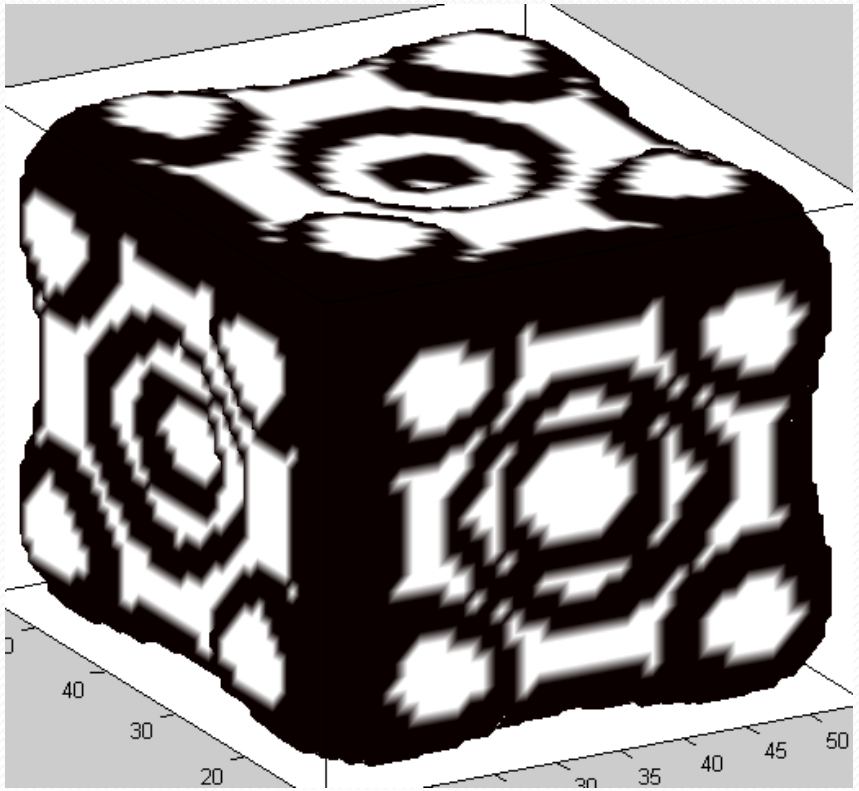
- Represented as a level-set of  signed distance function
  - obtained from the binary image
- Advantage
  - Computation of curvatures and evolution is straightforward.
- Disadvantage
  - Difficult to deal with thin regions – not enough data to compute derivatives.

# Evolution

- Evolution of the level set is done by flow of Laplacian of curvature.
- The level set is constrained to not change by more than 0.5
  - We can increase this limit to provide constrained smoothing.

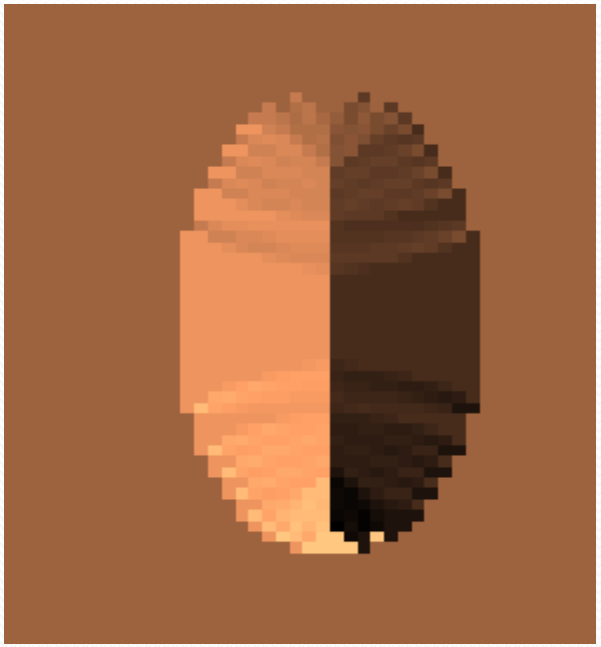
# Evolution

- Convergence may, however, take a long time.
  - for flat regions parallel to cardinal planes (shown in white on the quartic surface in the right)



# Heuristic for faster convergence

- Flat regions are identified –
  - Flat regions have zero K and zero H.
  - Flat regions are parallel to one of the cardinal planes.
- A distance metric change is used to compress distances along ‘longer directions’ – all directions become equi-distant from boundary.

