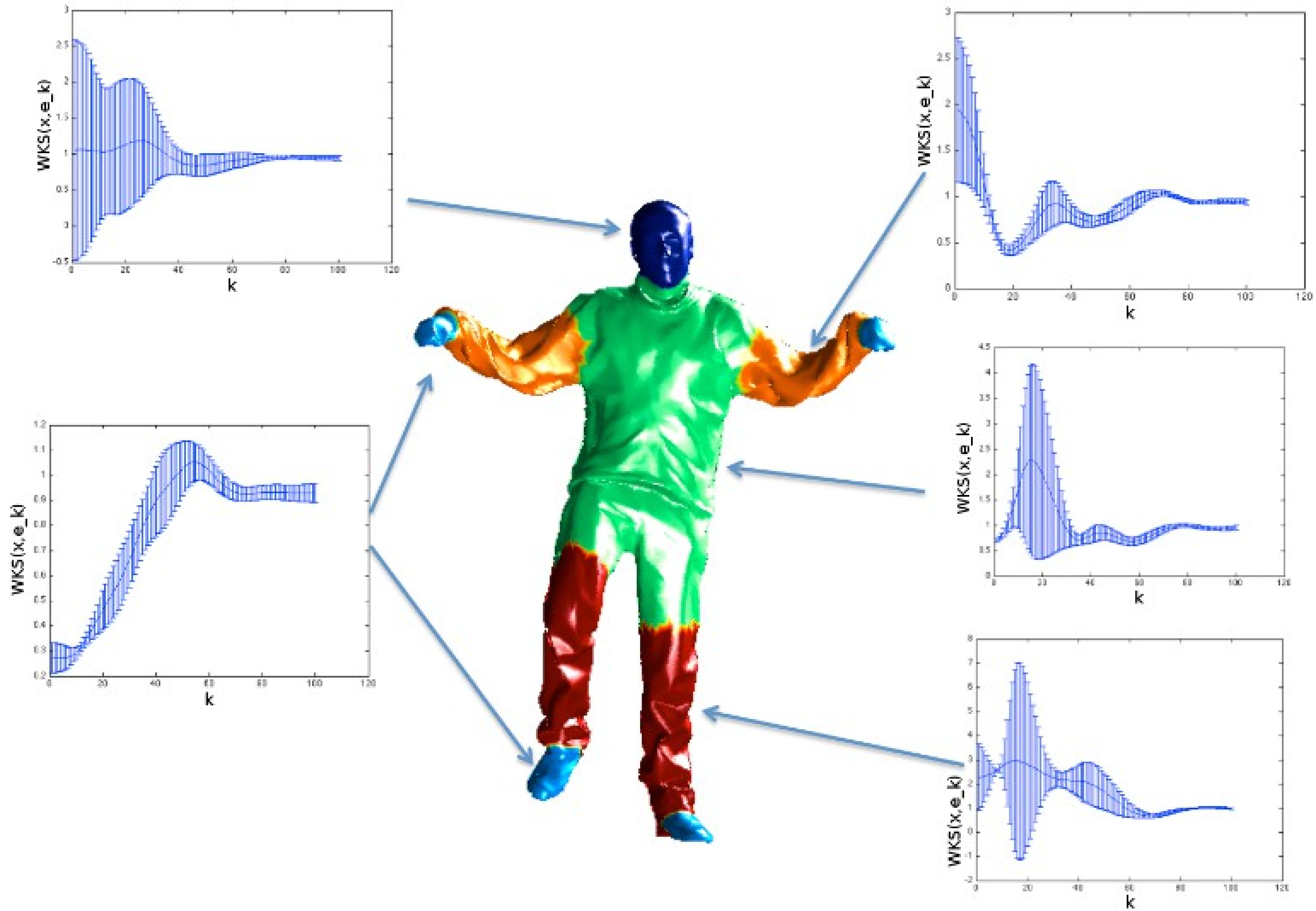
Aubry, Schlickewei, Cremers



Shape Descriptors - I

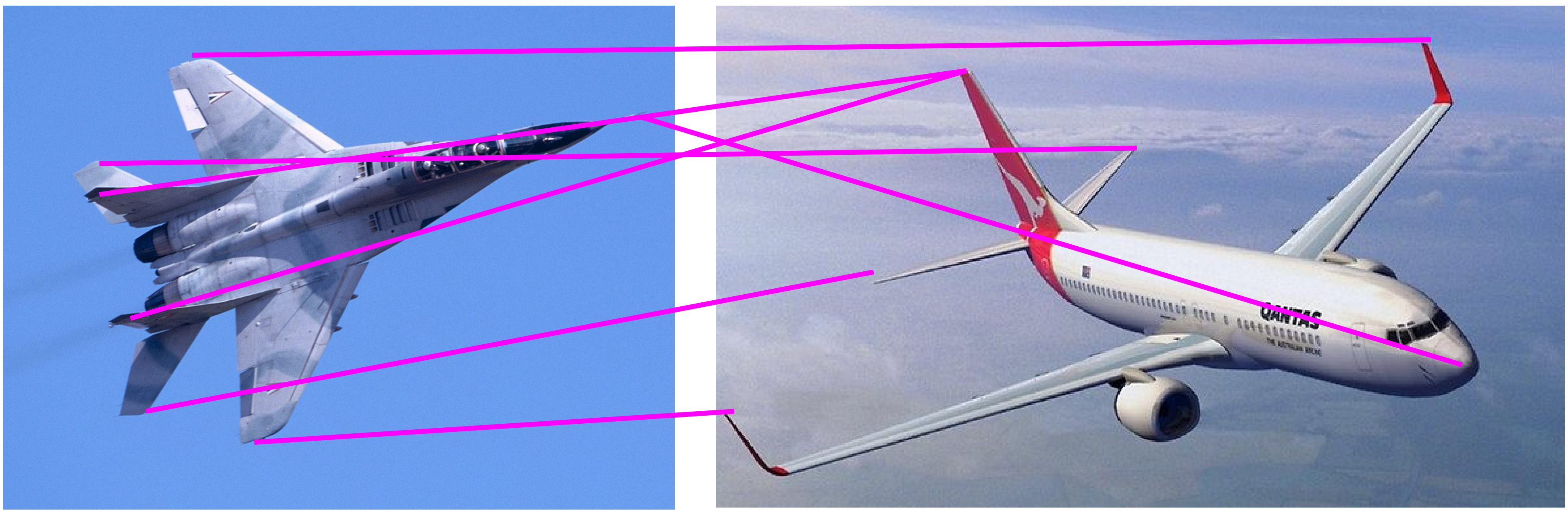
Siddhartha Chaudhuri http://www.cse.iitb.ac.in/~cs749

Lots of shapes out there!

... and lots of ways to analyse them

Two shapes from the same category

… have differences and similarities



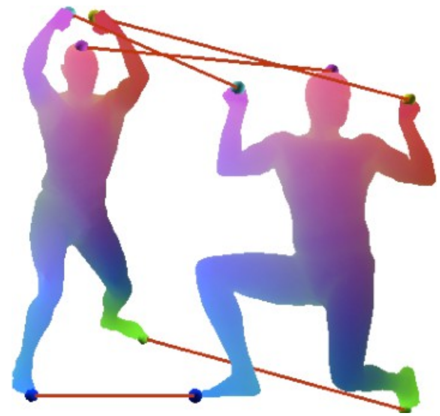
How can we succinctly capture this?

