

“Rainbow Color Map (Still) Considered Harmful”

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- PhD in Computer Science from the University of North Carolina at Chapel Hill in 2007
- Currently working half-time as a research fellow for IDIBAPS at the EventLab, and half-time as the manager of the EventLab's new CAVE immersive virtual reality installation at the University de Barcelona Campus Mundet
- Research Interests: designing and implementing algorithms and applications for scientific visualization, computer graphics, visualization environments, virtual environments, image processing and analysis, and haptic interfaces
- Most cited paper : This one (19 citation)

Russell M. Taylor II

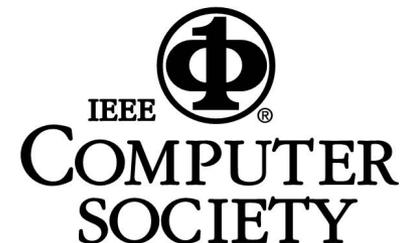
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- Research Professor of Computer Science,
- Physics & Astronomy, and Applied Physical Sciences at the University of North, Carolina at Chapel Hill
- Co-founder of Rheomics Incorporated, a company that is developing blood clotting diagnostics and a member of the board of directors for Pharaoh's Daughter
- Original developer and principal maintainer of the Virtual Reality Peripheral Network (VRPN) library. This public-domain software system provides local or networked access to various tracking, button, joystick, sound and other devices used in virtual-reality systems
- Most cited paper : VRPN: a device-independent, network-transparent VR peripheral system(101 citation)

IEEE Computer Society

- 1946, formation of the Subcommittee on Large-Scale Computing Devices (LCD) of the American Institute of Electrical Engineers (AIEE).
- 1951, the Institute of Radio Engineers (IRE) formed its Professional Group on Electronic Computers (PGEC). The principal volunteer officers of both these groups were designated chairs.
- The AIEE and the IRE merged in 1963 to become the Institute of Electrical and Electronics Engineers (IEEE).
- The Computer Society will celebrated its 70th anniversary in 2016.
- The IEEE Computer Society is the leading publisher of technical magazines, journals, and conference publications for computer science and related technologies.



Outline

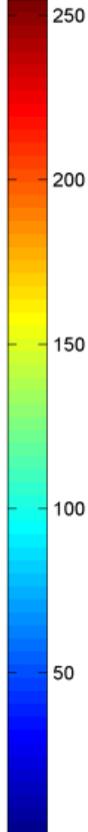
- Basic Idea of Rainbow Color Map
- Problems with the Rainbow Color Map
- Prevalence of the Rainbow Color Map
- Appropriate way to use
- Application to What-Why-How Framework
- Conclusion

Basic Idea of Rainbow Color Map

Original X-ray - left wrist



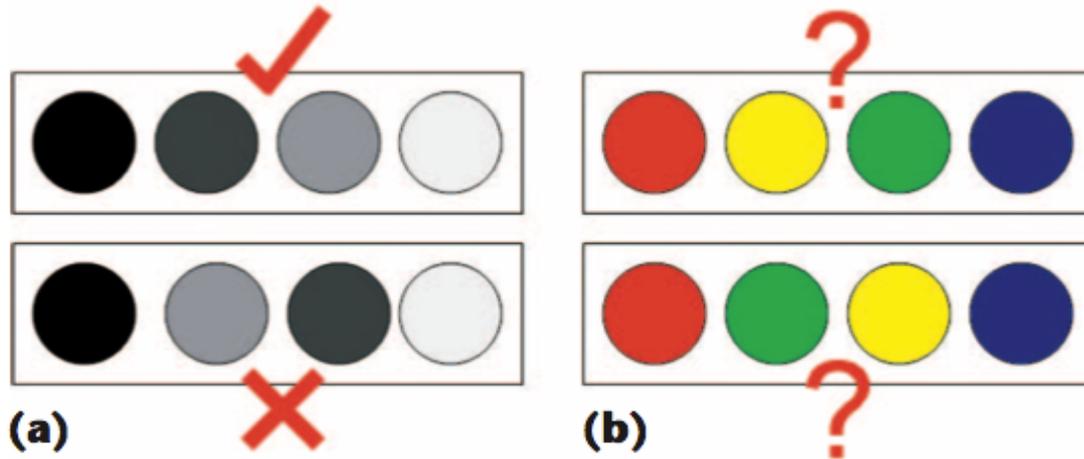
Original X-ray - left wrist - jet (rainbow) colormap



"A color map is used to assign colors to numbers, rainbow color map is based on the order of colors in the spectrum of visible light."