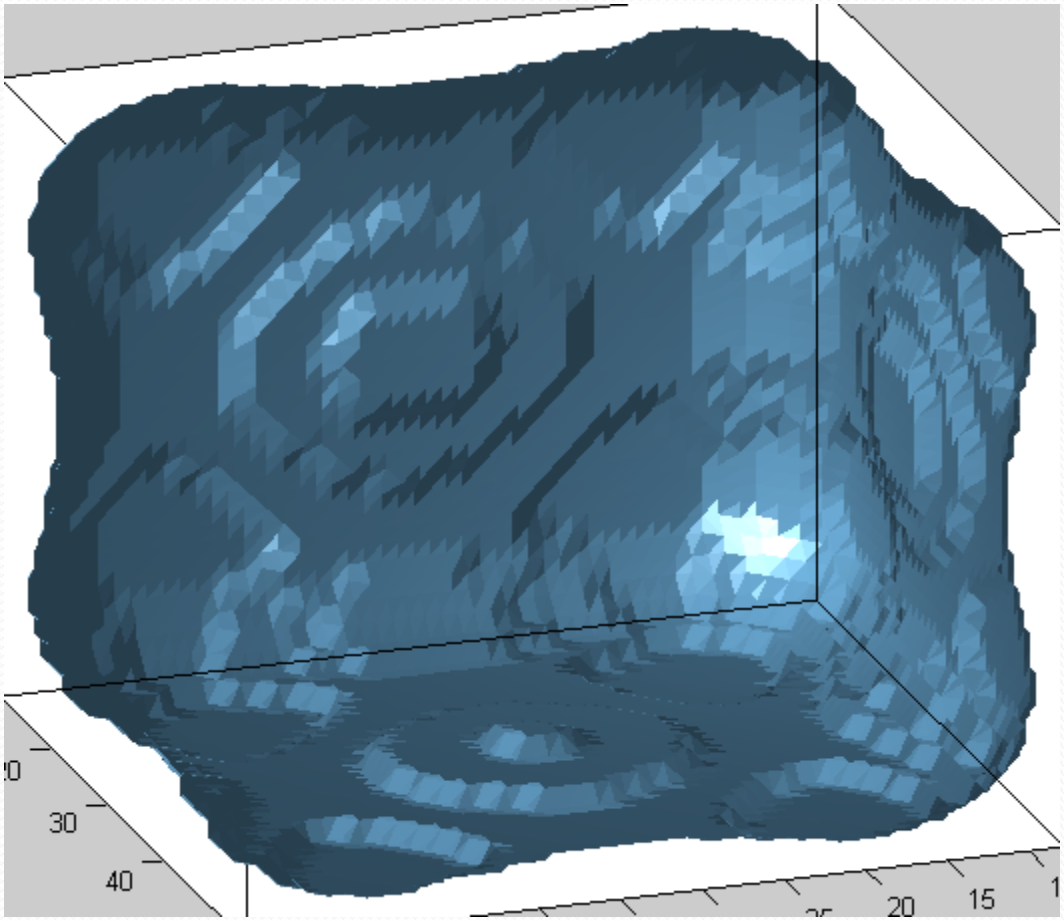


‘Lines’ along which compression takes place

# Heuristic for faster convergence.

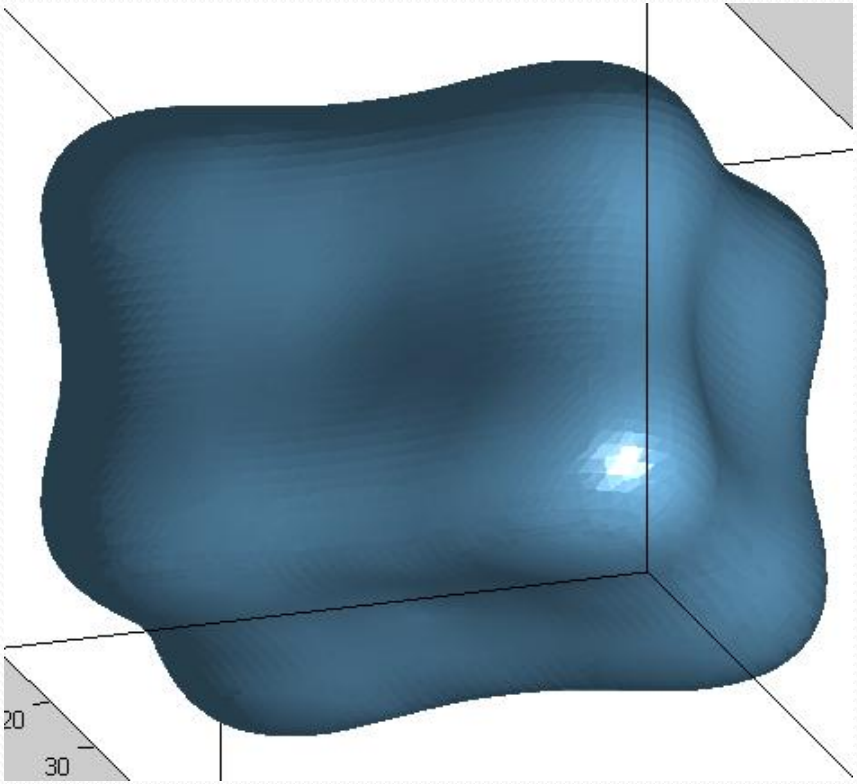
- The changed distance metric is used in the Laplacian of curvature computations.
  - This enables faster convergence in flat regions
- As iterations progress, the spacing is relaxed to be the original spacing
  - This needs to be done so that the smoothness is defined by the original curvature and not the curvature based on the new metric.

