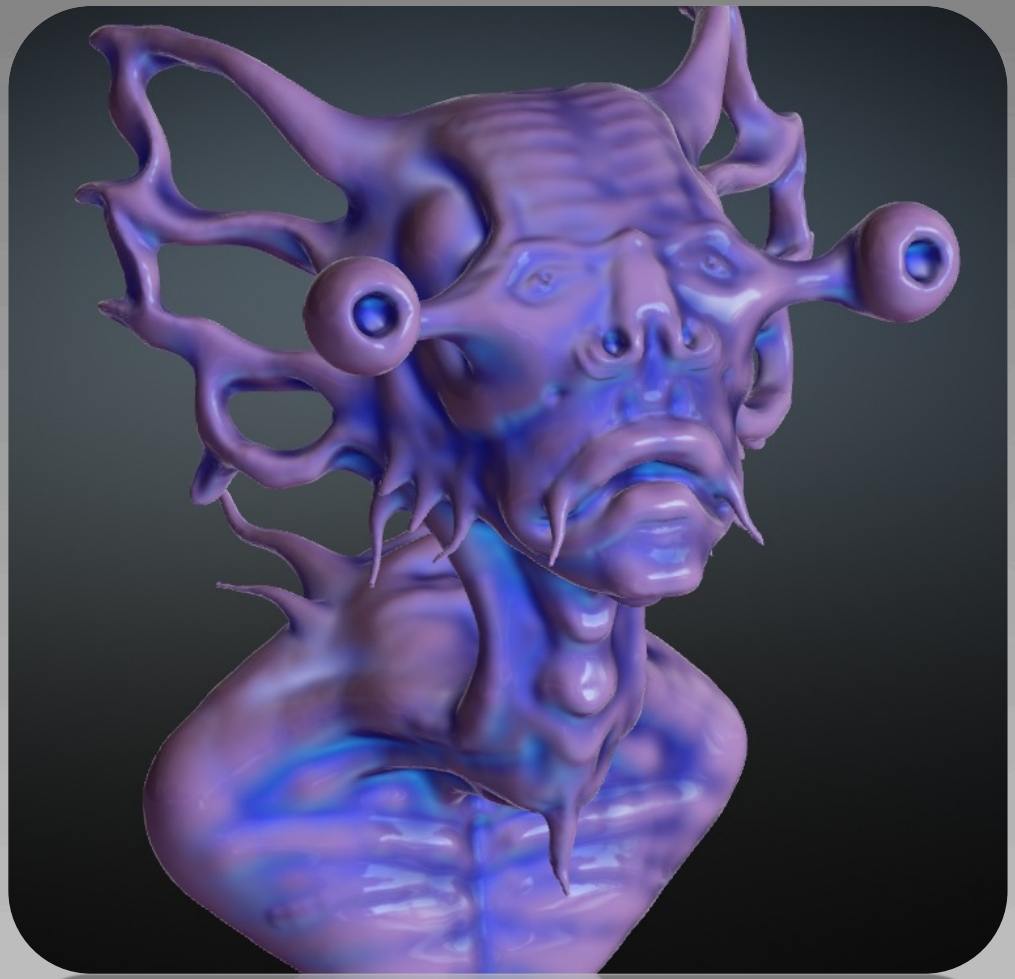
Freestyle

~ sculpting triangular meshes with topological changes ~



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1. Introduction

Motivation

- Digital sculpting : basic tool for content (character) creation for animated movies, special effects, computer games

- Few methods found in professional applications: polygonal (no changes in topology), regular grids (no color or texture)

- Most methods – speed problems

1. Introduction

Related work

- Grid-based sculpting
  - Local deformations and adaptive grids [Ferley 99, 01]
  - Large deformations – virtual clay [Dewaele 04]

- Mesh-based sculpting (no topology change)
  - Space deformations (volume preserving) – [Angelidis 04] [von Funck 06]
  - Model-based deformations – Laplacian editing [Sorkine 04]

- Surface tracking
  - Particle system + Delaunay tetrahedrization [Debard 07]
  - Restricted Delaunay tetrahedrization [Pons 07]
  - Segmentation of 3D data on voxel grid [Lachaud 99] <<

