CORENDERING THREE ATTRIBUTES AGAINST RED-GREEN-BLUE OR CYAN-MAGENTA-YELLOW – PROGRAM rgb_cmy_plot



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Overview

When multiple attribute volumes exhibit the same units and the same range of values they are amenable to color blending. The most common example is corendering three spectral magnitude components against red, green, and blue, where low values of spectral magnitude appear as black and high values are a pure color. Another example is to corender a near, mid, and far offset amplitude volumes against red, green, and blue. In this case, the extreme negative values are mapped against black and the extreme positive values against a pure color.

Some attributes are better represented against cyan, magenta, and yellow. If we compute coherence for three different bandpass filtered seismic amplitude volumes, we will map high coherence against white and low coherence against the pure cyan, magenta, and yellow. In this kind of image, when all three volumes exhibit low coherence, we obtain the same black anomalies as see in conventional coherence displays plotted against a gray scale.

Most, but not all interpretation workstation software provides RGB blending. Some provide CMY blending as well. For those that have RGB blending but not explicit CMY blending, a CMY blended image can be obtained by properly defining the range and polarization of the data and color bars. In the AASPI software package, color blending is most conveniently implemented using program **corender**. Program **rgb_cmy_plot** is provided for those interpreters whose workstation does not provide RGB color blending. For these interpreters, the composite (blended) output volume from program **rgb_cmy_plot** can be loaded into the workstation along with the corresponding multiplexed colorbar for subsequent integration with well control and other kinds of data.

Computation Flow Chart

Program **rgb_cmy_plot** reads in two attribute volumes and outputs a composite volume, a color legend, a histogram, and a suite of multiplexed colorbars that can be used to load the composite volume into the more common interpretation workstations software products.



Output file naming convention

Output file description	File name syntax		
Composite	Hue_axis_title_vs_saturation_axis_title_vs_lightness_title_unique_project		
attribute	_name.H		
Color legend (2D	rgb_cmy_plot_color_legend_ <i>hue_axis_title_</i> vs <i>_saturation_axis_title_</i> vs_ <i>h</i>		
colorbar)	ue_axis_title_unique_project_name.H		
	rgb_cmy_plot_histogram_ <i>hue_axis_title_</i> vs_ <i>saturation_axis_title_</i> vs_ <i>hue</i>		
2D histogram	_axis_title_unique_project_name.H		
Multiplexed 1D			
colorbars	rgb_cmy_colorbar.alut, rgb_cmy_colorbar.CLM, etc		
Program log			
information	rgb_cmy_plot_ <i>unique_project_name</i> .log		
Program			
error/completio	rgb_cmy_plot_ <i>unique_project_name</i> .err		
n information			

Program **rgb_cmy_plot** will always generate the following output files:

where the values in red are defined by the program GUI. The errors we anticipated will be written to the **.err* file and be displayed in a pop-up window upon program termination. These errors, much of the input information, a description of intermediate variables, and any software traceback errors will be contained in the **.log* file.

Invoking the rgb_cmy_plot GUI

To invoke program **rgb_cmy_plot**, on the **aaspi_util** GUI select *Display Tools* and then select **rgb_cmy_plot** on the drop-down menu:

🗙 aaspi_util GUI - Post Stack Util	ities (Release Date: 20_July_2022)		_	o x
] <u>F</u> ile Single Trace Calcula	tions Spectral Attributes G	eometric Attributes Formation Attributes Volumetric Classification	Data Conditio	ning Help
Attribute Correlation Tools	Display Tools Machine Lea	ning Toolbox Surface Utilities Well Log Utilities Other Utilities Se	t AASPI Defaulf	t Parameters
SEGY to AASPI format conversion	corender 4D spectral data viewer hlplot	AASPI to SEGY format conversion AASPI QC Plotting AASPI W (single file)	orkflows	AASPI <u>F</u>
SEGY to AASPI - Convert P	hsplot hlsplot	SEGY to AASPI format		
2D SEG-Y Line rather than	rgb_cmy_plot			
SEGY-format input Plot 3 a (*.segy,*.sgy,*.SEGY,*.SGY	ttributes against either red-gr define geobodies	een-blue or cyan-magenta-yellow color models Browse]	
SEGY header utilities:	generate_roses	E header content SEGY h	eader utility	
AASPI binary file datap	graph_pioc			

The following GUI opens up:

