Literature Review -2

Tejaswini Gaddam, 01672822

Primary Paper: Rainbow Color Map (Still) Considered Harmful, by David Borland and Russell M.Taylor II *University of North Carolina at Chapel Hill*

Secondary Paper: Choosing Effective Colours for Data Visualization by Christopher G. Healey, Department of Computer Science, University of British Columbia

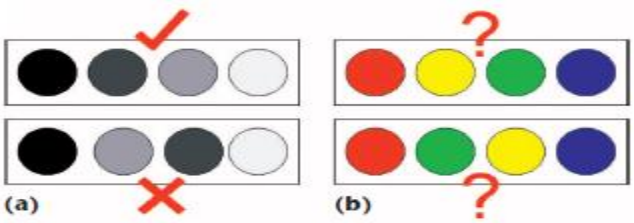
Introduction:

In the secondary paper author has formulated a technique for choosing any multiple colours for the use of data visualization. His primary goal was to find a synthetic method for maximizing the use of total number of colours available for us, while still allowing an observer to rapidly and accurately search a required content from the data. While in the primary paper the author has a case to prove the content in the first paper was wrong on a selection of colors. Author explains that Rainbow Color Map (using colors violet, indigo, blue, green, orange, red) is not a good choice for the data visualization and it has many negative effects. The author was trying to explain in the secondary paper that the data visualization should help us to easily and most accurately understand the data rather the theoretical. But the purpose is being violated if we use the rainbow color map for visualization.

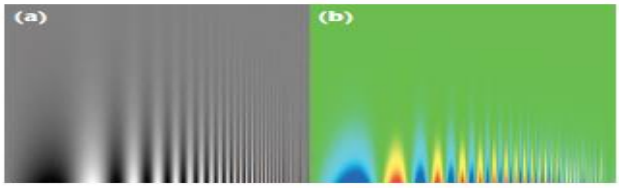
Experiments:

In the secondary paper author explains that selection of effective colours for the data visualization depends on 3 main criteria They are colour distance (this is the Euclidean distance between colours (how different the color is from the other)), line separation (this is the ability s separate the target and non-target colours) and colour category. Author has conducted experiments comparing finding the target colors with the time. (Target color is nothing but the colour which indicates the important information of the data), He has done four studies They are Three colour study, five colour study, seven colour study and nine colour study. This colour study means for example if we consider 3 colour study, the author has picked 3 colours Red, green yellow and purple blue. Using these colors author first used red as the target colour and tried to find that colour midst of other colors. This is repeated taking green yellow and purple blue as target colors as well.

Where as the author of the primary paper says that selecting the colors of the rainbow would always give incorrect results. The main problems are confusing, obscuring and actively misleading. Author says that if we select a gray-scale map it has the perceptual ordering, but the rainbow map doesn't have any perceptual ordering. Perceptual ordering is the method in which we can place the colors in an order from low intensity to higher intensity. This can be seen in the figure 1, Because the rainbow colors cannot be perceptually ordered it creates a confusion to us. Another thing is that if the data is given in a series of numbers for example. If there is sudden peak in the value we cannot identify it from the change of colors used, but instead if used a grey scale it gives the actual increase in the numbers. This can be seen in figure 2. The author has made statistics of all the papers which have used rainbow map for data visualization in their experiments or the papers in any way. This can be seen in the table below.



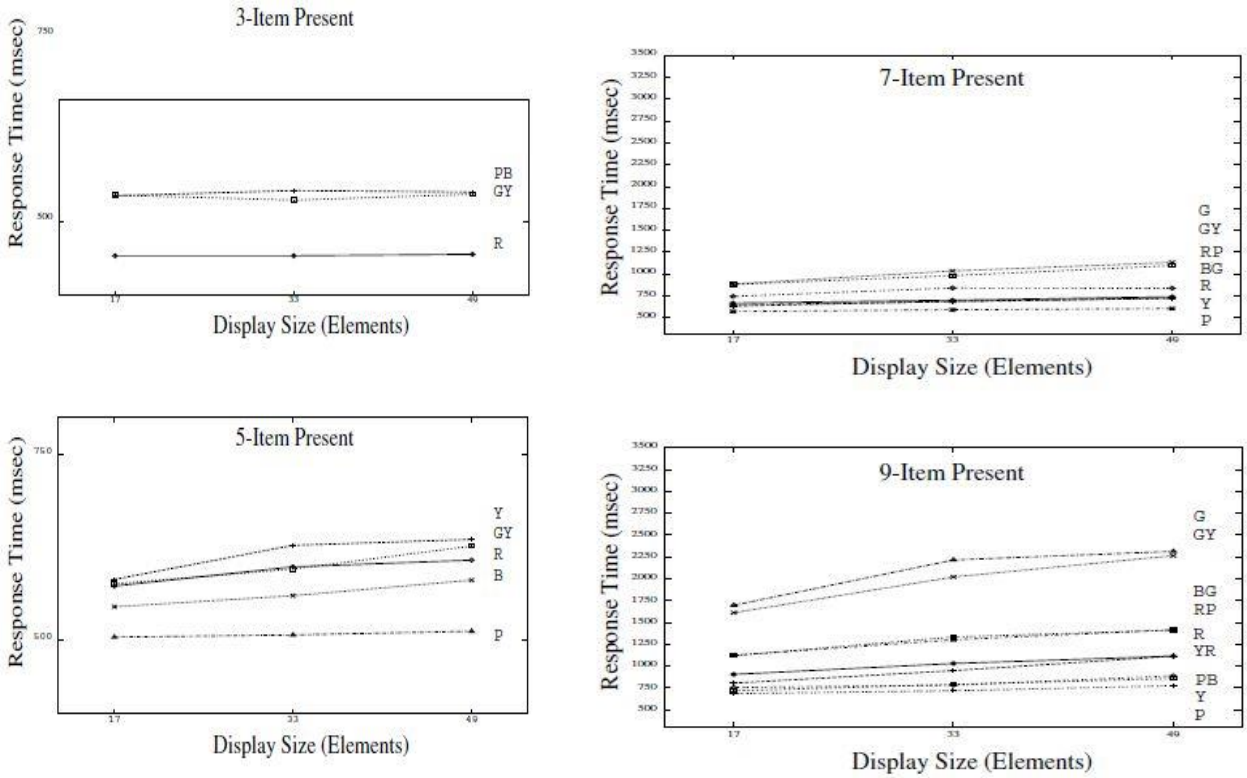
1 Perceptual ordering. (a) We can easily place the gray paint chips in order based on perception, (b) but cannot do this with the colored chips.



