Shape Transformation Using Variational Implicit Surfaces

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Overview

- Goal
  We designed and wrote a program to create smooth transformation of implicit surfaces based on the SigGraph-1999 paper:
  "Shape transformation using variational implicit functions",
  Greg Turk, James O'Brien

- What use does this have?
  - Special effects to feature films and commercials
  - Contour interpolation in medicine
  - Computer aided geometric design

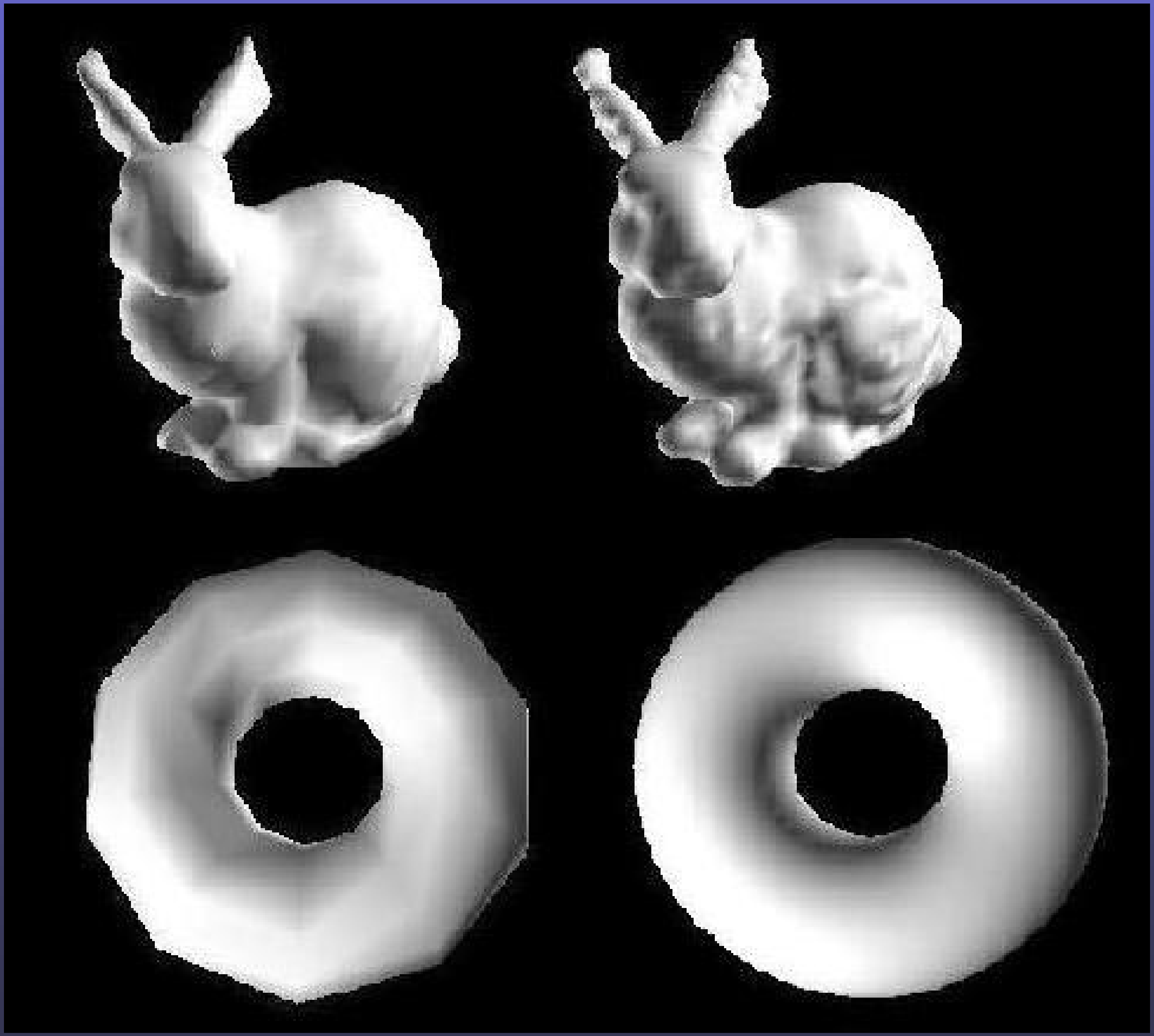
Next up: How does this work?

