Emergent Orange

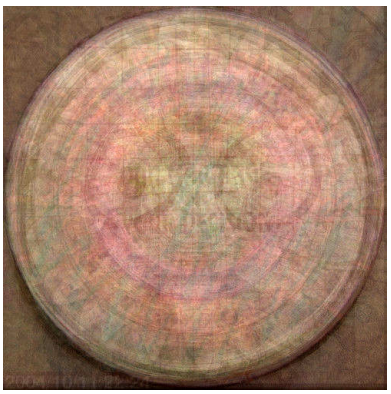
Jim Bumgardner
Disney Interactive Labs
jbum@jbum.com
www.krazydad.com

Abstract

When the pixels of multiple uncorrelated digital photographs are averaged together, the resultant hue skews orange. The effect is also observed in human-generated digital artwork.

Introduction

Since 2005, in the early days of Flickr, the social photography sharing website, I've been playing with combining large quantities of images in various ways. Fairly early on I discovered a group called Squared Circle that pools photographs that have nothing in common except that the images contain a large circle that fills a square frame (figure 1). I produced a number of mosaics using these images (figure 7).



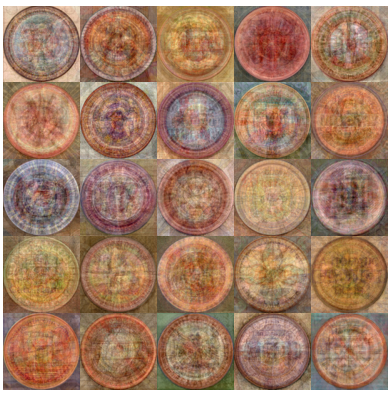


Figure 1 (left): 25 *Images from Flickr's Squared Circle pool*

Figure 2 (center): *25 squared circle images averaged together and normalized*

Figure 3 (right): *Twenty-five bronze shields, each made from 25 randomly selected images*

I also produced a number of composite or amalgam images by averaging several images together. For example, given 25 images, the red component of pixel[x,y] would be produced by averaging the red components of each of the 25 pixels in the same position in each of the 25 images. This produces a dull colored image. I brought out the contrast by normalizing the RGB components, which increases the saturation (figure 2).

I called these images "bronze shields" because they resembled primitive shields. I made a lot of them, and in doing so, I noticed a curious phenomenon (figure 3). Most of my bronze shields, even when made with as few as a dozen photos, tend to look orange! The more photos I use, the more reliable the effect is.

Further Investigation

At the time, the production of this color, which I now call *emergent orange*, seemed very counter-intuitive to me. The squared circle photographs were essentially uncorrelated, albeit in a very non-rigorous way. The only thing tying them together was the presence of a circular shape (which clearly shows up in these averaged images).

It seemed possible that the orange effect was specific to this particular collection of photographs, so I tried some other collections. I have found that every large Flickr pool I tried that didn't have a very strong intentional or subject-related color correlation (e.g. photos tagged "pink") produces this effect. Moreover, images collected from other sites, such as Instagram, or via Google Images also produce this effect.

I tried a number of specific digital image collections in an attempt to investigate some plausible theories as to what caused this orange color.

One explanation, which is often proposed to me, is that a lot of photos contain humans, and that this color resembles flesh tones. However, I have also observed emergent orange in pools of photos that exclude humans, such as the Graffiti pool on Flickr.

The level of saturation may differ, but the hue in these averaged images tends to fall within a fairly narrow area. If I look at results from a few other large uncorrelated image sets, I find the average hue in HSB space varies from about 16° to 27°, a range of about 10°.

Interestingly, I found it easier to obtain this result than to avoid it. I thought I could make the orange go away by combining a large collection of synthetic digital artwork (e.g. fractal renderings and other generative art). If the orange effect were caused by the nature of sunlight, or the chemical composition of the things being photographed, then perhaps synthetic abstract digital images wouldn't skew orange. Surprisingly, the pools of synthetic imagery that I found on Flickr do indeed skew orange (figure 4).

I find this effect in synthetic color and art collections particularly counter-intuitive. Perhaps it demonstrates that human abstract art intentionally or unintentionally mimics the colors found in the natural world.

