A system’s architecture for Warping and Morphing of Graphical Objects

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Our Goal

*Develop a testbed system for warping and morphing of graphical objects*
System Requirements

- Use different graphical objects
- Use different shared techniques
- Plug in new objects
- Plug in different techniques
- Uniform and coherent interface

Importance of the Goal

- Warping and morphing is a basic operation in graphics
  - Registration
  - Motion warping
  - Texture mapping
  - Correction of Optical distortion
  - Image stitching
  - Image based rendering and modeling

- Many applications
Current Status

- Research has covered particular classes of graphical objects
- There has been no attempt to obtain an integrated framework
- There exists no flexible system architecture
  - Different graphical objects
  - Different techniques

Need for an integrated system
Key concepts

- Graphical object
- Warping and morphing

Graphical Objects

- Drawings
- Volume data
- Images
Definition of a Graphical Object

• Shape
  \[ U \subset \mathbb{R}^n \]

• Attributes
  \[ f: U \subset \mathbb{R}^n \rightarrow \mathbb{R}^k \]

• Dimension of the GO

Image

\[ f : U \subset \mathbb{R}^2 \rightarrow \mathcal{C} \]

• Shape is a rectangle
• Attribute is color
• Dimension = 2
Audio

- Shape is an interval
- Attribute is air pressure
- Dimension = 1

\[ f : U \subset \mathbb{R} \rightarrow \mathbb{R} \]

Solid (volumetric object)

\[ f : U \subset \mathbb{R}^n \rightarrow \mathbb{R} \]

- Shape is an spacial domain
- Attributes: density, ... 
- Dimension = n
Curves (Drawings)

- One-dimensional graphical objects of the plane

Surfaces

- Two-dimensional graphical objects of the space
Two-Dimensional Solids

- 2D graphical objects of the plane
- Binary image
  - Shape is the focus

Animation

- Variation of a graphical object along the time

\[
\mathcal{O} = (U, f), \quad U \subset \mathbb{R}^n
\]

\[
\varphi: [a, b] \times \mathcal{O} \rightarrow \mathbb{R}^n
\]

\[
t \mapsto \varphi(t, \mathcal{O}) = \mathcal{O}_t
\]
Warping and Morphing

- Transformation of GO
  - Transforming shape
  - Transforming attributes

Transforming Shape

- transformation of the image shape
Transforming Attributes

- Texture transformation

Transforming Shape and Attributes

- An example:
  - Color, Geometry and topology
Our goal: Continuous Deformation

Continuous Deformation

• *Twist*: Rotation angle increases with height
Continuous twist

\[ R(x, y, z) = \begin{pmatrix} \cos f(z) & -\sin f(z) & 0 \\ \sin f(z) & \cos f(z) & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix} \]

- Parameter space (z axis)

Families of Transformations

Graphical Object

\[ T(p, v) = \]

Parameter Space
From families to animation

Warping and Morphing

- Warping
  - Continuous family of transformations of a graphical object
- Morphing (metamorphosis)
  - Warping between two graphical objects
Warping and Morphing

- **Warping**
  - Source object
  - No target object
- **Morphing**
  - Source object
  - Target object

\[
\text{morphing} = (\text{warping})^2 + \text{blending}.\]
Attribute Blending

Shape Warp + Attribute Blending
Computing Graphical Objects

- Description
- Representation
- Reconstruction

Computing transformations

- Specify transformations
- Represent transformations
- Reconstruct transformations
A Warping and Morphing System

- System components
System components

• Support level
  • input and output of graphical objects
  • file formats
  • commonly used classes
    • vectors, lists, matrices

• Platform Level
  • User interface
  • Platform-dependent resources

• Kernel level

The Kernel Level
Graphical Objects

- Hierarchy of abstract data types

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Specification
Specification

- Hierarchy of Manipulators
  - Basic
  - Composite
Composite manipulators

- Instantiation hierarchy

\[ \text{morphing} = (\text{warping})^2 + \text{blending}. \]
Computation

• Warping and Morphing engine

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Computation

• Animation schedulers
  • slow-in, slow-out
The *Morphos* System

- Windows / C++ / OpenGL
- Side by side user interface
- Figure 13
- How to get it
  - Book & CD-ROM
  - *Warping and Morphing of Graphical Objects*
  - Morgan kaufmann Publishers, 1998
- The morphing site

Future additions to Morphos

- Addition of volumetric objects
- Addition of surface warping
- Addition of surface morphing
- Single window interface (displacement vector)
- Automatic feature detection
- Temporal warping (video sequence)
- Port the system to UNIX