Digital Geometry

JJCAO

Pleasure may come from illusion, but happiness can come only of reality.

Content

- Applications
- Prerequisites
- Traditional Computer Graphics
- Advance Computer Graphics
- Modern Computer Graphics

Prerequisites

- Familiarity with basic calculus, linear algebra, & vector calculus
- Familiarity with a graphics API (e.g. OpenGL)
  - If not, learn quickly (for the sake of visualization)
- C++/Matlab coding skills
  - If Java is preferred, you will be on your own
- Capability to search Google and forums for useful information

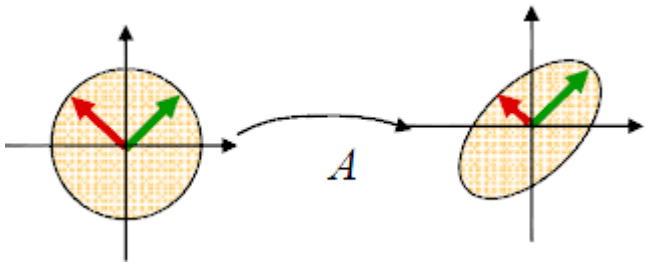
Coding

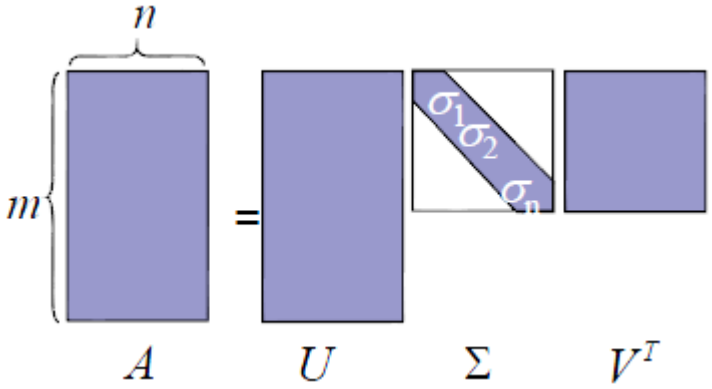
Coding is very import in this area!

If you can not program, you will study nothing in this subject!

Math

- Differential Geometry
- Liner algebra: transformations, spectral decomposition, PCA, SVD
- Graph theory
- …





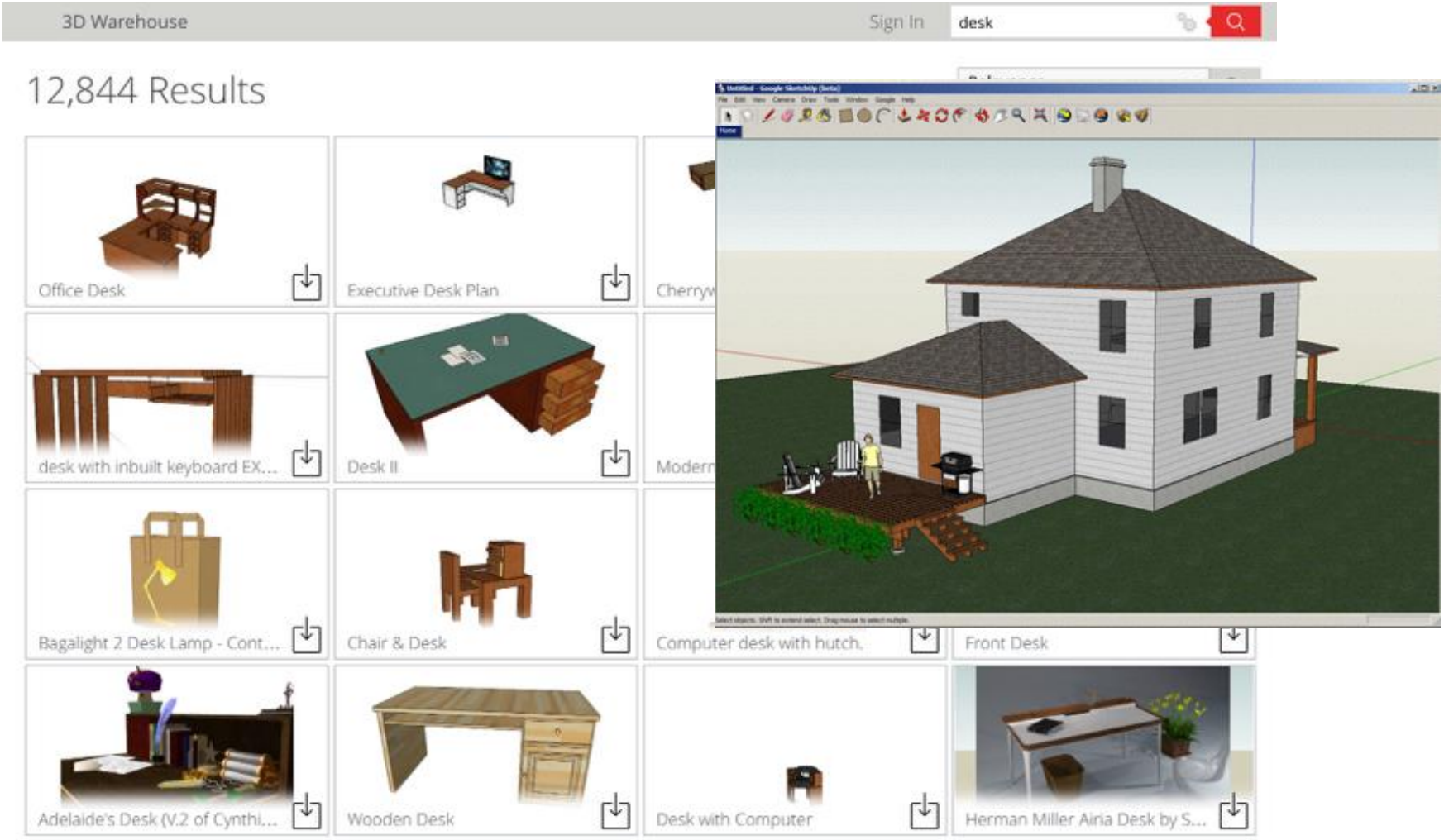
- Combined with a lot of intuition …
- Work on real data = Write/use a lot of code!

How to pass

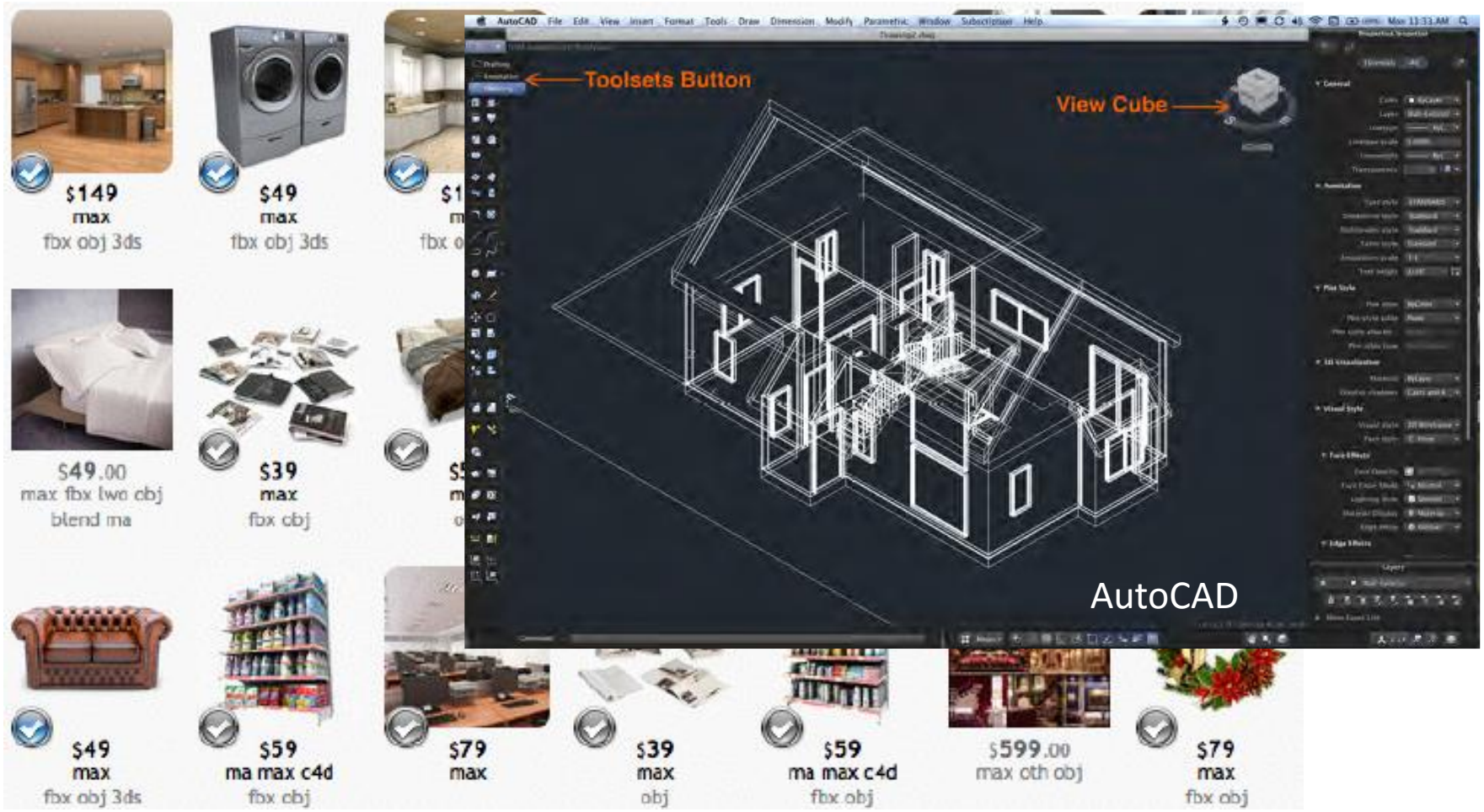
- 2 assignments
  - Shape descriptors & retrieval
  - // Shape matching / correspondence
  - Mesh filter
- 2 presentations
  - Mesh filter
  - ?