To test the idea that the orange in synthetic art amalgams was coming from human choice, I did a synthetic art test of my own, in which the source artwork was generated with the aid of a pseudo-random number generator (PRNG), rather than a human. Amalgams produced using these source images, finally, showed no orange bias (figures 5 and 6).

Discussion

Since 2005, I have demonstrated the emergent orange effect a few times, and have heard a number of theories as to what causes it. Some of these theories are mutually conflicting. I'll offer a few of them here. Thus far, the theories fall into four general classes.

1) It's not real - it's an artifact of my method. For example, it's caused by JPEG compression, or has something to do with my choice of RGB space for my averaging.

2) It's caused by humans. For example, humans are making (and photographing) colors that contrast against the green of plants and the blue of the sky. Or it is somehow related to human color perception.

3) It's caused by the way cameras work. One suggestion is that it caused by white balance on cameras. One correspondent writes "Another point to think is the white balance and it's relation to the black body spectrum of illuminants used. ...the collective camera of the group under-estimates the color temperature of the illuminant, the colors won't be pushed far enough into the blue range when the white balance compensation is performed. And everything shows up more reddish-orangish."

4) It's caused by chemistry & physics. The amalgam photos are functioning as a kind of mass spectrometer, reflecting the average chemical composition of the subjects being photographed, and/or the chemical composition of the light sources shining on the objects being photographed.

Directions for Further Work

This is not intended to be a particularly rigorous paper. I am not trained as a scientist, and the images I made intentionally straddle the boundaries between science and art. Nonetheless, I can unequivocally state that the emergent orange effect is real and persistent. As I have pointed out, it is hard to avoid once you start averaging images together. It would be interesting to find a more rigorous way to confirm and measure it.

I imagine that people who have a deeper understanding of chemistry, optics and human color perception may have a fairly simple, prosaic explanation for this effect. If so, I'd love to hear about it.

Interestingly, and perhaps purely coincidentally, the hue value that is directly opposite emergent orange on the hue wheel is a close match for the color of the sky. The five year old in me still wants to know why the sky is blue.

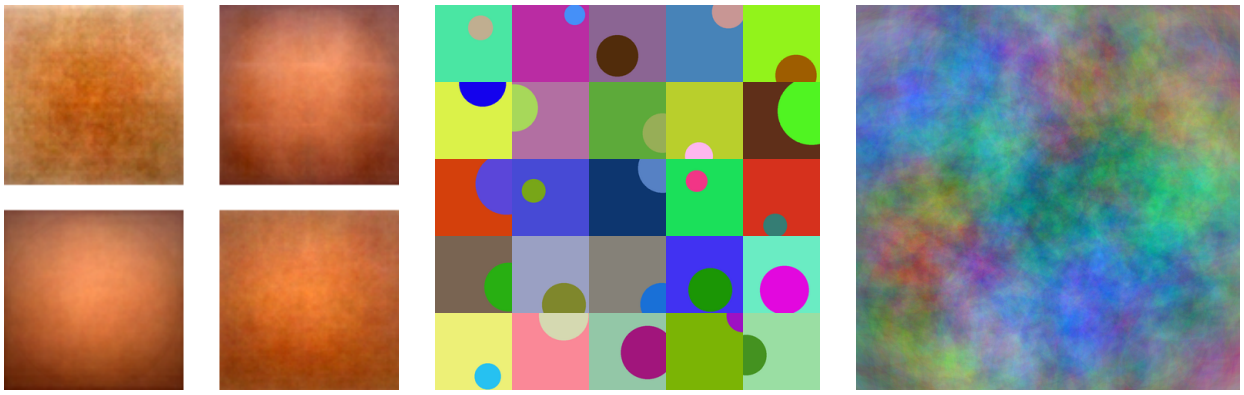


Figure 4: (left) *Averages of four different pools of digital abstract art found on Flickr. Pools used: Processing, CGArt, Computer Art Creations, Generative and Evolutionary Art*

Figures 5 (center): *Twenty-five simple images of a circle, produced using a PRNG. Each image contains a single circle, of random size and position. The foreground and background colors are randomly selected from all possible values.*

Figure 6 (right): *Normalized average of 2,000 randomly generated images, as from figure 5.*