1. Introduction

Objective

- Perform **deformations** and **topological changes** on a **detailed** surface mesh at **interactive** frame rates

- Create **displacement** fields and adapt existing ones to model and facilitate sculpting process

- Develop **intuitive** tools for professional and amateur users

2. Quasi-uniform mesh structure

- Start with and maintain a *triangular manifold mesh* with **quasi-uniform sampling**

- Topological changes = **collisions** between spheres and local change in connectivity

- Facilitates the tracking of surface deformations

2. Quasi-uniform mesh structure

Parameters

Underlying model characterized by only two parameters describing material behavior

- **d_detail** – level of detail supported by the material

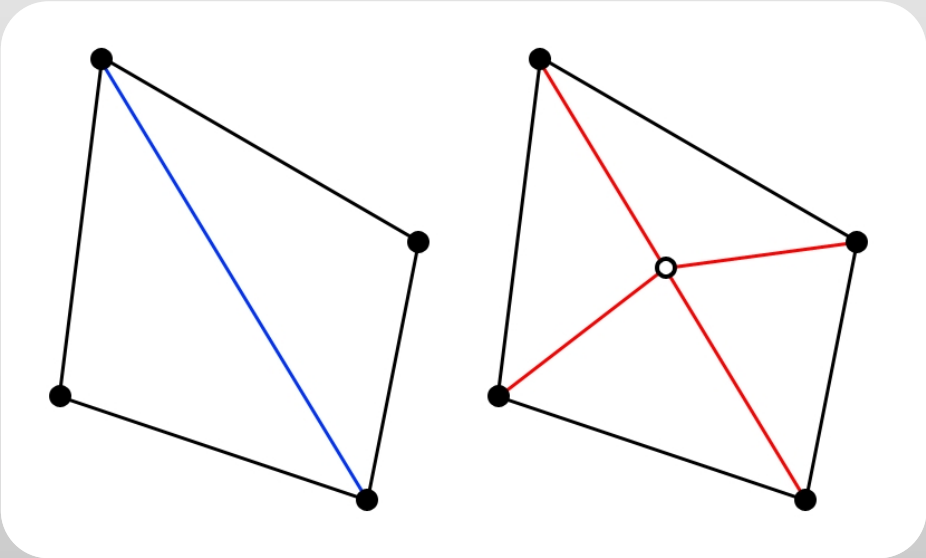
- **d_thickness** – threshold below which the material is locally torn