A large and complex dataset

Shape Analysis Applications

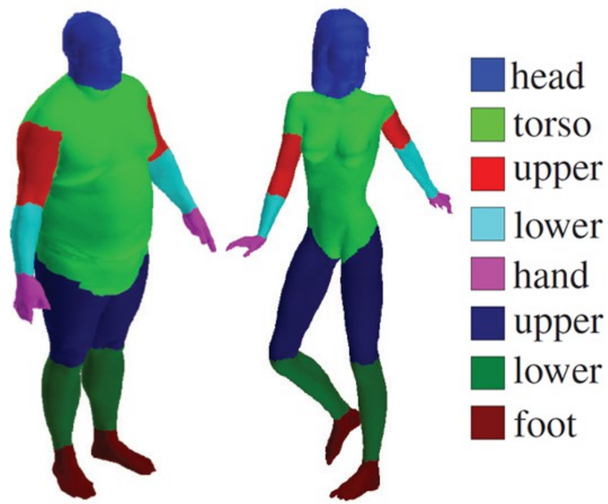
Feature detection

Find salient feature points



Correspondences

Find matching points
between two shapes



Segmentation

Break a shape into meaningful parts

Labeling

Assign labels (“hand”, “wheel”,
“wing”...) to segments

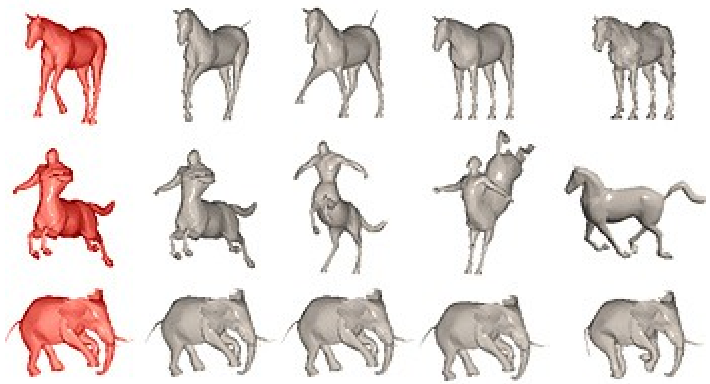
Registration

Bring two or more shapes
into pointwise alignment

Symmetry detection

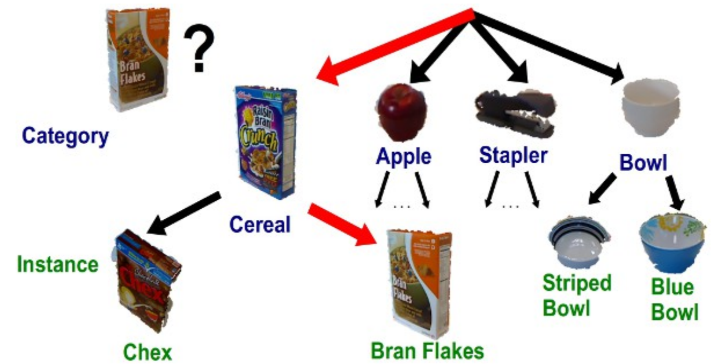
Find dominant symmetries
of a shape

Shape Analysis Applications