Reproducing my results

I have written some sample Python code which produces amalgam images (that will exhibit the emergent orange effect) using a collection of randomly selected Flickr photos. You can find it in the following github archive.

https://github.com/jbum/emergent-orange

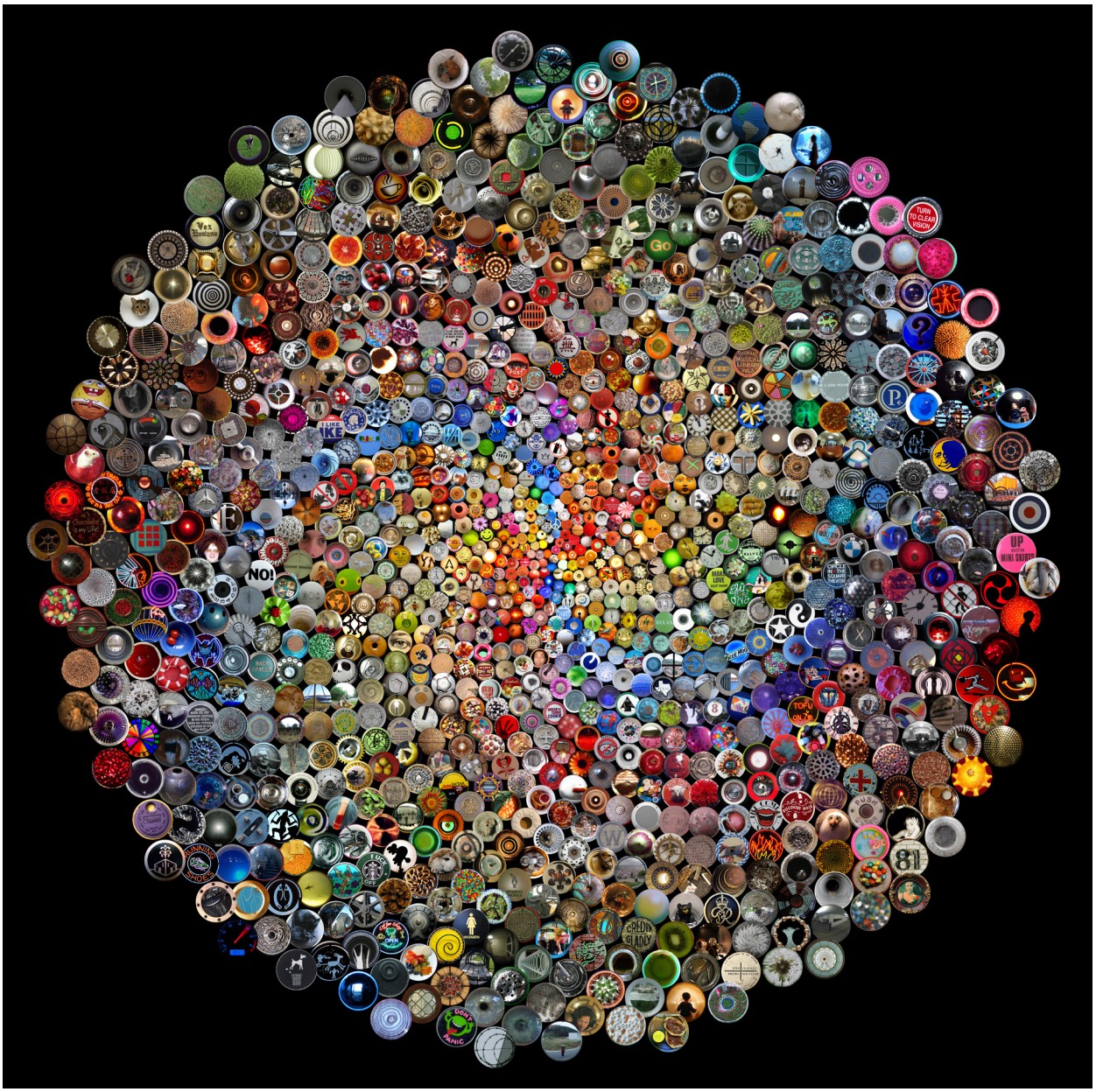


Figure 7: *Mosaic produced from Flickr's Squared Circle pool.*