# Example: Quartic Surface (Original)

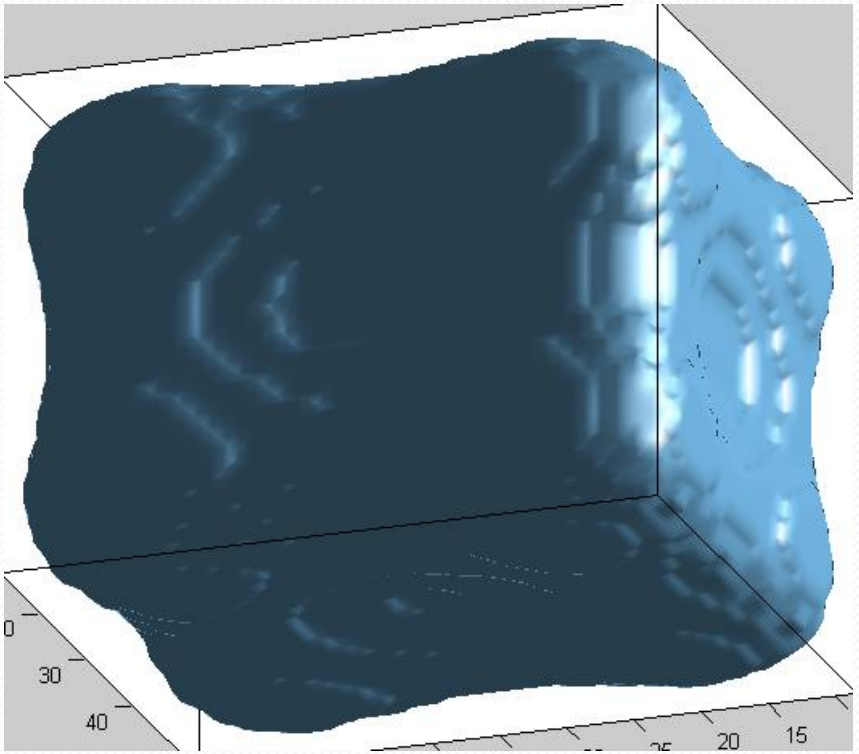


# Example: Quartic Surface (Anti-aliased)

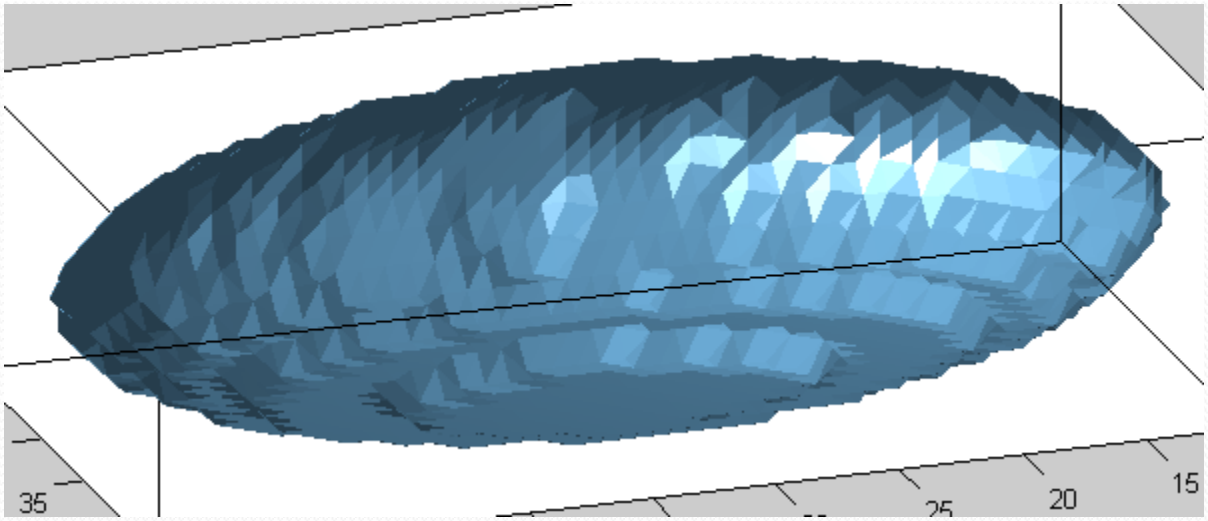
**Laplacian of curvature**




**Curvature**

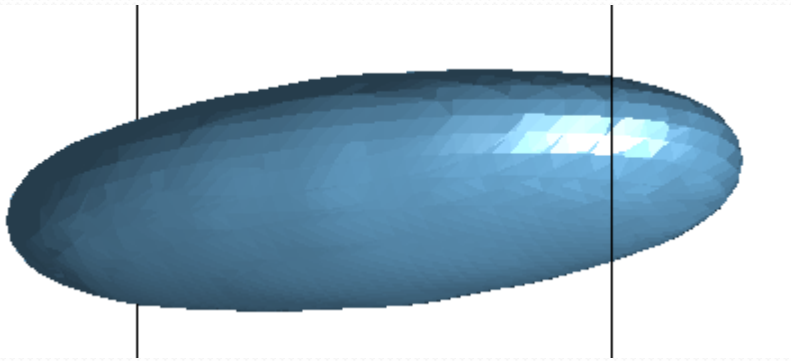


# Example: Ellipsoid (Original)

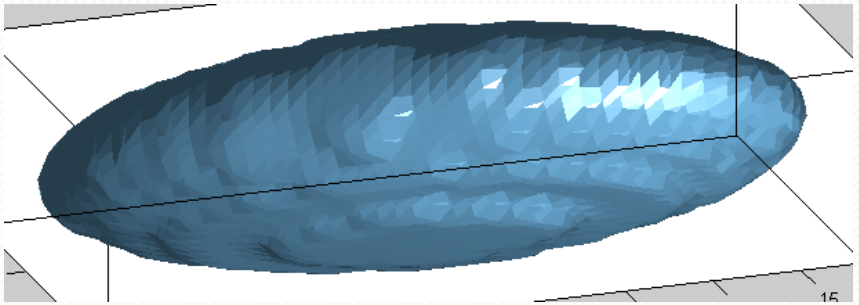


