Contrast

Simply put, the term contrast refers to the evaluation of difference. It is general term that can be used almost anywhere: a round thing may be contrasted with a square thing, a male may be contrasted with a female, our expectations may be contrasted with reality etc.

Contrast within color is important to painters for the simple reason that it constitutes their up and down in the navigation of their palette. Any such compass is important as color is such a devilish realm to pilot. As David Bachelor declared in his book Chromophobia [i]:

> *'Color is uncontainable... it effortlessly reveals the limits of language and evades our best attempts to impose a rational order on it'.*

Contrast is an easy word to use, but very difficult to use precisely. John Ruskin alluded to its importance when he wrote that, 'Of course the character of everything is best manifested by Contrast' [ii]. However, the literature on the topic is old, partial and wildly inconsistent [iii]. In the following pages I shall address some of the many forms that this beast assumes. It shall be a non-technical summary of some of what I have learned from three years of collaboration with engineers at Singapore's Nanyang Technological University whilst researching the topic of computational aesthetics.

Color as hue, saturation and lightness

I shall be addressing color as an expression of the three values: hue, saturation and lightness. These values are not the only way to chart color, nor are they the most accurate, but they are the most friendly to human understanding [iv].

Lightness and saturation both exist as dimensions of intensity that are measured according to ascending or descending values (e.g. lighter, darker, greyer, more colorful etc.). Hue exists as a dimension of quality that is commonly mapped by terms (e.g. red, green, purple etc). The word term was first used in this context by the perceptual psychologist W. H. Nault. It was Nault who demonstrated that children generally associate change in lightness and saturation with a change in intensity, such as depth, degree etc., however change in hue they associate with a change in quality, such as the difference between water, land, coral etc. [v].

Differences in quality are difficult to evaluate, which makes any addressal of hue contrast a problematic one. For example, can the average of blue and yellow be said to be green? Is red greater than purple? It is a topic that deserves more room than this article can afford and for this reason I shall avoid hue contrast and concentrate exclusively on lightness and saturation contrast. For our purposes we may assume that there are two types of contrast: local and global.

Local contrast

A local contrast is a contrast of one thing with another. The atomic indivisible of human judgment is the pair-wise comparison [vi] (e.g. 'A' is taller than 'B'). In the Rembrandt painting (Figure 1) region C can be described as being lighter than region B. This pairwise comparison may be staggered to include more values; hence region C is lighter than region B but darker than region A. Expressed in this way the fundamentally relative nature of local contrast is revealed.

In mathematics such evaluation through staggered, relative comparison lies at the heart of something called a sorting algorithm, using which large data sets may be sorted into meaningful configurations. In the same way the painter, in the manufacture of a painting, will sort its values by the application of many staggered local contrast appraisals. In this manner a blob of color on an artist's pallet may be considered as existing in a state of suspended animation, waiting to be related to other blobs of color within a painting. This observation is nicely validated by the Language Philosopher Diana Soeiro who declared that "Like mathematics, color is only demonstrated when we use it" [vii].

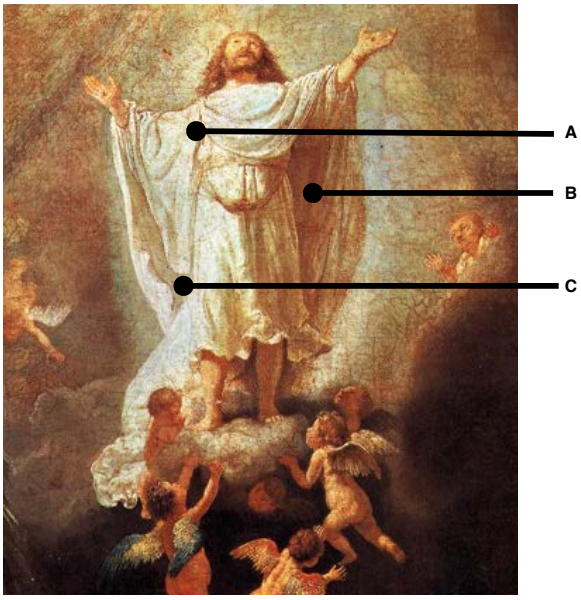

Figure 1. Rembrandt Van Rijn, The Ascension Of Christ (detail), (1636)

Global contrast

The global contrast of a painting is the contrast of all the values in that painting understood or expressed as a singular. In the case of the lightness and saturation values of a painting this is done with respect to its statistical extremes, i.e. its highest, lowest and average intensity values. Different to the ongoing nature of a local contrast appraisal, it is generally related to the finished 'fact' of the painting: that which has been left behind after the painter has finished (or died).

