Applications of Computer Graphics in Cel Animation

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3-D and 2-D animation

Homer 3-D
Homer 2-D

Advantages of 3-D

• Complex lighting and shading
• Reuse from scene to scene
• Automatic in-betweening
• Ease of camera motion
• Realism
• Texture mapping

Advantages of 2-D

• Easier for traditional animators
• Simple gestures convey emotion
• Art form refined for 80 years

Key idea

Use 3-D methods in 2-D animation!
• Expressiveness of 2-D
• Technical benefits of 3-D

Related work

Automating cel animation pipeline
[Fekete 95, Robertson 94, Shantzis 94, Wallace 81]

Hybrid 2D/3D for cel animation
[Rademacher 99, Williams 91]
Two forms of art work

Overview

• Introduction
• Multiperspective panoramas
• Texture mapping
• Shadows

Multiperspective Panoramas for Cel Animation

Daniel Wood University of Washington
Adam Finkelstein Princeton University
John Hughes Brown University
Craig Thayer Disney Feature Animation
David Salesin

[SIGGRAPH '98]

Suggesting a moving camera

A multiperspective panorama incorporates many perspectives into a single locally coherent image.

A moving window slides across the panorama, selecting frames for the animation.
**Objective**

Given: 3D model and camera path

Create: Panorama and moving window such that the 2D animation resembles the 3D animation

1. 3-D scene and camera path

2. Panorama and moving window

3. Illustrated panorama

4. Extracted frames

5. CG Elements
Creating a panorama

- Take snapshots of 3D scene
- Arrange snapshots in a plane
- Merge snapshots into single image

Arranging consecutive snapshots

1. Sample points from first snapshot
2. Find corresponding points on second snapshot
3. Align snapshots using a transform

Taking snapshots

Arrange snapshots

Merge snapshots

Find corresponding points
**Limitations**

Panoramas cannot do it all  
(e.g., circling centerpiece of table)

Our method does not do it all  
(e.g., *Beauty and the Beast* library)
**Strengths**

- Wide variety of camera motion
- Easy experimentation
- Easy CG integration
- Illustrator creates detail
- Hand-drawn artistic style

**Texture Mapping for Cel Animation**

Wagner Corrêa
Rob Jensen
Craig Thayer
Adam Finkelstein

Princeton University
Disney Feature Animation

[SIGGRAPH '98]

**Traditional cel animation**

**Textured cel animation**

**The process**

**Input of the warp**
Marker curves

Input of the warp

Output of the warp

A pair of marker curves

At parameter $t$

Many parameter values
Output of the warp

Controlling the warp
- Weights
- Viewing parameters
- Extra markers

Viewing parameters
- upright
- tilted

Extra markers
- without
- with

Video

Limitations
**Strengths**
- Fits into current production pipeline
- Little effort per frame
- Avoids temporal artifacts
- Combines strengths of:
  - 2-D: gestures, timing, anticipation
  - 3-D: texture, occlusion, foreshortening

**Shadows for Cel Animation**
Lena Petrović
Brian Fujito
Lance Williams
Adam Finkelstein

[Princeton University] [Disney Feature Animation]

**Motivation**
- Cast shadows (red) - shadows on background
- Tone mattes (blue) - character shading
- Contact shadows (green) - darkness underfoot

**Shadow Mattes**
- No shadow
- Shadow
Project Goal

Approach: 3D Models

Process: Overview

- Background Construction
- Character Inflation
- Depth Specification
- Specifying Lights
- Rendering
- Compositing

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Character Inflation

Inflate 3-D shapes using Teddy [Igarashi 99]

• Two caveats: perspective & layers

<table>
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<tr>
<th>character layer</th>
<th>3D model</th>
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Character Inflation

Obtaining layers

- Line art
- Layers
- 3D Model

Character Inflation

Camera view
Off-angle view

Depth Specification

Adjust depth while preserving silhouette

- Translation
- Shear

Depth Specification

Camera view
Off-angle view

Compositing

Tone matte (blue) modifies character color.
Other mattes (red & green) darken background.

Video

- 33 frames
- 16-frame cycle
- 16-frame cycle
**Limitations**

Manual creation of character layers

No aesthetic controls for:
- shadow simplification
- shadow stylization

**Strengths**

- Less human effort than hand-drawn
- Plausible shadows
  - even in complex scenes
- Lighting effects:
  - animated lights, gobos
- Freedom to experiment with lights

**Conclusions**

3D methods may be used in 2D for:
- reducing human effort
- achieving new effects

Lines between 3D and 2D are blurring