2. Quasi-uniform mesh structure

Definition

***d_detail* mesh** - mesh with all edges smaller than *d_detail*.

- *d_detail* can always be guaranteed – **edge split**

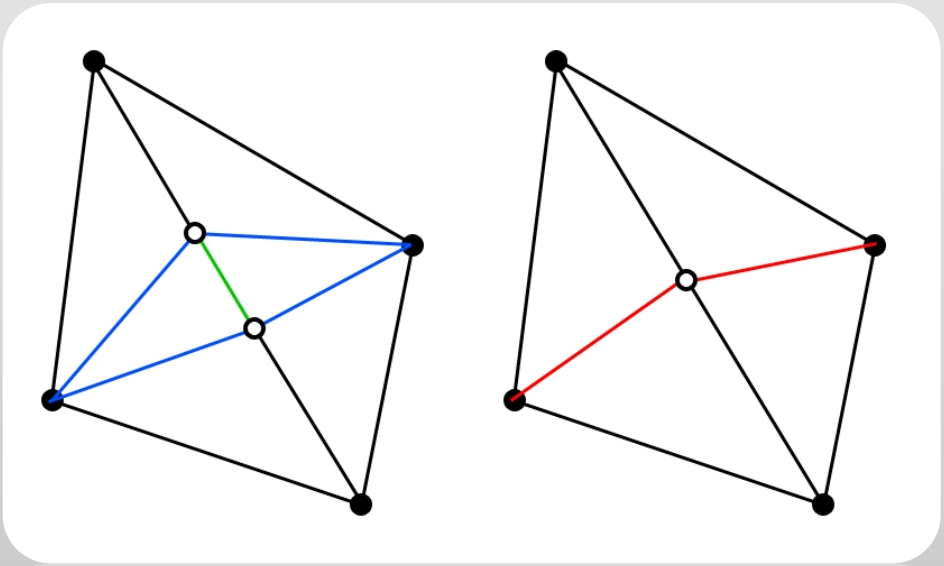


2. Quasi-uniform mesh structure

Definition

***d* compliant mesh** - mesh obtained by iterating over all edges and collapsing those that are smaller than *d*.

- Introduced to improve triangle quality



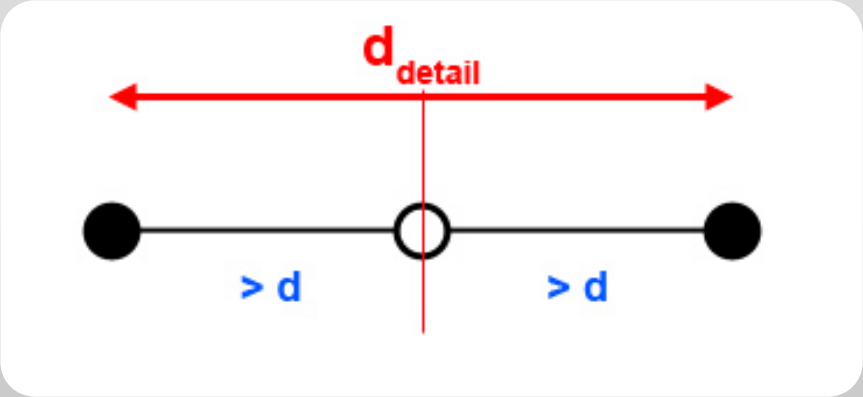
2. Quasi-uniform mesh structure

- Cannot guarantee a *d_detail* mesh that has all edges larger than *d*.

Definition

A mesh **M** is **quasi-uniform** ⇔ ∃ *d_detail*, *d*, *d* < *d_detail* such that **M** results from compliance with *d*, followed by restoration of *d_detail.*

d < *d_detail/2*
(split-collapse)



3. Temporal evolution under deformation

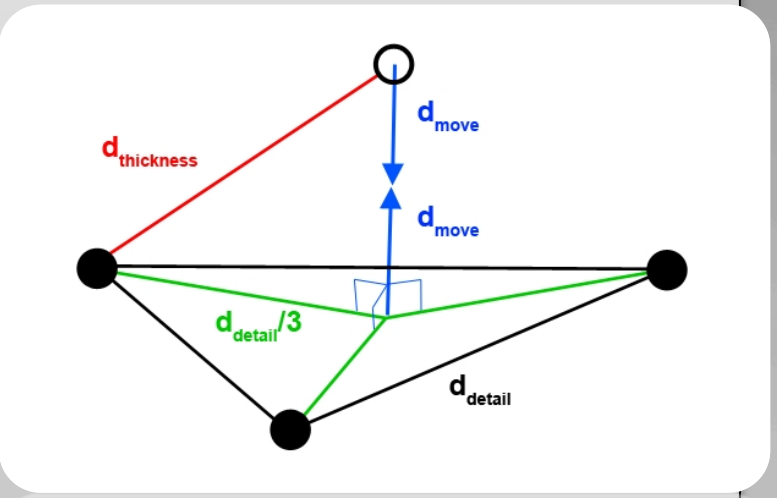
Ensure that **all** important mesh changes are detected **before** *self-intersections* occur.

Definition

A quasi-uniform mesh with minimum thickness *d_thickness* is a mesh with all non adjacent vertices separated by more than *d_thickness*.