Problems with the Rainbow Color Map

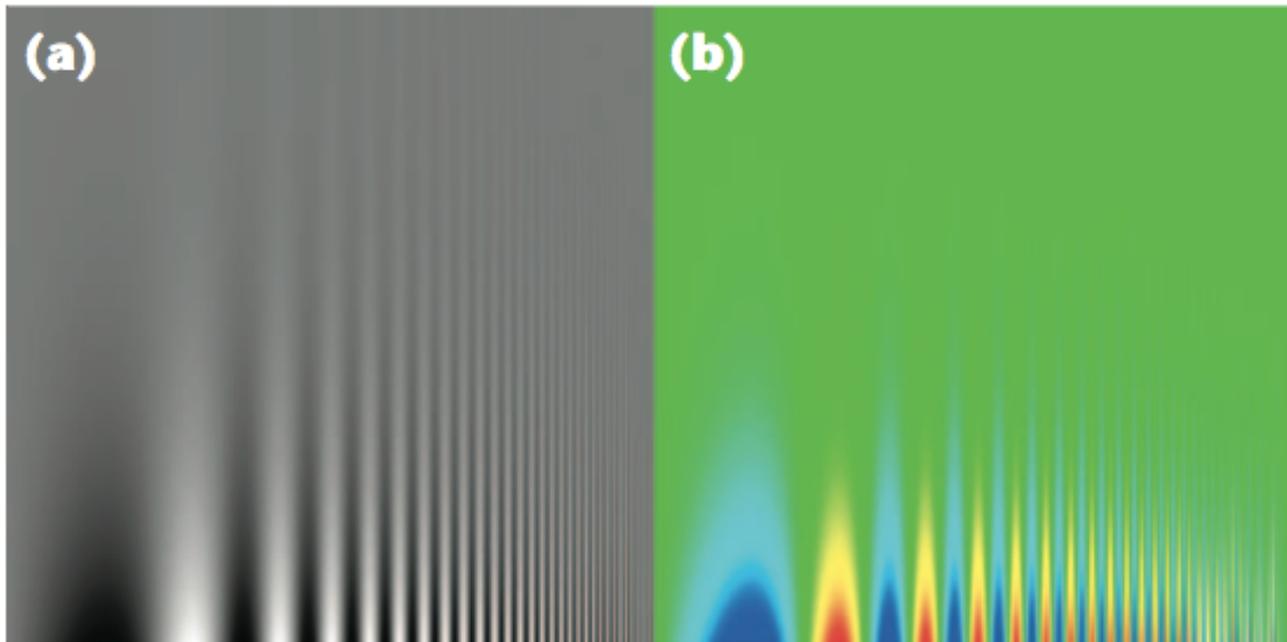
Confusing -Perceptual ordering



- (a) We can easily place the gray paint chips in order based on perception,
(b) but cannot do this with the colored chips

Problems with the Rainbow Color Map

Obscuring - apparent changes only at color boundaries



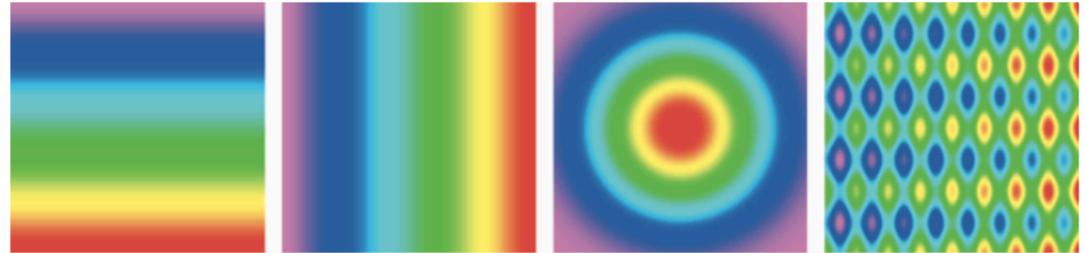
Spatial contrast sensitivity function. Frequency increases to the right and contrast increases toward the bottom of both images in the figure. We can see detail at much lower contrast in the (a) luminance-varying gray-scale image than with the (b) rainbow color map.