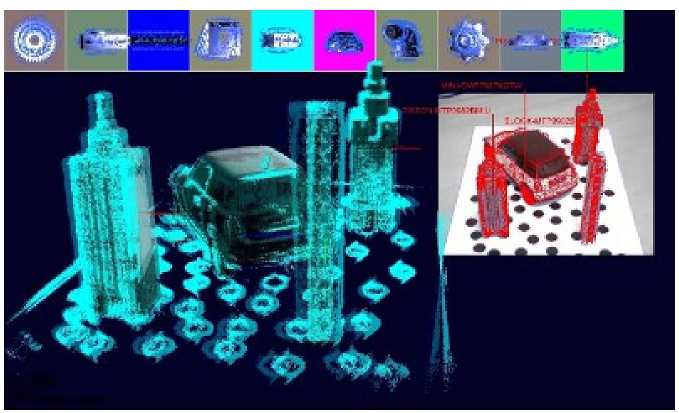
Retrieval

Find shapes matching the query shape



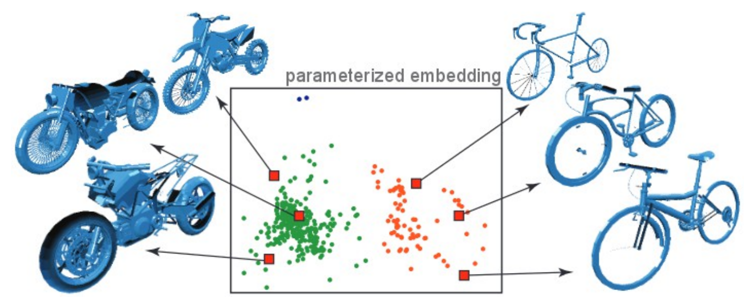
Classification

Find the category ("human", "car", "bird") of a shape



Recognition

Find instances of a given shape in a scene

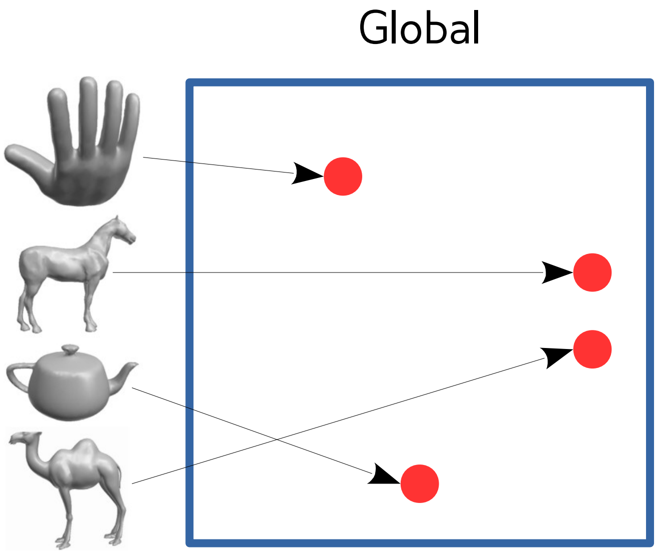


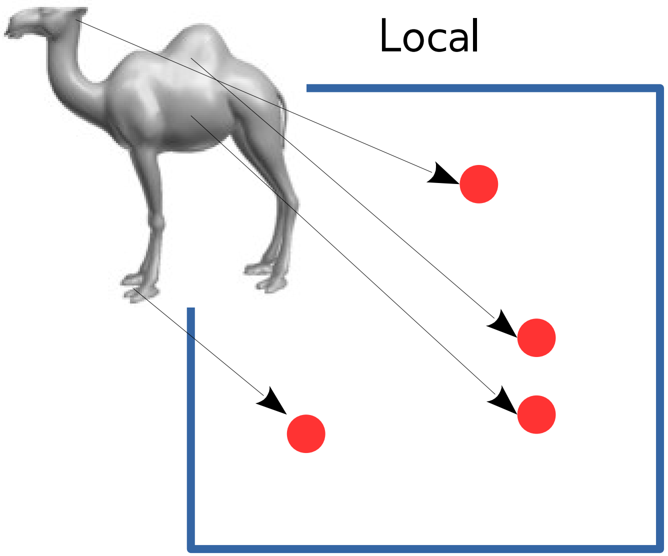
Clustering

Group shapes by similarity

Shape Descriptor

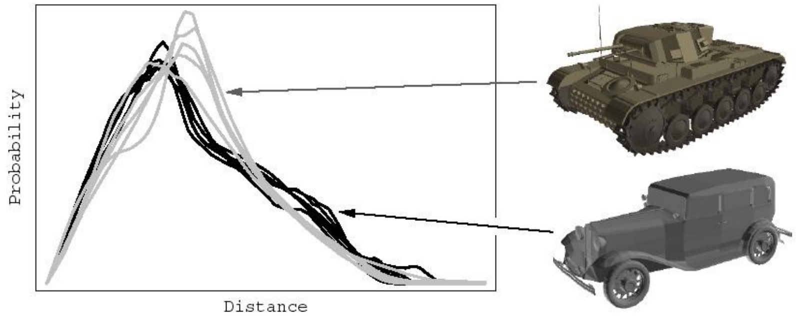
- A set of numbers that describes a shape in a way that is
  - Concise