Motivation

Large and growing repositories of 3D Models



Large and growing repositories of 3D Models

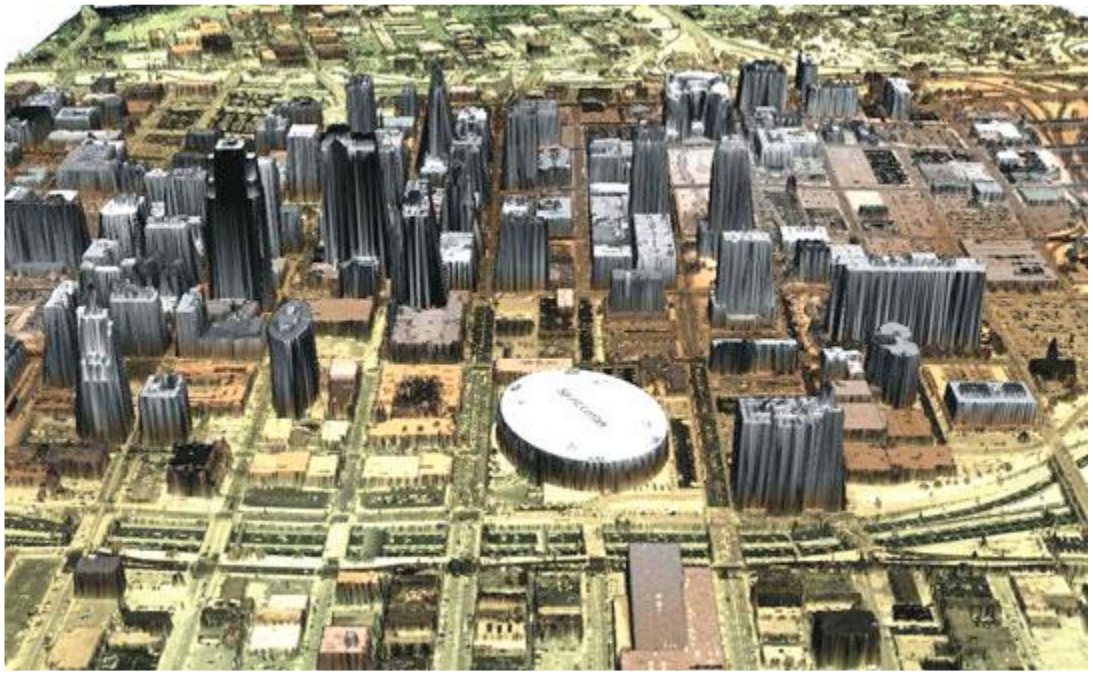


TurboSquid

Digimation

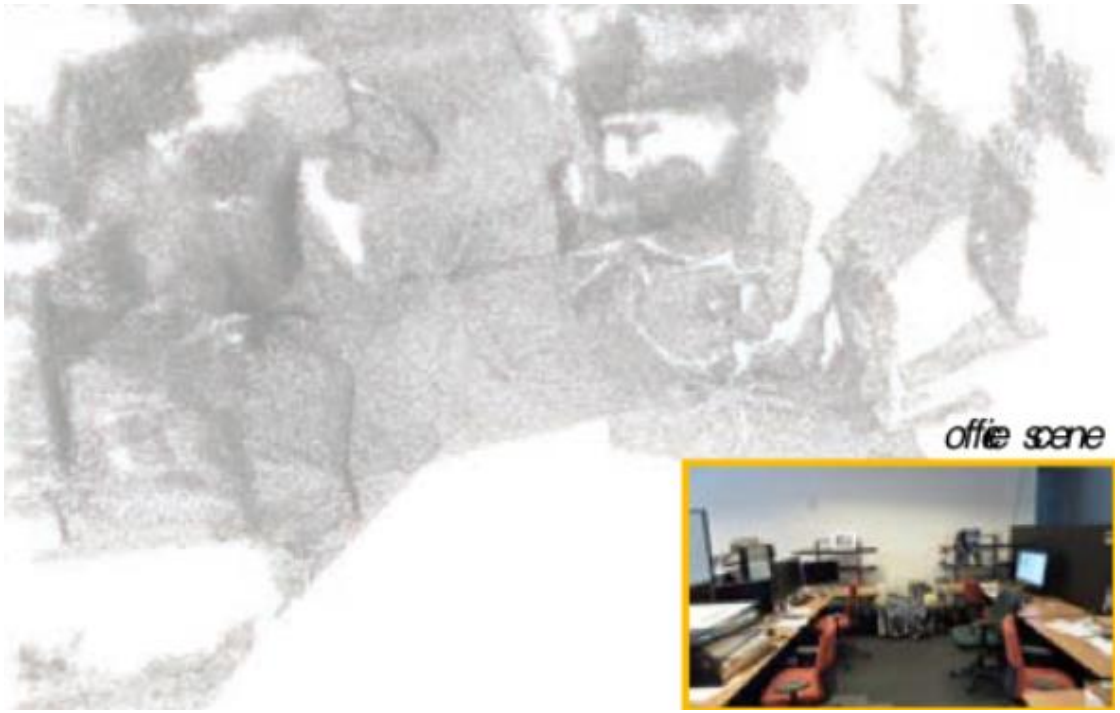

ZBrush

Large and growing repositories of 3D Models



Streetview Scans

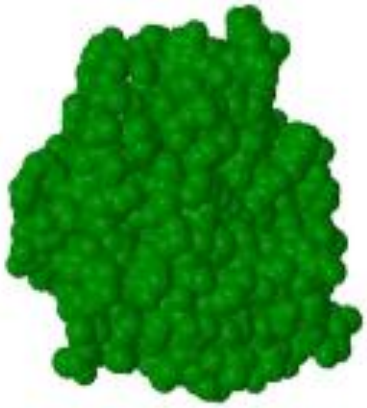
Large and growing repositories of 3D Models



RGB-D data

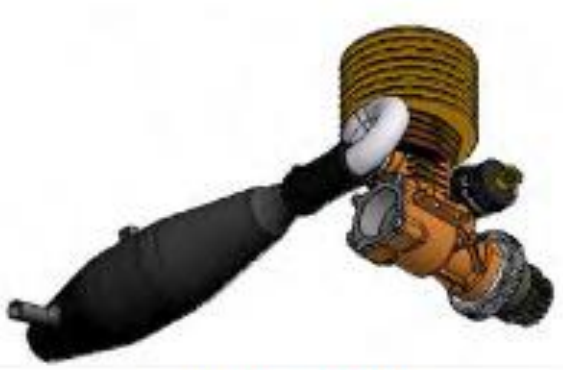
Motivation

- **Lots** of geometric data in different domains!



Molecular Biology

Medicine



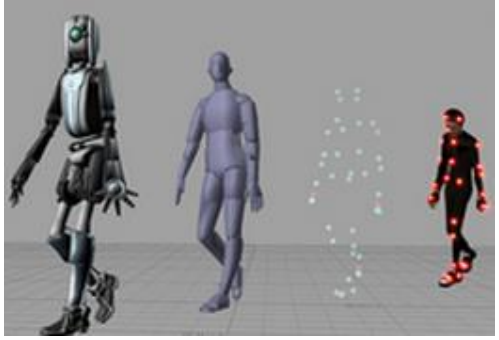
Engineering

Cultural Heritage

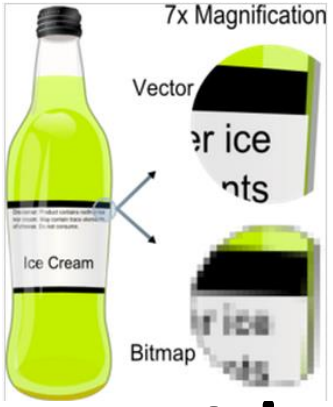
Paleontology

Computer Graphics

What is CG?



