readicculus/animaloptics

Animal Vision Simulator

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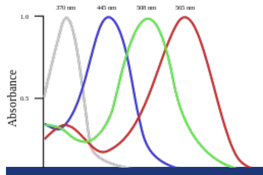
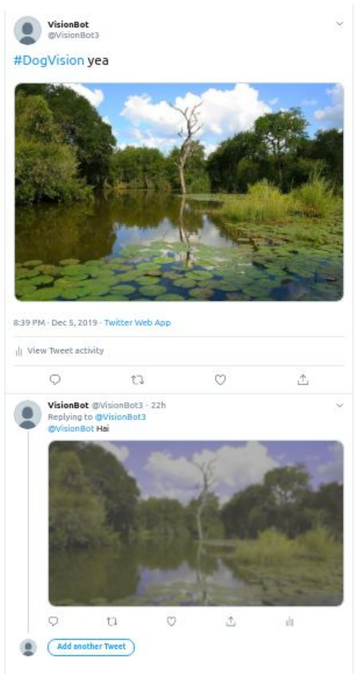


Introduction

For this project, we wanted to learn and implement methods to simulate the vision of different animals. To approximate what an animal might see, we needed to modify the colors of an image based on an animal's rods and cones, the brightness based on the animal's brightness discrimination, and the clarity based on visual acuity. We were able to create a framework using these techniques to simulate the vision of dogs and cats. We made this project accessible for people to try out by building a twitter bot that responds to tweets with a converted image that simulates the vision of the specified animal.

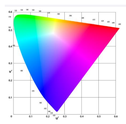
Twitter Bot

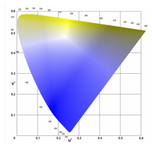
To make this project easily accessible, we built a twitter bot around our image processing framework. To use our bot, twitter users can post a picture that they want transformed along with the hashtag #DogVision or # CatVision. When running, our bot is constantly filtering tweets by the aforementioned hashtags using the Twitter API. If it finds a tweet with an appropriate hashtag, it downloads the image, converts it into the simulated animal, and replies to the original poster with the new image.



Methods

Cone Catch Modeling





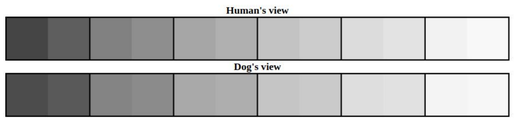
Human View

Dog View

These images show the full visible spectrum and how a dog may perceive the colors. Dog vision is very similar to humans with Deuteranopia, a type of colorblindness where there is no working green cone so reds are seen as brown/yellowish. [5]

Cone catch modelling means creating a model that maps one illumination spectrum into another. This model can then be used to map an image from the human color spectrum, or from the raw data a camera captures, into the spectrum that dog eyes capture or any other animal's spectrum. The issue here is to do this well you need to be able to normalize color and this would be impossible to do in our use case of simulating twitter images. It is possible however to calibrate a normalization function for a camera if they first take a picture of a color palette.

Brightness Discrimination



Ability to differentiate between different shades, and is measured by determining the smallest discernible difference in brightness (ΔR) relative to the absolute brightness (R).

- Weber fraction = ΔR/R
- For humans ~.11 [3]
- For dogs ~.22 [4]
- So dogs discriminate brightness about 2x worse.


/2 =

we can't simply divide by 2 as we get [0,127] too dark :(

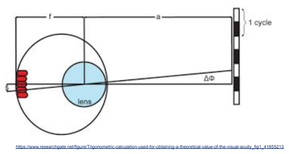
$$\text{brightness}_{mean} = (.3 \; \text{R} + .59 \; \text{G} + .11 \; \text{B})$$

$$\left(\text{I} + \text{brightness}_{mean}\right)/2 =$$

[0,256] but still half the brightness discrimination as humans :)

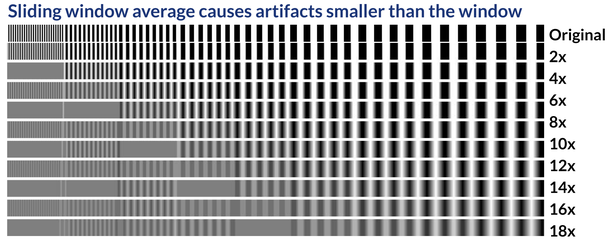
Visual Acuity

- Visual Acuity = 1/(gap size [arc min])
- Visual Angle measured in CPD (cycles per degrees)
  - CPD = 1/arctan(cyclewidth/distance)
  - Suppose at 36 ft away,can see .014ft wide cycle, then your CPD = 45, or 45 changes in color in one degree
  - Humans are estimate to average around 50-60 CPD but 20/20 is only 30 CPD
  - Dog ≈10CPD
  - More https://github.com/readicculus/animaloptics/tree/master/data [2]

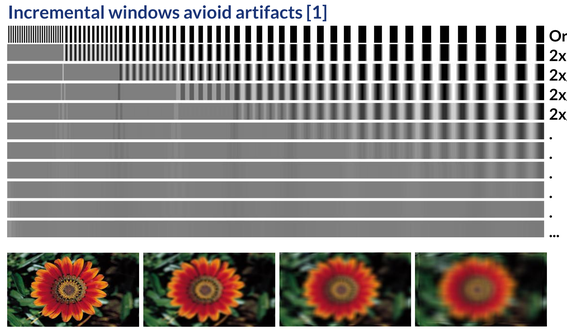


https://www.researchgate.net/figure/Trigonometric-calculation-used-for-obtaining-a-theoretical-value-of-the-visual-acuity_fig1_41659213

Sliding window average causes artifacts smaller than the window



Incremental windows avioid artifacts [1]



Putting it all together

Gamma expansion

Color model (dog)

Brightness discrimination

Acuity correction

Gamma compression

Concluding thoughts

This sort of stuff crosses many fields of study and we only brushed the surface in this study. We learned that color science is a field, that studying how animals see can be near impossible, and that regardless of how well you try to simulate something there is the whole other level that is how we perceive what we see[6]. As far as I know none of this is measurable and therefore evaluation impossible but seeing how your pup sees the world is an important and impactful step forward in your relationship. The twitter bot is currently in a prototype form but we do hope to expand on it and create more #hashtags for the people. Finally go check out theScinder/cuttleVision on github if you want to see some crazy cephalopod stuff.

References

[1] https://dog-vision.andraspeter.com/
[2] http://www.empiricalimaging.com/
[3] Griebel U, Schmid a (1997) Brightness discrimination ability in the West Indian manatee (Trichechus manatus). J. Exp. Biol. 200:1587-92.
[4] Pretterer G, Bubna-Littiz H, Windischbauer G, Gabler C, Griebel U (2004) Brightness discrimination in the dog. J. Vis. 4:241-249.
[5] https://blog.chartlr.com/post/125064641908/whos-afraid-of-red-orange-and-green
[6] https://en.wikipedia.org/wiki/George_M._Stratton