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Modeling & Rendering of Realistic Feathers

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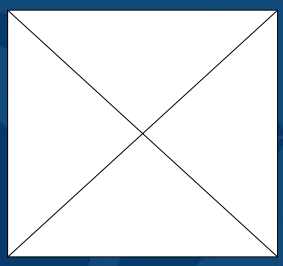
Goals



- A complete pipeline for modeling & rendering feathers systematically
- Realistic details for close-up views
- Efficient rendering for a wide range of viewing distances

Challenges

- **Modeling individual feathers**
  - Mesostructures of feather blade
  - Different types of feathers
    - Contour feather, flight feather, semi-plume, etc.
    - Everything in between
  - Randomness
- **Feathering a bird**
  - Arranging thousands of feathers on a bird's body

Contributions

- **Modeling & rendering of individual feathers**
  - An L-system for feather geometry
  - A technique for rendering feather mesostructures using bi-directional texture function (BTF)

Contributions

- **Modeling & rendering of individual feathers**
  - An L-system for feather geometry
  - A technique for rendering feather mesostructures using bi-directional texture function (BTF)
- **Feathering a bird**
  - A recursive collision detection algorithm

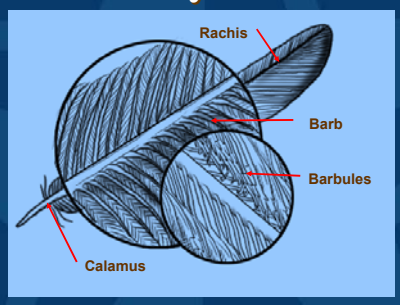
Related Work

- **Feathers**
  [Dai *et al.* 95, Schramm *et al.* 97, Franco & Walter 01, Streit & Heidrich 02]
- **L-system**
  [Lindenmayer 68, Prusinkiewicz et al. 90, 95, 96, ..., 01, Parish & Müller 01]
- **BTF**
  [Dana *et al.* 97, Liu *et al.* 01, Tong *et al.* 02]

Outline

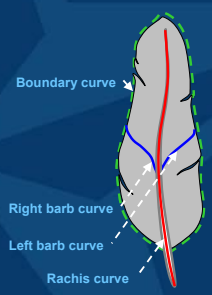
- **Individual feathers**
  - Feather geometry
  - Feather appearance
- **Feathering a bird**
  - Generating feather coat using key feathers
  - Recursive collision detection
- **Results**

Feather Anatomy

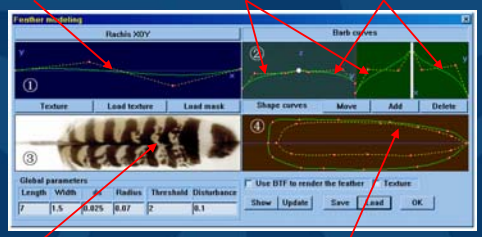


Feather Geometry

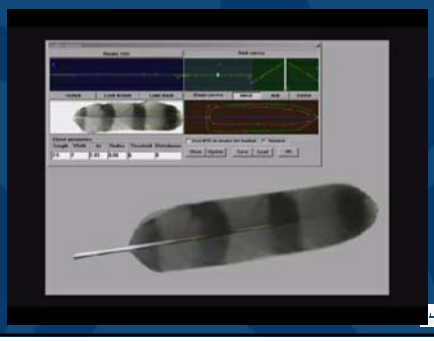
- **Modeled by L-system**
  - Branching structure
    - Rachis → barb → barbule → barbicle
  - Compact representation
  - Morphing by parametric interpolation
  - Randomness
- **Interactive editing**