$4d\_move^2 < d\_thickness - d\_detail^2/3$

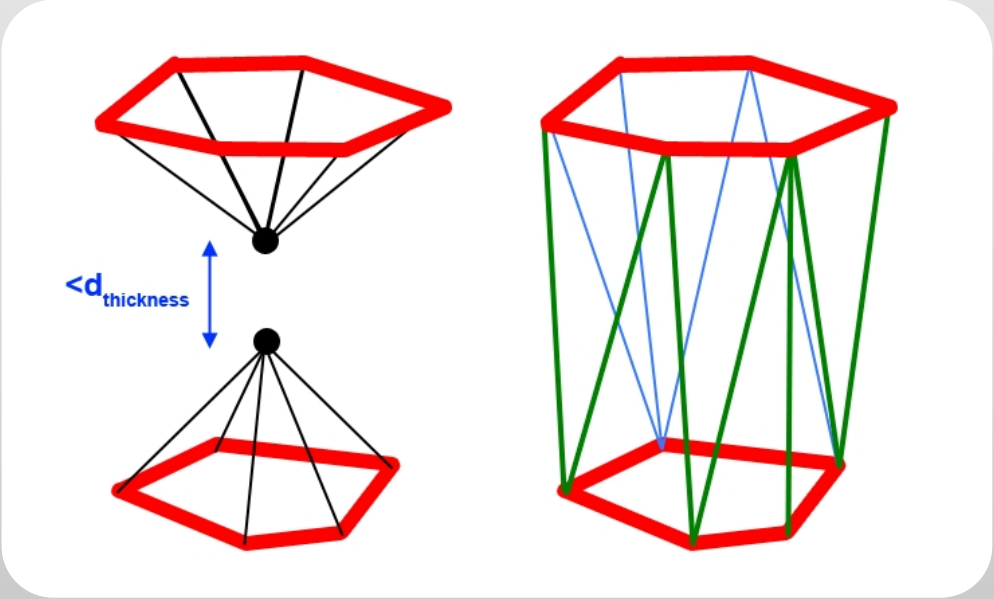
d_move – maximum displacement



3. Temporal evolution under deformation

Topological genus change

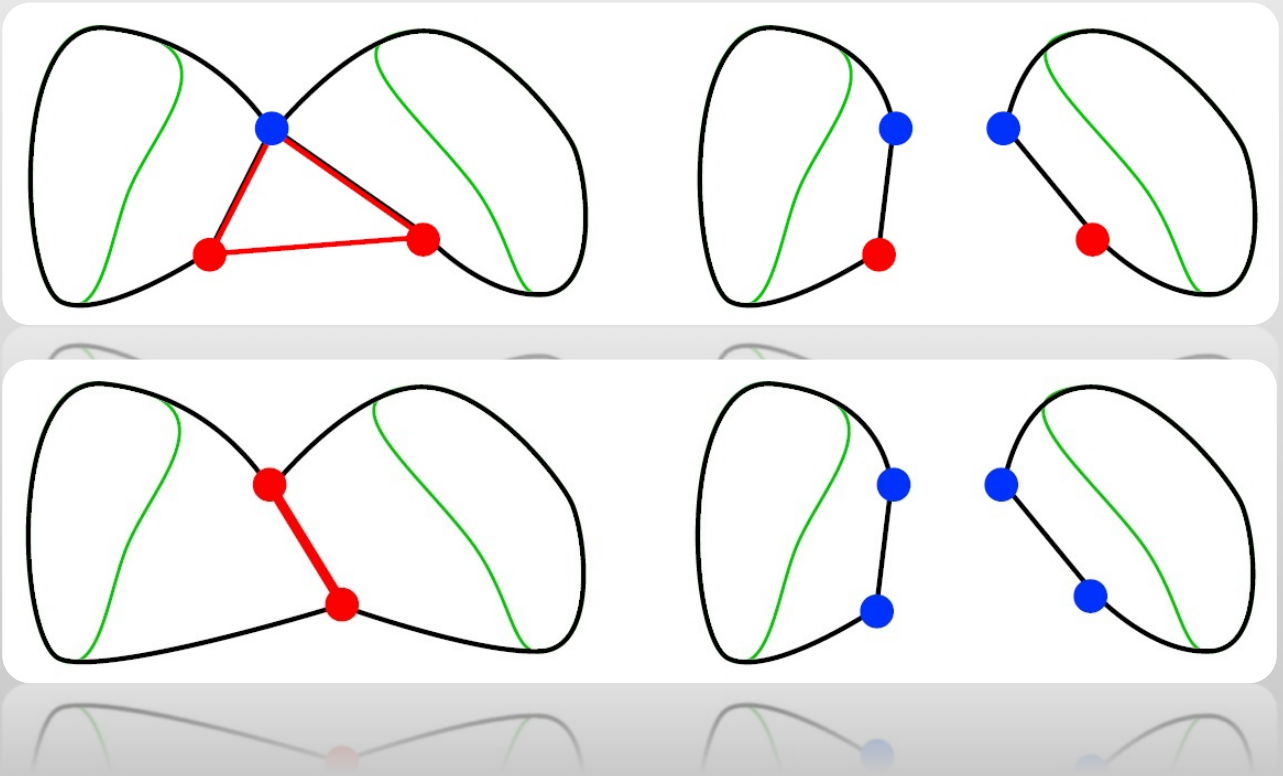
vertices closer than *d_thickness* – delete vertices, connect 1-rings