Shapes

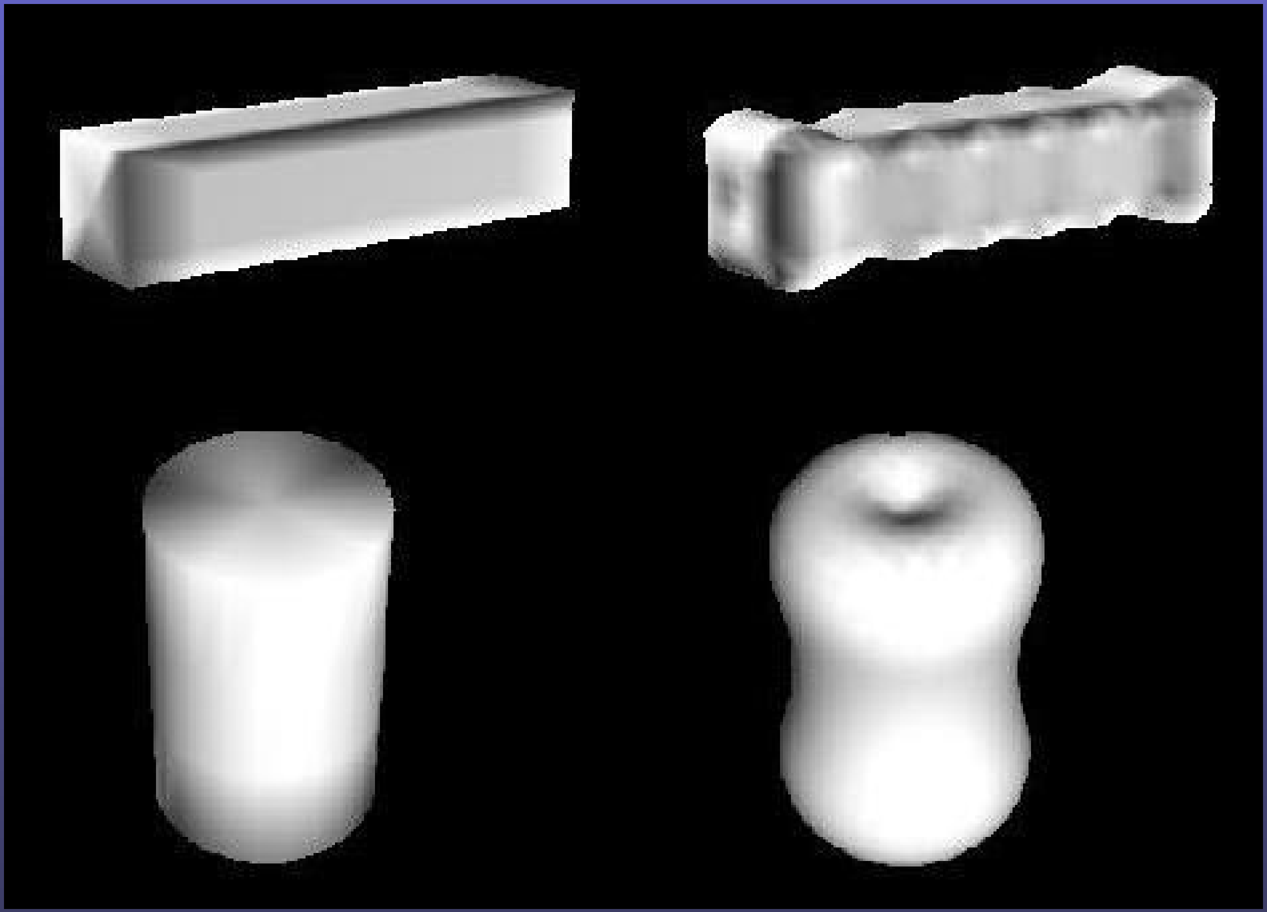
Unlike some other approaches to shape transformations, our shapes are **not** meshes, but rather smooth surfaces which pass through a set of specified points.

For convenience, we used vertices from existing mesh files as these points.