    - a few numbers that capture the “essence” of the shape)
  - Quick to compute
  - Efficient to compare
  - Discriminative
    - Different shapes have different descriptors
    - Similar shapes have similar descriptors
- Typically, the descriptors form a vector space with a meaningful distance metric



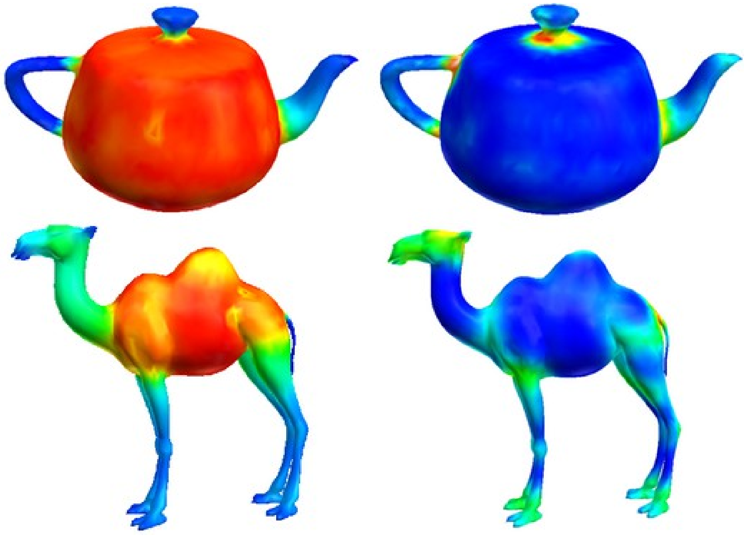


Global and Local Descriptors

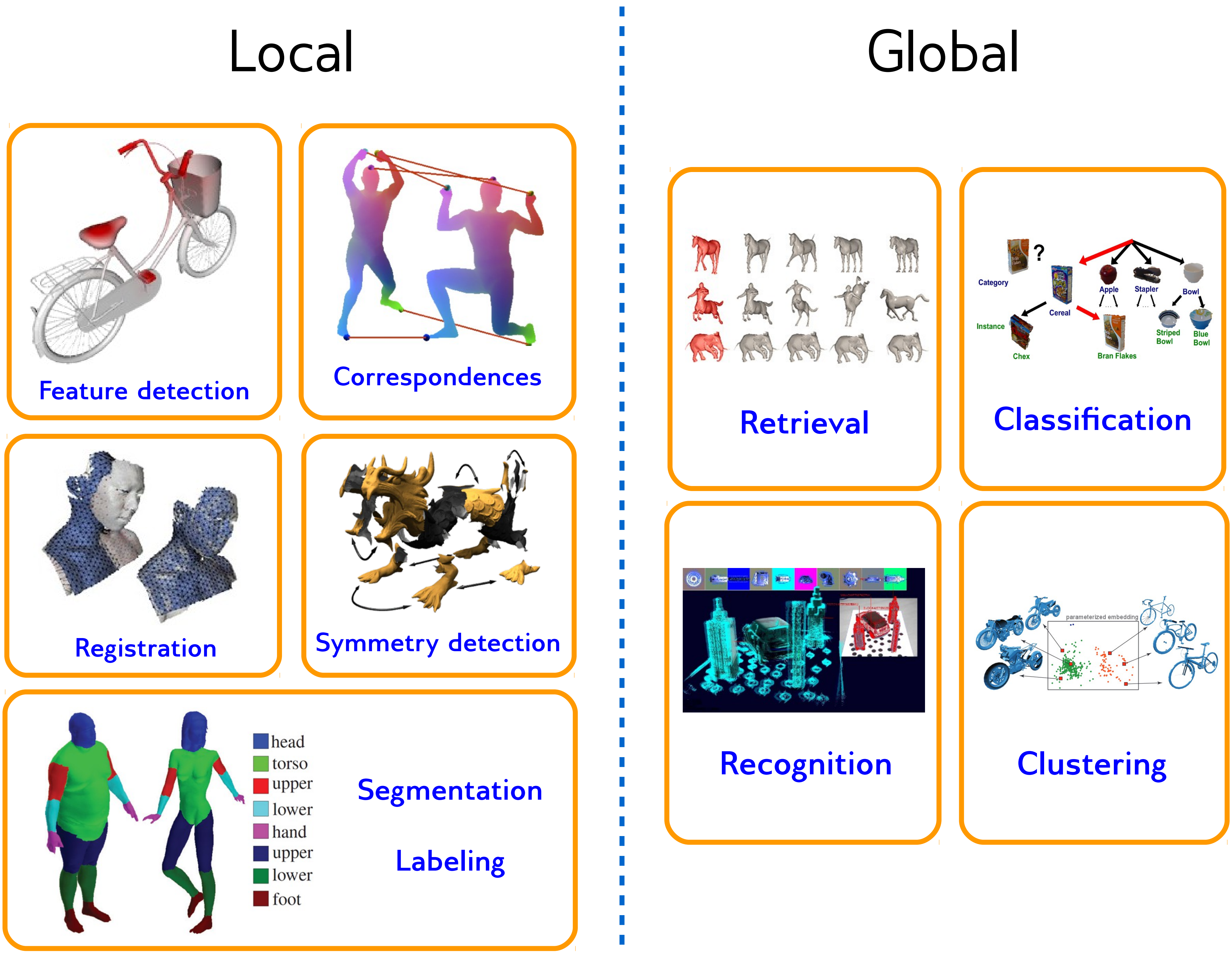
- **Global descriptor**
  - Captures the structure of the entire shape
  - Can tell different shapes apart
  - Useful for retrieval, object recognition etc



