Visualization, DD2257

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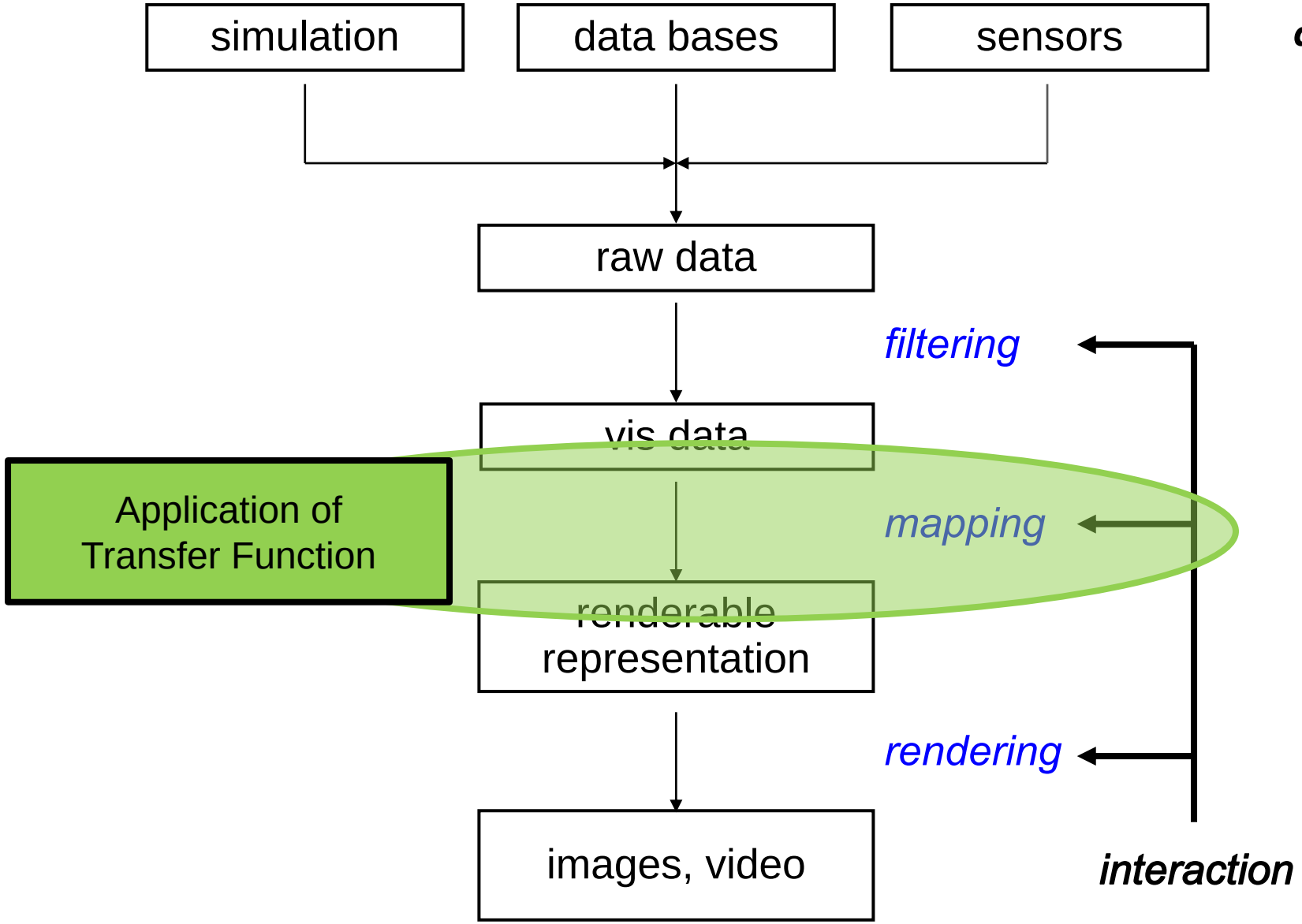
Transfer Functions

Definition

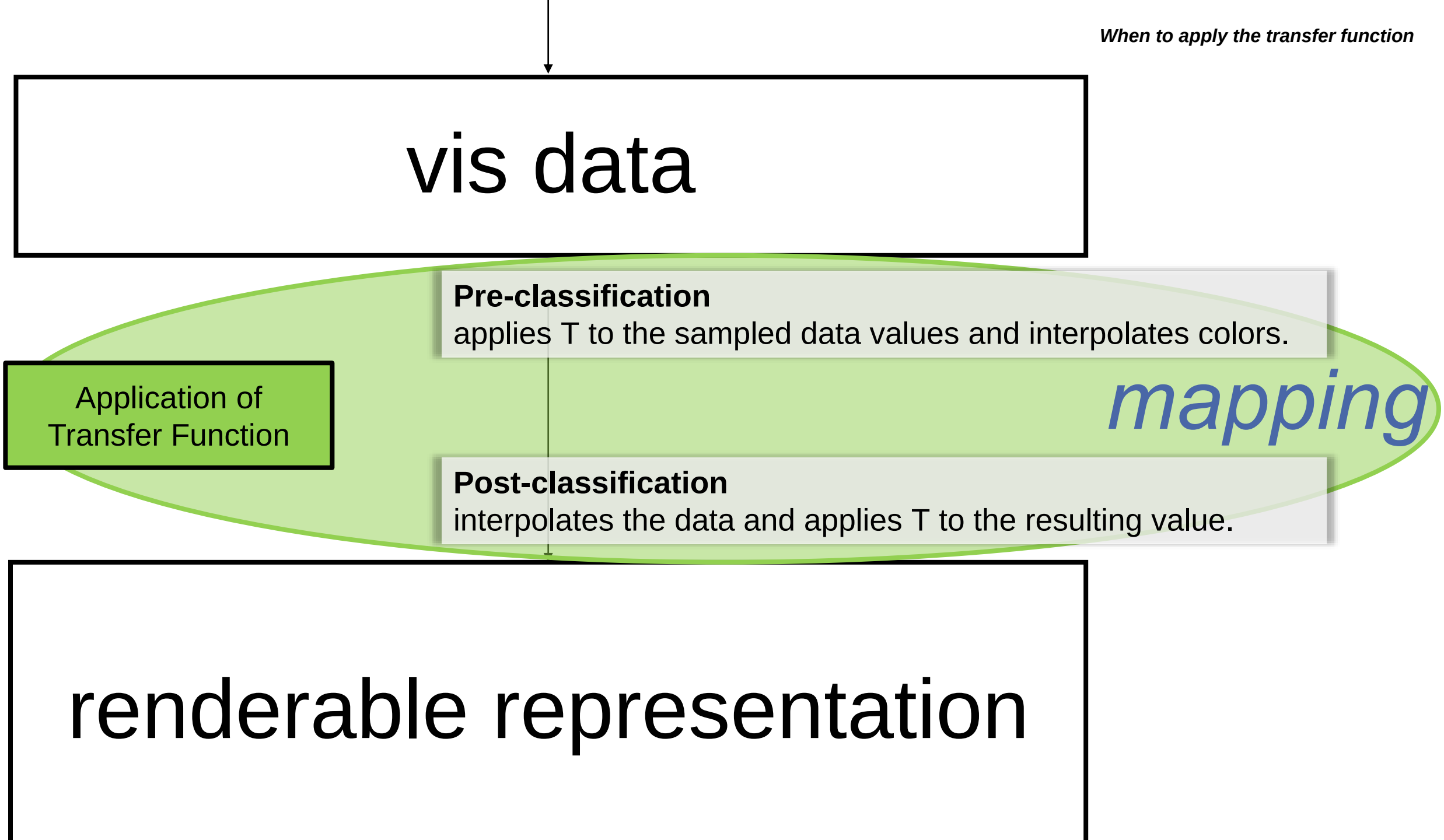
A **transfer function** maps data values to colors that can be used to visually display the data:

$$T : \mathbb{R} \rightarrow C$$

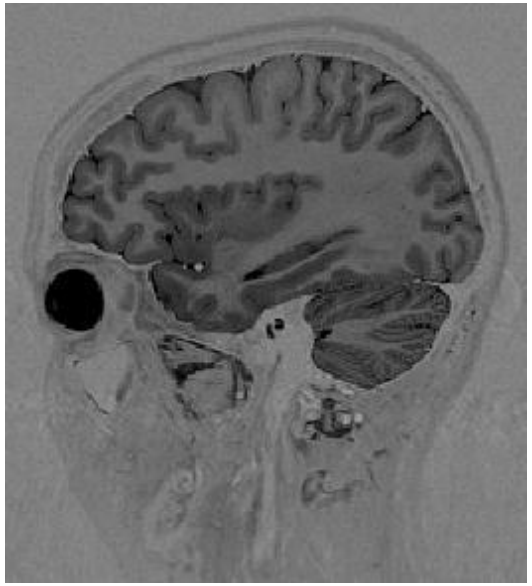
In most implementations, the color type C is a (red, green, blue) triple of either floating-point [0,1] or unsigned char [0,255] values.


simulation
data bases
sensors
data acquisition
raw data
filtering
vis data
Application of Transfer Function
mapping
renderable representation
rendering
images, video
interaction

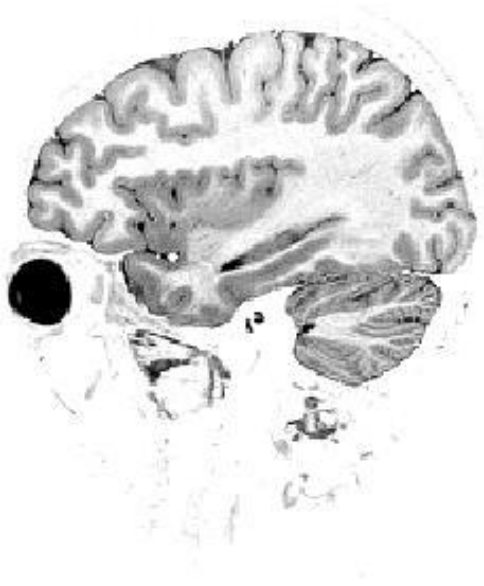
When to apply the transfer function



One of the simplest transfer functions maps a range of data values **(“window”)** to a linear ramp of grayscales. Values outside that range are mapped to black or white, respectively.



