A Biologically-Inspired Appearance Model for Snake Skin

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Abstract

We present a multilayered appearance model for snake skin, inspired on its anatomy: The top layer is a thin film layer producing a specular iridescent reflection, while the bottom layer is a diffuse highly-absorbing layer, that results into a dark diffuse appearance that maximizes the iridescent color of the skin.

Introduction

Photo-realistic rendering of biological tissues and structures, like feathers, fur or reptile skin, is still an open problem. The structural complexity at multiple scales of these biological elements result into complex light-matter interactions, manifested as intriguing appearances at macroscopic scale. One of the most remarkable and studied examples of biological tissues are the reptile scales, which present a combination of photonic structures and pigmentation. Unfortunately, current appearance models in computer graphics mostly ignore the complex anatomic structure of scales and its coloration mechanisms. In this work, we present a practical and efficient appearance model for snake skin [1] (see Figure 1 for an overview).

Our Appearance Model

We represent the snake skin appearance as a multilayered BSDF that represents the outermost layer *oberhäutchen* [2]. The first layer reproduces the iridescent effects via thin-film interference. The second layer consists of a diffuse surface surrounded by an absorbing media, modeling the darkening and saturation of the final appearance. In Figure 2, we show an example of our appearance model for several geometries.

Scales Mesogeometry

We model the scales of the snake skin as a mesogeometry, using a tileable bump mapping. In our examples, we manually create the bump map texture of the *Xenopeltis unicolor*'s scales, which roughly follow a uniform hexagonal grid.

Iridescent Layer

The outermost layer in the skin of snakes is the so-called iridescent layer, which is a dielectric non-absorbing layer with a quasi-regular photonic structure consisting of several (potentially oriented) iridescent platelets. We assume that the aggregated effect of the platelets can be approximated well by a single thin iridescent layer, following the Airy reflectance and its analogous for transmittance. This approximation has been shown to be very accurate for oriented platelets [4], and assuming a fixed IOR allows for changing the appearance of the skin by using a single parameter (the layer thickness).

Absorbing Layer

The second layer in our model is an absorbing diffuse layer, modeling the dielectric volumetric layer with melanosomes in snake skin, and the diffuse reflector behind that volumetric layer. As mentioned before, a pigmented layer behind the iridescent layer is crucial for enhancing the structural coloration of snakes. We model the absorbing layer using the classical Beer-Lambert exponential transmittance, on top of a diffuse reflector. For quick evaluation, we combined these two effects together in a single BRDF.

Conclusions

We presented a practical reflectance model for efficient rendering of skin of snakes. Our appearance model is built as a multilayered material composed of two layers: The irodophores layer (top layer) responsible of the highly iridescent colors is represented as a thin-film layer, while the bottom layer responsible for the dark pigments is modeled as a diffuse substrate surrounded by an absorbing media. We verify visually that our appearance model (see Figure 1, right) can qualitatively match the appearance of a real snake *Xenopeltis unicolor*.

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We simplify the modeling of the iridescent layer as a simple global thin-film interference layer. This is practical and efficient, but a coarse simplification of the actual structure. Including a platelet-based iridescent model [5], potentially with a distribution of platelets orientation, might likely increase the expressivity of our model, at the cost of making it more expensive.

Additionally, while our structural coloration model (thin-film interference) is one of the main sources of structural coloration, others such as diffraction gratings due to regular nanoscopic structure of the epidermis [6] have been omitted in this work. A deeper comparison or combination between the two mechanisms is left as future work.

Our appearance model is potentially capable of generating a wide range of appearances. Nevertheless, only a relatively small subset corresponds to real snakes' appearances. Exploring a wider range of snakes, as well as a broader set of reptiles and fishes that present comparable structure in their skin, is an interesting avenue of future work.

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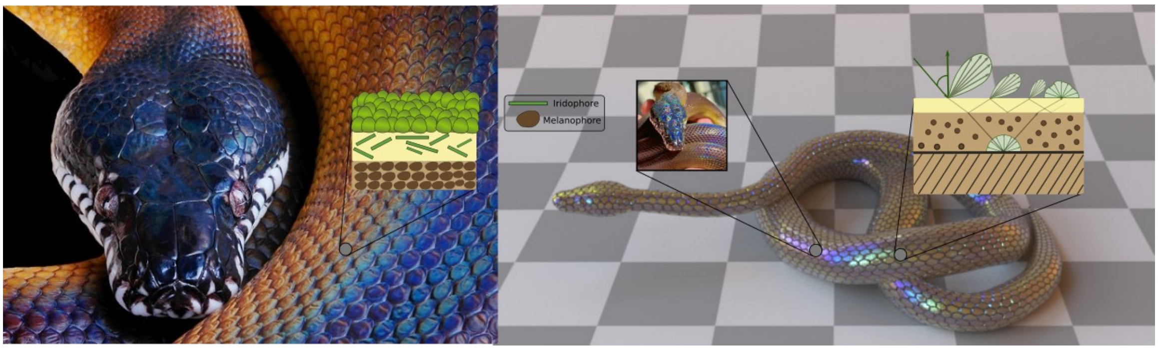
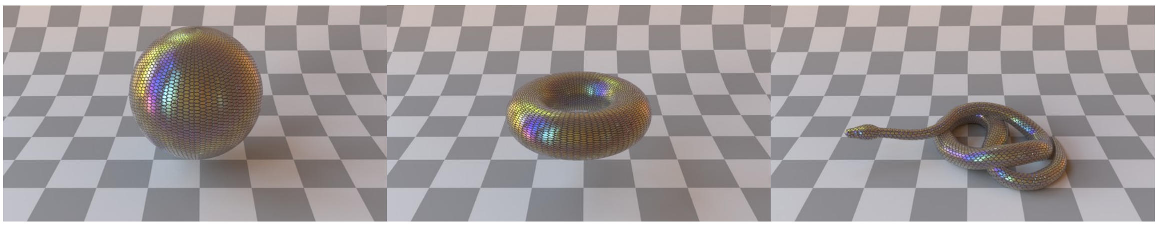


Figure 1: **Left:** Real photograph of a white lipped python [3]. A reptile scale is a biological tissue composed of multiple layers of chromatophores (see right inset) like irodophores (platelets) and melanophores (irregular ellipses). **Right:** A rendering of a snake 3D model using our practical reptile skin reflectance model roughly matching the general appearance. The snake skin is represented as a multilayered material with two layers (right inset): a thin film layer responsible for the iridescent patterns and a diffuse substrate surrounded by an absorbing media responsible for the darkening of the final appearance.



Sphere **Toroid** **Snake**

Figure 2: Renderings of several geometries (sphere, toroid and snake) using our practical reptile skin reflectance model. BSDF parameters: iridescent layer ($\eta_0 = 1$, $\eta_1 = 1.56$, $\eta_2 = 1.0$, $\delta_0 = 900$ nm), absorption layer ($\sigma_a = 0.7$, $\delta_1 = 2$ nm).