- **Local Descriptor**
  - Captures the shape around a point
  - Can tell different points apart
  - Useful for segmentation, point correspondences etc
- Each motivates the other: can modify any global descriptor to produce a local descriptor, and vice versa



Princeton; Feng, Liu, Gong

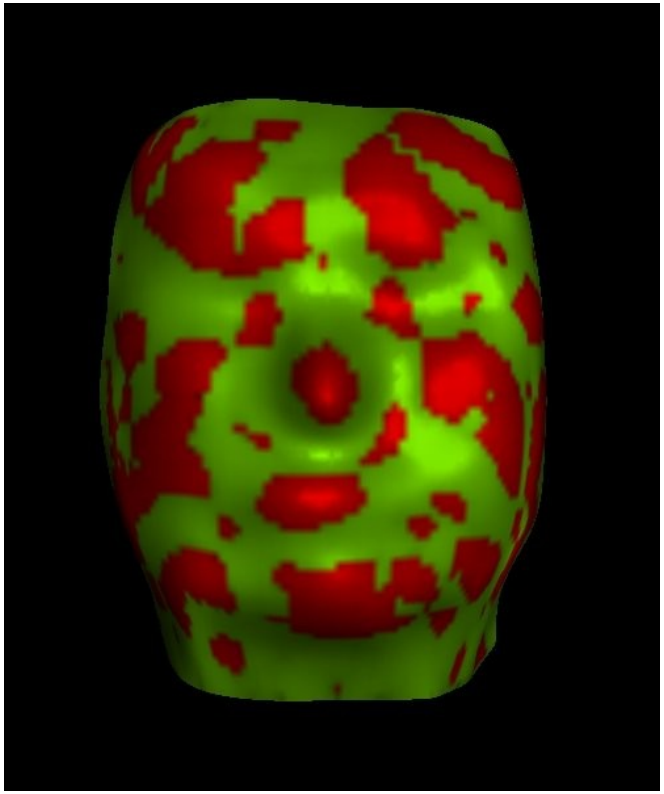

Local
Global
Feature detection
Correspondences
Registration
Symmetry detection
head
torso
upper
lower
hand
upper
lower
foot
Segmentation
Labeling
Retrieval
Category
Cereal
Apple
Stapler
Bowl
Instance
Chex
Bran Flakes
Striped Bowl
Blue Bowl
Classification
Recognition
parameterized embedding
Clustering

Local Descriptors

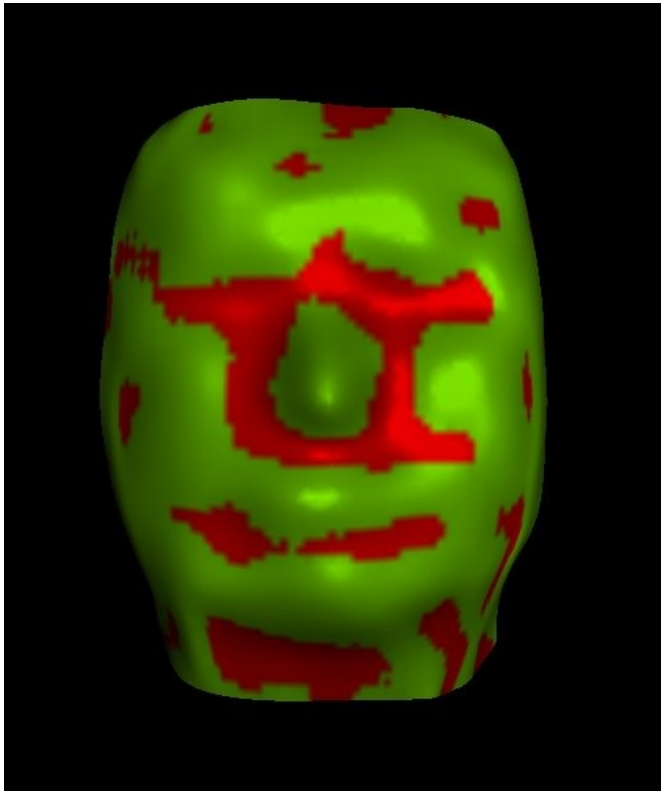
- Describes the shape in a neighborhood around a point
  - Neighborhood may be surface-based or volume-based
- We will look at the following descriptors today
  - Mean curvature
  - Shape diameter
  - Principal components
  - Average distance
  - Distance histogram