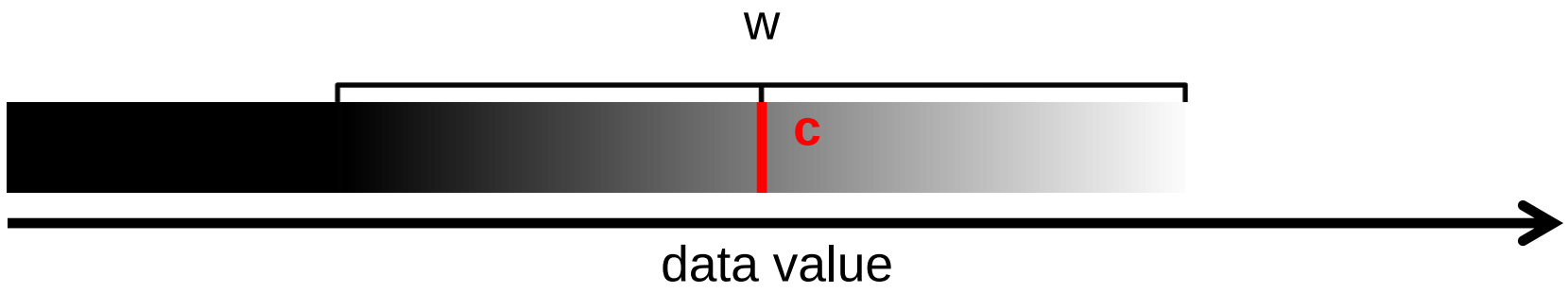
Full Data Range



Brain Window

Tissue Window

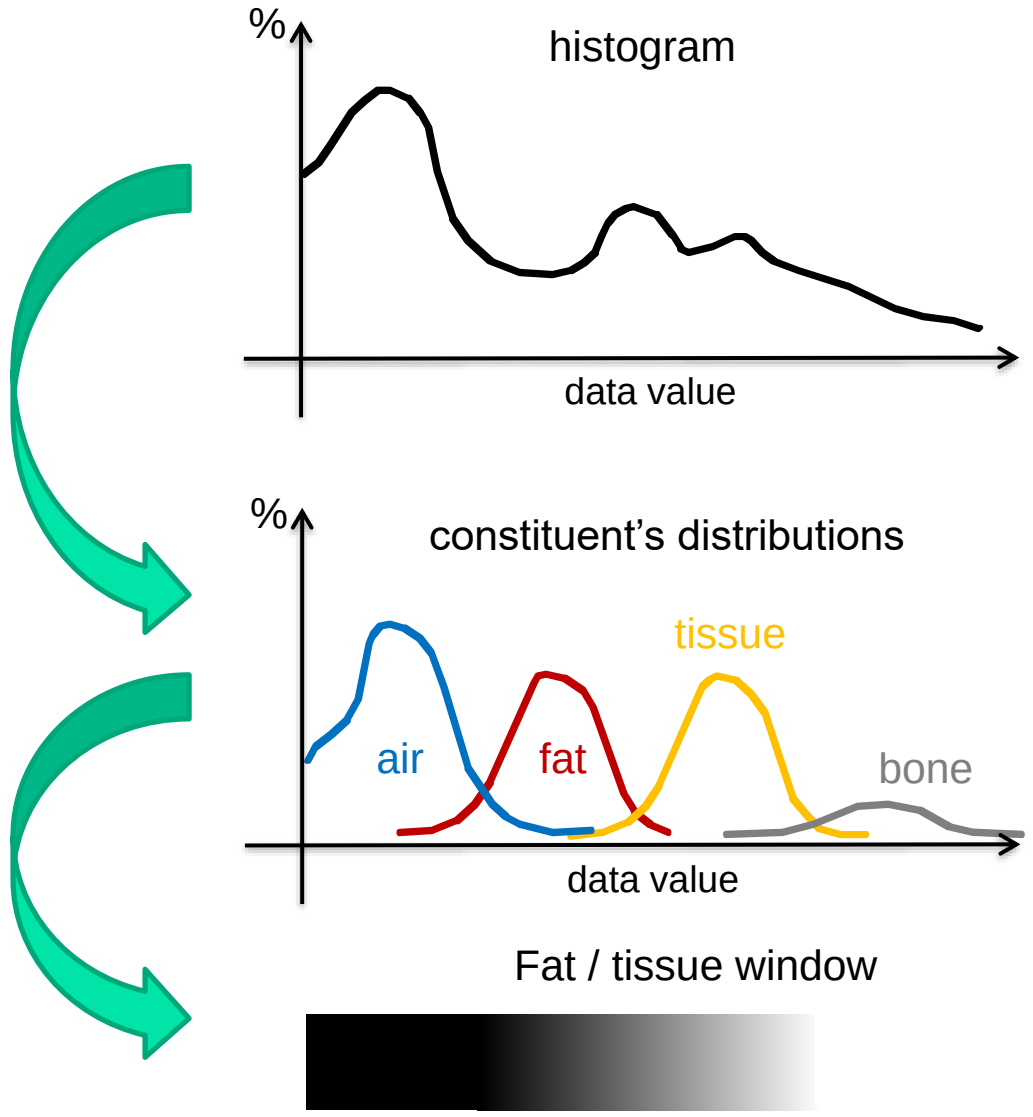
Windows are commonly defined by their center c and width w≥1.



For data value x and color output range C∈[0,1], the following pseudo-code applies:

```
if (x <= c - 0.5 - (w-1)/2) then C := 0
else if (x > c - 0.5 + (w-1)/2) then C := 1
else C := (x - (c - 0.5)) / (w-1) + 0.5
```

Histogram of all data values in a volume dataset:



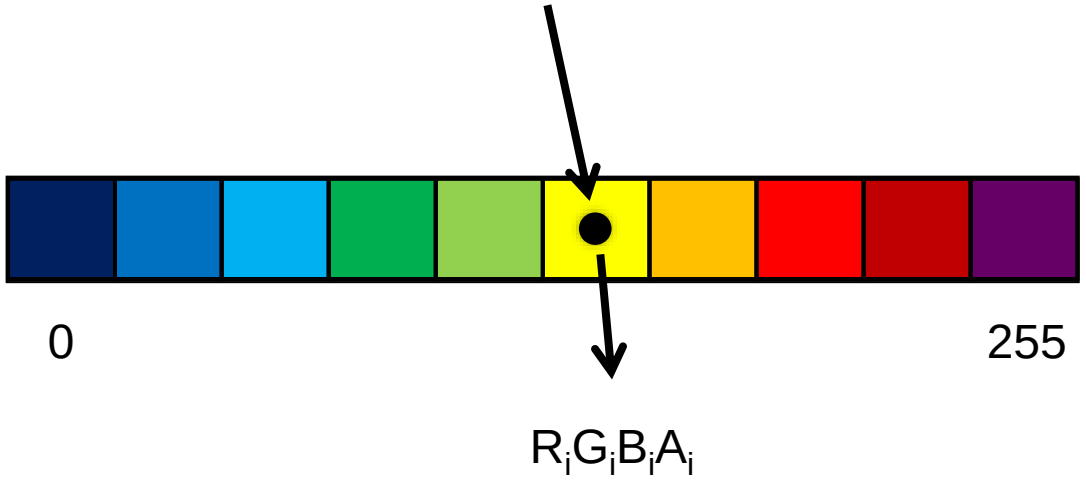
Implementations

Can be implemented as a color lookup table:

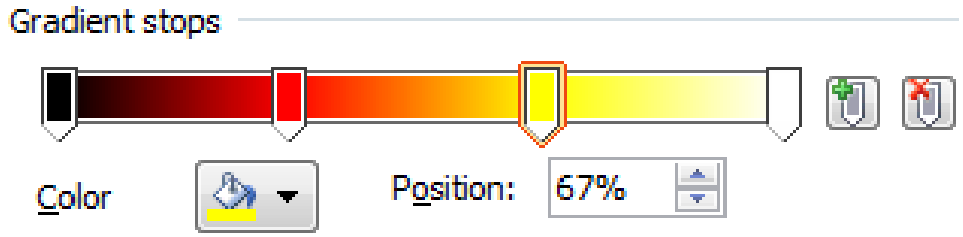
Scalar data $\in [d_{min}, d_{max}]$

$[d_{min}, d_{max}] \rightarrow [0, N-1]$

Index $\in [0, N-1]$



Often specified by defining the color for a discrete set of data values (“gradient stops”) and interpolating in between (e.g., in RGB):



