

# Computer Graphics **-Geometry Processing**

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<http://jjcao.github.io/ComputerGraphics/>

# Last time: Curves, Surfaces & Meshes

- **Mathematical description of geometry**

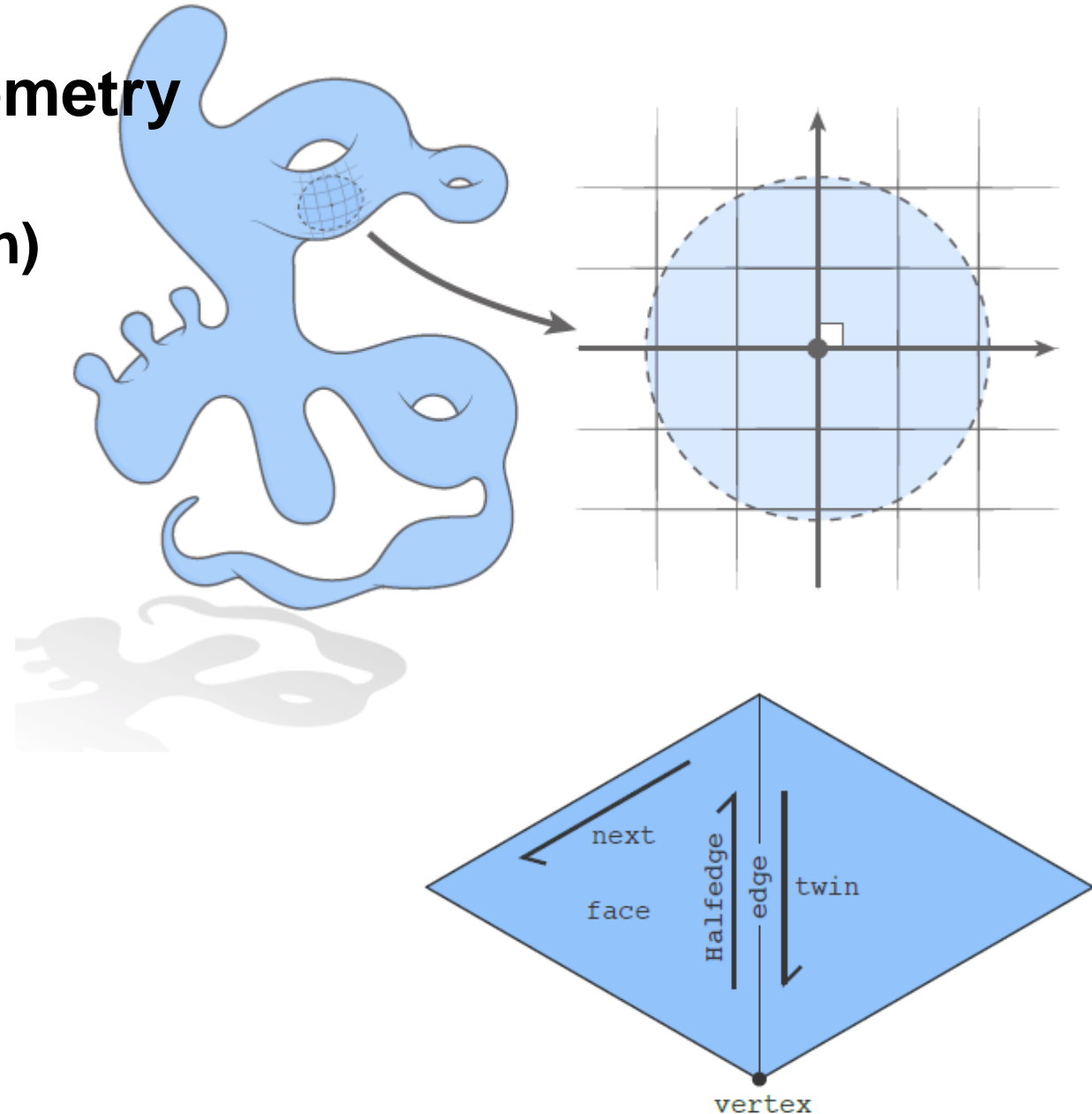
- simplifying assumption: *manifold*
- gives local coordinates (Manhattan)

- **Data structures for surfaces**

- polygon soup
- halfedge mesh
- storage cost vs. access time, etc.