Problems with the Rainbow Color Map

Actively misleading - the viewer by introducing artifacts to the visualization.

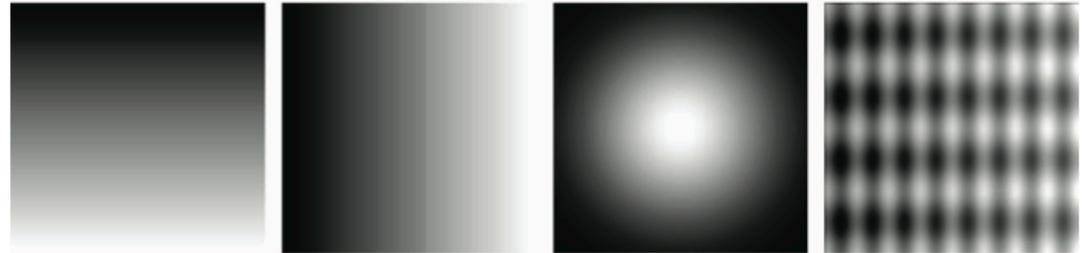
(a) Rainbow

(a)



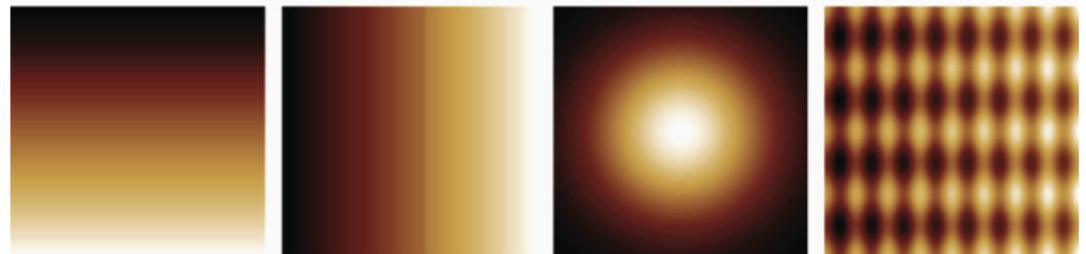
(b) gray-scale

(b)



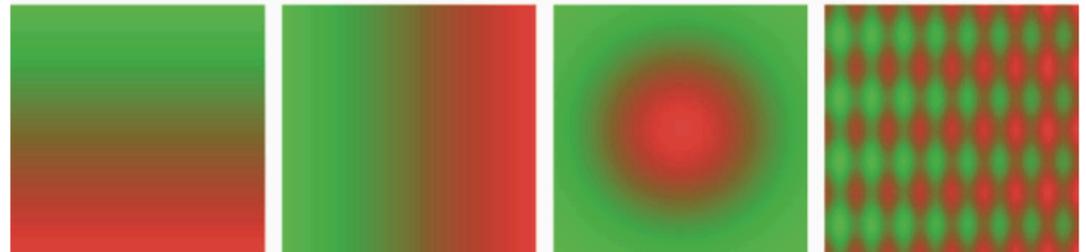
(c) black-body radiation

(c)