3. Temporal evolution under deformation

Maintaining manifold mesh

Vertex neighborhood cleanup



4. Sculpting tools and user interaction

Deformations

- Displacement field *defined at each vertex position*
  - Volume preserving or depending on local properties such as normals, geodesic distance, color …

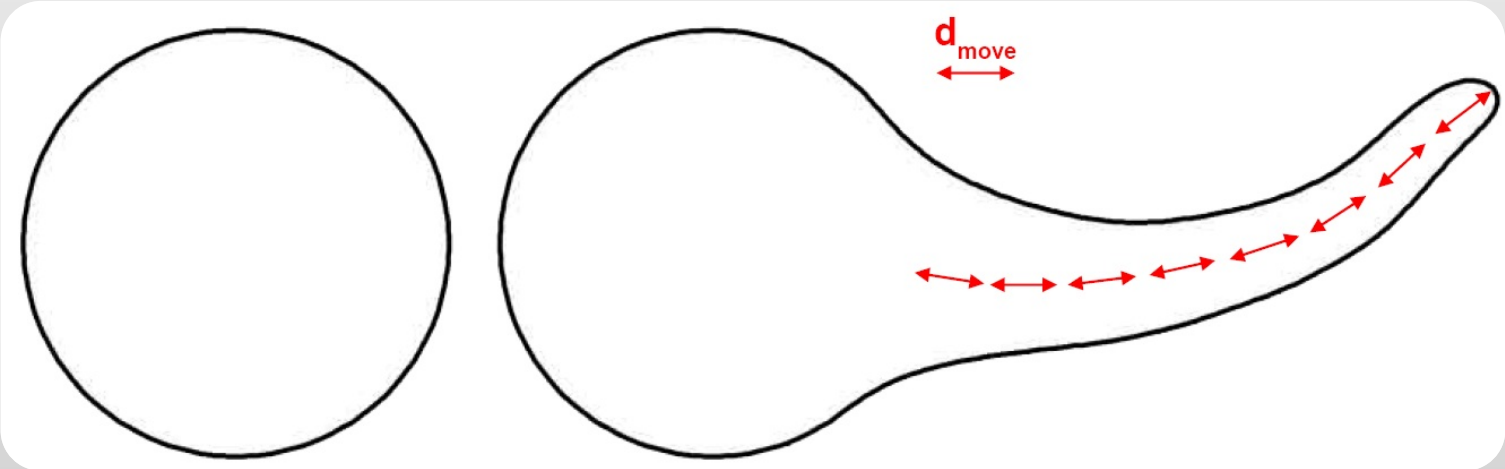
- The deformation is applied *discretely*
- Limited to *d_move* per vertex