- The study of computer graphics is a sub-field of computer science which studies methods for digitally synthesizing and manipulating visual content.
  - 3D
  - Image processing

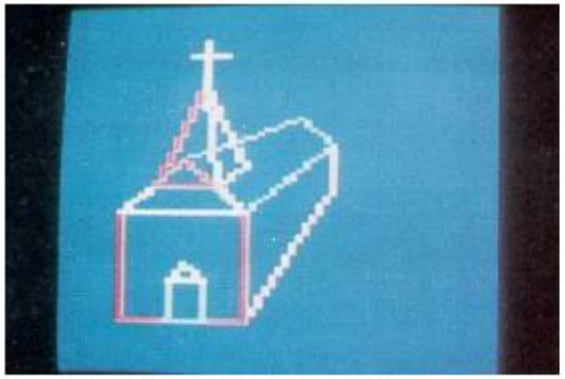


- CG studies the manipulation of **visual** & **geometric** information using *mathematical* & *computational* techniques.
- CG vs. Visualization

Computer Graphics

The big picture

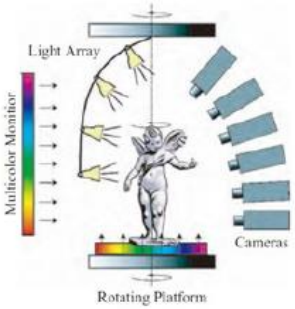
- 3D graphics programming in 1979



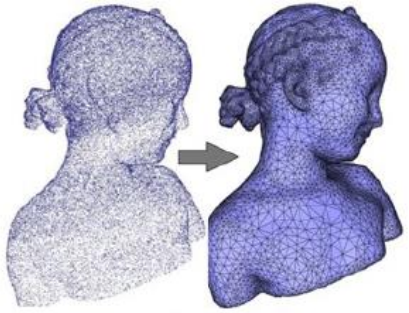
approx. 25 triangles

approx. 50 x 100 pixels

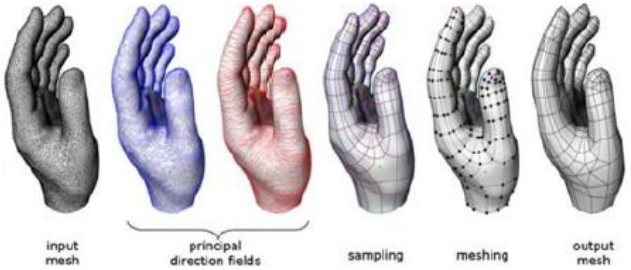
Advance Computer Graphics



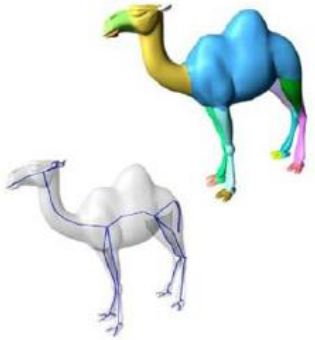
(a)获取



(b)曲面重建

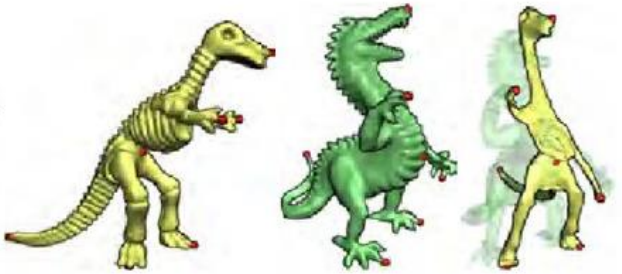


(c)重新网格化

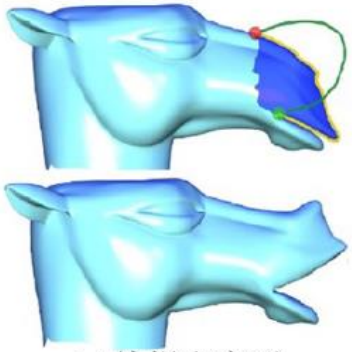


(d)分割和骨骼提取

(e)参数化

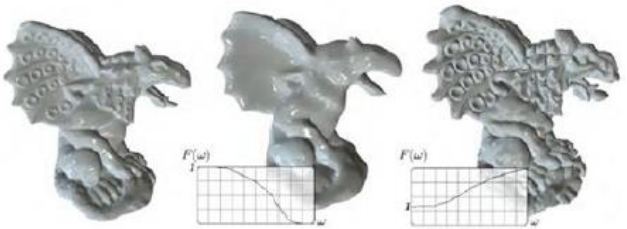


(f)匹配和检索

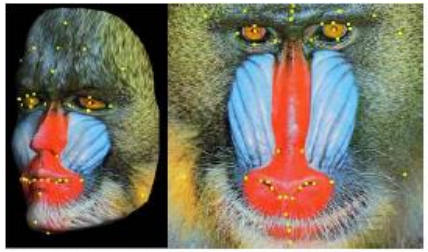


(g)编辑和变形

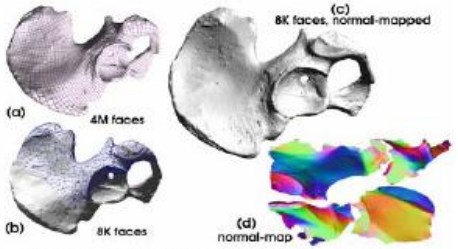
(h)简化和压缩



(i) 滤波（光滑和增强）



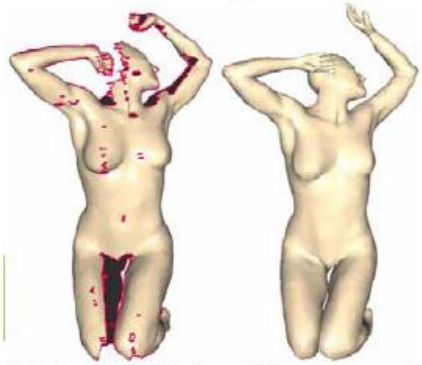
Texture Mapping [Lévy 2001]



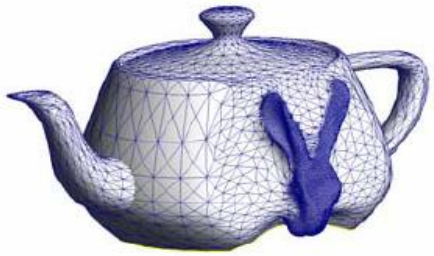
Normal Mapping [Sheffer et al., 2005]

Detail Transfer [Biermann et al. 2002]

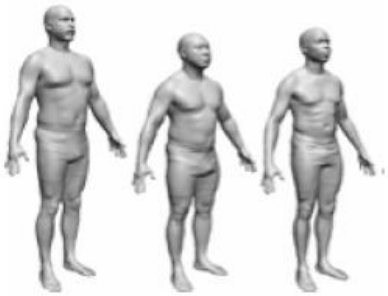
Morphing [Lee et al. 1999]



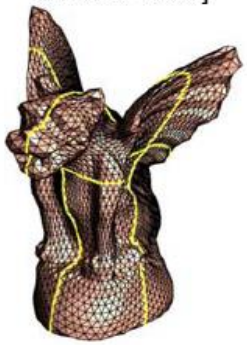
Mesh Completion [Kraevoy and Sheffer 2005]



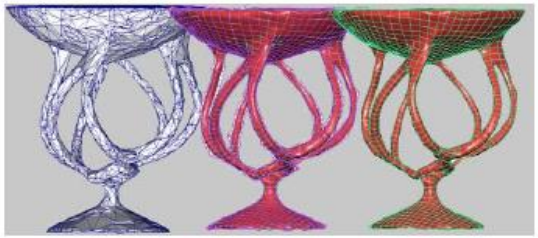
Editing [Lévy 2003]



Databases [Allen et al. 2003]



Remeshing [Praun and Hoppe 2003]



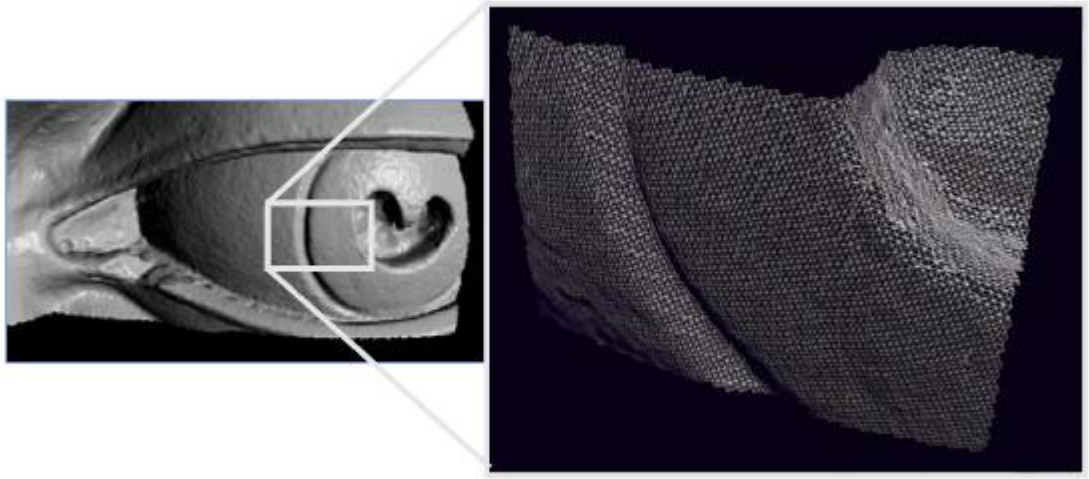
Surface Fitting [Li et al. 2006]

Advance Computer Graphics

- Shape acquisition
- Point Set Processing
- Reconstruction
- Digital geometry processing
- Shape modeling and deformation
- Shape analysis
- GUI

Shape Acquisition

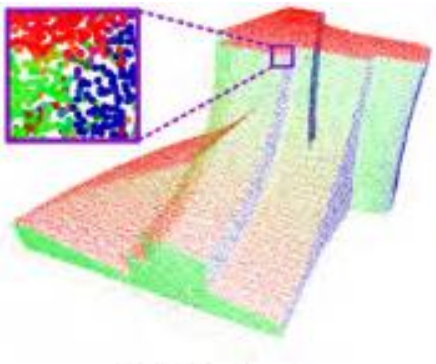
- David:
  - 480 individually aimed scans
  - 2 billion polygons
  - 7,000 color images
  - 32 gigabytes
  - 30 nights of scan
  - 22 people