- **Today:**

- how do we manipulate geometry?
- geometry processing / resampling



# Comparison of Polygon Mesh Data Structures

	Polygon Soup	Incidence Matrices	Halfedge Mesh
storage cost*	$\sim 3 \times \text{\#vertices}$	$\sim 33 \times \text{\#vertices}$	$\sim 36 \times \text{\#vertices}$
constant-time neighborhood access?	NO	YES	YES
easy to add/remove mesh elements?	NO	NO	YES
nonmanifold geometry?	YES	YES	NO

**Conclusion: pick the right data structure for the job!**

# Digital Geometry Processing

- Extend traditional digital signal processing (audio, video, etc.) to deal with *geometric* signals:
  - upsampling / downsampling / resampling / filtering ...
  - aliasing (reconstructed surface gives “false impression”)
- Also some new challenges (very recent field!):
  - over which domain is a geometric signal expressed?
  - no terrific sampling theory, no fast Fourier transform, ...
- Often need new data structures & new algorithms

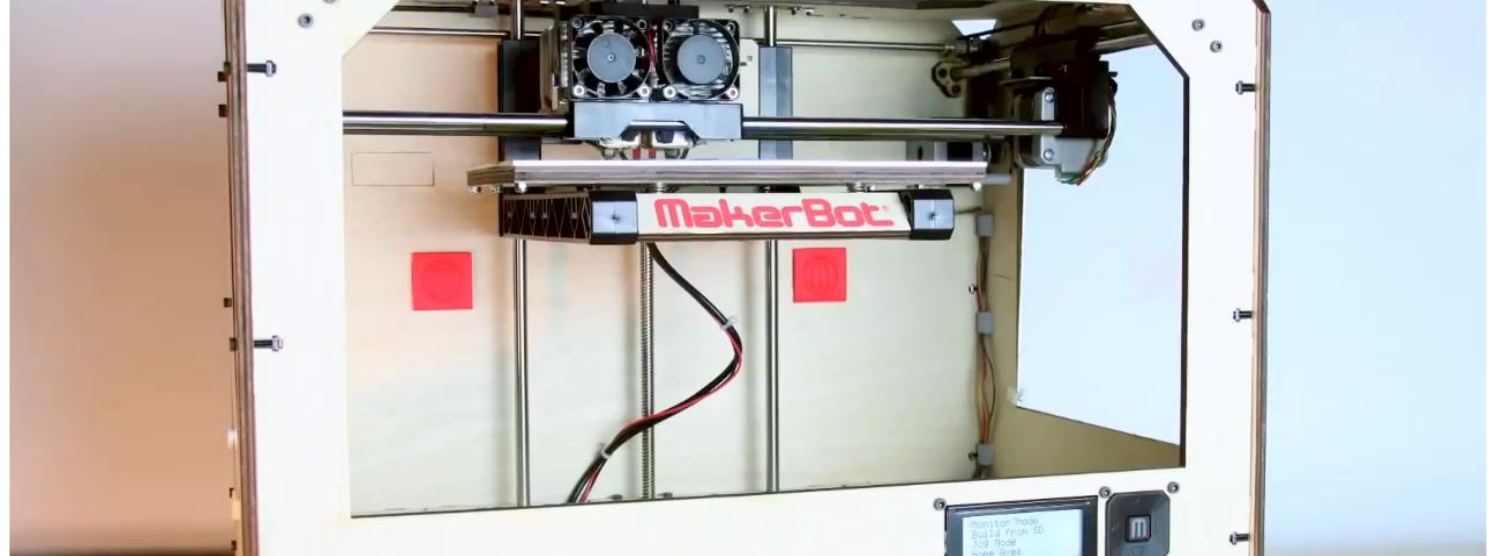


# Digital Geometry Processing: Motivation

- 3D Scanning



- 3D Printing

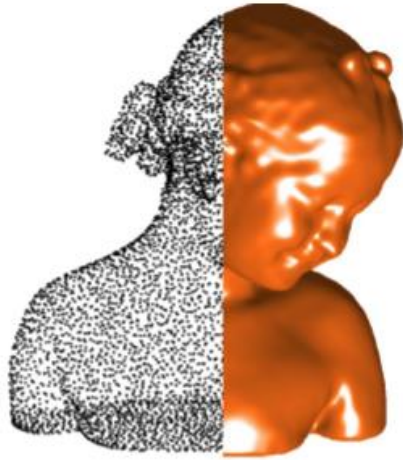


# Geometry Processing Pipeline

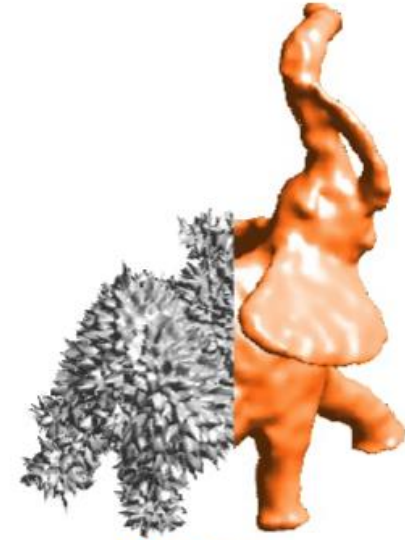




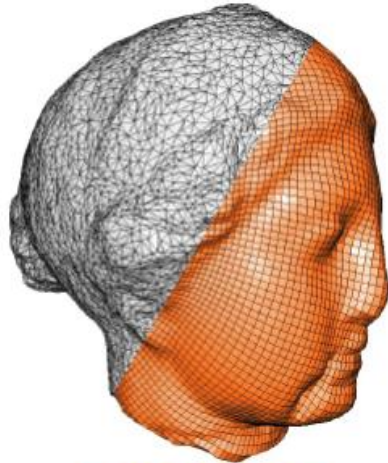
# Geometry Processing Tasks



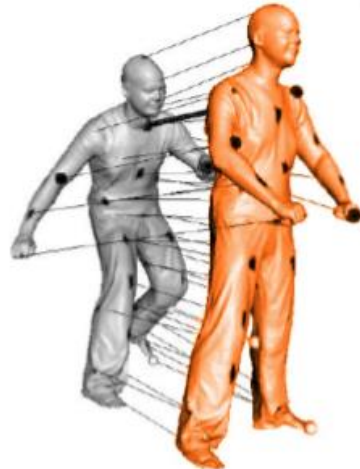
reconstruction