All these examples show exactly the same data:

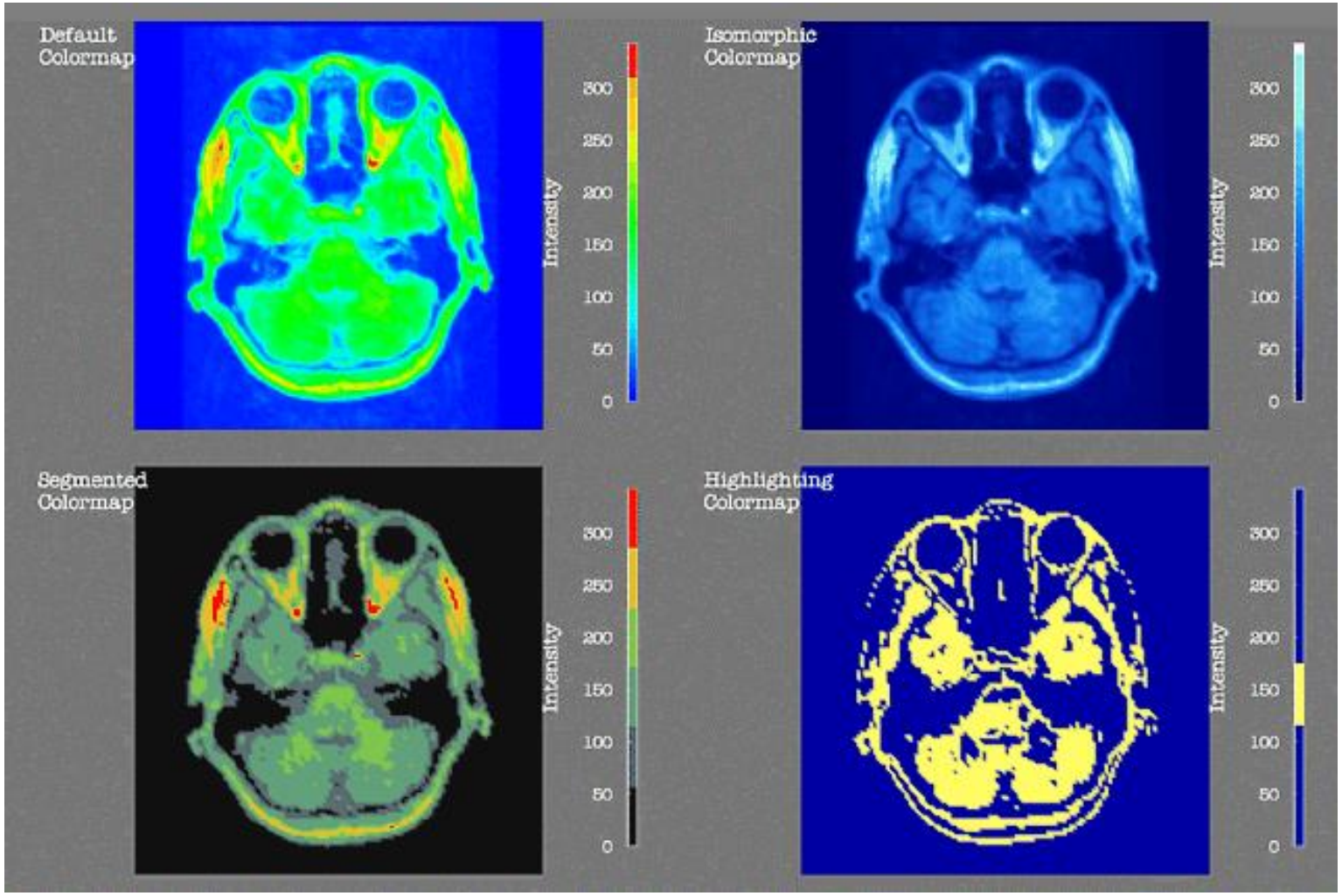


Image Source:
Rogowitz et al.

In this case, unnecessary surgery was performed based on a poorly adjusted color map:

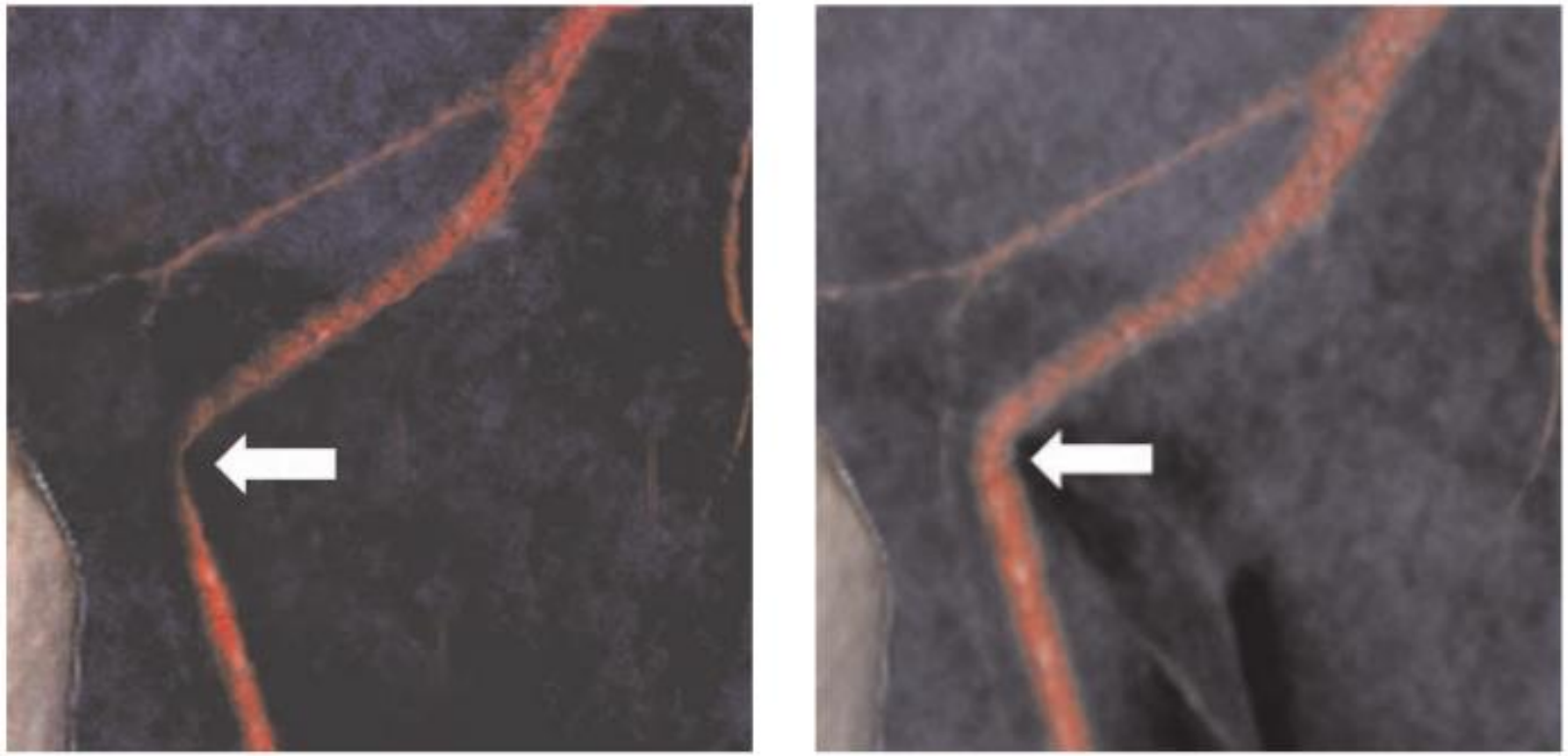
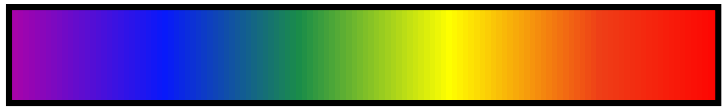