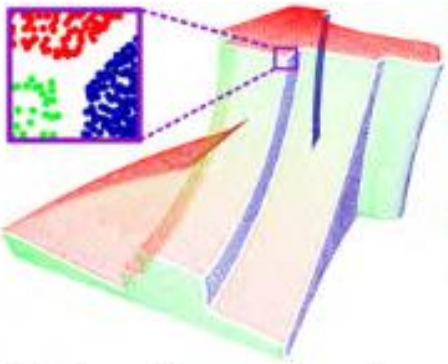
siga15_Autoscanning for Coupled Scene Reconstruction and Proactive Object Analysis

Point set consolidation

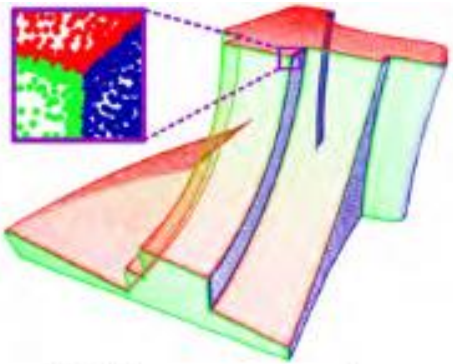
tog13_Edge-Aware Point Set Resampling
with a c++ code framework for visualizing and processing



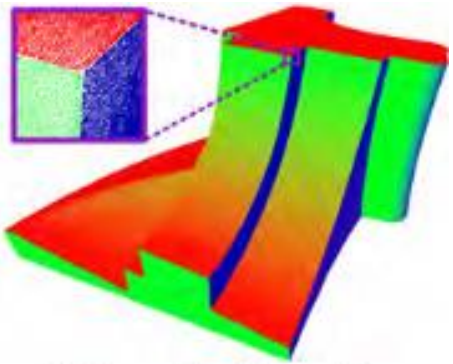
(a) Noisy input.



(b) Resampling away from edges.

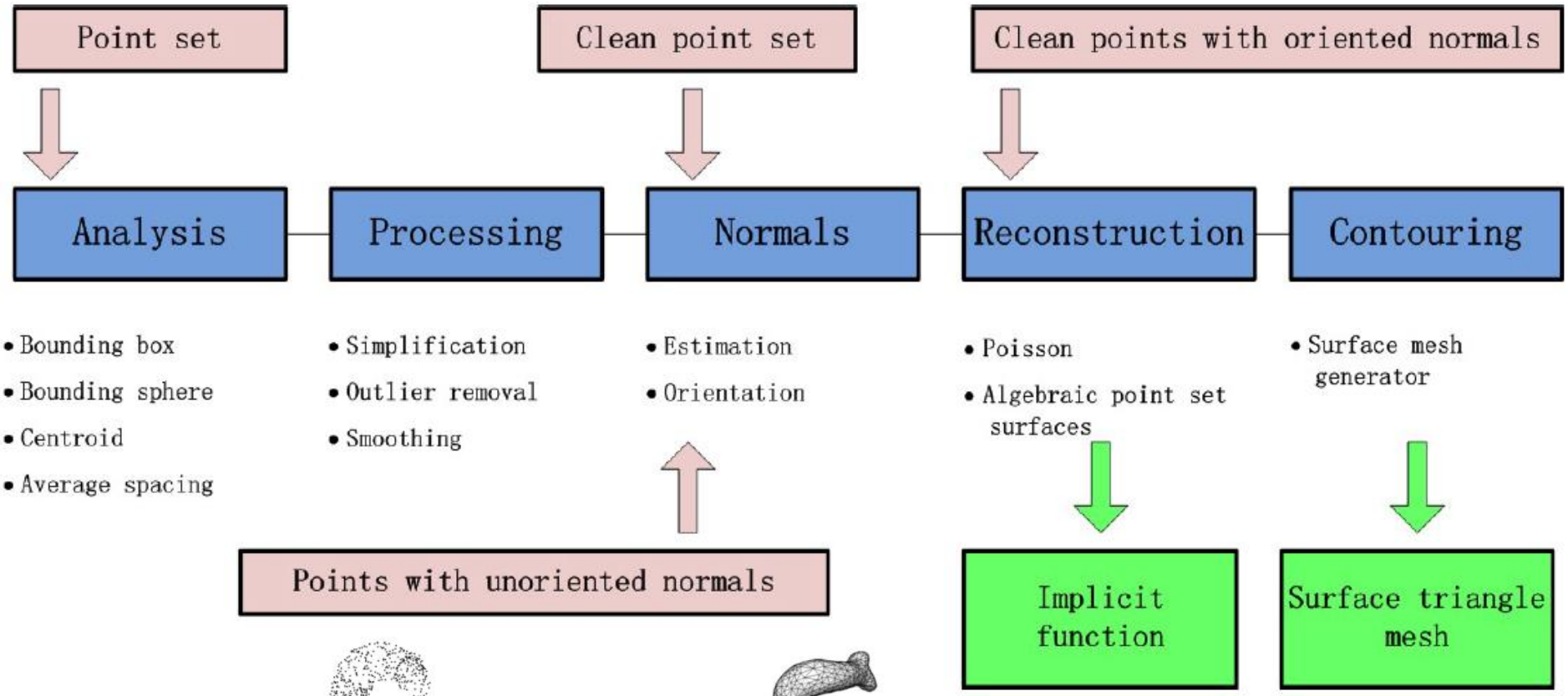


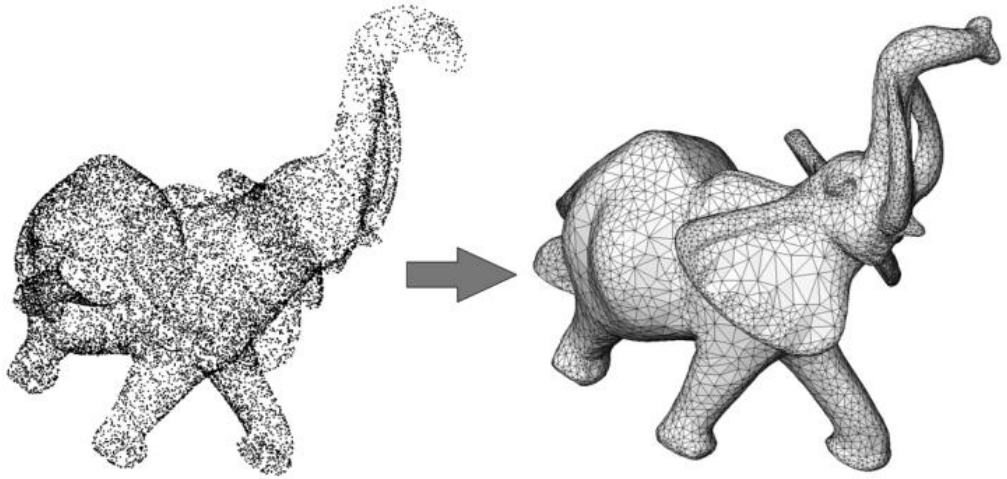
(c) Edge-aware upsampling.



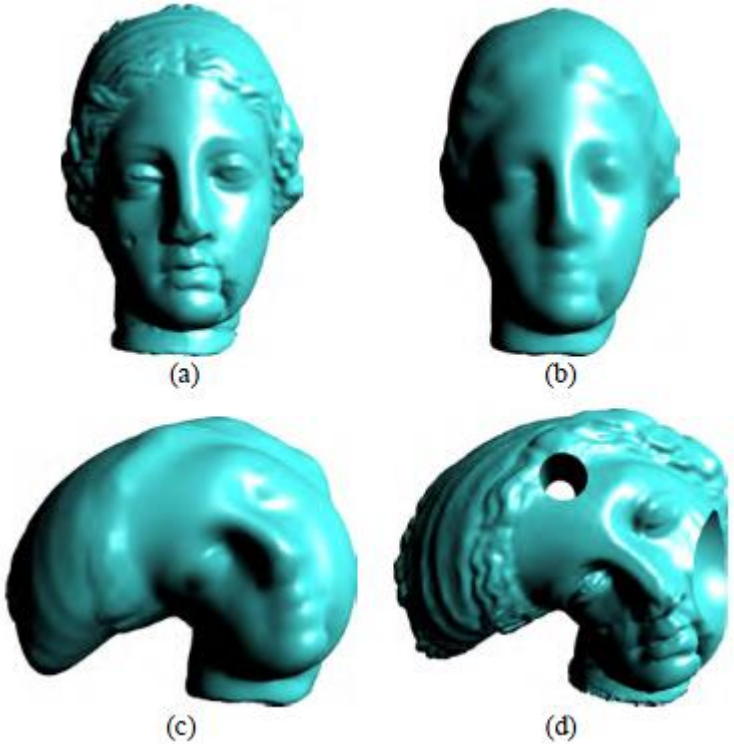
(d) Upsampling for rendering.