Curvature

The **Gaussian curvature** is the product of the principal curvatures

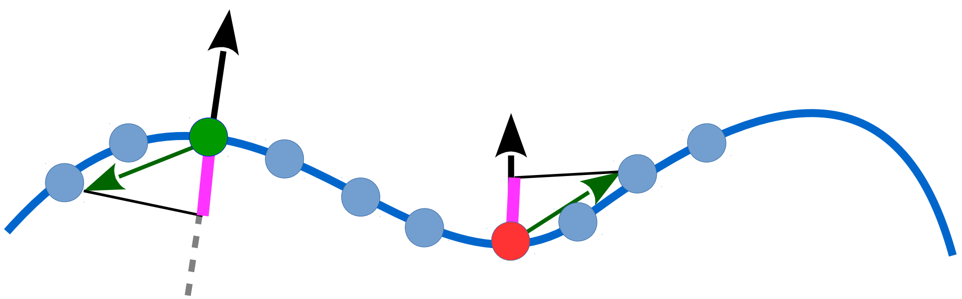


The **mean curvature** is the average of the principal curvatures

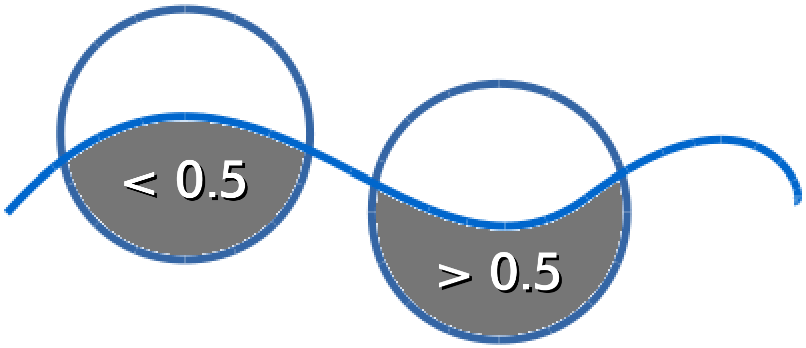


Mean curvature

- How can we (approximately) compute the mean curvature at a point?
- Two possible approximations:
  - Average projection of neighboring points onto normal vector