Image Source: Lundström et al.

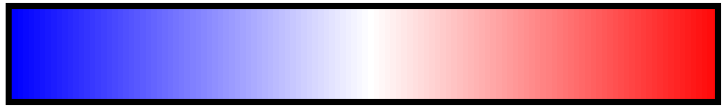
- Gray scale color table
  - Intuitive ordering

- Rainbow color table
  - Based on HSV color space



- “Black body radiation”

- Cool-to-warm



- Blue-to-yellow

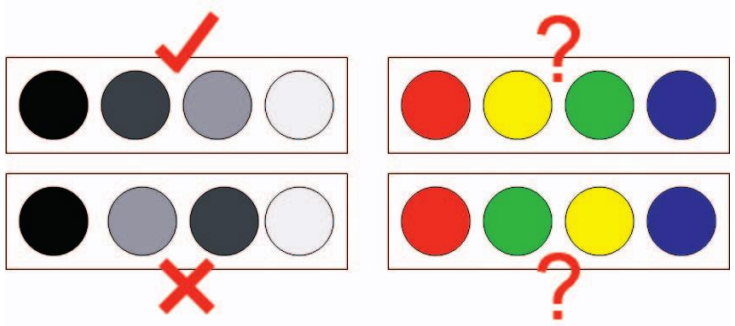
Some General Rules:

- Stick to conventions
  - Temperature: warm=red, cool=blue
  - fMRI: activation=red, deactivation=blue
  - “Natural” appearance (bone=white, muscle=red)
- When in doubt, interactively changing the transfer function can increase confidence
- 5-10% of the male population suffer from (partial) color blindness
  - Red-green weakness most common type
  - Women much less affected

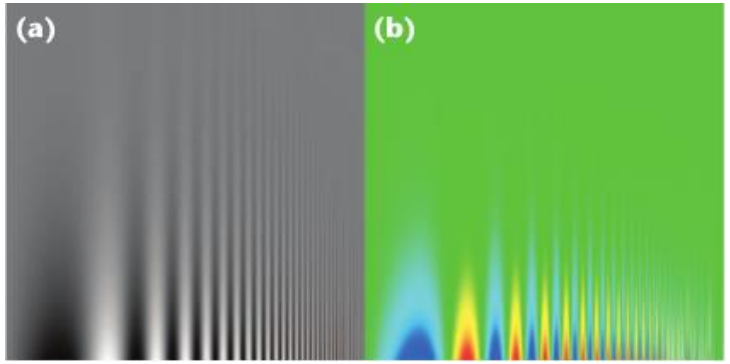
Issues with Rainbow Color Map

Default color map in many visualization systems, **but…**

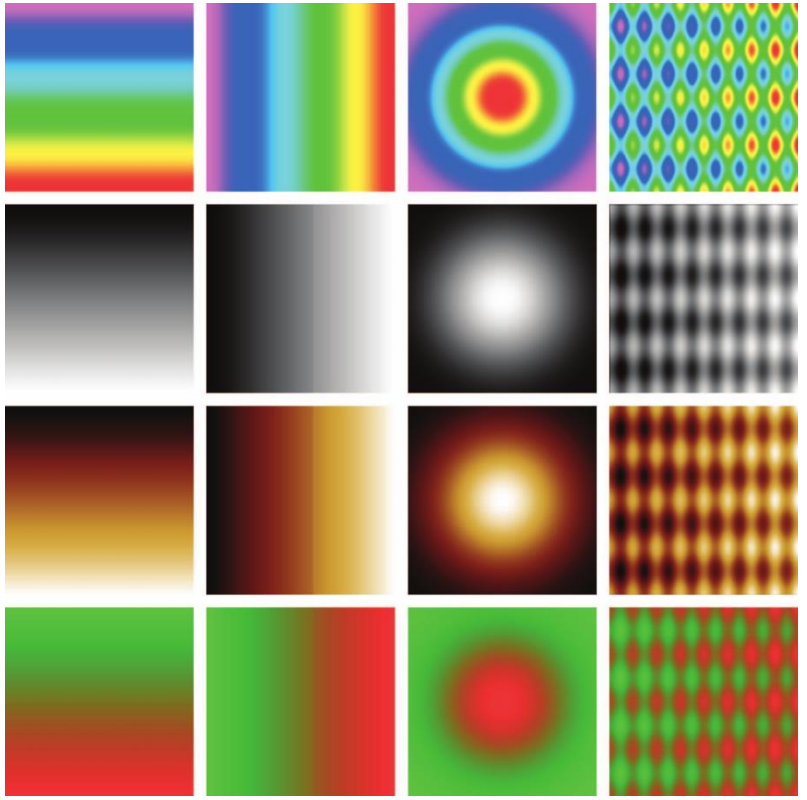
1. No intuitive ordering:



2. Can reduce sensitivity:



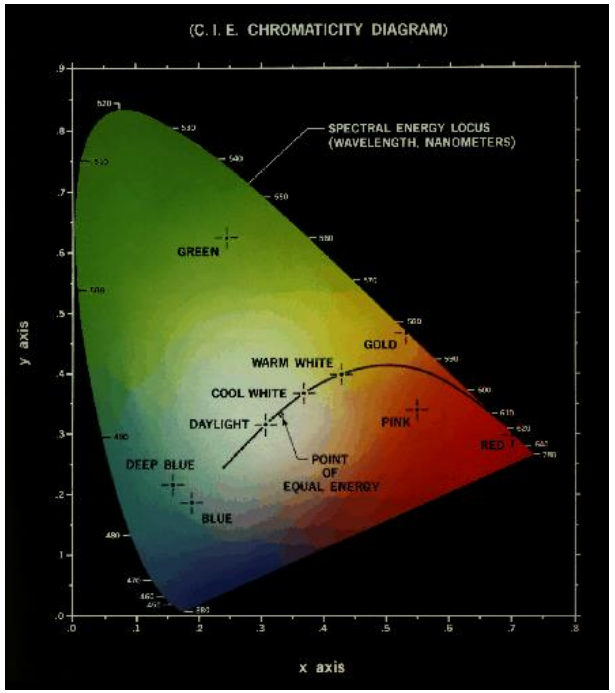
3. Artifactual gradients:

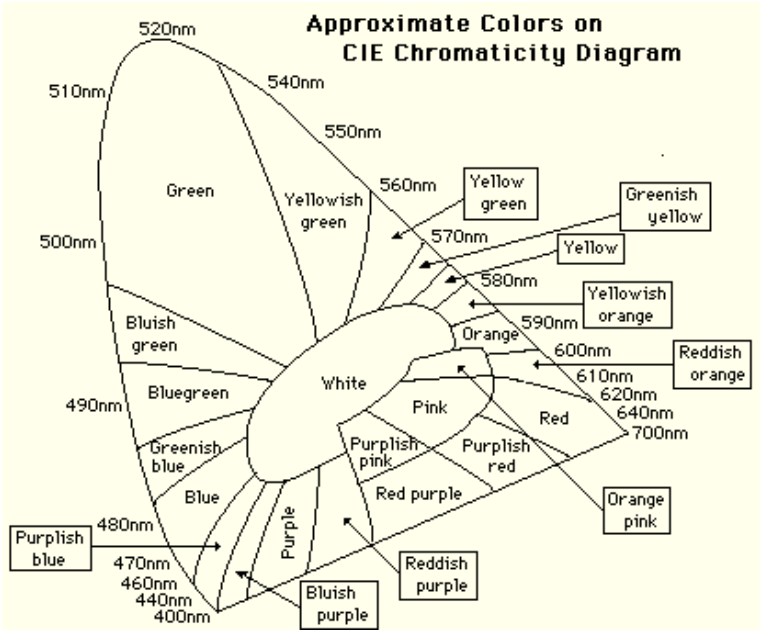


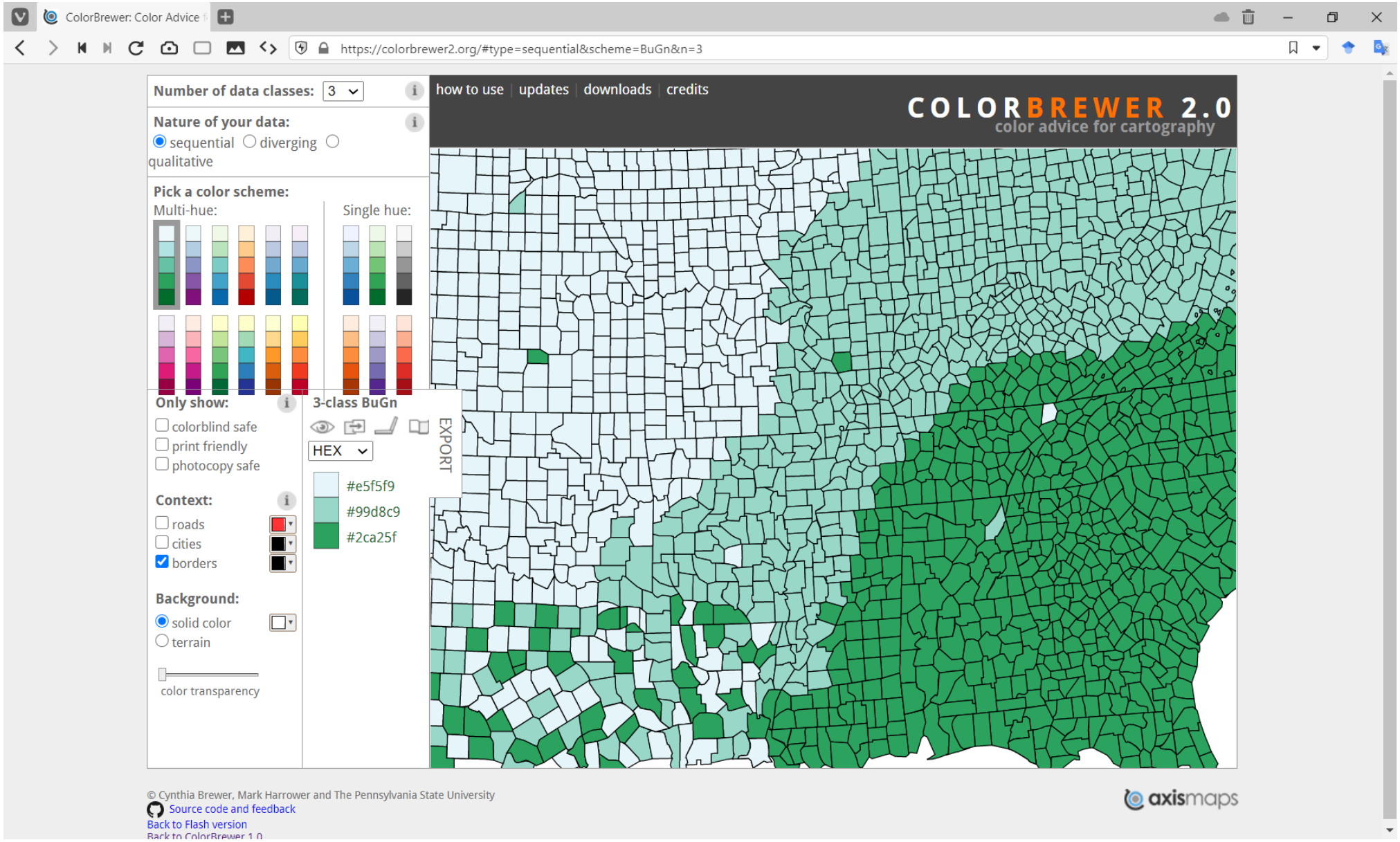
Reference: Borland/Taylor, Rainbow Color Map (Still) Considered Harmful, CG&A 2007

