Visualization of Color as Birds See It

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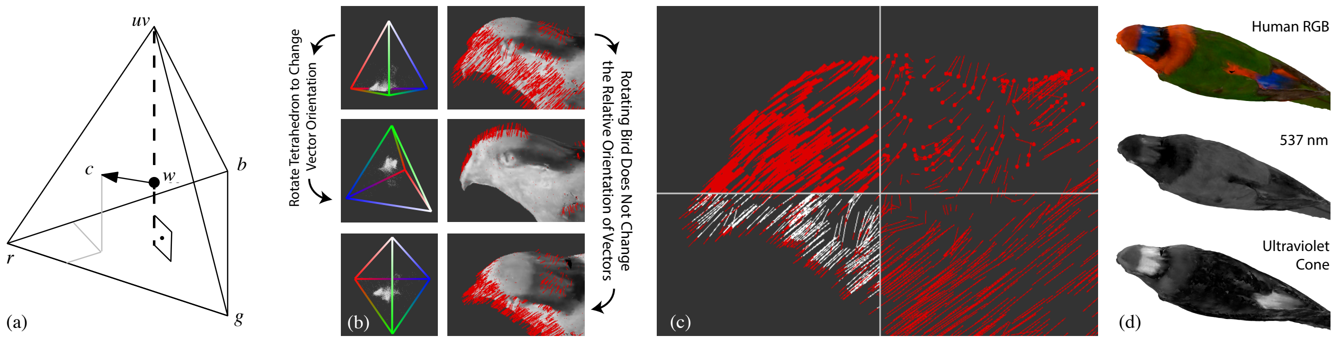

Figure 1: *(a) Tetrahedron Geometry (b) Data Exploration Workflow (c) Different Vector Styles (d) Three Different Texture Maps*

1 Introduction

Our objective is to provide ornithologists with a tool for looking at 3D models of birds through the eyes of other birds. This tool overcomes the limits of the human visual system to allow scientists to quantify and analyze avian color in a completely novel way.

Avian color vision is tetrachromatic. In addition to the roughly human-like r, g, and b color cones, a bird's eye is also equipped with a uv cone. This extra cone plays a role in mate selection, camouflage detection, and food foraging, thus making avian (and other non-human) vision a point of interest for biologists [Stoddard and Prum 2011]. Because the uv color cone adds an extra color dimension, the chromaticity diagram gets extended from a triangle to a tetrahedron [Goldsmith 1990]. Consequently, each color can be visualized as either a point c in the tetrahedron, or a vector from w to c, see Fig. 1a. It is important to realize that monitors cannot display UV light and even if they could, the human eye would be incapable of perceiving it. Our dataset consists of a 3D model, a spectral texture, and an tetra-color texture. Our current pipeline acquires these spectra by using a coded-aperture [Kim et al. 2012] or by using a specialized multi-filter camera, while the 3D models are acquired by laser scanning museum bird specimens from Yale's Peabody Museum. The tetra-color texture is computed by convolving the respective avian response curves with the acquired spectra.

2 Our Visualizing Tool

We designed our tool with two primary use-cases in mind: 1) visualizing avian colors and 2) navigating and analyzing these data.

Each color is expressed as a unique vector, which is a standard approach with which ornithologists are familiar. Patches of roughly similar color are therefore visualized as patches of roughly parallel vectors (the user can choose between perspective and orthographic projection), allowing the user to make high-level judgments about the distribution and variation of color on the bird. As the vectors can point in any direction, some of them might be occluded by the bird's 3D model. To avoid this issue, the user can manipulate the tetrahedron's orientation (tetrahedron and the bird model are shown and manipulated separately), simultaneously changing the orientation of the vectors on the bird to reveal the desired data, see Fig. 1b.

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Alternatively, the user can choose not to display the bird surface and only show the vectors emanating from the nearest surfaces, hiding vectors emanating from occluded surfaces. To better anchor the vectors in space, we allow the user to choose between several visualization styles where the base and the tip of the vectors are easily discernible (Fig. 1c). Because our vectors represent avian colors, we intentionally avoid any complex color-coding (e.g. gradients, mapping data to color channels) within our visualization to avoid introducing any psychological bias for the human observer.

All vectors are also plotted as points in the tetrahedron. By selecting color patches on the bird, the user can isolate all corresponding points in the tetrahedron and vice versa. Lastly, we provide the user with the ability to plot the spectrum for any point or selection on the bird and to display the intensity texture for each spectral band (Fig. 1d).

3 Conclusions

Our tool gives biologists a new way to quantify and analyze spatial variation in coloration of animals in contexts where traditional visualization techniques are impractical. Our way of visualizing color using vectors, especially with the vectors possibly pointing inward, seems not to be mentioned in previous literature. Currently, the project is still a work in progress. We hope to further improve both the user experience and the visualization itself based on a small user study, possibly comparing our approach with methods with a possible human color perception bias. This work is supported by NSF 0852844.

References

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