Some Examples



More Examples



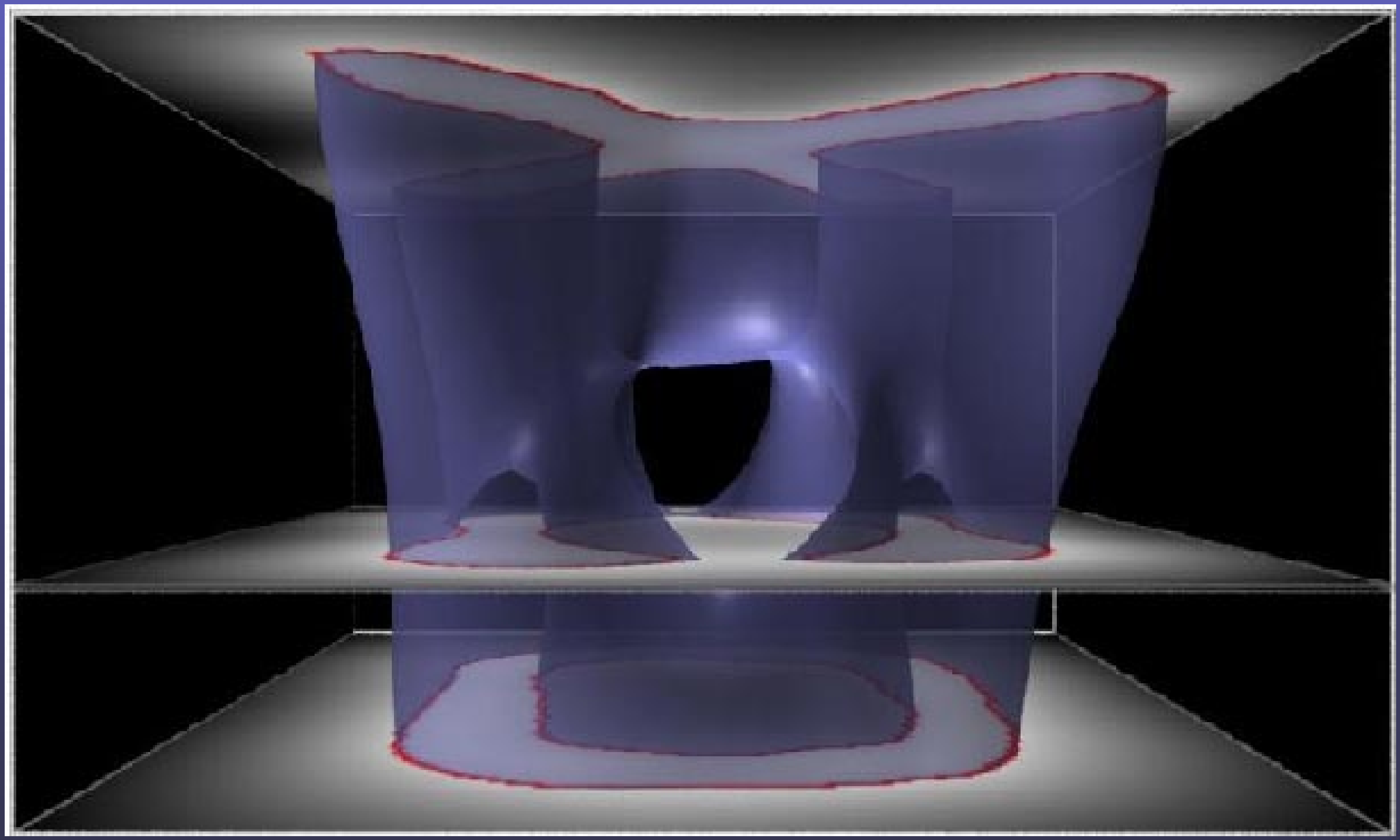
Transformations

We now need to handle the problem of transforming smoothly between two different such shapes.
We can do this using the same method by creating a single higher-dimensional shape as follows:

- Place each point p_1 from mesh m_1 at position $(p_1, 0)$
- Place each point p_2 from mesh m_2 at position $(p_2, 1)$
- Build a smooth surface through all of the points specified above
- Render slices of the surface at location $(\mathbb{R}^3, n), n \in [0, 1]$

A Picture Is Worth a Thousand Words

Taken from Greg Turk's Home Page: http://www.gvu.gatech.edu/gvu/people/faculty/greg.turk/morph/morph.html



New, Improved, and in 3D

Implicit Functions

There are two ways to represent mathematical functions:

- Explicit Functions: (e.g. $(\cos(t), \sin(t)), 0 \leq t < 2\pi$)
- Implicit Functions: (e.g. $x^2 + y^2 - 1 = 0$)

Advantages of implicit functions:

- Compact representation
- Easy to add two functions.

Variations

- Scattered data interpolation problem:
  Create a smooth function that passes through a given set of data points
- One common approach: to use variational techniques
- Use radial basis functions of the form:

$$\phi(x) = |x|^2 * log(|x|)$$

- Shape construction function:

$$f(x) = \sum_{j=1}^{n} d_j * \phi(x - c_j) + P(x)$$

Features

- Surface Representation
  - Polygonization
    - Variable Coarseness
  - Silhouette Tracing
- Algorithmic Improvements
  - Fast function evaluation
  - Explicit normal computation
- Support for loading and saving implicit functions

Results

- Pre-built films
- Interactive demos