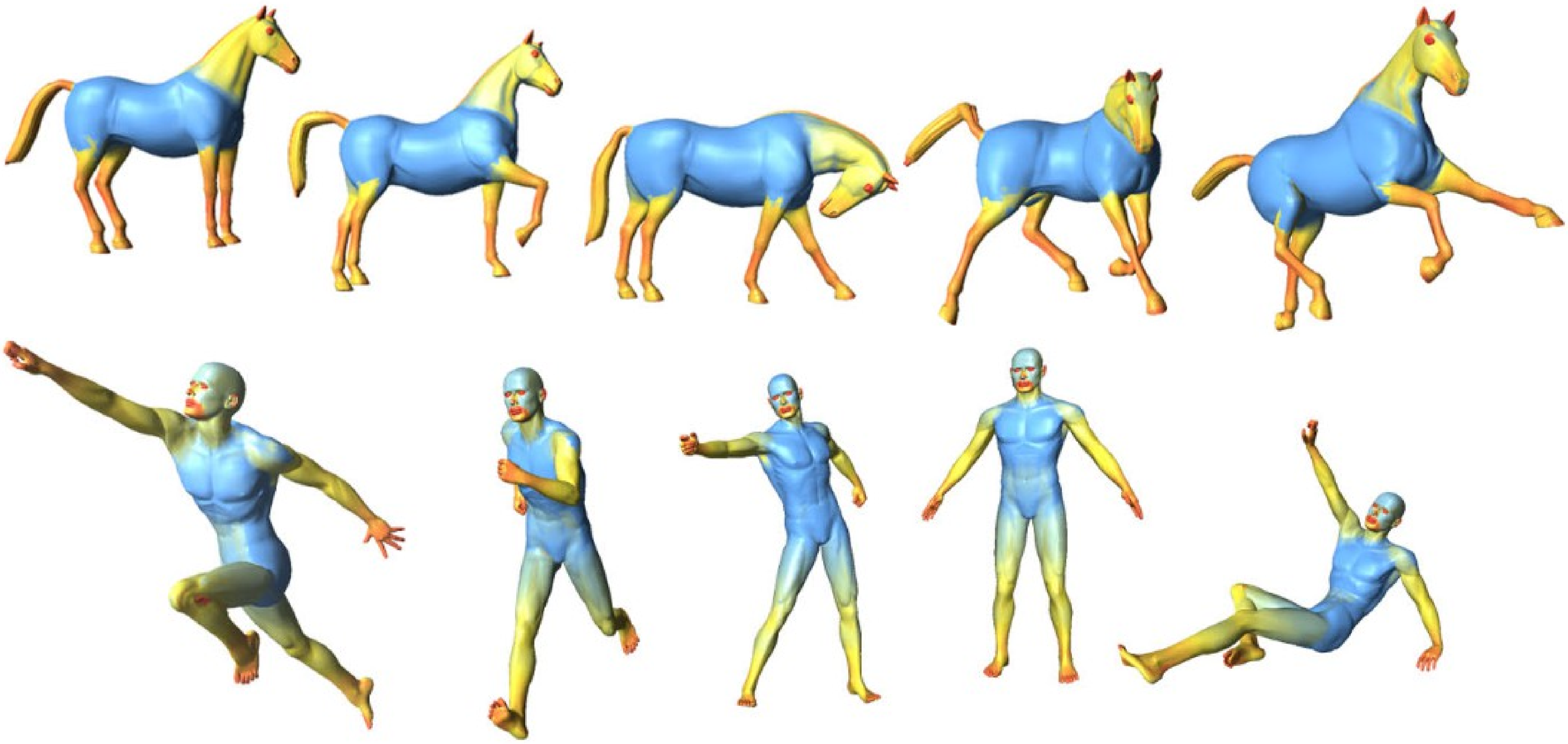


  - Fraction of unit ball covered by neighboring volume



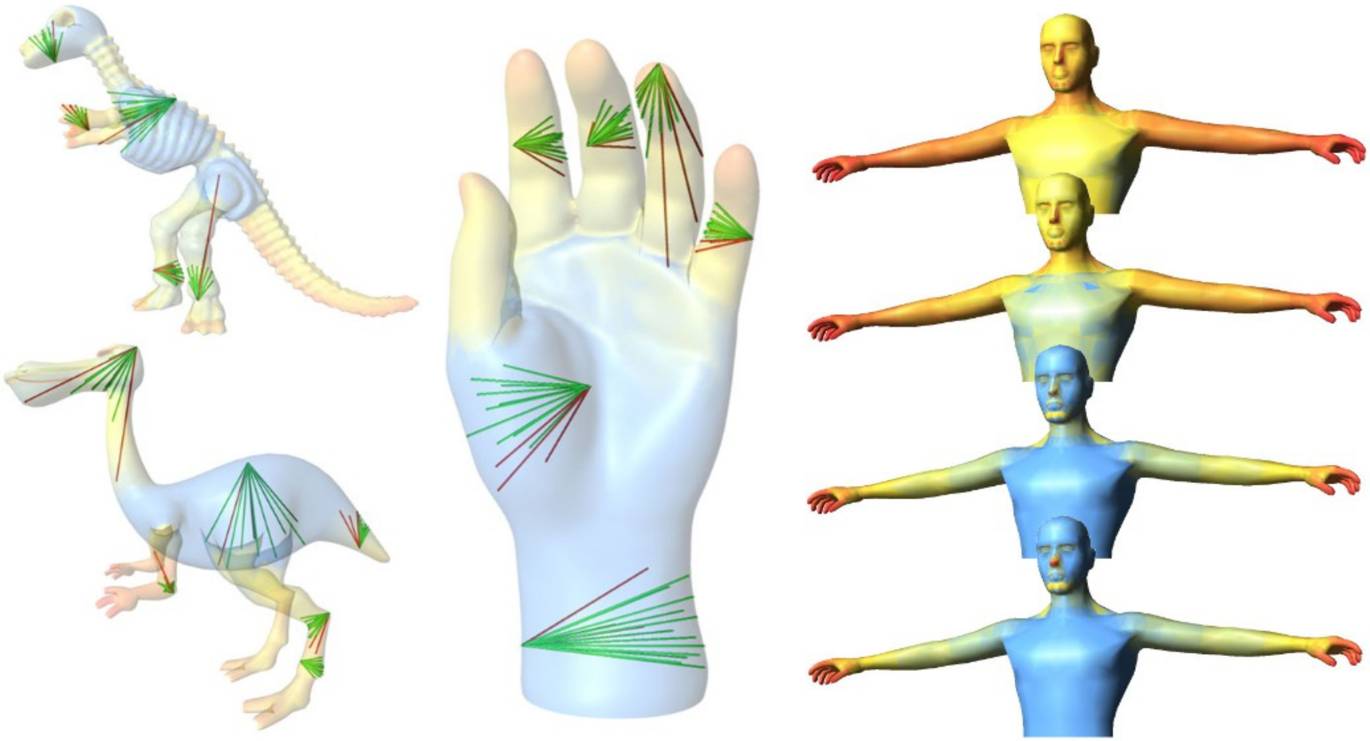
Shape Diameter

- The **shape diameter function (SDF)** of a shape gives its “local thickness” at each point



