Applications of Computer Graphics in Cel Animation

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3-D and 2-D animation

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
Adam Finkelstein
John Hughes
Craig Thayer
David Salesin

University of Washington
Princeton University
Brown University
Disney Feature Animation

[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.

[Pinocchio, 1940]
**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

Arrange consecutive snapshots

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

![Traditional cel animation](image1)

**Textured cel animation**

![Textured cel animation](image2)

**The process**

![The process](image3)

**Input of the warp**

![Input of the warp](image4)
Marker curves

Input of the warp

Output of the warp

A pair of marker curves

At parameter \( t \)

Many parameter values

Model marker

drawing marker

\( P \) Q

\( P \) Q

\( M(t) \) \( D(t) \)
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

**[SIGGRAPH '00]**

**Motivation**

- character  
- background  
- scene

**Shadow Mattes**

- cast shadows (red) - shadows on background
- tone mattes (blue) - character shading
- contact shadows (green) - darkness underfoot
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

First layer

Adding a second layer

Adding a third layer
Character Inflation

Obtaining layers

line art → layers → 3D model

camera view → off-angle view

Depth Specification

Adjust depth while preserving silhouette

translation → shear

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
<table>
<thead>
<tr>
<th>Limitations</th>
<th>Strengths</th>
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<tbody>
<tr>
<td>Manual creation of character layers</td>
<td>• Less human effort than hand-drawn</td>
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<td>No aesthetic controls for:</td>
<td>• Plausible shadows</td>
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<tr>
<td>• shadow simplification</td>
<td>– even in complex scenes</td>
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<tr>
<td>• shadow stylization</td>
<td>• Lighting effects:</td>
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<td></td>
<td>– animated lights, gobos</td>
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<td>• Freedom to experiment with lights</td>
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<th>Conclusions</th>
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<td>3D methods may be used in 2D for:</td>
<td>Lines between 3D and 2D are blurring</td>
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<tr>
<td>• reducing human effort</td>
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<tr>
<td>• achieving new effects</td>
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