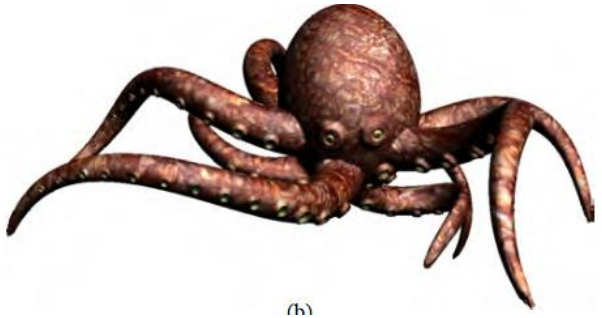
Mesh Reconstruction





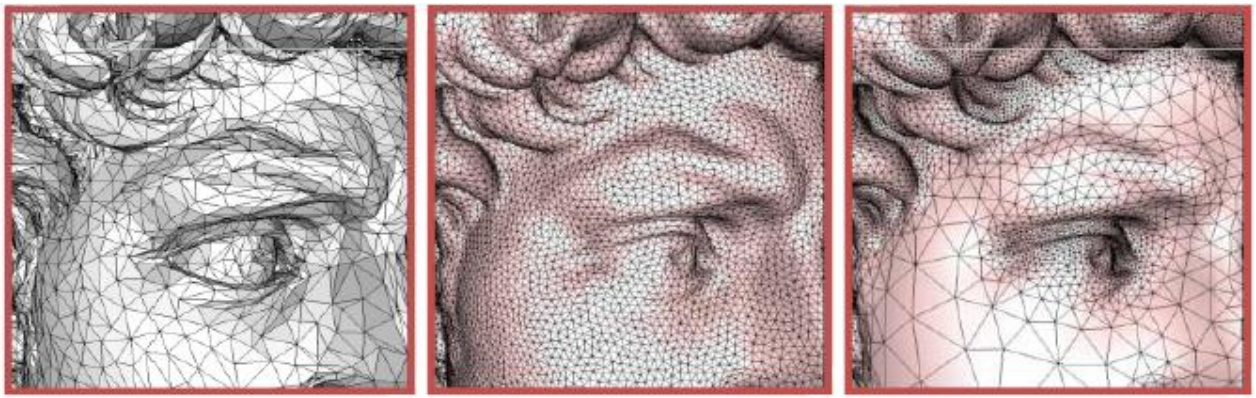
tog03_Shape Modeling with Point-Sampled Geometry



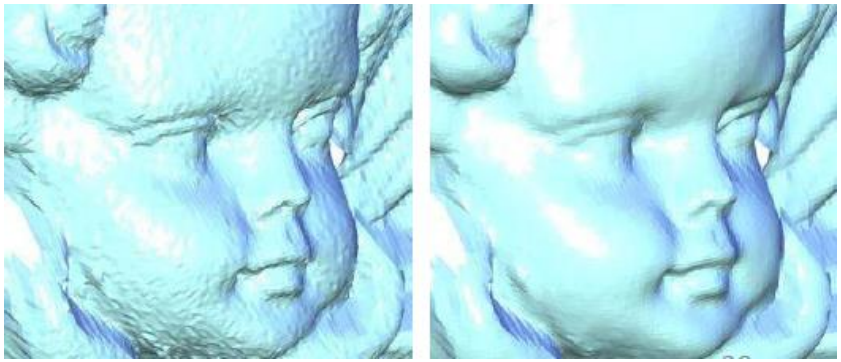


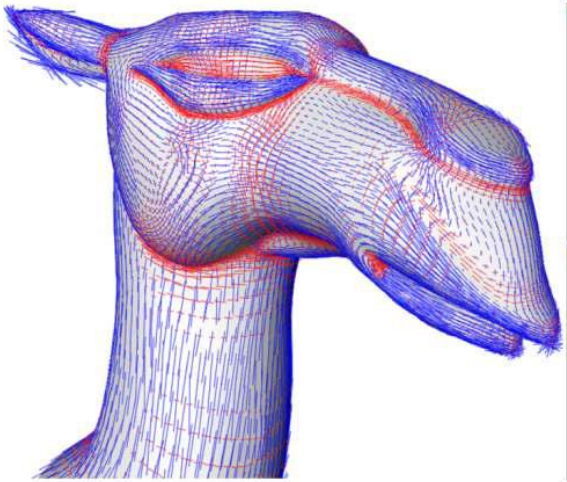
Digital geometry processing

- Denoising, smoothing, simplification/remeshing, parameterization, compression

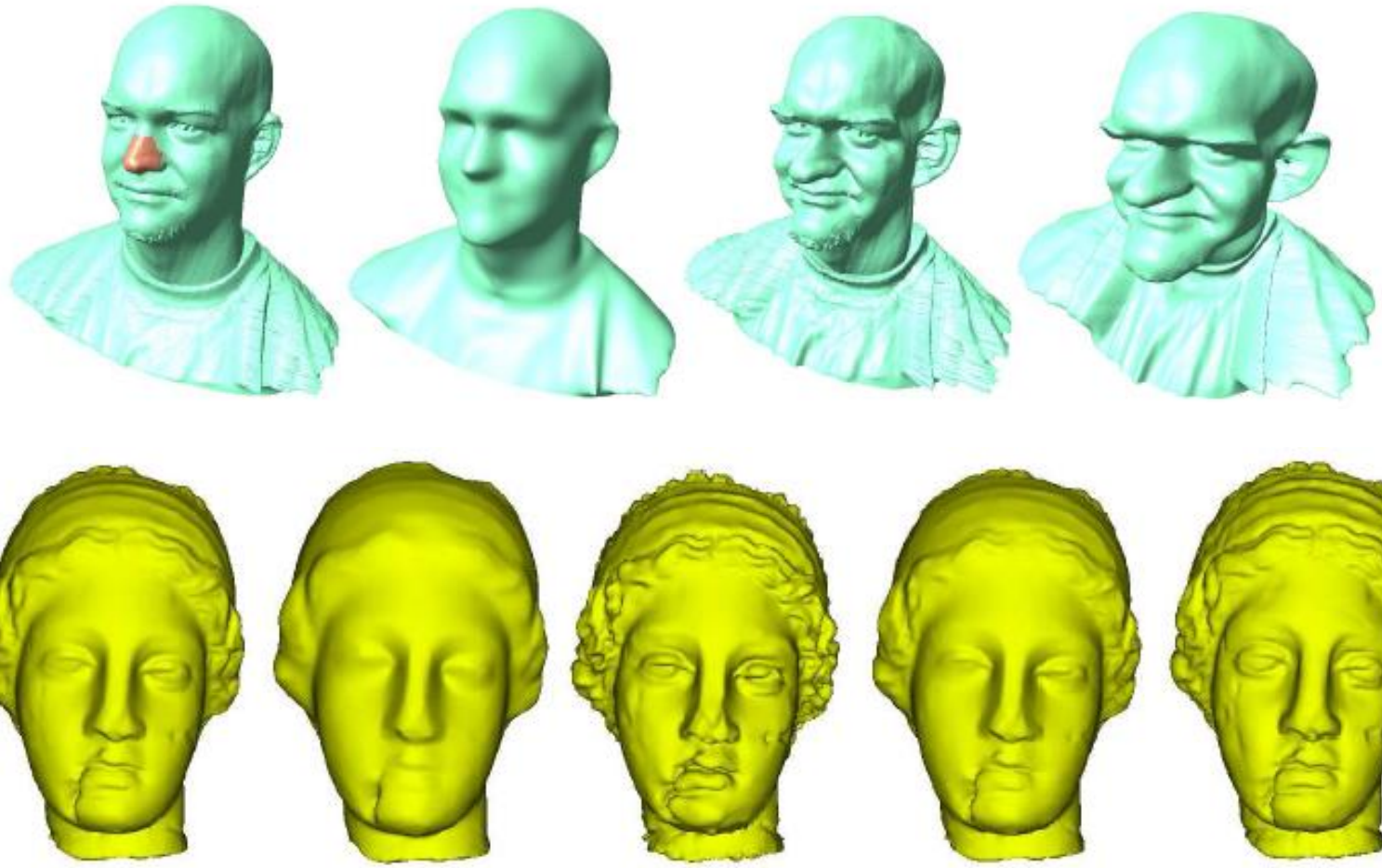


Deep exploration 6.3 => SAP Visual Enterprise Author 7.1





Mesh processing- Filtering

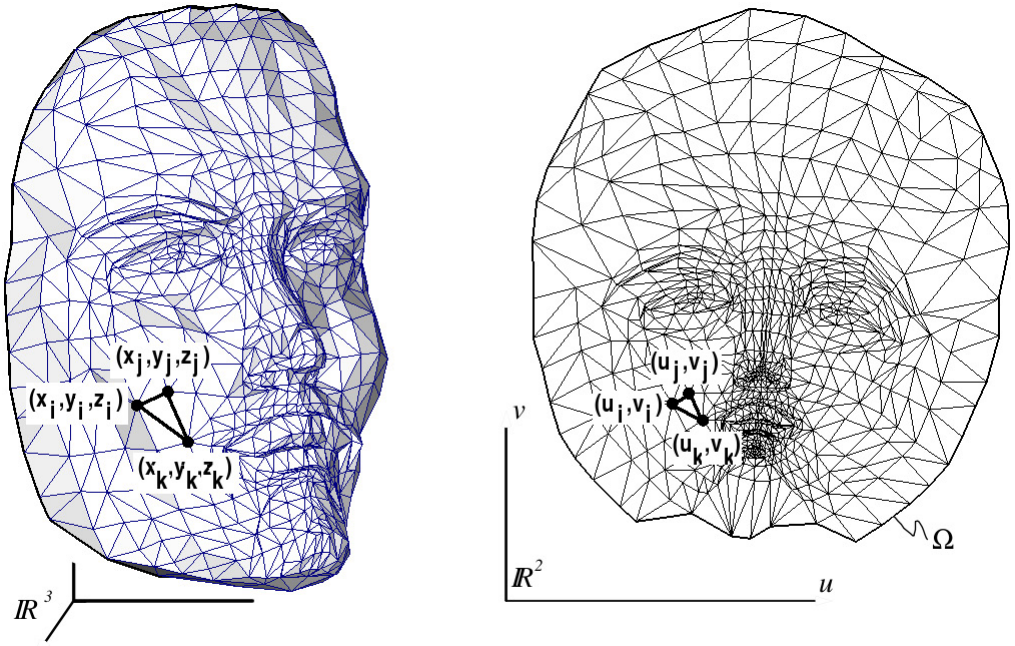


Several of filtering results.