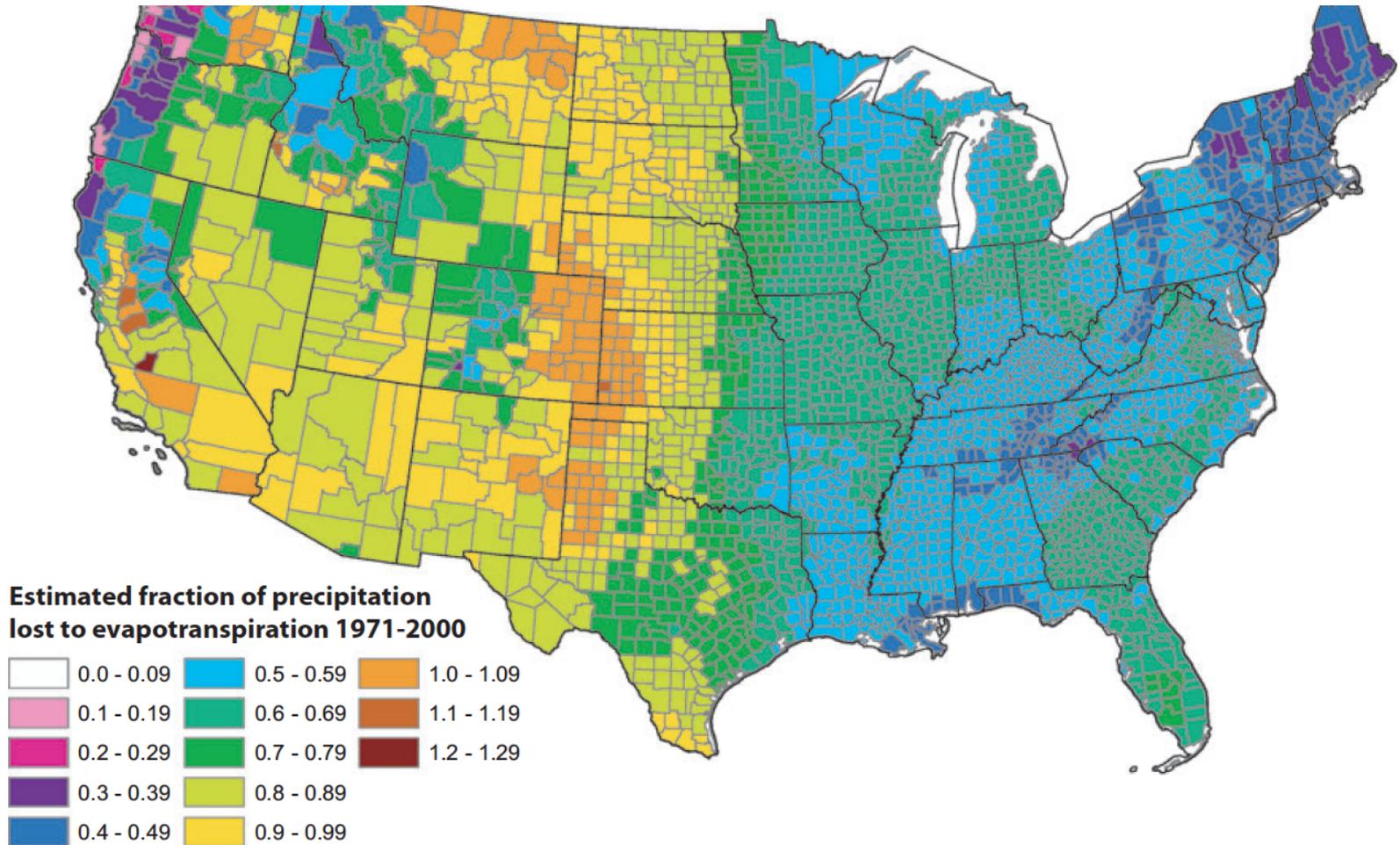


(d) isoluminant green-red color maps