# Example: Ellipsoid (Anti-aliased)

**Laplacian of curvature**

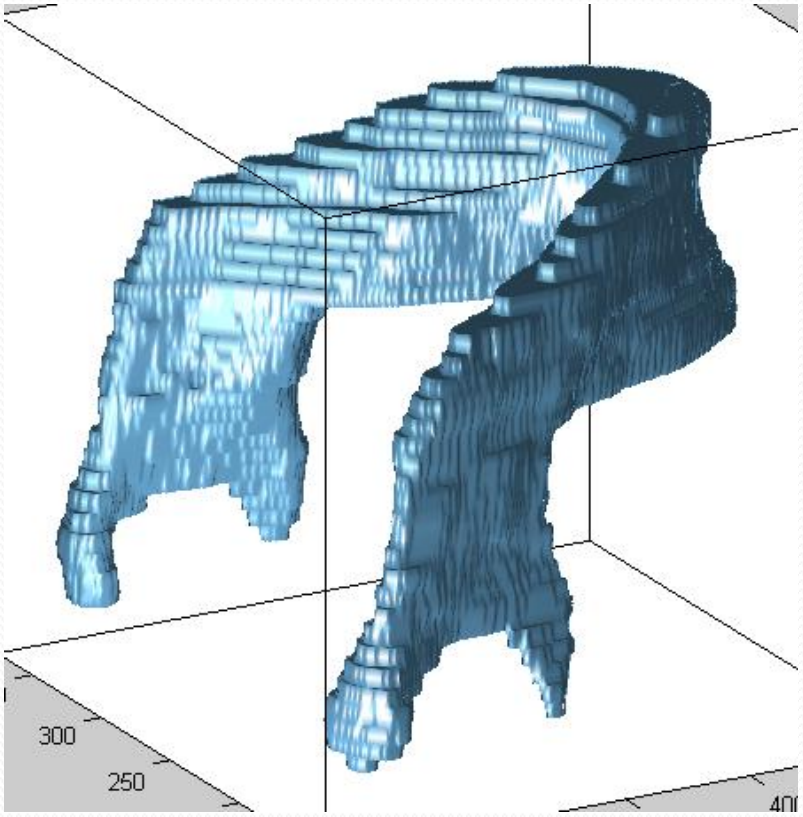


**Curvature**

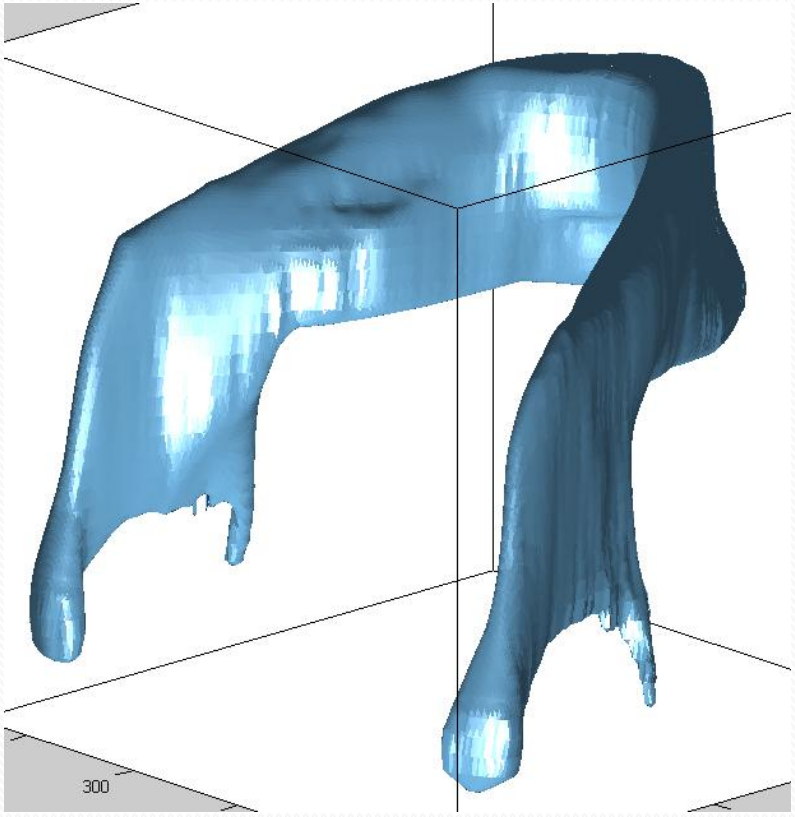


# Example: Mandible

**Original**




**Anti-aliased**



# Acknowledgements


- I would like to acknowledge Ross Whitaker for some valuable discussions on the topic.

# References


- Ross Whitaker, “Reducing Aliasing Artifacts In Iso-Surfaces of Binary Volumes” IEEE Volume Visualization and Graphics Symposium, October 2000, pp. 23-32
- David L. Chopp , J. A. Sethian, “Motion by Intrinsic Laplacian of Curvature” Interfaces and Free Boundaries, volume 1, 1999, pp. 1-18