The Simulation of Paint Cracking and Peeling

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Realism

- Realistic / believable images

e-commerce

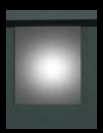
architecture

effects

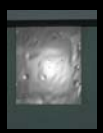
- Simulation (Physics, Mathematics)
- Precision (perception, measurement)
- Constraints (time, memory)
- Tradeoff (increased realism)

Aging

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



before



after

Aging in Computer Graphics

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

before

after

Peeling

- Thin layer (paint)
- Cracks, peels

photo

photo

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

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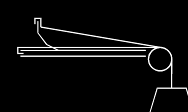

Physical Phenomenon

- 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

synthetic

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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

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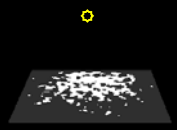
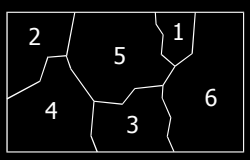


Previous Work

Peeling



- [Gobron2001]
  - cellular automata
  - order in which parts detach

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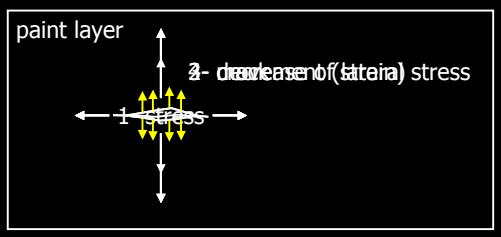
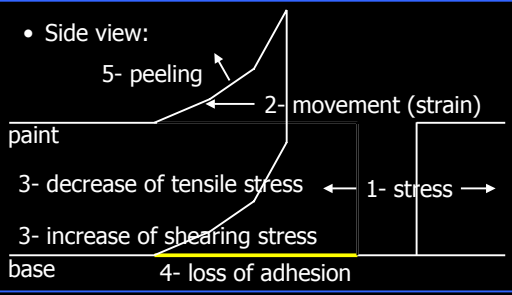
Overview

- Top view:



Overview

- Side view:



Implementation

- Paint properties
  - 2D grid
  - directional

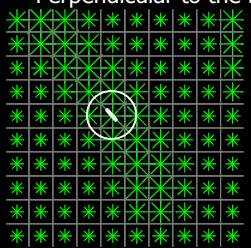
- Cracks
  - sequence of linear segments
  - independent of the grid

Cracks Control

- Texture
  - tensile strength
  - white = low

Creation

- Perpendicular to the maximum ratio



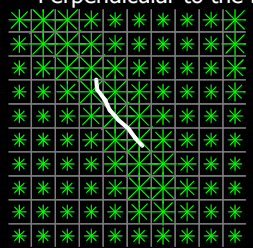
- Grid property:

$$\frac{\text{tensile stress}}{\text{tensile strength}}$$

- New crack

Propagation

- Perpendicular to the maximum ratio

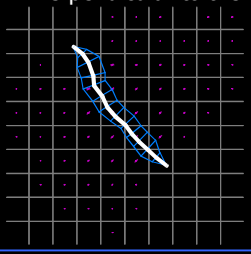


- Grid property:

$$\frac{\text{tensile stress}}{\text{tensile strength}}$$

Relaxation

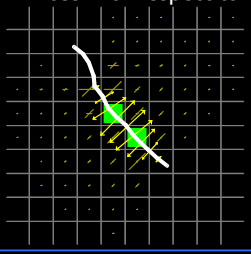
- Perpendicular to the crack



- Grid property
  - displacement induced by the relaxation

Adhesion

- Loss with respect to ratio



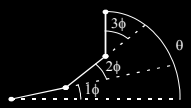
- Grid property

$$\frac{\text{shearing stress}}{\text{adhesion strength}}$$

- Adhesion loss distance

Peeling

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

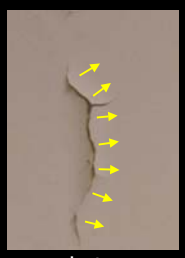


cross section

mesh

rendered

Peeling Direction



photo

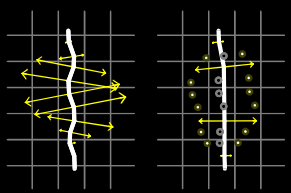
- Crack path is "jaggy"
- Direction of peeling is more continuous

Peeling Direction

photo

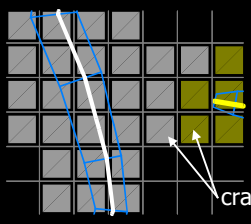
- Direction of peeling is even more continuous

Segment Fusion



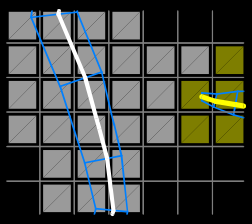
- Level of detail
- Fusion metrics
  - loss of adhesion
  - length
  - direction
- Detail information

Intersection



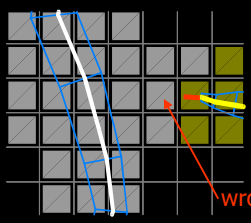
- Crack propagation

Intersection



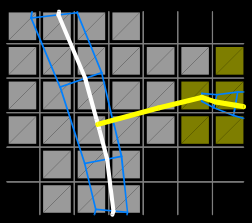
- Crack propagation

Intersection



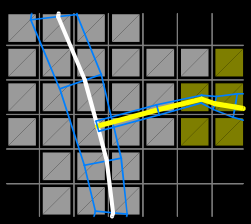
- Crack propagation
- Detect with crack ID

Intersection



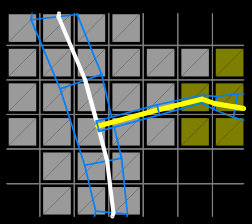
- Crack propagation
- Detect with crack ID
- Join intersecting to intersected

Intersection



- Crack propagation
- Detect with crack ID
- Join intersecting to intersected
- Compute relaxation

Intersection



- Crack propagation
- Detect with crack ID
- Join intersecting to intersected
- Compute relaxation
- Split the intersected crack

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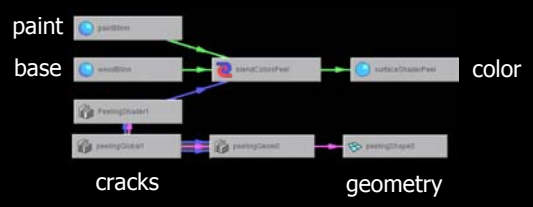
Simulation System

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

Maya Plugins



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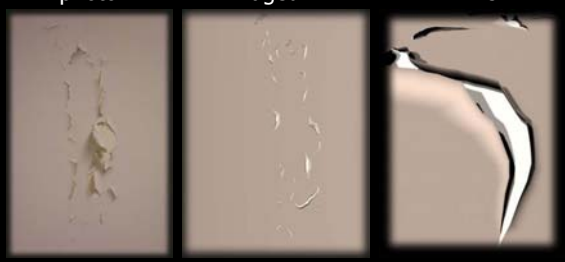
Results: Wall

photo aged 2nd view



Results: Shutters

photo aged 2nd view

Results: Garage Door

Results: Video

- Propagation
  - wall
  - text (GI 2002)

Results: Statistics

	wall	shutters	garage
nb crack segments	700	1500	2900
simulation (400 MHz)	3 min	20 min	75 min
rendering (16 x 400 MHz)	3 min	3 min	3 min

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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