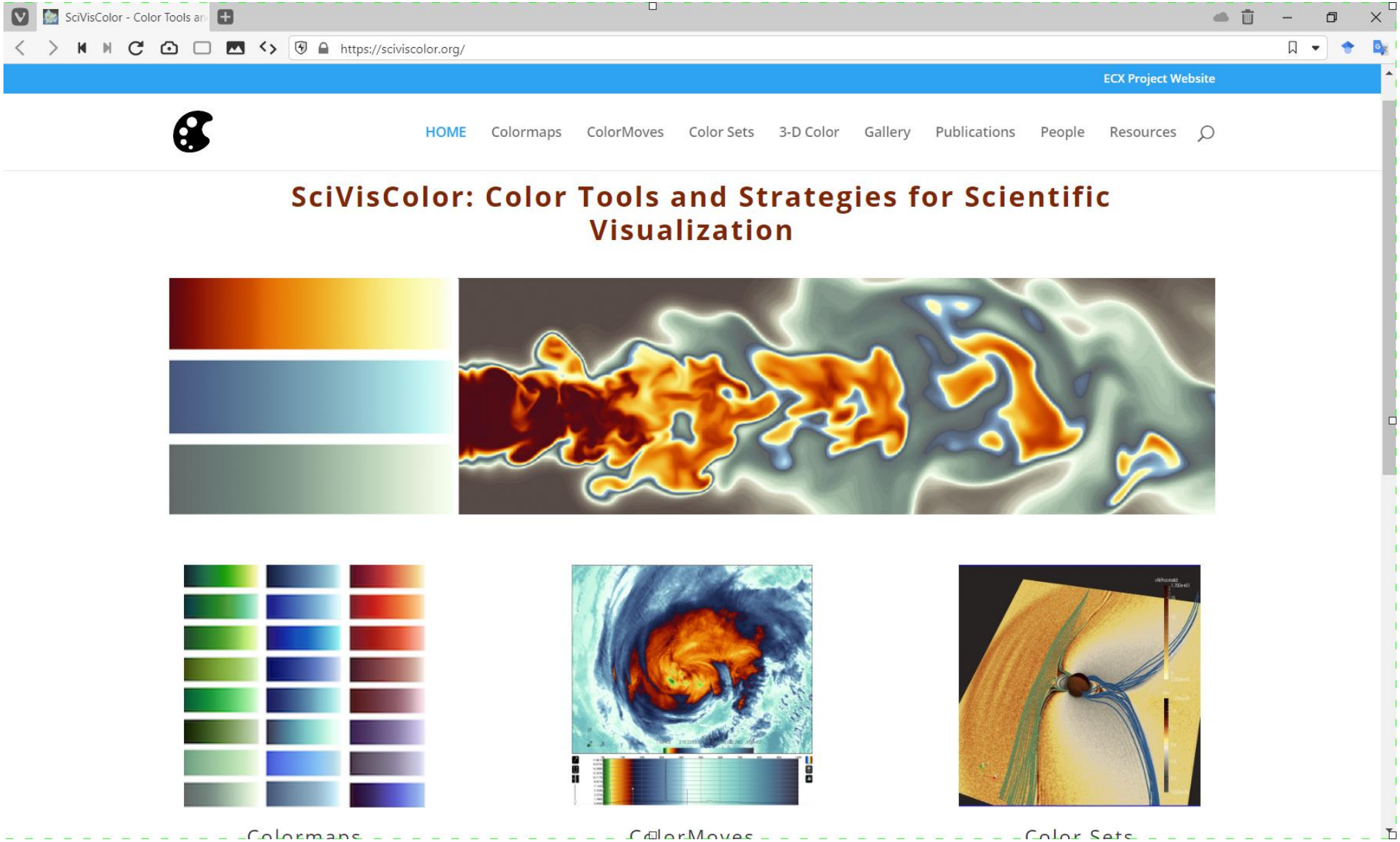
Around 9 basis colors are reliably distinguished:

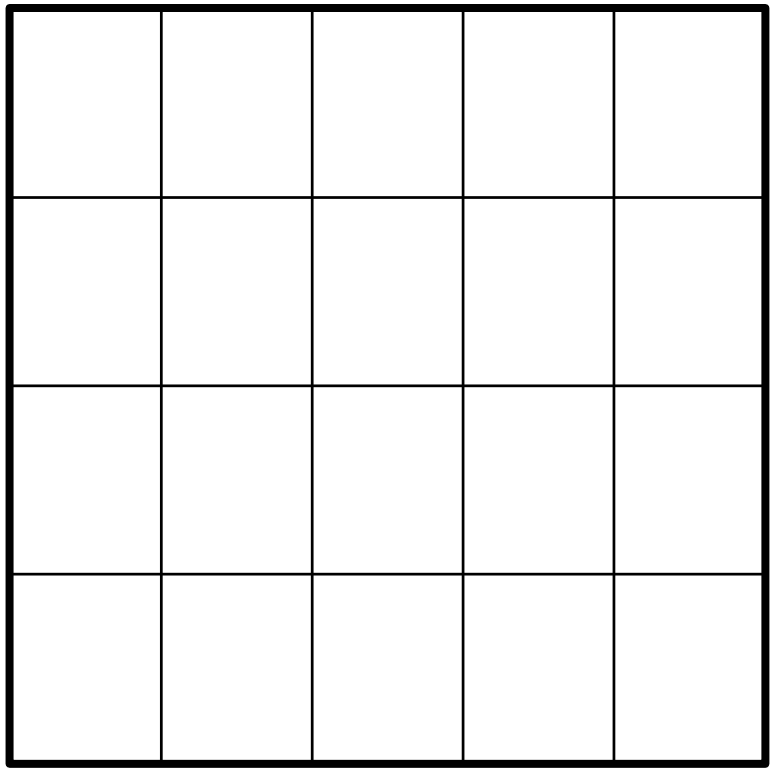
- Magenta (430 nm)
- Blue (476 nm)
- Blue-green (504 nm)
- Green (515 nm)
- Yellow green (556 nm)
- Yellow (582 nm)
- Orange (596 nm)
- Reddish orange (610 nm)
- Red (642 nm)