- Large displacements – division in elementary steps

- **All deformations can lead to change in topological genus.**

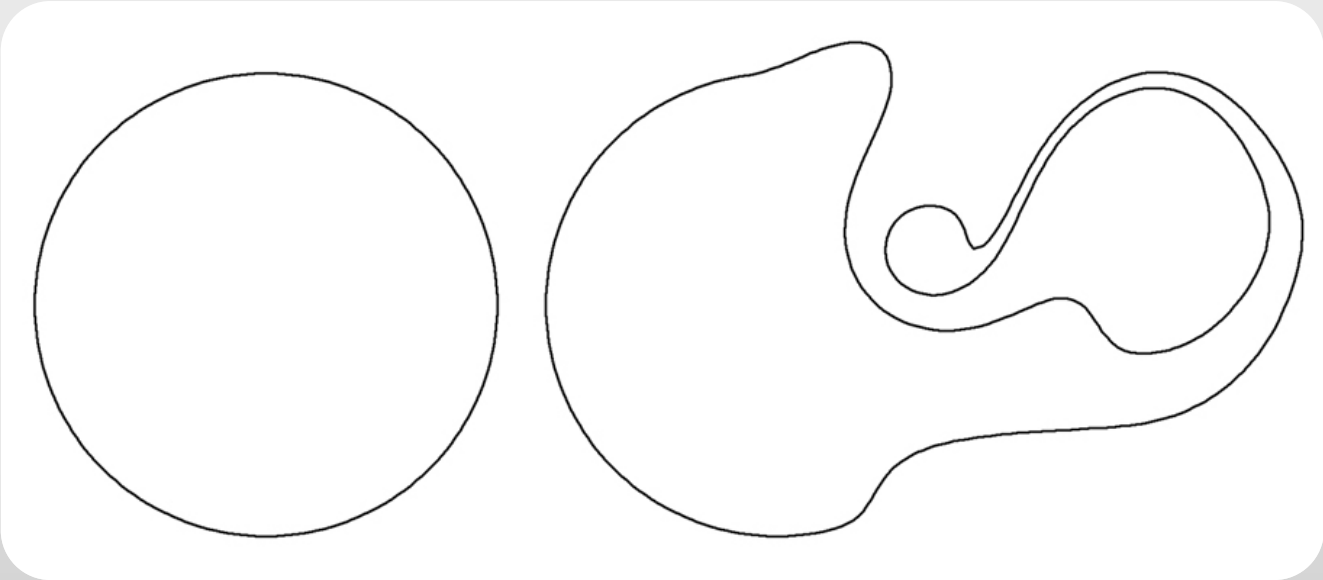
4. Sculpting tools and user interaction

Large deformation



4. Sculpting tools and user interaction

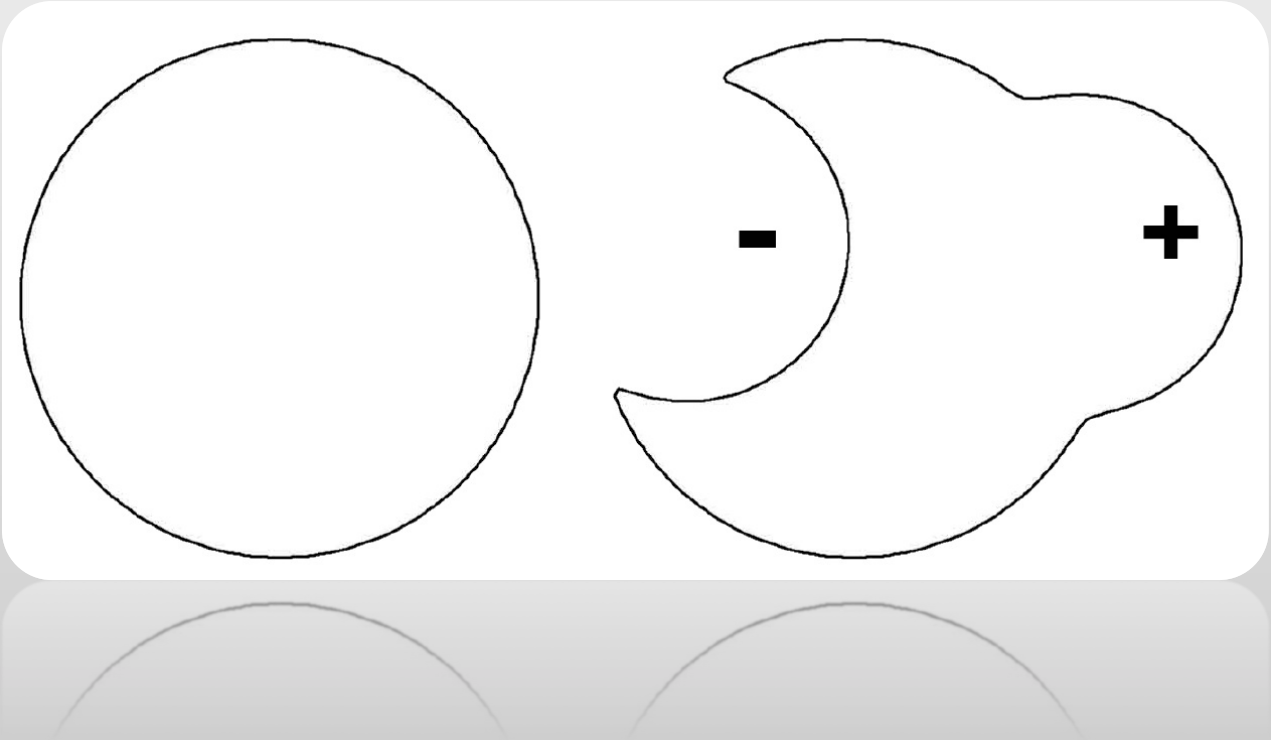
Volume-preserving sweep deform [von Funck 06]
- space deformation