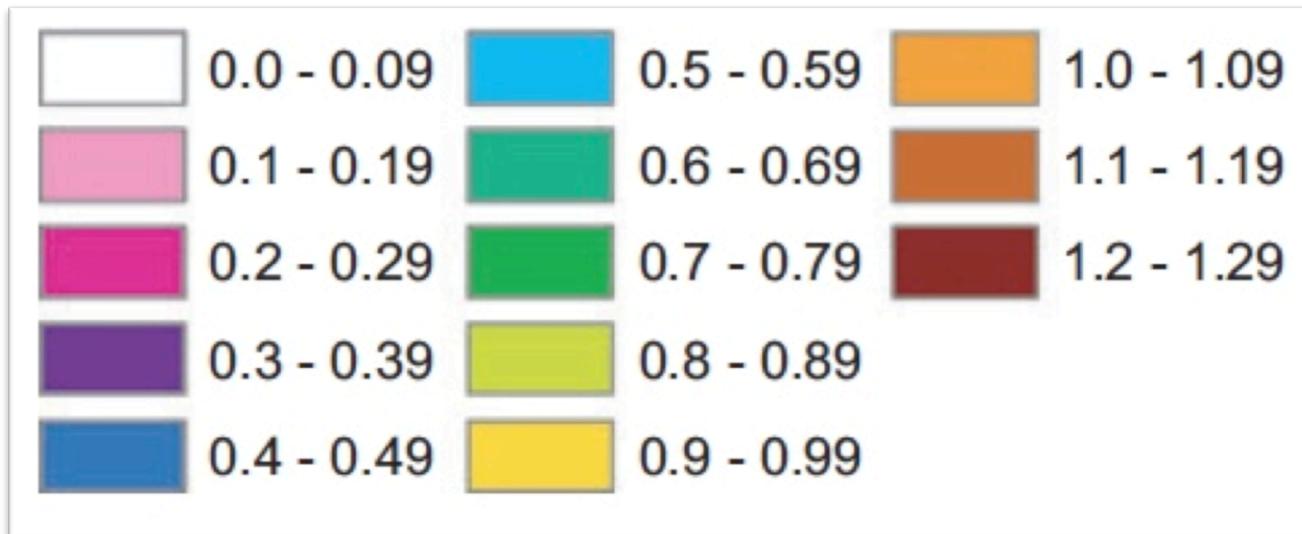
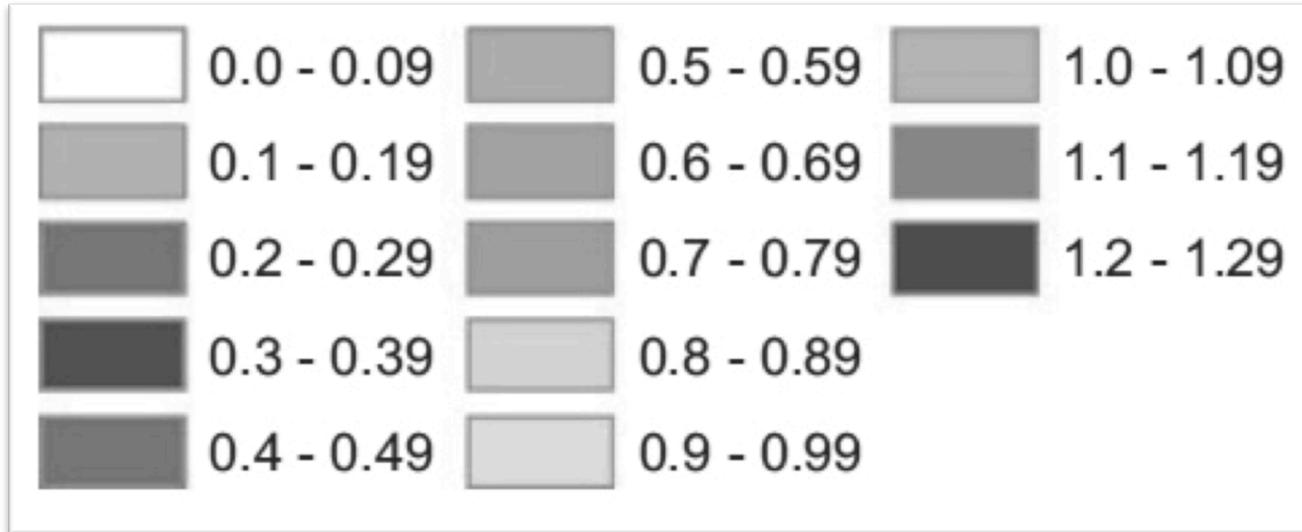
(d)