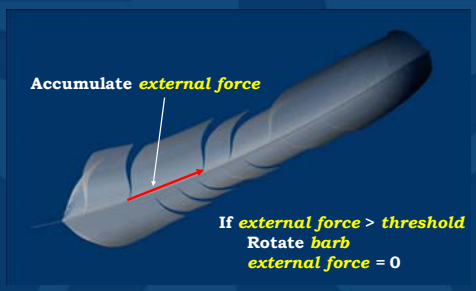
Editing Feather Geometry



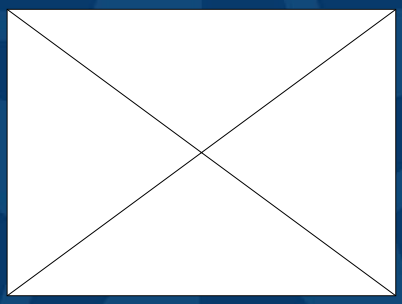
Editing Feather Geometry



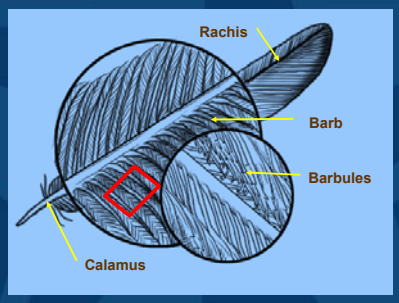
Adding Randomness



Feather Examples



BTF Sampling



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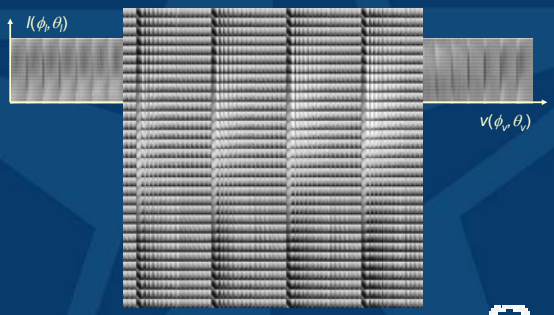
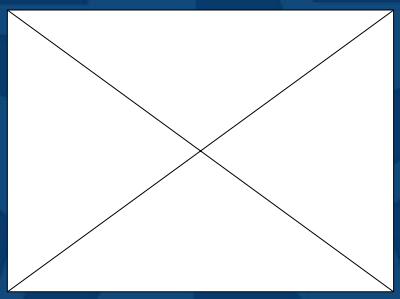
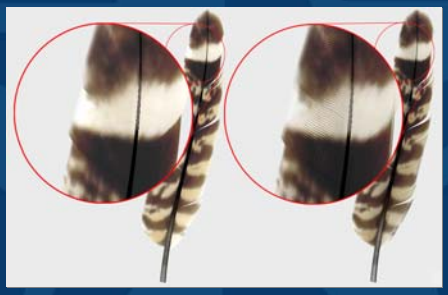


BTF Rendering



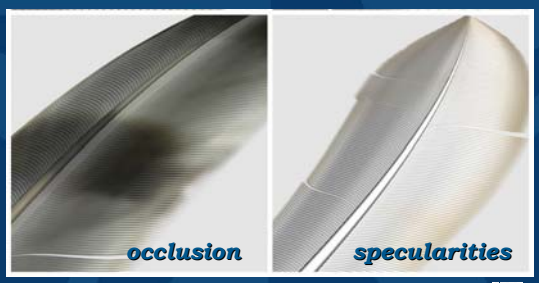
BTF vs Texture



Why BTF?

- **Realistic details in close-up views**
  - Mesostructures & directional radiance distribution
  - Occlusions & specularities
  - Oil film interference
- **LOD support for mipmap**

Occlusion & Specularities



Oil Film Interference

Outline

- **Individual feathers**
  - Feather geometry
  - Feather appearance
- **Feathering a bird**
  - Generating feather coat using key feathers
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Starting with a Bird Model

Finding Feature Positions

Biased retiling [Turk 91]

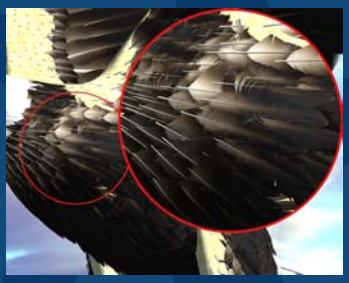
Specifying Key Feathers

Initializing Feather Directions

RBF interpolation [Praun 00]

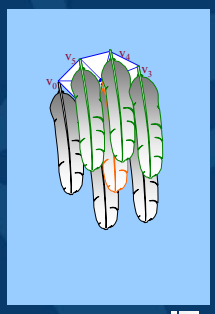
Adding Flight Feathers

Recursive Collision Detection



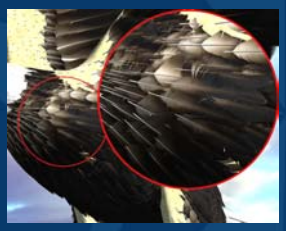
Recursive Collision Detection

- Only local collisions
- Collision detection in order
  - For each vertex, sort surrounding vertices
  - Perform collision detection in order & adjust feather directions recursively
- Use simplified geometry



Recursive Collision Detection

Recursive Collision Detection



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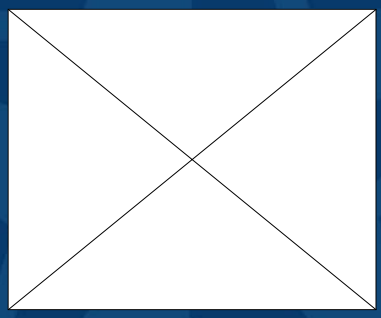
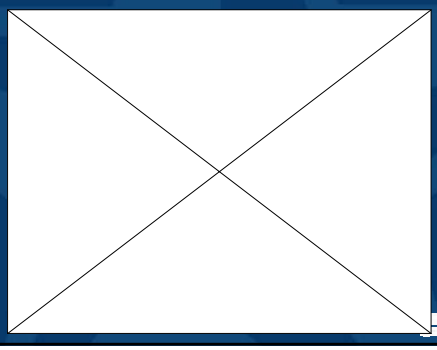
Real vs. Synthetic



Feathering a Bird



Summary

- **A comprehensive system for feather modeling & rendering**
  - L-system for feather geometry
  - BTF for feather appearance
  - Recursive collision detection for feather arrangement

Future Topics

- **Fine control of barbs**
- **Feather iridescence**
- **Bird animation**
- **& more!**