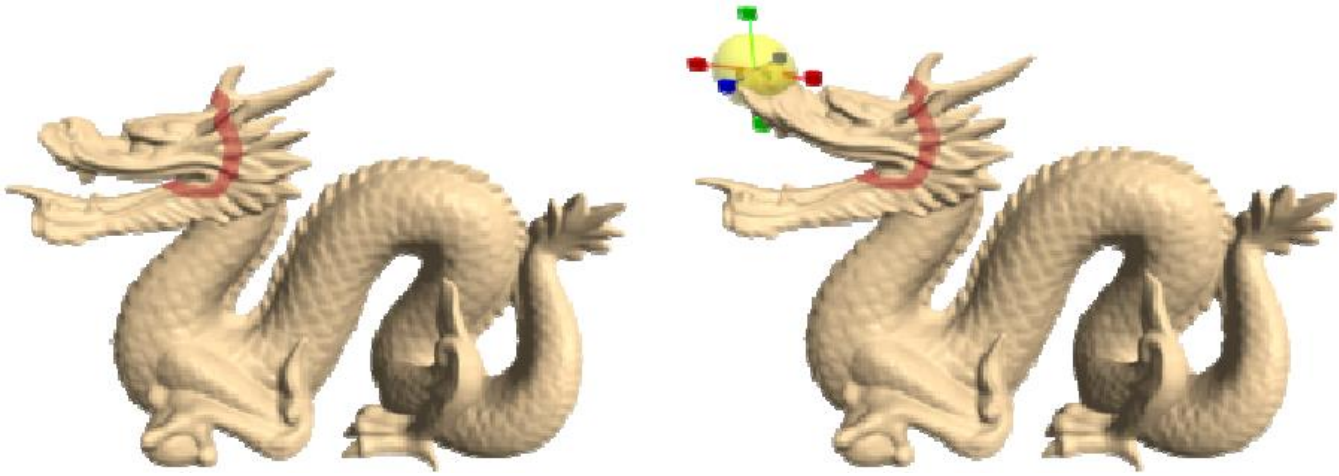
Mesh parameterization

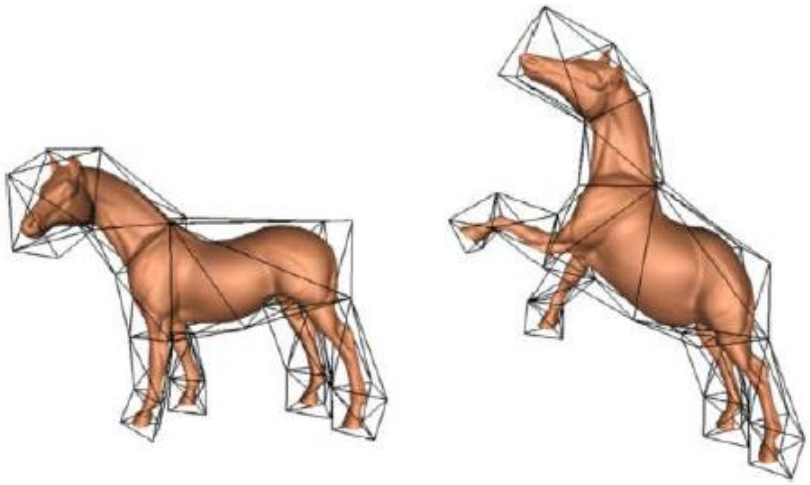
The goal: find the 2D parametric field of the triangle mesh.

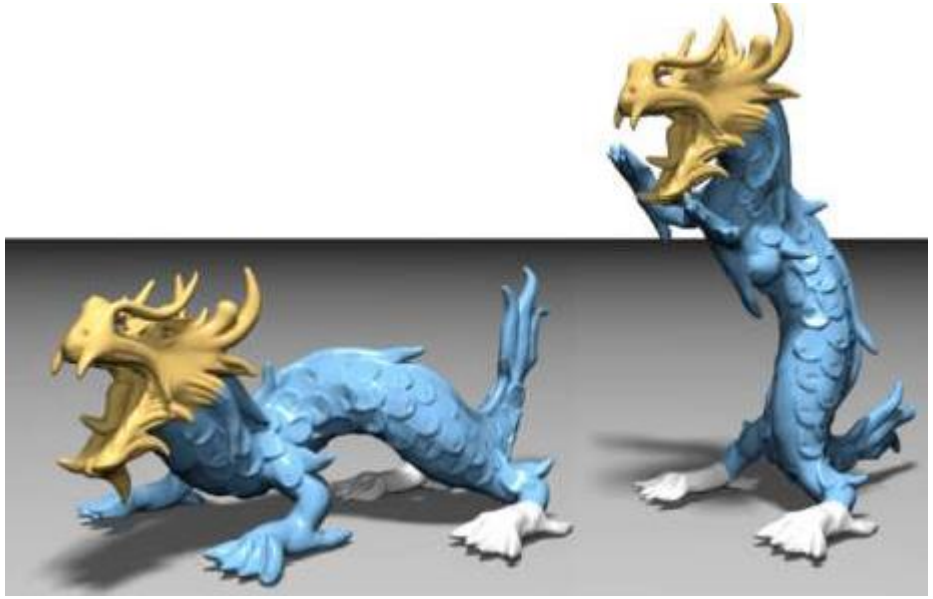
A parameterization of a triangle mesh can be seen as a piecewise linear function, determined by the coordinates (u_i, v_i) at each vertex (x_i, y_i, z_i) .