If the artist's contrast toolbox were an armory then the histogram would be an atomic bomb. It was invented 120 years ago but it is only since the development of the digital image that it has been commonly used to visualize the global intensity values of a picture. It can offer an elegant visual summery of the lightness and saturation global contrast of a painting and it can fairly be assumed that there is no digital photographer alive today who does not know how to read one. Figure 2 illustrates how nicely the histogram can visualize the difference between two paintings. See how the ‘top and tail’ of the Gwen John painting values are dark grey and light grey and how light the bulk of the values are, compared to the black to white, bottom-loaded values of the Rembrandt.

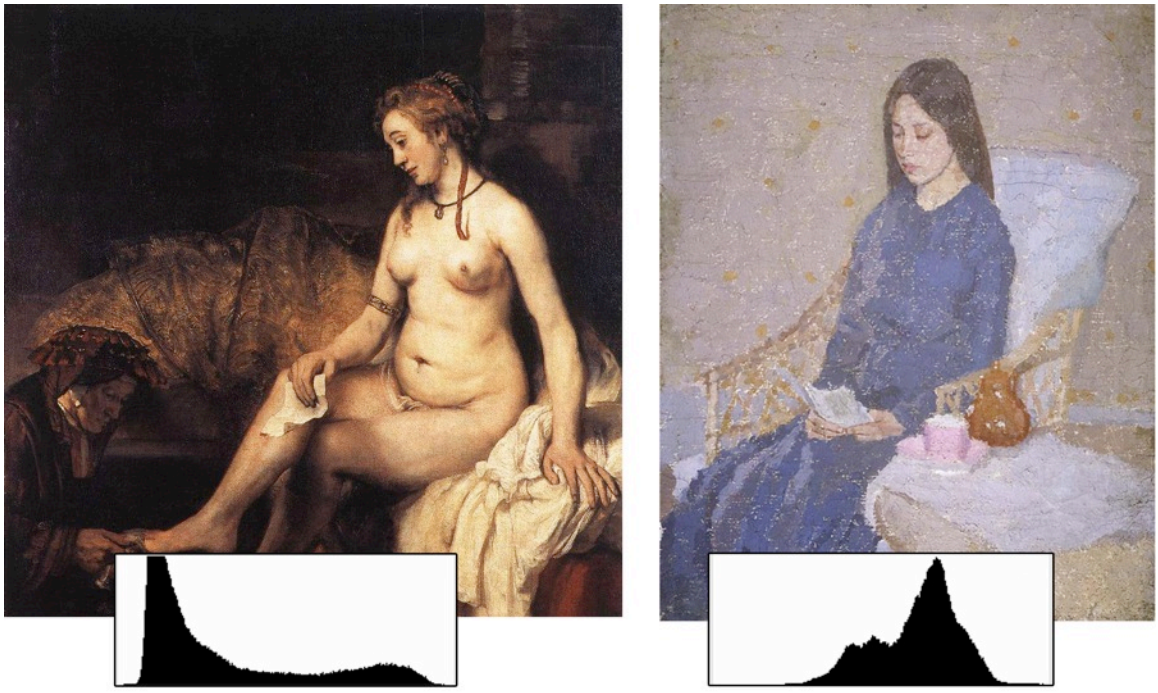

Figure 2. Top left: Rembrandt Van Rijn, Bathing Bathsheba (1654). Top right: Gwen John, The Convalescent (1918). Bottom: the histograms of these paintings.

The workings of a histogram are simple: imagine a painting chopped up into many even squares. These squares are arranged into stacks according to their average intensity values and these stacks are then further arranged in order of ascending intensity. A histogram is therefore blind to how values are spatially distributed. To illustrate this point, I present in Figure 3 two images that share nearly identical lightness histograms yet are plainly different in terms of contrast impact. This difference resides in the spatial distribution of their lightness values.

Figure 3. Top left: Rembrandt Van Rijn, Portrait of Nicholas Ruts (1631). Top right: Eugène Delacroix, The Good Samaritan (1849). Bottom: the histograms of these paintings.

Global contrast and spatial distribution

The importance of this spatial distribution becomes very apparent when lightness and saturation are considered. Hue, saturation, and lightness are generally co-dependent, but with a bias towards light. Should the hue and saturation of an image be changed, the lightness will be little affected. However, decrease the light till there is only blackness or increase it to the point of whiteness and hue will disappear and the saturation will flatline. In this way, lightness can be said to play the role of the master in the HSL triumvirate.