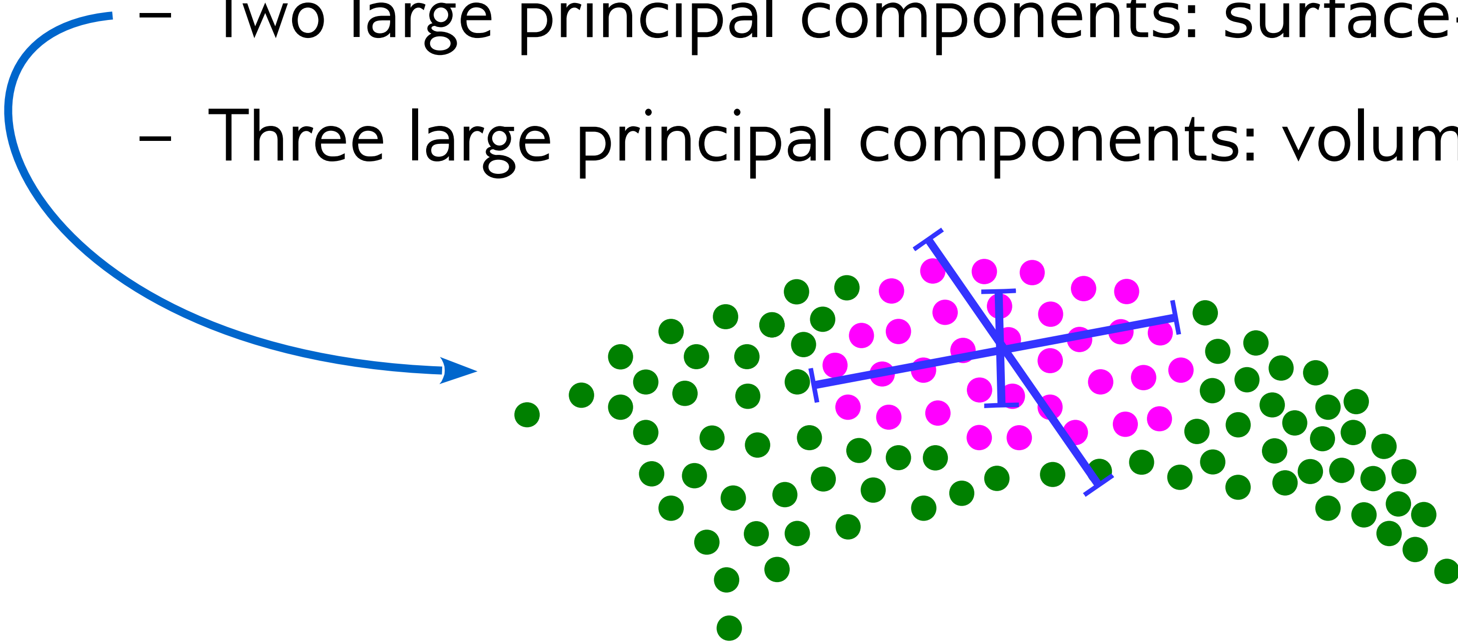
Shape Diameter

- Shoot rays randomly sampled from cone surrounding inward normal
- SDF is average distance (weighted by inverse angle) to next intersection with the shape, after removing outliers



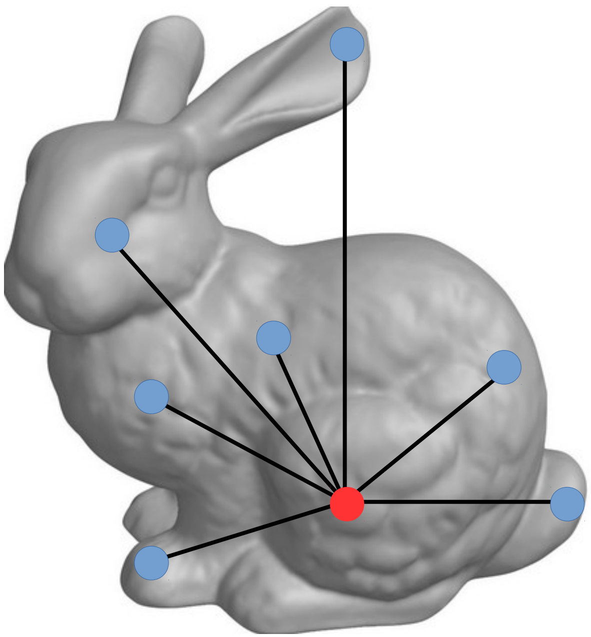
Principal Components

- The **principal components** (eigenvalues of the covariance matrix) of points in the neighborhood capture the directional variation of the shape
  - One large principal component: line-like
  - Two large principal components: surface-like
  - Three large principal components: volume-like



Distance-Based Descriptors

- **Average (geodesic or euclidean) distance** to all other points on shape



(Composite plot)

- A more discriminative measure: plot a **histogram** of the distribution of distances