The Simulation of Paint Cracking and Peeling

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Realism

- Realistic / believable images
- e-commerce architecture
- Simulation (Physics, Mathematics)
- Precision (perception, measurement)
- Constraints (time, memory)
- Tradeoff (increased realism)

Aging

- Synthetic objects often look too perfect
- Deterioration
  - environment
  - everyday use
- Long term

Aging in Computer Graphics

- Important for realism
  - film
  - virtual reality
  - video games
  - design / prototyping
- Semi-automatic methods
- Control

Peeling

- Thin layer (paint)
- Cracks, peels

Outline

- Peeling
- Previous work
- Simulation
- Implementation
- Results
- Conclusion
### Paint Properties

- **Elasticity**
  - can be stretched
- **Tensile stress**
  - force required to stretch
- **Tensile strength**
  - force required to tear
- **Adhesion strength**
  - force required to peel

### Physical Phenomenon

- **Paint**
  - dries, shrinks, tensile stress
- **Deterioration**
  - moisture, uv, pollution
  - elasticity, strength, adhesion
- **Peeling**
  - cracks, loss of adhesion, peels

### Method

- **Simplified model**
  - easy control
  - efficiency
- **Surface properties**
- **Cracks**
  - formation and propagation
- **Loss of adhesion**
- **Peeling**
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Previous Work

• Fracture
  – [Norton1991] [Hirota2001]
  – [O’Brien1999] [Smith2000]
• Cracks
  – [Hirota1999] [Gobron2001]

Previous Work

Peeling

• [Wong1997]
  – tendency (peeling sources, 3D noise)
  – threshold (no simulation)
• [Gobron2001]
  – cellular automata
  – order in which parts detach

Previous Work

Peeling

• [Wong1997]
  – tendency (peeling sources, 3D noise)
  – threshold (no simulation)

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Overview

- Top view:
  - Paint layer
  - Movement (strain)
  - Stress
  - Decrease of lateral stress

- Side view:
  - Paint layer
  - Movement (strain)
  - Stress
  - Decrease of tensile stress
  - Increase of shearing stress
  - Loss of adhesion
  - Peeling

Implementation

- Paint properties
  - 2D grid
  - Directional

- Cracks
  - Sequence of linear segments
  - Independent of the grid

Cracks Control

- Texture
  - Tensile strength
  - White = low

Creation

- Perpendicular to the maximum ratio
- Grid property:
  - Tensile stress
  - Tensile strength
- New crack

Propagation

- Perpendicular to the maximum ratio
- Grid property:
  - Tensile stress
  - Tensile strength
**Relaxation**
- Perpendicular to the crack
- Grid property
  - displacement induced by the relaxation

**Adhesion**
- Loss with respect to ratio
- Grid property
  - shearing stress
  - adhesion strength
- Adhesion loss distance

**Peeling**
- Curls perpendicular to the crack
- Local geometry
- Control: mesh resolution

**Peeling Direction**
- Crack path is "jaggy"
- Direction of peeling is more continuous

**Peeling Direction**
- Direction of peeling is even more continuous

**Segment Fusion**
- Level of detail
  - Fusion metrics
    - loss of adhesion
    - length
    - direction
- Detail information
- Crack propagation
- Detect with crack ID
- Join intersecting to intersected
- Compute relaxation
- Split the intersected crack
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Simulation System

- Simulation system
  - crack formation & propagation
  - relaxation and adhesion
- Cracks information
  - path, widths
- Rendering

Maya Plugins

paint
base

color

Cracks
geometry

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Results: Wall

photo
aged
2nd view

Results: Shutters

photo
aged
2nd view
### Results: Garage Door

- Photo
- Aged
- 2nd view

### Results: Video

- Propagation
  - Wall
  - Text (GI 2002)

### Results: Statistics

<table>
<thead>
<tr>
<th></th>
<th>Wall</th>
<th>Shutters</th>
<th>Garage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nb crack segments</td>
<td>700</td>
<td>1500</td>
<td>2900</td>
</tr>
<tr>
<td>Simulation (400 MHz)</td>
<td>3 min</td>
<td>20 min</td>
<td>75 min</td>
</tr>
<tr>
<td>Rendering (16 x 400 MHz)</td>
<td>3 min</td>
<td>3 min</td>
<td>3 min</td>
</tr>
</tbody>
</table>

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### Conclusion

- Control through textures
- Cracks and loss of adhesion
- Peeling
- Local geometry
- Segment fusion

### Extensions

- Multi-layer
  - Paint over primer over base surface
- Multi-processing
  - One crack / processor
- Interaction with other effects
  - Example: rust
Questions?

- Thanks to
  - Alias|Wavefront
  - NSERC, FCAR, MRI-MEQ, FES-UdeM
  - Université de Montréal, INRIA, UFJ
  - M. Glisse, A. Reche, C. Puech