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Bad Colourmaps Can Hide Big Structures

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Colourmaps are often selected with little awareness of the perceptual distortions they might introduce. A colourmap can be thought of as a line or curve drawn through a three dimensional colour space. Individual data values are mapped to positions along this line which, in turn, allows them to be mapped to a colour. For a colourmap to be effective it is important that the perceptual contrast that occurs as one moves along the line in the colour space is close to uniform.

Many colourmaps are designed as piecewise linear paths through RGB space. This is a poor colour space to use because it is not perceptually uniform. Accordingly many colourmaps supplied by vendors have uneven perceptual contrast over their range. They may include points of locally high colour contrast leading you to think there might be some anomaly in your data when there is none. Conversely, colourmaps may also have flat spots of low perceptual contrast that prevent you from seeing features in your data. In some cases it is possible for structures having a magnitude of 10% of the full data range to be completely hidden by a flat spot in the colourmap.

The deficiencies of many colourmaps can be revealed using a simple test image consisting of a high frequency sine wave superimposed on a ramp function. The amplitude of the sine wave is modulated from a maximum value at the top of the image to zero at the bottom. Ideally the sine wave should be uniformly visible across the image at all points on the ramp. For many colourmaps this will not be the case. At the very bottom of the image, where the sine wave amplitude has been modulated to 0, we just have a linear ramp which simply reproduces the colourmap. Given that the underlying data is a featureless ramp the colourmap should not induce the perception of any features across the bottom of the test image.

Good colourmaps are difficult to design. A greyscale colourmap is generally a safe choice but is not always what is desired. For non-greyscale colourmaps the perceptual colour contrast between adjacent entries of the map should be constant across the whole colourmap. In addition, and more importantly, the colour lightness change between successive entries in the colourmap should also be constant. These conditions, if observed, constrain the design of colourmaps considerably, and they exclude the construction of rainbow style colourmaps. It is shown that good colourmaps can be formed from smooth curves constructed in a perceptually uniform colour space such as CIELAB. Colour lightness values should be monotonically increasing at a constant rate while at the same time the colourmap curve should stay close to the boundary of the colour space gamut to ensure that the colours are vivid.