4. Sculpting tools and user interaction

Inflate-deflate

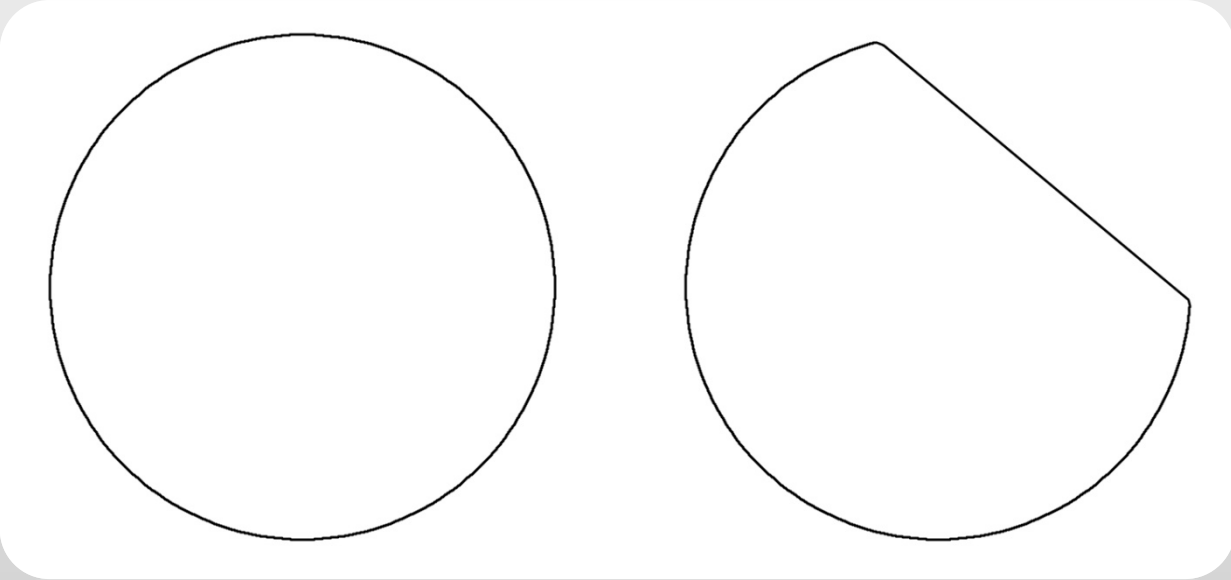
- depends on vertex normal



4. Sculpting tools and user interaction

Trim

- partial projection on a plane



4. Conclusions

- Development of a data structure highly adapted to sculpting operations
  - Closer to real life sculpting with respect to existing software
  - *Helping* amateur users to make “beautiful shapes”

- Simple and efficient model for intuitive interaction.

5. Future work

- Optimizations
  - Divide object on regions, VBO/region
  - Parallelize collisions on GPU (OpenCL, CUDA 30x)
- Addition of texture
- Reconciling with adaptive sampling
- Validation by tests with different types of users

6. Demo