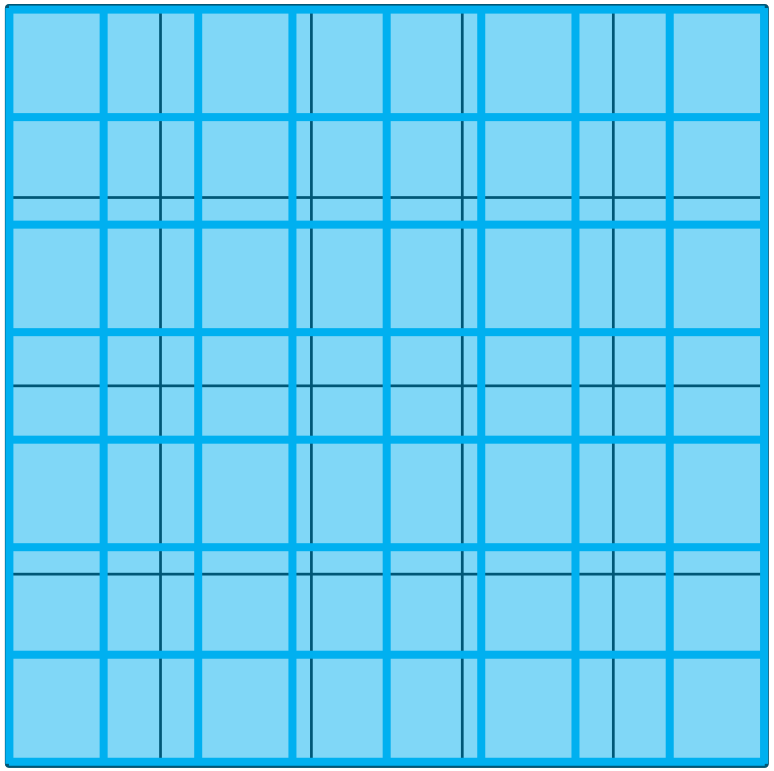



ColorBrewer: Color Advice
https://colorbrewer2.org/#type=sequential&scheme=BuGn&n=3
Number of data classes: 3
Nature of your data:
sequential diverging qualitative
Pick a color scheme:
Multi-hue:
Single hue:
Only show:
colorblind safe
print friendly
photocopy safe
Context:
roads
cities
borders
Background:
solid color
terrain
color transparency
3-class BuGn
HEX
#e5f5f9
#99d8c9
#2ca25f
EXPORT
how to use | updates | downloads | credits
COLORBREWER 2.0
color advice for cartography
© Cynthia Brewer, Mark Harrower and The Pennsylvania State University
Source code and feedback
Back to Flash version
Back to ColorBrewer 1.0
axismaps

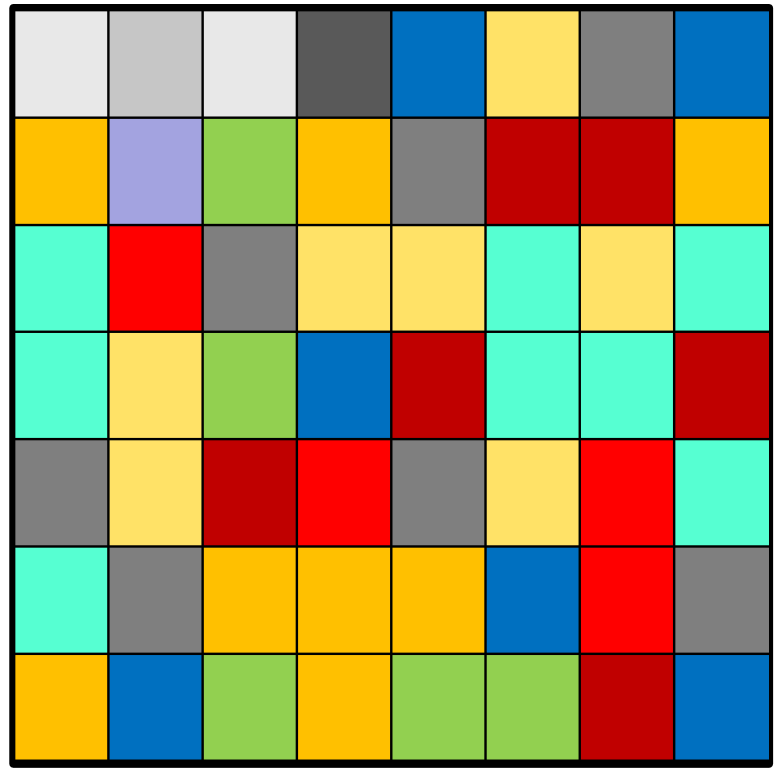

SciVisColor - Color Tools ar
https://sciviscolor.org/
ECX Project Website
HOME
Colormaps
ColorMoves
Color Sets
3-D Color
Gallery
Publications
People
Resources
SciVisColor: Color Tools and Strategies for Scientific Visualization
Colormaps
ColorMoves
Color Sets



2D scalar field



2D scalar field
overlaid pixel grid
transfer function



colored pixel grid

Summary

- Transfer Function maps data to color
  - pre-classification
  - post-classification
- Care when mapping to color
  - Potential to hide information
- Good color choices
- Color mapping for scalar field visualization