filtering



remeshing



shape analysis



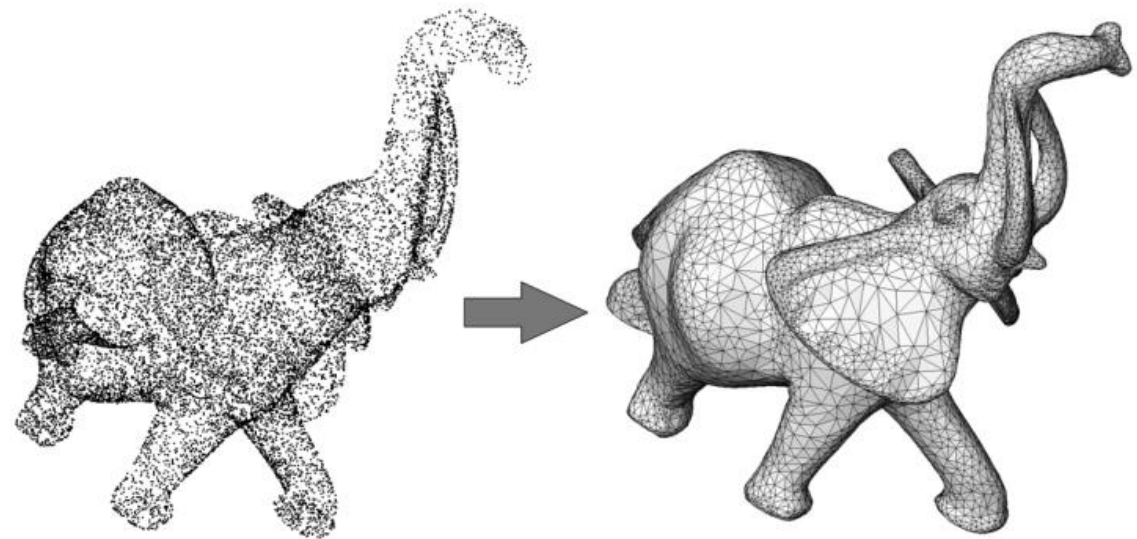
parameterization



compression

# Geometry Processing: Reconstruction

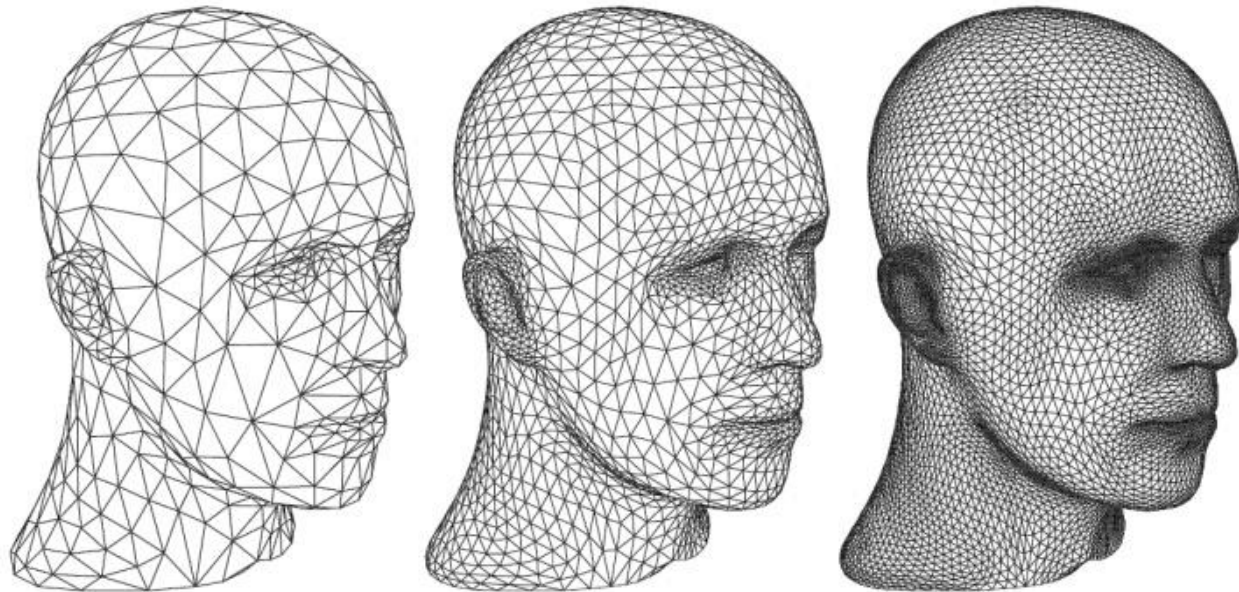
- **Given samples of geometry, reconstruct continuous surface**
- **What are “samples”? Many possibilities:**
  - points, points & normals, ...
  - image pairs / sets (multi-view stereo)
  - line density integrals (MRI/CT scans)
- **How do you get a surface? Many techniques:**
  - PDE-based (e.g., Poisson reconstruction)
  - Voronoi-based (e.g., power crust)
  - silhouette-based (visual hull)
  - Radon transform / isosurfacing (marching cubes)