In most paintings the form of the saturation will be generally similar to that of the lightness, which in turn will be a close perceptual equivalent to the full color image. This is especially true of pre-modern paintings. In Figure 4 a painting by Gainsborough is shown together with its lightness and saturation values expressed as grey-scale maps. See how braodly similar all three images are.

Figure 4. Thomas Gainsborough, A Peasant Girl with Dog and Jug (1784), saturation map (middle) and lightness map (right).

Of course, this linking of lightness and saturation is not absolute. The two values will always lead different lives, but it was Delacroix who was the first to knowingly and aggressively unlink them. He was one of the first artists to take a serious interest in color theory and may disputably be regarded as Western art histories' first colorist. What is a colorist? In my view it is someone who recognizes that color (i.e. saturation and hue) may have a life that is significantly independent of lightness. Figure 5 shows a painting by Delacroix together with its lightness and saturation maps. See how the intense points of saturation are concentrated in a cluster, yet the lightness values are evenly distributed. See also how the lightness map is a close perceptual equivalent to the full color image, yet the saturation map seems to refer to a different painting altogether.

Figure 5 Eugene Delacroix, Still Life with Lobster (1826), saturation map (middle) and lightness map (right).

This unlinking was one of the key turning points of color application in Western art history and was rigorously and knowingly pursued by such artists as the impressionists, post impressionists, op artists and color field painters. An extreme example of its usage can be found in the painting ‘Impression, Sunrise’ by Monet (Figure 6), in which the visual impression of the sun is carried by the saturation, being almost invisible in the lightness map.

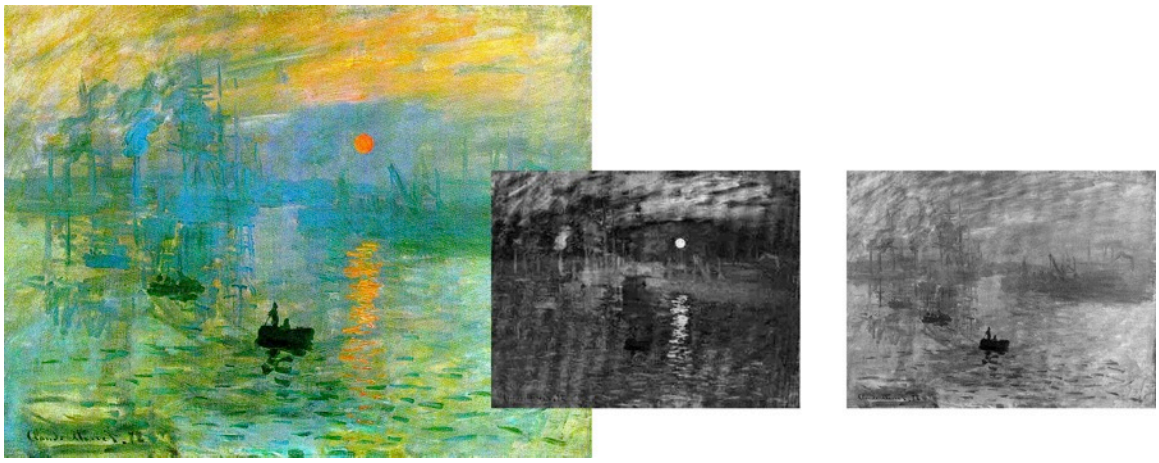

Figure 6 Edward Monet, Impression, Sunrise (1872), with lightness map (bottom left) and saturation map (bottom right).

This disengagement of saturation from lightness may be understood as a difference in the contrast impression between the two, which is in turn driven by the spatial distribution of these values.

Even-form spatial distribution:

> This manifests as a steady state of small-scale change in the spatial dimension (i.e. ‘speckled’) and a similar evenness of distribution in intensity values. Even-form is predominately, though not exclusively, associated with lightness.

Event-form spatial distribution:

> This manifests as infrequent and large-scale events in the spatial dimension (i.e. ‘clumpy’) and a sudden dark to light (i.e. ‘stepped’) appearance in intensity values. Event-form is predominately, though not exclusively, associated with saturation.

Defining Global Contrast

A histogram may fairly be described as a re-presentation of a painting: a painting that has been chopped up and re-assembled into a new form. It does not define global contrast, not unless you subscribe to the notion that a dismembered dog is a definition of a dog.

Mathematics provides us with two definitions that we can use to define global contrast (there are other definitions that are not suitable for the purpose). The Michelson contrast definition [viii] defines contrast in relation to its maximum and

minimum intensity values. It was invented by Albert Michelson (1852 – 1931) and it is of narrative testament to the conceptually fugitive nature of contrast that he was also the first person to measure the speed of light. For its dependence upon the highest and lowest values, the Michelson contrast definition is suitable for the purpose of defining the even-form nature of lightness global contrast.