Shape modeling and deformation

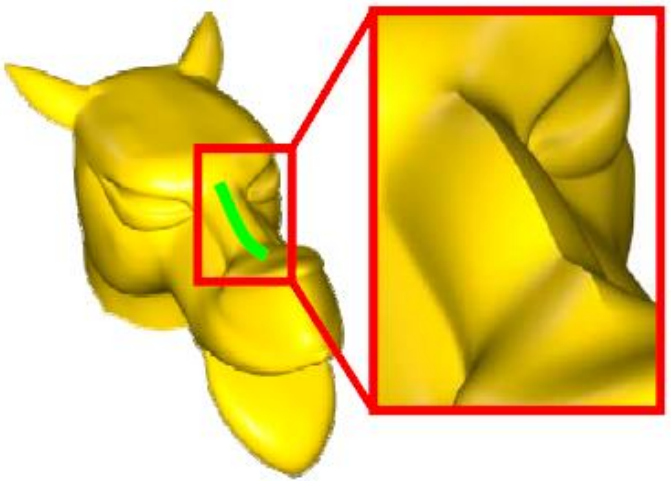


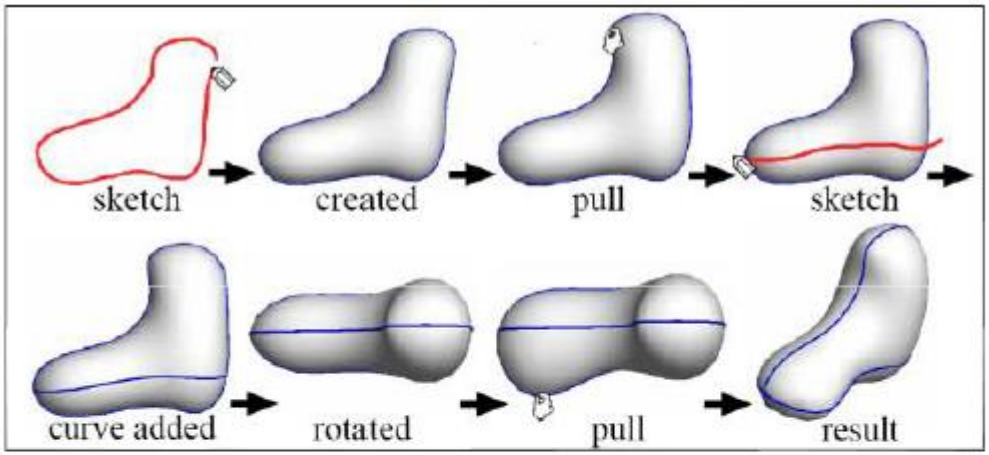


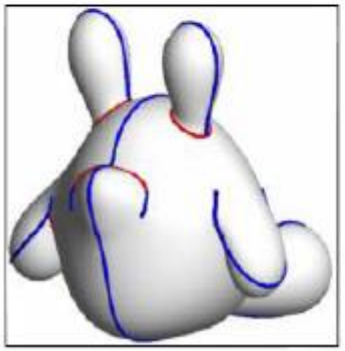


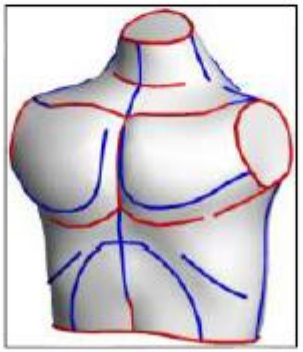
Sketch-based interfaces

- Shape creation, editing & retrieval



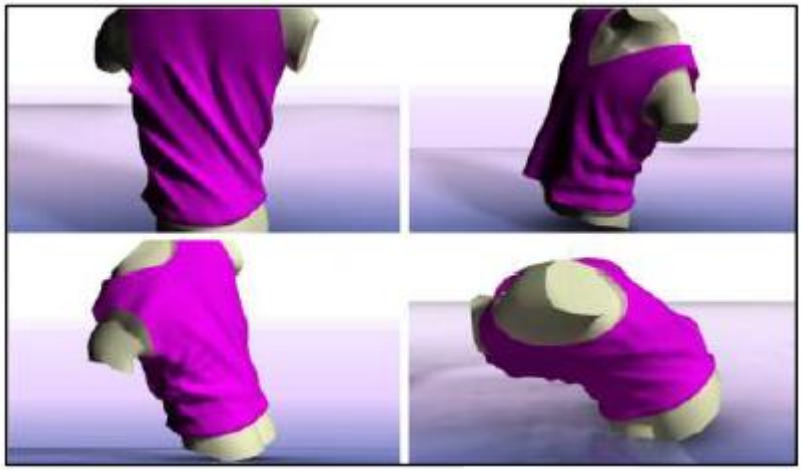


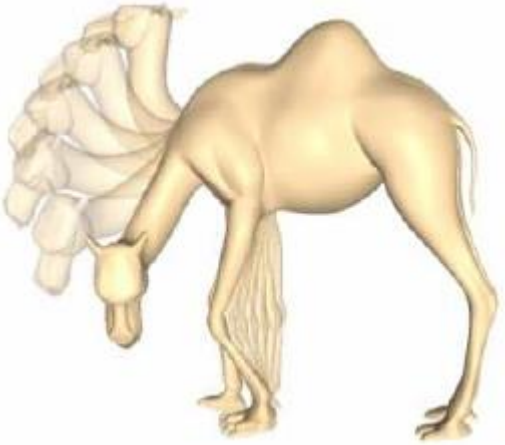




More applications of geometric deformation

- Skeleton-skin animation; morphing
- Image/video retargeting

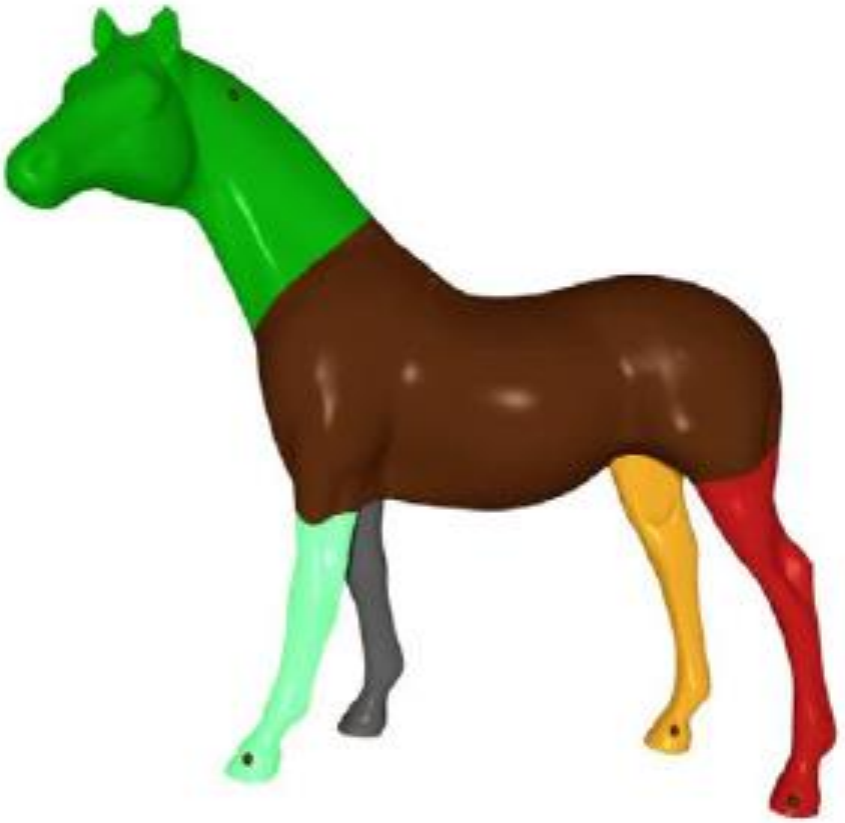




2.4 Shape analysis

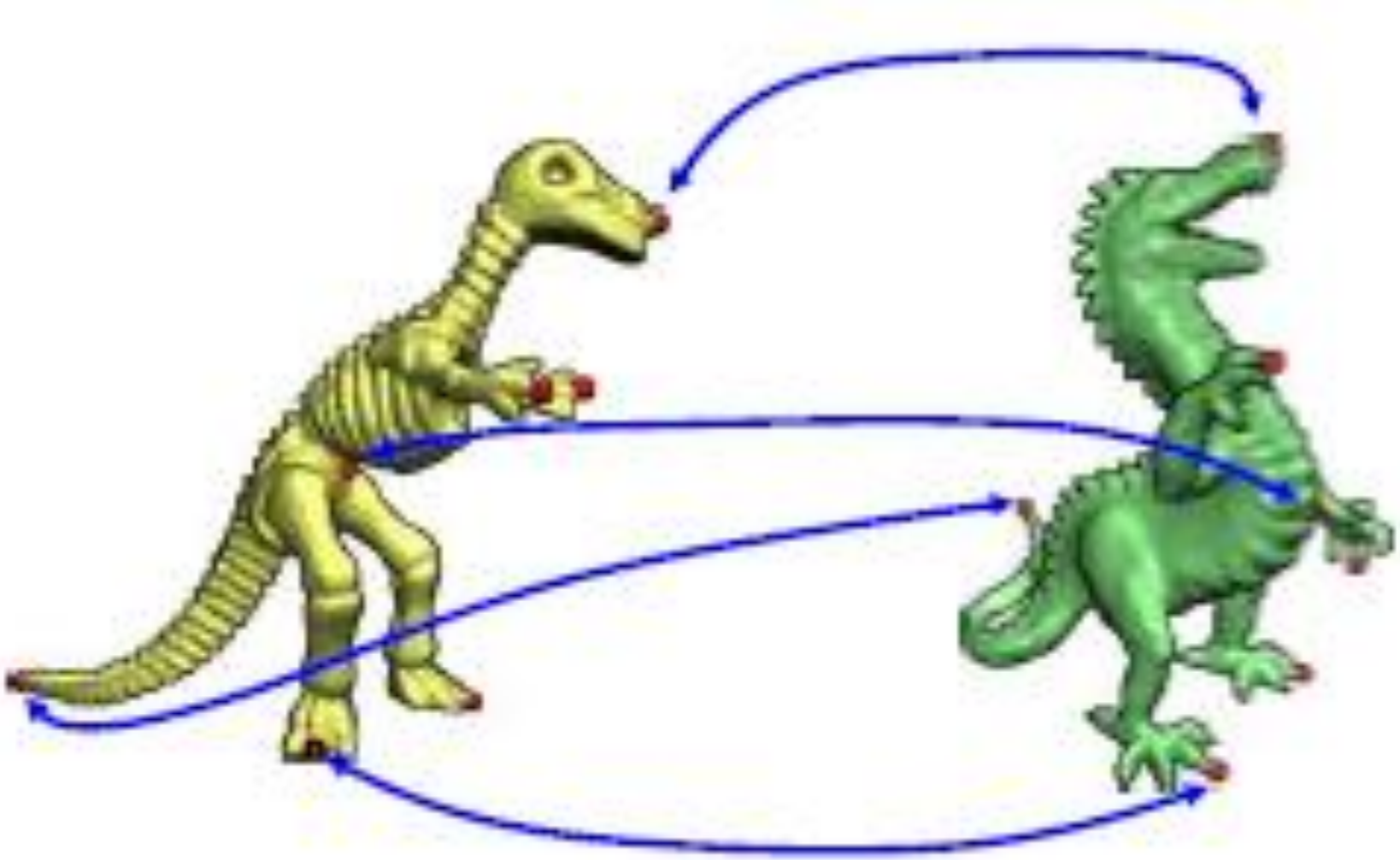
Current research focus!