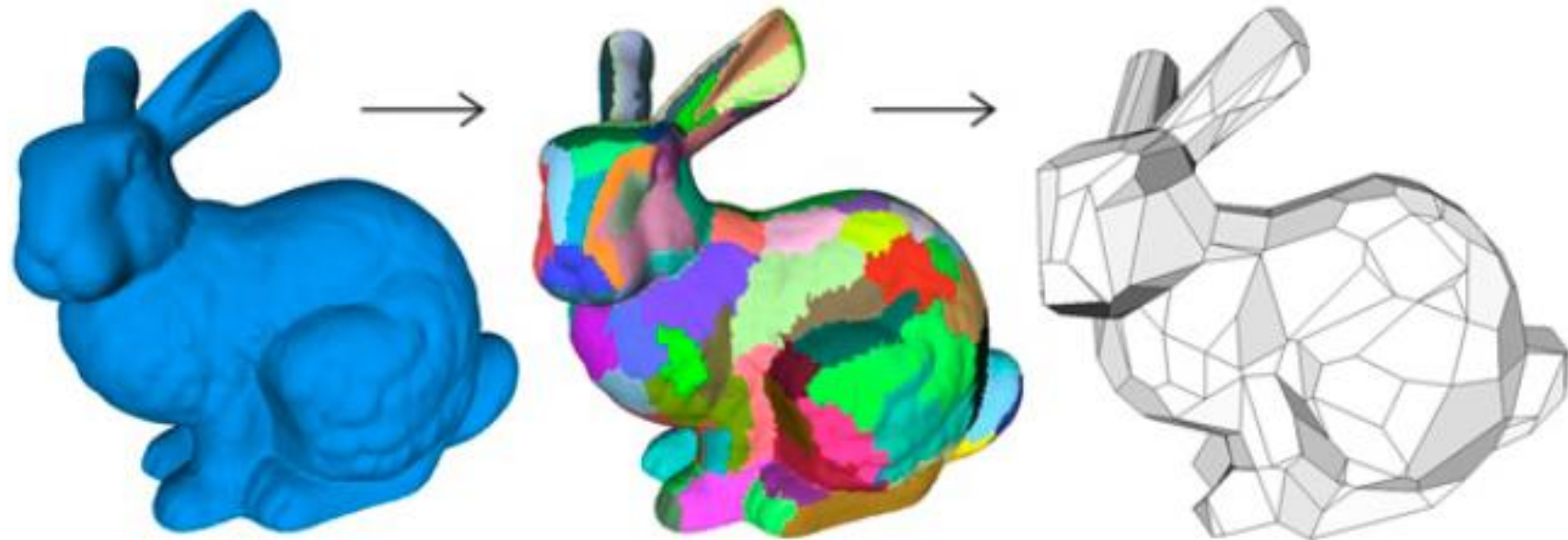
# Geometry Processing: Upsampling

- Increase resolution via interpolation
- Images: e.g., bilinear, bicubic interpolation
- Polygon meshes:
  - subdivision
  - bilateral upsampling
  - ...



# Geometry Processing: Downsampling

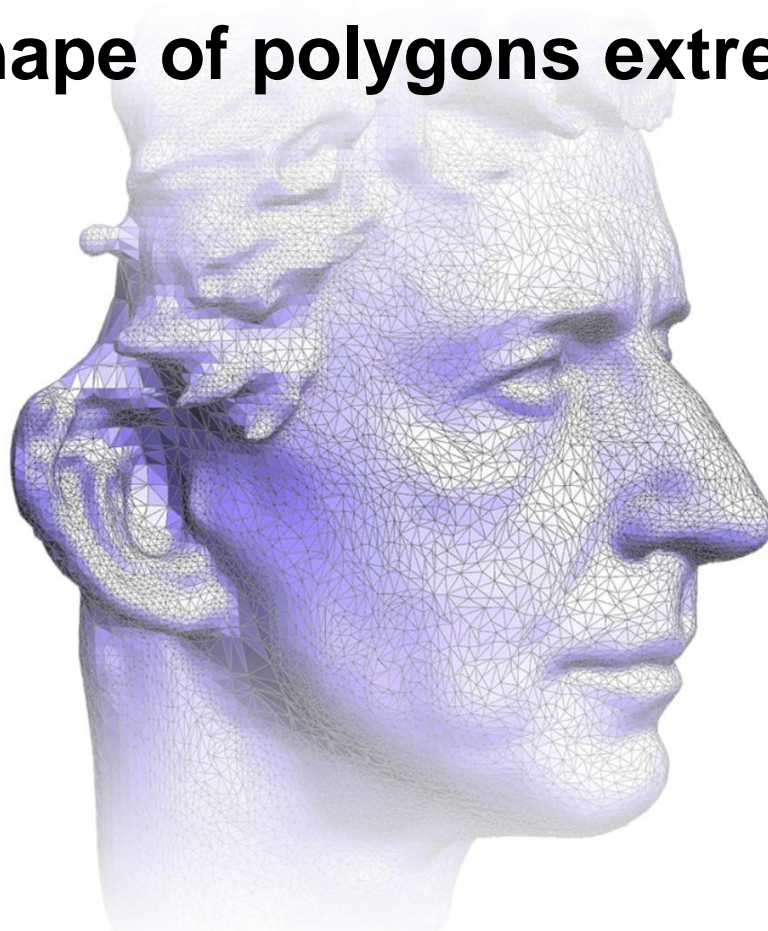
- Decrease resolution; try to preserve shape/appearance
- Images: again, bilinear, bicubic interpolation (again)
- Polygon meshes:
  - iterative decimation
  - variational shape approximation
  - ...