Beautiful example of a terrible color map



Luminance, Hue



Prevalence of the Rainbow Color Map

IEEE Visualization proceedings

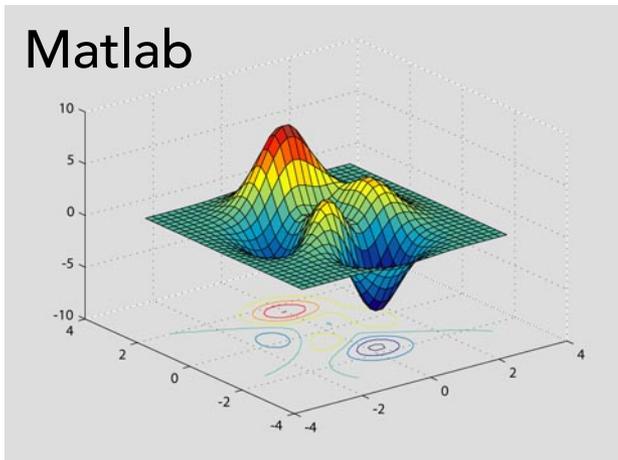
Table 1. Statistics from the 2001 through 2005 IEEE Visualization Conference proceedings papers implementing pseudocoloring to display data and that use the rainbow color map.

Year	Relevant Papers Including Medical Images (%)	Relevant Papers Excluding Medical Images (%)	Number of Pages
2001	47	62	8
2002	40	45	18
2003	52	71	32
2004	59	68	62
2005	52	59	61
Total	51	61	181

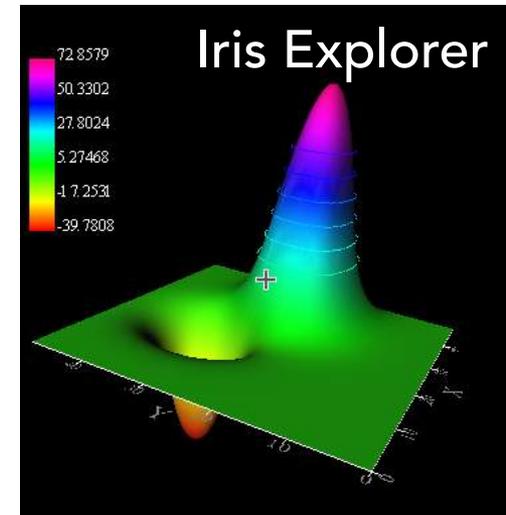
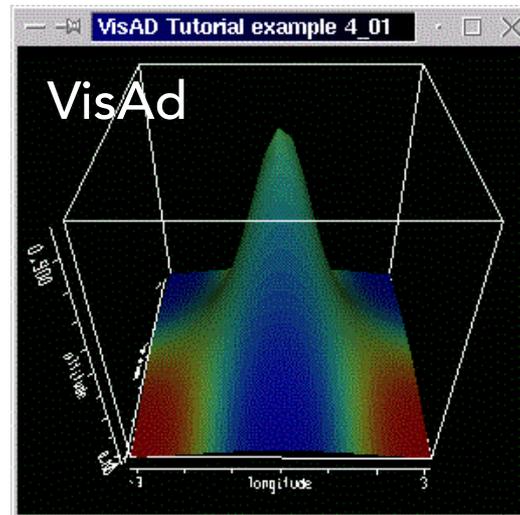
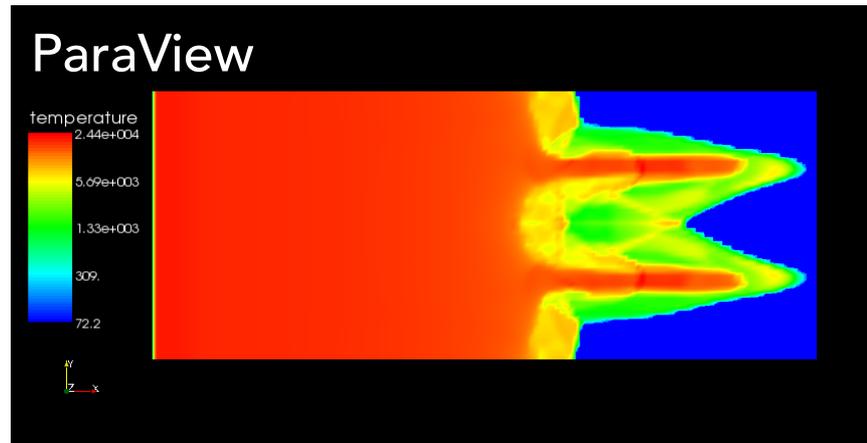
Prevalence of the Rainbow Color Map