2.4 Shape analysis-Segmentation

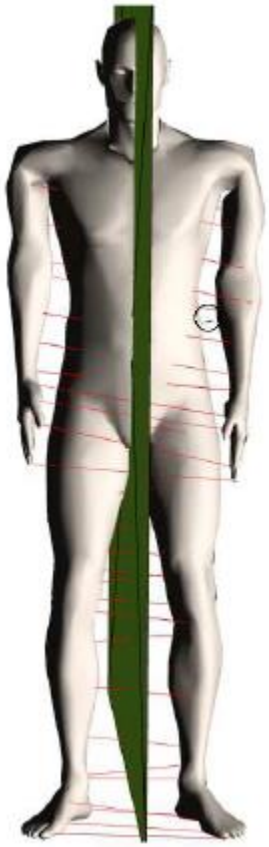


Part based vs patch based

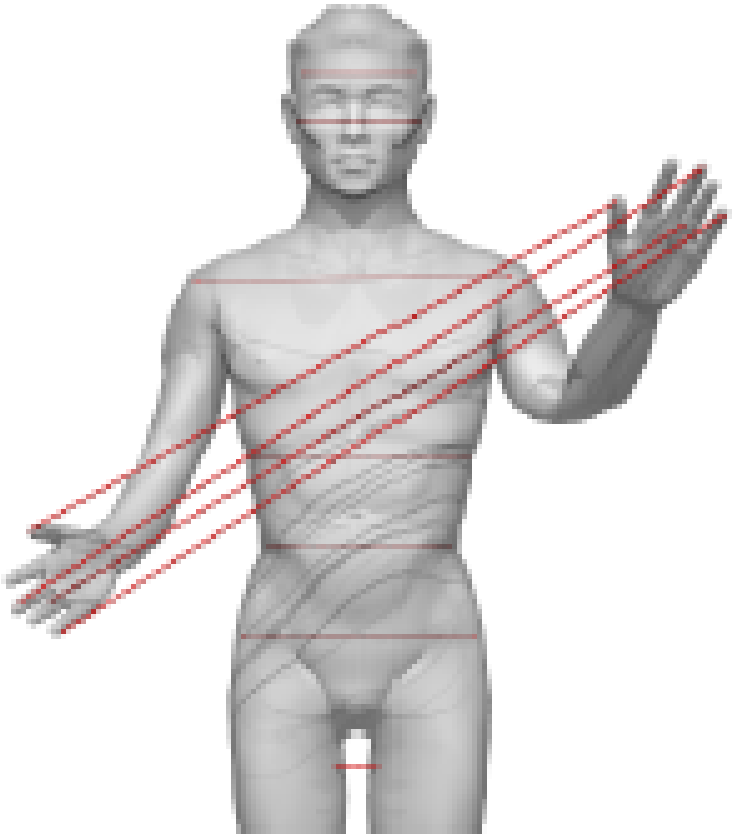
2.4 Shape analysis-Correspondences



2.4 Shape analysis-Symmetry detection



Planar-reflective system



Intrinsic system

2.4 Shape analysis-Retrieval

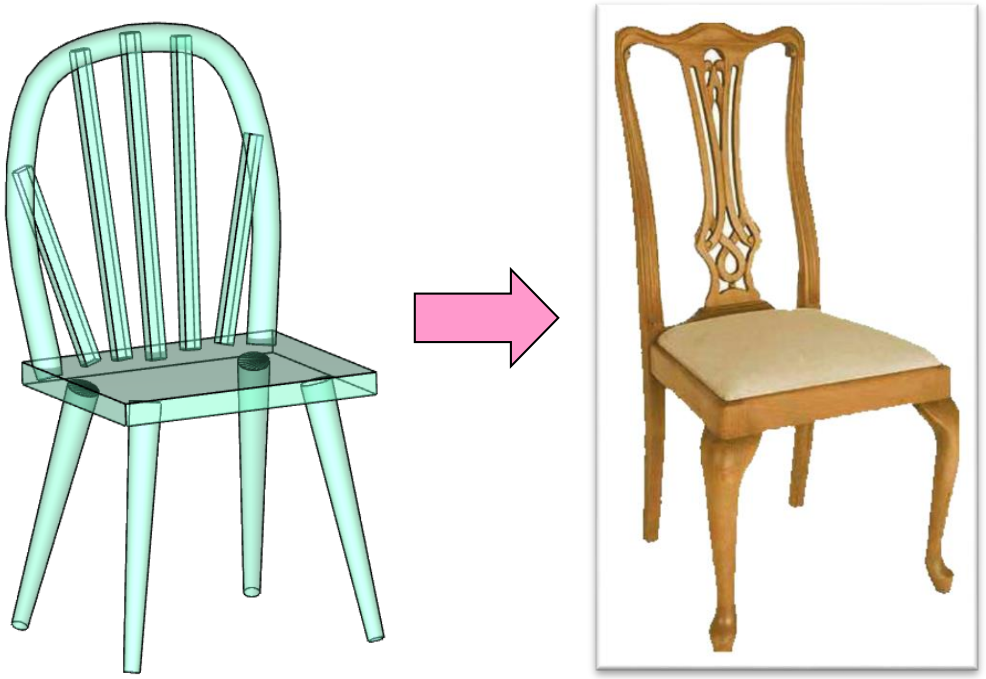
What is graphics?

- Creation, display, storage, and animation of visual content

First step, perhaps least well known: content creation

3D Content Creation

Modeling via part re-assembly
[Funkhouser et al., SIG 2004]

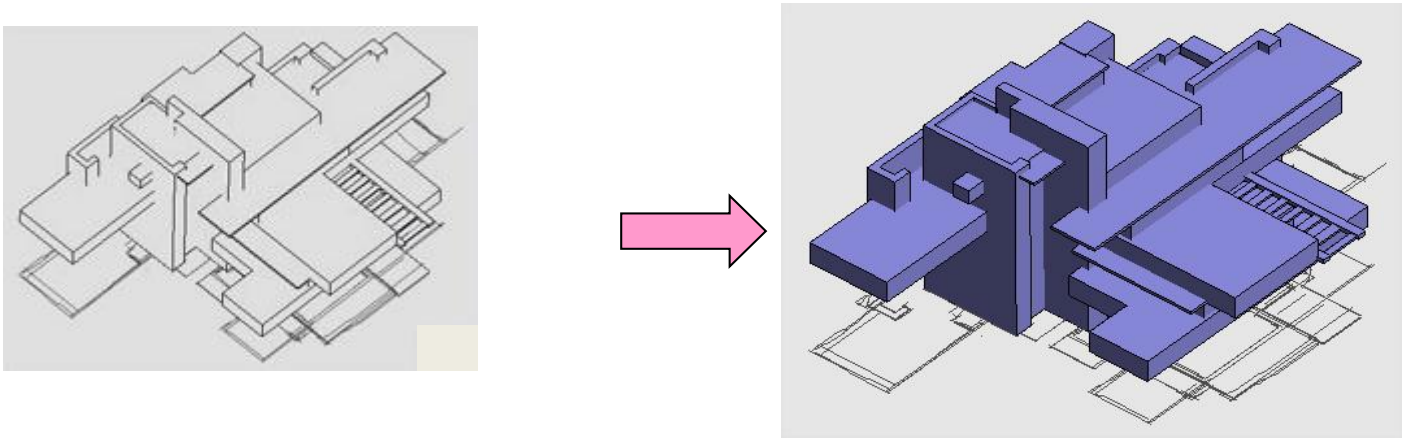


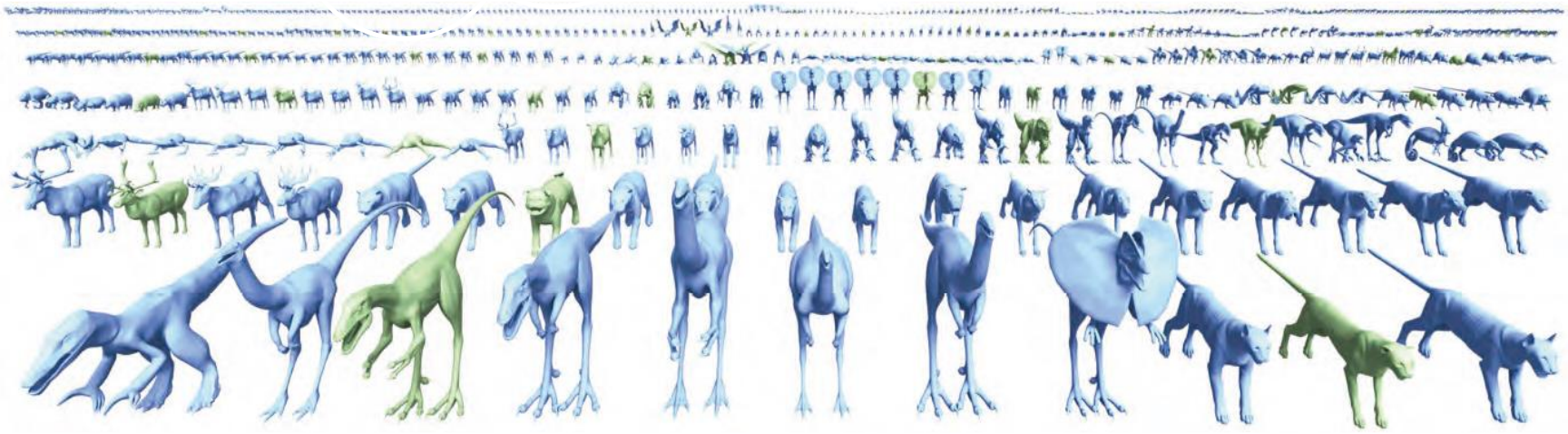
Warping to photo [Xu et al., SIG 2011]

3D model retargeting

Structure-preserving retargeting of irregular 3D architecture
[Lin et al., SIG Asia 2011]

3D Content Creation





sig12_A Probabilistic Model for Component-Based Shape Synthesis

sig12_Fit and Diverse-Set Evolution for Inspiring 3D Shape Galleries

Human Body Geometry and Motion Recovery from a Single Depth Camera