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Model of Peacock Tail Covert Feather Based on Its Microscopic Structure

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Abstract

This article presents a mathematical model called "the ridge model", which is used to create peacock tail covert feathers based on the relationships among the morphological data. A feather consists of diverse microscopic structures that include the rachis, barbs and barbules, which can, in modeling terms, be represented by curves. In this research, the Bezier curve is used. The methods used to generate the colour patterns of peacock tail covert feathers, which can be applied to feathers with similar features from different species, are developed and presented.

Keywords: Feather modeling, Rendering, Computer Graphics

1. Introduction

Feathers are the important structures for birds which protect birds' skin and support for flight. Feathers are the most complex structures on the epidermis and, additionally, a complex array of various colours and patterns. They cosist of small conmponent: calamus, rachis, barb and barbules and vary in size, shape, length, colour and colour-pattern according to their species, sex, age, environment and function [7]. The principal function of each feather varies according to its position: contour feather, down feather, filoplume, semiplumes and bristle. So creating an artificial feather that resembles a real one is very challenging.

In computer graphics and software, the development algorithms and techiques for creating and rendering realistic feathers were developed without relying on any biological knowledge. There were many rendering techniques to generate feathers. Y. Chen, Y. Xu, B. Guo and H.Y. Shum used L-system to generate feather, but this technique requires consumption time [1]. L. Streit and W. Heidrich represented feather using Bezier curves their method required less time than the L-system, but it was specific for the generation of Contour feather and filoplume [2]. C. G. Franco, M.Walter used Bezier curves representing feathers

Like L. Streit and W. Heidrich's technique, their method was powerful enough to generate down and semiplume feathers, but not to contour feathers or to complex feathers such as the peacock tail coverts [3-4].

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Ornithologists and general biologists have also attempted to study the morphology of feathers. Colour patterns have been studied using the diffusion of colour pigments [5], whilst the biological factors that affect the structure of peacock tail covert feathers have been evaluated to define the shapes of various parts of the ocelli separately, using equations and the polar coordinate system in accordance with the oval, circle and cardioids [6].

We develop mathematical model representing peacock tail covert and their pattern and implement them into computer graphics. This model can generate any kind of feathers.

2. Materials and Methods

To render peacock tail covert we begin with observing the peacock tail covert collected from pheasant breeding and research center. Then we represent each feather structures with Bezier curve and create mathematical model for feather skeleton and feather pattern. Finally we render peacock tail covert into computer graphics with algorithm as follows:

1. Create Bezier curve to represent rachis and boundary (see Figure 1).
2. Generate barb position which distal points are on rachis and boundary.
3. Use mathematical model called "Ridge model" to generate barb shape.
4. Generate feather pattern by using mathematical model.
5. Draw and colour each Bezier curve to render feather.

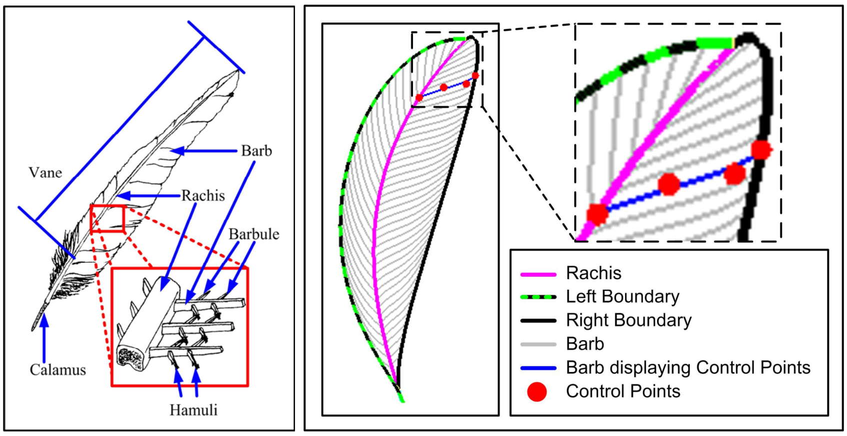

Figure 1 Represent feather structure

3. Results and Discussion

For generating feather skeleton, we present "the ridge model", a model which uses a function of the angles between the rachis and the barbs to control the control points' positions which affect barb shape. For changing the control points we consider the control points into the polar coordinate system. If barb curve contains $n+1$ control points where $P_m = (r, \omega)$ be the m^{th} control point of barb, p_0, p_n are the distal points of curve and θ be the angle changing to new barb then barb shapes are changed by assigning new position of control point P_m as

$$\hat{P}_m = \left(re^{\alpha_m\theta}, \omega + \lambda_m\theta\right) \; ; \qquad m = 1, 2, \ldots, n-1 \qquad \text{------------------------- (1)}$$

where α_m, λ_m represent the invariant for adjusting the curve of the m^{th} control point (see Figure 2).

