Map Color and Other Channels

Introduction

- **Color**

The ***color*** is best understood in terms of three separate channels: luminance, hue, and saturation.

The major design choice for **colormap** construction is whether the intent is to distinguish between categorical attributes or to encode ordered attributes.

Sequential ordered colormaps show a progression of an attribute from a minimum to a maximum value, while diverging ordered colormaps have a visual indication of a zero point in the center where the attribute values diverge to negative on one side and positive on the other.

- **Color**

  Bivariate colormaps are designed to show two attributes simultaneously using carefully designed combinations of luminance, hue, and saturation.

  The characteristics of several more channels are also covered: the magnitude channels of size, angle, and curvature and the identity channels of shape and motion.

- The retina of the eye has 2 different kinds of receptors.
- The **rods** actively contribute to vision only in low-light.
- The main sensors in normal lighting conditions are the **cones**.
- There are 3 types of cones, each with peak sensitivities at a different wavelength within the spectrum of visible light.
- The visual system immediately processes these signals into three opponent color channels: one from red to green, one from blue to yellow, and one from black and white encoding luminance information.

Color Spaces

- The **color space** of what colors the human visual system can detect is three dimensional; that is, it can be adequately described using three separate axes.
- There are many ways to mathematically describe color as a space and to transform colors from one such space into another.
- Some of these are extremely convenient for computer manipulation, while others are a better match with the characteristics of human vision.

Four Levels of Design

- At the top is the situation level, where you consider the details of a particular *application domain* for vis.
- Next is the *what–why abstraction level*, where you map those domain-specific problems and data into forms that are *independent of the domain*.
- The following how level is the design of idioms that specify the approach to *visual encoding* and *interaction*.
- Finally, the last level is the *design of algorithms* to instantiate those idioms computationally

RGB System

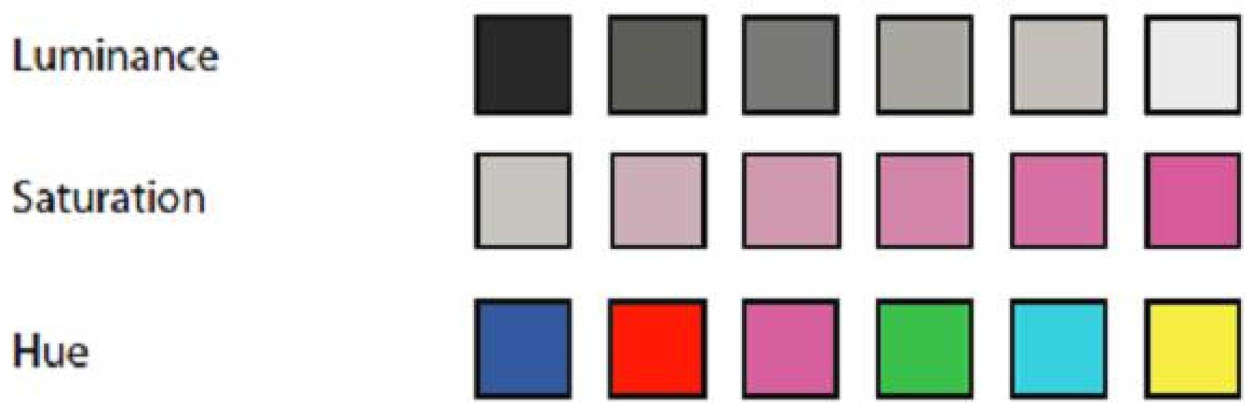
- The most common color space in computer graphics is the system where colors are specified as triples of red, green, and blue values.
- Although this system is computationally convenient, it is a very poor match for the mechanics of how we see.
- The red, green, and blue axes of the RGB color space are not useful as separable channels; they give rise to the integral perception of a color.

steps

HSL System

- The hue–saturation–lightness or **HSL** system is more intuitive and is heavily used by artists and designers.
- The **hue** axis captures what we normally think of as pure colors that are not mixed with white or black: red, blue, green, yellow, purple, and so on.
- The **saturation** axis is the amount of white mixed with that pure color. For instance, pink is a partially desaturated red.
- The **lightness** axis is the amount of black mixed with a color.

- Color can be confusing in visual analysis because it is sometimes used as a magnitude channel and sometimes as an identity channel.
- *Luminance* and *saturation* are **magnitude** channels, while *hue* is a **identity** channel.



Transparency

- A fourth channel strongly related to the other three color channels is **transparency**: information can be encoded by decreasing the opacity of a mark from fully opaque to completely see-through.
- Transparency cannot be used independently of the other color channels because of its strong interaction effects with them.
- Transparency is used most often with superimposed layers, to create a foreground layer that is distinguishable from the background layer.
- It is frequently used redundantly, where the same information is encoded with another channel as well.

Colormaps

- A **colormap** specifies a mapping between colors and data values; that is, a visual encoding with color. Using color to encode data is a powerful and flexible design choice, but colormap design has many pitfalls for the unwary.
- Colormaps can be **categorical** or **ordered**, and ordered colormaps can be either **sequential** or **diverging**.

Categorical colormap

- A **categorical** colormap uses color to encode categories and groupings.
- Categorical colormaps are normally segmented. They are are also known as **qualitative** colormaps.
- Very effective when used appropriately; for categorical data, they are the next best channel after spatial position.
- Categorical colormaps are typically designed by using color as an integral identity channel to encode a single attribute, rather than to encode three completely separate attributes with the three channels of hue, saturation, and luminance.
- The number of discriminable colors for coding small separated regions is limited to between six and twelve bins.
- You should remember to include background color and any default object colors in your total count: some or all of the most basic choices of black, white, and gray are often devoted to those uses.
- Easily nameable colors are desirable, both for memorability and ability to discuss them using words.

Ordered Colormaps

- An **ordered** colormap is appropriate for encoding ordinal or quantitative attributes.
- A **sequential** colormap ranges from a minimum value to a maximum value.
- A **diverging** colormap has two hues at the endpoints and a neutral color as a midpoint, such as white, gray, or black, or a high-luminance color such as yellow.

Other Channels

Size Channels

- Size is a magnitude channel suitable for ordered data.
- Length is one-dimensional (1D) size; more specifically, height is vertical size and width is horizontal size. Area is two-dimensional (2D) size, and volume is three-dimensional (3D) size.
- Our judgements of length are extremely accurate.
- Our judgement of area is significantly less accurate.
- The volume channel is quite inaccurate.

Angle Channels

- The *angle* channel encodes magnitude information based on the **orientation** of a mark: the direction that it points.
- There are two slightly different ways to consider orientation that are essentially the same channel. With **angle**, the orientation of one line is judged with respect to another line. With **tilt**, an orientation is judged against the global frame of the display.
- This channel is somewhat less accurate than length and position, it is more accurate than area.

Curvature Channel

- The **curvature** channel is not very accurate, and it can only be used with line marks.
- It cannot be used with point marks that have no length, or area marks because their shape is fully constrained.
- The number of distinguishable bins for this channel is low, probably around two or three; it is in an equivalence class with volume (3D size) at the bottom of the magnitude channel ranking.

Shape Channels

- Shape as a identity channel that can be used with point and line marks.
- Applying the shape channel to line marks results in stipple patterns such as dotted and dashed lines.

Motion Channels

- Several kinds of **motion** are also visual channels, including **direction** of motion, **velocity** of motion, and flicker **frequency**.
- Motion is less studied than other channels.