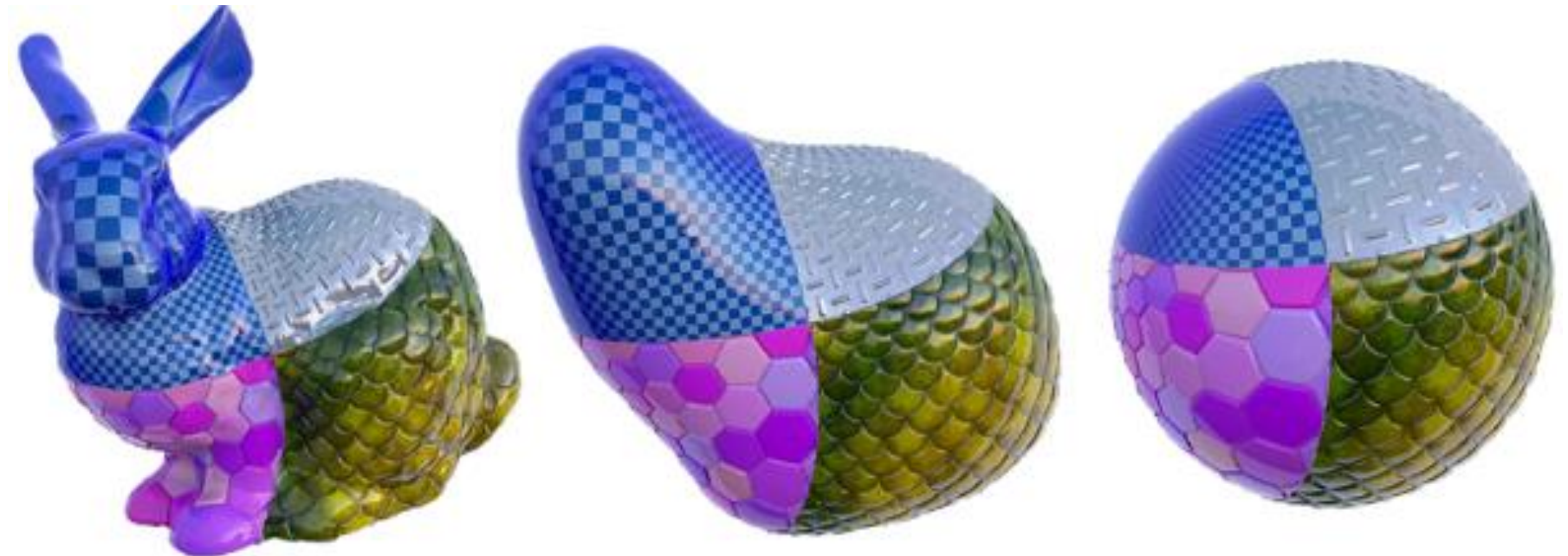
# Geometry Processing: Resampling

- **Modify sample distribution to improve quality**
- **Images: ...not usually an issue!**
  - pixels are always stored on a regular grid
- **Polygon meshes: shape of polygons extremely important!**
  - approximation
  - simulation
  - further processing



# Geometry Processing: Filtering

- Remove noise, or emphasize important features (e.g., edges)
- Images: blurring, bilateral filter, compressed sensing, ...
- Polygon meshes:
  - curvature flow
  - bilateral filter
  - ...



# Geometry Processing: Shape Analysis

- Identify/understand important semantic features
- Images: computer vision, segmentation, face detection, ...
- Polygon meshes:
  - segmentation
  - correspondence
  - symmetry detection
  - ...





**Ok, enough! Let's process some geometry!**