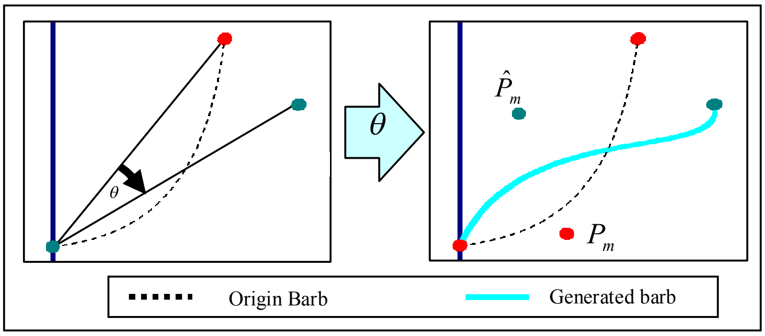

Figure 2 Ridge model changing barb shape

For generating feather pattern, it is dynamically various which depend on the bird evolution. This paper presents functions generating peacock tail covert pattern, consist of different shaped regions and its' ocelli pattern. The cardioid and the oval shape were used to create the ocelli by

$$f(r,\theta) = \qquad a + b\cdot\cos(c\cdot\theta + d) - r \qquad \text{-------------------------- (2)}$$

where a, b, c and d represent the parameters adjusting the shape.

Then we combine these models for rendering the peacock feather and other feathers. These results were compared with real feathers as show in Figures 3 and 4.

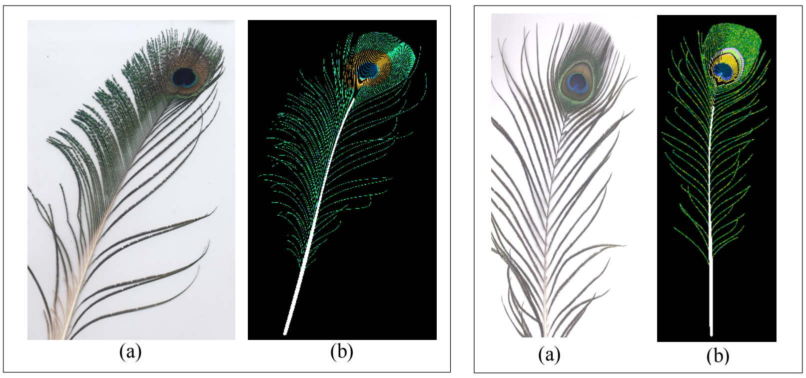

Figure 3 Comparing real peacock tail covert (a) and the modeling (b)

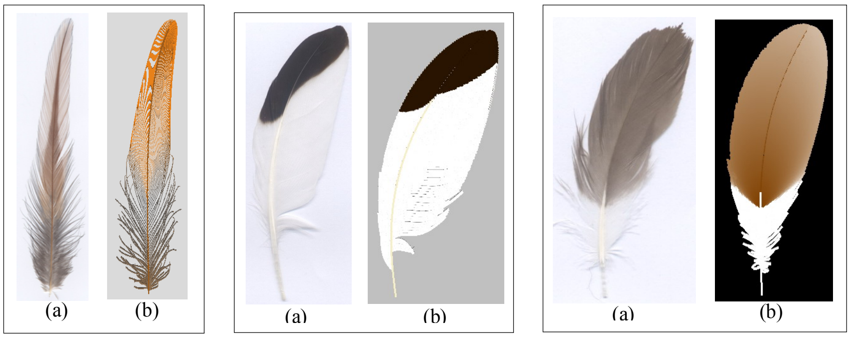

Figure 4 Comparing real feathers (a) and the modeling (b)

4. Conclusions

The ridge model can create peacock feathers and some types of birds' feathers as well. This can be useful when animated feathers are produced.

The pattern design of this model suits the pattern of peacock feathers or other similar feathers. Many patterns in feather vary on bird species. It is difficult to design the general model for a specific feather pattern of any position of birds.

In the future, the model will be developed to the point where it can generate feathers of each position and other kinds of patterns and colours of feathers. We can use this model and apply to previous techniques to render realistic feather.

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