Animal Vision – 2/3 Report

DESCRIPTION OF THE ALGORITHM

In order to simulate animal vision, we use the algorithm described hereafter, which makes use of the spectrum representation of an RGB triplet.

Let us first specify the transformation applied to a single pixel of the input image, which is described by an RGB triplet: The first step is to convert the RGB triplet to a spectral representation ranging from 380 - 720 nm using 10 equally sized bins. To obtain this representation we use the RGB values to linearly combine the known spectra of white, yellow, magenta, cyan, red, green and blue, making use of the method and spectral data described in [1].
In order to simulate the vision of a specific animal, we need to specify its cone sensitivities: this is done by defining a certain number of wavelengths which correspond to the peak cone sensitivities of the respective animal. As an example, the white-tailed deer has peak cone sensitivities at approximately 455 nm and 537 nm [2]. Having the spectral representation of the RGB triplet and the wavelengths to which the animal is most sensitive, we can now look up the values of the spectrum at these wavelengths. For the case of the deer this gives us two values, let's say 0.4 and 0.6. Using the inner product of the wavelengths with the spectrum values, we obtain the wavelength of the colour perceived by the animal, i.e., 0.4*455 + 0.6*537 = 504 nm for the example of the deer. However, before applying the inner product we need to normalize the spectral values, so as to make sure to stay in the range 380 - 720 nm. The final step is to map the obtained wavelength back to an RGB triplet, which is done using the values provided by [3] and using a discretization of 10 nm per RGB value.

In order to see the input image through the eyes of an animal we apply the above transformation to every pixel. To make the image appear more natural, we would like to preserve the luminance of the input image. Hence, we transform both input and simulated image to CIE 1976 L*a*b space using the Matlab built-in function *rgb2lab*. To assemble the final image, we use the luminance values of the original image and the a*b* values of the simulated image and transform it back to RGB.

MATLAB CODE

The following scripts/functions are provided in the Matlab Code:

- *main.m:* reads an image and displays it like an animal would see it (using the luminance of the original image). In the variable *sensitivities* one can specify the cone sensitivities of the animal we wish to simulate (ex: [420, 530, 560]. These wavelengths must be in ascending order and in the range 380-720 nm.)
- *img2Animal(in, sensitivities):* takes an image and transforms every pixel to the corresponding animal vision RGB triplet using the sensitivities specified above.
- *rgb2Animal(R, G, B, sensitivities):* transforms a single RGB triplet to the corresponding animal vision RGB triplet.
- *rgb2spectrum(red, green, blue):* converts an RGB triplet to a spectrum with 10 bins, ranging from 380nm to 720 nm.
- *wavelength2rgb(lambda):* takes a wavelength in the range 380-720 nm and outputs a corresponding RGB triplet using a discretization of 10 nm per RGB value.
- *getInterpolated(samplePoints, spectrum, x):* returns the value of the spectrum — which is only known at positions *samplePoints* — at wavelength x using interpolation.

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[1] Smits, Brian. "An RGB to Spectrum Conversion for Reflectances." (2000).

[2] VerCauteren, Kurt C. and Pipas, Michael J., "A review of color vision in white-tailed deer" (2003). USDA National Wildlife Research Center - Sta Publications. Paper 284.

[3] https://academo.org/demos/wavelength-to-colour-relationship/ . Accessed April 2017.

RESULTS

Below we show example outputs for

1. the made up cone sensitivities [390, 450],
2. the sensitivities [435, 546, 700] corresponding to the wavelength of blue, green and red
3. the sensitivities [455, 537] corresponding to the cone peak sensitivities of the white-tailed deer

1.

2.

3.

For comparison, the input image is the following[4] :

[4] taken from Flickr user zaveqna, "Apples," (2008). Accessed March 2017, https://www.flickr.com/photos/zaveqna/2872120203/