Root Means Squared (RMS) contrast definition defines contrast as the average of the lightness in relation to its maximum possible (i.e. white) and minimum possible (i.e. black). For its dependence upon the variation of intensity the RMS contrast is suitable for the purpose of defining the event-form nature of saturation global contrast.

The useful thing about having a single, exact value to define a global contrast is that it can be used to evaluate groups of paintings from which general conclusions may be wrought. I present in the following section a highly précised account of a case study that our team performed that should illustrate this point.

Painters and the exaggeration of contrast

The Hudson River school of painters all operated around the 1830s and they got their name for their predilection for using the Hudson River and its environs as their subject matter. Being rooted in the romantic tradition, their skies were particularly notable. In our study these skies were isolated from the painting and analyzed according to their saturation and lightness global contrast values using RMS and Michelson contrast definitions respectively. These results were compared to a similar study of skies sourced from snapshot style photographs that were found online (Figure 7). Each image set comprised 30 images.

Figure 7. Left: Fredrick Edwin Church, Home by the Lake, 1852. Right: a snapshop photograph of the Hudson River area.

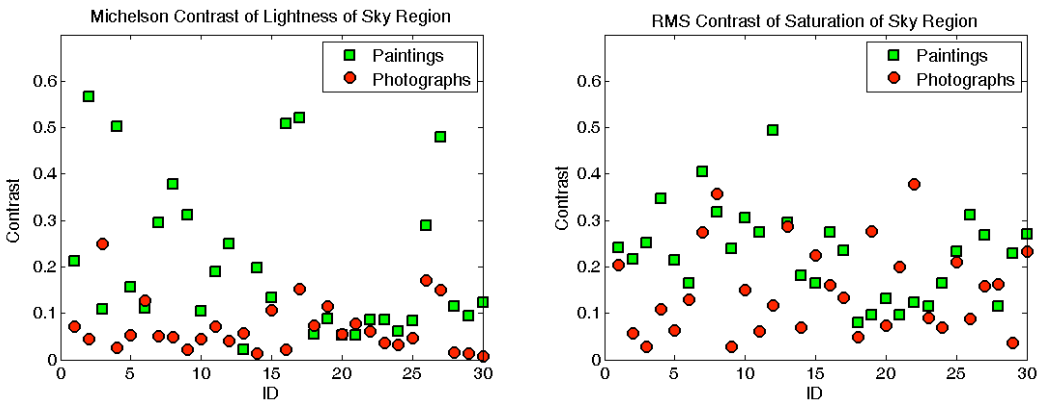

Figure 8. Left: Global lightness contrast (using the Michelson contrast definition) of the isolated sky regions of the Hudson River images (paintings and photographs). Right: Global saturation contrast (using the RMS contrast definition) of the same.

Though it is apparent that the global lightness and saturation contrast of the painted skies is generally higher than those of the photographs, there is also a significant number of paintings with very low global contrast values. If we define a scene of high visual interest as being one of high contrast, then these results (Figure 8) can be summarized thus:

- A real sky is usually very boring.
- A painter's sky is either very boring, or wildly interesting.

A wonderful validation of this observation may be found in the work of the German art theorist Rudolph Arnheim who declared in his book 'Art and Visual Perception' [ix] that 'a configuration of colors will strive either toward contrast or toward assimilation'. Thus our results support the simple dictum: that it is an artist's job to exaggerate and that this may be an exaggeration of similarity or of difference.

Conclusion

When I was an art student I had a reputation for being a dreadful colorist. The advice I received from my art teachers was vague, confusing and contradictory. This was not willful obfuscation on their part but rather a natural response to the complexity and perversity of color. With its multiple dimensions and its heavy reliance on the human perceptual apparatus, color is not a domain that is easy to chart. But things have changed since then: in the painting studios of the school where I now work I am able to access a range of powerful digital tools that may make complex points easier to digest and offer a compass to those who are lost in their pallets.

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i Batchelor, D., Chromophobia, (2000).

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iv Kuehni, R.G., Color Space and its Divisions, Color Order from Antiquity to the Present (2001).

v Nault, W. H., Children's Map Reading Abilities, (1967). Geographic Society of Chicago, Newsletter, III

vi L. L. Thurstone, A Law of Comparative Judgment, *Psychological Review,* (1927).

vii Soeiro, D. Colour as Mathematics: an Approach on Wittgenstein's‘ Remarks on Colour’ (Bemerkungen über die Farben), (2009).

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ix Arnheim, J., Art and Visual Perception, (1954).