2 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.

Results:

The results of the experiment at first, conducted by author of secondary paper were a bit agreeing with the primary papers main point. In the 3 colour study and 5 colour study the results were appropriate , the 32 viewers took around a mean of 550-600 msec to find their target colour from the region of all colours. Though they were appropriate there was a little error of 2% by them in 3 colour study and around 2.5% in five colour study experiments. For the 7 colour and 9 colour study the results were not as expected. The viewers were not able to easily spot their target colours when there were 7 and colours around. It took more time around 1000-1100 msecs for to find some specified target colours. The error was also increased to 13% which leads to wrong information's from the data. These faulty results made author to evolve a new concept of colour category thinking this might improve the results. Colour category can be said as the colour region. This concept may be useful further for the identifying of the target colors, for example finding the blue colour in the red colour region would be easier than finding blue in green colour region. Then the author has conducted the experiments of 7 colour study and 9 colour study finding one of the best colour regions which is unstable for those colours in the colour study. This provided the appropriate results. The time taken for identifying the target colours were easier when kept in those colour categories. The response time for finding the target color was reduced to 200 ms and the error was also reduced to 2%.



Though these results were positive, the main point here of selecting the appropriate colour categories will create a problem. The same was projected by the author of the primary paper. The author of the primary paper has collected the papers as described and showed the no of people using the rainbow map for the medical images is being reduced in a couple of years. This is an indication that people were not satisfied as they were not giving appropriate results. In this way the first paper proves and shows that the assumptions made in the secondary paper are wrong for the range of colour selected.

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

Solution for the data visualization:

Our discussion of the problems with the rainbow color map immediately draws to a question, that is What is the best choice for data visualization? The author of primary papers suggest that the best choice depends on the viewer's task, on whether another visualization technique such as a height field is used in conjunction with color, and on the frequency content and noise within the data displayed. Although the rainbow color map is universally inferior to other color maps, there is no color map that is better than all other maps in all circumstances. So the author has proposed the taxonomy of measurement scales defining four scalar data types: nominal, ordinal, interval, and ratio. They are:

Nominal data: For labeling nominal regions of data whose categories have no implied ordering (such as material types or political affiliations) a selection of distinct colors is optimal. The author treats the question of which colors are optimal to label *n* different categories based on color separability, distance in CIE LUV space, and color categories. Author also 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) for this purpose.

High-frequency ordinal data: Ordinal data has a specified order but no metric for distance— for example, describing small, medium, and large pizza pies does not specify actual size. Our experiment reulsts shows that viewers can see details more readily when luminance contrast is present than when it is not. Luminance is based on inputs from only the red and green channels—making it impossible to generate a uniform-luminance rainbow scale including deep blue. The most obvious perceptually ordered color map with luminance contrast is the gray-scale color map.

Color map on a surface: The desire for luminance contrast directly conflicts with the presentation of a color map on top of an underlying geometric shape. This is because the human visual system uses luminance variation for the determination of object segmentation, shape, motion, and stereo depth.

Interval and ratio data: Interval data sets have measurable distances (degreesCelsius, height) and ratio data sets also have a zero point (degrees Kelvin, height above sea level). Although attempts to display interval and ratio data often use color maps, user studies have shown that contrast effects and other perceptual distortions make the user incapable of coming up with accurate absolute value judgments.

Conclusion:

The purpose of visualization is to effectively convey information to human viewers. Though the author of the secondary paper tried to convince that the data can be visualized when the colored categories are appropriate, this does not work in the all circumstances. Selecting the right category is a big problem. This was proved in the secondary paper. The experiments revealed that the number of people using rainbow map is also being reduced. This shows that the data visualization cannot be done with a100% of accuracy. 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.

References:

Rainbow Color Map (Still) Considered Harmful, by David Borland and Russell M.Taylor II *University of North Carolina at Chapel Hill*

Choosing Effective Colours for Data Visualization by Christopher G. Healey,
Department of Computer Science, University of British Columbia