Visualization toolkit defaults

Matlab



ParaView

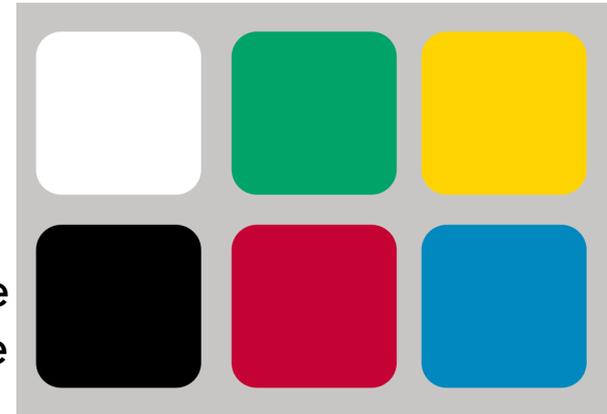


Appropriate way to use

Nominal data

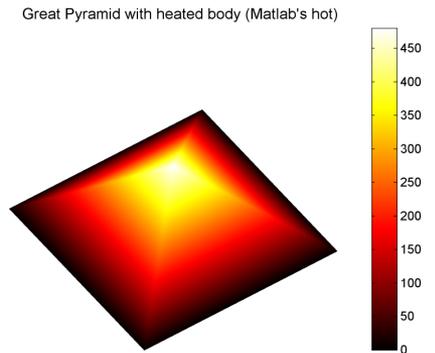
recommends the **six opponent-channel colors** (red, green, yellow, blue, black, white) followed by **six other distinct colors** (pink, cyan, gray, orange, brown, and purple)

Luminance and saturation variations enable use of more colors than the eight distinguishable colors found in the rainbow color map.



High-frequency ordinal data

A perceptually ordered choice is the **heated body scale**, also known as the black-body radiation spectrum because it reproduces the colors coming from a heated black body (such as a canon ball) through red and yellow to white hot.



Appropriate way to use

Color map on a surface

For cases where accurate presentation of the underlying surface shape is important, an **isoluminant** color map should be employed.



(a) Isoluminant colormap created by user study

Interval and ratio data

Interval data sets have measurable distances and ratio data sets also have a zero point.

Abandonment of the presentation of continuously varying data enables the use of intentional regularly spaced banding in the color map.

By selecting **a number of perceptually ordered colors**, we can construct a scale with equally sized bands of constant color.

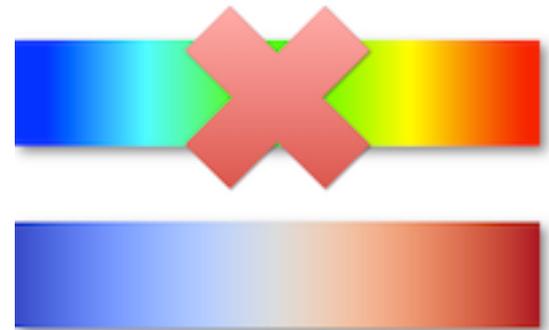
Application to What-Why-How Framework

What: Data - Two categorical key attributes, one quantitative value attribute

How: Encode: - Diverging colormap.

(A colormap is used to assign colors to numbers.)

Why: Task – Trend, summarize.



Conclusions

The purpose of visualization is to effectively convey information to human viewers.

The rainbow color map hinders this task by confusing, obscuring, and actively misleading.

Despite this knowledge, the visualization community predominantly chooses the rainbow color map over other approaches.

We as a visualization community must do better, making the rainbow color map as rare in visualization as the *goto* statement is in programming.