	X aaspi_rgb_cmy_plot GUI (Release Date: 20_July_2022) -		\times
	Ele		Help
	OBJECTIVE: Generate a composite image by plotting each of three attributes against either red, green, and blue color or against cyan, magenta, and yellow		
	INPUT FILES: For RGB, three input files of similar type		
	(e.g. 3 spectral magnitude components, 3 offset amplitude volumes, three euler curvature components, etc.). For CMY, three attributes that illuminate the same kind of feature (e.g. dip magnitude, similarity, curvedness)		
	OUTPUT FILES: A color lookup file and a composite AASPI-format header/data volume		
<u> </u>	Use RGB additive color model. Click here to switch to CMY subtractive color model		
K I	Axis 1		
1a 📐	Attribute against red (*.H): uhomes6/marf2925/projects/GSB_AAPG/spec_mag_cwt_GSB_0_20.00000.H Browse		
1b	Title of red axis: Spec_mag_20_Hz		
15	Minimum magnitude : 0 Re-scan		
	Maximum magnitude : 1194.32		
<u>`</u> N	Axis 2		
2a 📐	Attribute against green (*.H): uhomes6/marf2925/projects/GSB_AAPG/spec_mag_cwt_GSB_0_40.00000.H Browse		
26 N	Title of green axis: Spec_mag_40_Hz		
2c	Minimum magnitude : 0 Re-scan		
24	Maximum magnitude : 1621.64		
<u> </u>	Axis 3		
3a N	Attribute against blue (* H): ubomes6/marf2025/projecte/GSB_AAPG/spec_mag_cwt_GSB_0_60,00000 H_Browse		
3h	Title of hise avis: Ener mag 60 Hz		
	Minimum magnitude :		
30	2480.77		
K	- Output File Definition		
4 N	Unique project name: GSB		
5	Suffix: 0		
6	Composite Output File (*.H): spec_mag_20_40_60_Hz_GSB.H		
	Color Parameters		
7a	Maximum number of colors		
	(256 for petrel, geoviz, geomodeling, seisworks)		
7b	Number of colors along each axis:		
8a	Color intensity to plot against minimum data values:		
8b	Color intensity to plot against minimum data values: 1 (black = 0.0, fully saturated color=1.0)		
	Bias (needed only for Voxelgeo):		
9	Colorbars to Generate		
	E AASPI (.alut) E GeoFrame (.iesx) E Landmark (.landmark .cl2) VoxelGeo (.color) E Geomodeling (.geor	nodelir	ng)
	□ SeisWare (.xml) □ Transform (.cmp) □ Kingdom (.CLM) □ GeoProbe (.gpc) □ Shell internal 1D cm	ap (.cr	nap)
	I Shell internal 2D cmap (.cmap)		
	(c) 2008-2022 AASPI for Linux - The University of Oklahoma	h cm	nlet
	Execute rg	J_emy	pior

The 0th step is to use the (0) RGB vs CMY toggle to decide whether we wish to plot three attribute volumes against red-green-blue (RGB) or against cyan-magenta-yellow (CMY) color axes. In this example, I have selected the default *RGB additive color model*.

Next, I *Browse* to find the file names of the three attribute volumes I wish to corender. In this example I have selected spectral magnitude components at (1a) 20 Hz to plot against red, (2a) 40

Hz to plot against green, (3a) 60 Hz to plot against blue. The (1b, 2b, 3b) title of the color bar axes are extracted from the titles of the input data volumes and can be edited to make them more meaningful and/or more succinct. When loaded, the (1c, 1d, 2c, 2d, 3c, 3d) minimum and maximum values of each data volume are read from their respective *.H files.

As with almost all AASPI GUIs, I enter (2) a *unique_project_name* and (5) a *Suffix*. The default name of the (6) *Composite output file* will be a concatenation of the three titles of the input data volume with a ".H" added to the end. In general, this file is very long, so in this example I shortened it to be more succinct. **Be sure this file name ends in *.H!**

In general, you will want to use the same number of color levels for R, G, and B. If your commercial interpretation software allows you to only load 256 colors, then the largest cubed value that fits in memory will be 6³=216, which are the defaults (6b and 6a).

For spectral magnitude, you will want to plot large magnitude values (7a) against fully saturated colors and 0 values (7b) against black. If all three axis are saturated you will obtain white. If you want the limit the range of the color bars you can choose values between 0.0 and 1.0.

I click *Execute rgb_cmy_plot* and obtain displays of the 3D color legend, the 3D histogram, and time slices through the RGB corendered data volume. All three of these AASPI-format *.H volumes are saved to your local directory.





On the first (R, G, B=0) plane, I see that the 20 Hz axis for G=0 ranges from black to red and the 40 Hz axis for R=0, B=0 ranges from black to green. In the upper right corner where the 20 Hz component is maximum, the 40 Hz component is maximum, and the 60 Hz component is minimum, (R=1, G=1, B=0), I get yellow. For the 6th plane where the 60 Hz component is maximum (B=1) I have blue when R=0, G=0, and B=1, cyan when R=0, G=1, B=1, magenta when R=1, G=0, B=1, and white when R=1, G=1, B=1. The middle (3rd panel for B=0.4) I obtain intermediate colors. Note the multiplexed 1D colorbar on the right of each image.

Next, I capture the 1^{st} , 3^{rd} , and 6^{th} blue levels of the 6x6x6 histogram:



Note that most of the data fall within the first panel, indicating that I need to modify the scaling of my input data to better map against the range of the R, G, and B color axes. This poor scaling where I set my range to the minimum and maximum values of the three spectral components (i.e., an upper percentile of 100) results in this suboptimum time slice at t=1.44 s:



Defining the data range to better map to the color axes

Unlike program **corender**, program **rgb_cmy_plot** is not interactive, requiring a more careful definition of the range of the three input volumes to be plotted against the three different color axes. To better understand the range of my input data, I click the (10a, 11a, 12a) *Re-scan* button for each of the three values

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Three windows pop up summarizing providing some useful statistics:

X aaspi_completion_status
Program Completion Status
Number of samples analyzed = 962334 min_amplitude = 0.000000E+00 max_amplitude = 1095.634 mean_amplitude = 153.0532 rms_amplitude = 117.9136 2.000000 percentile = 0.6129747 98.00000 percentile = 482.7162 Normal completion. routine extract_data_statistics
X aaspi_completion_status
<u> </u>
Program Completion Status
Number of samples analyzed = 962334 min_amplitude = 0.0000000E+00 max_amplitude = 1464.576 mean_amplitude = 147.0183 rms_amplitude = 123.3021 2.000000 percentile = 0.4855584 98.00000 percentile = 503.8480 Normal completion. routine extract_data_statistics
X aaspi_completion_status
Program Completion Status
Number of samples analyzed = 962334 min_amplitude = 0.0000000E+00 max_amplitude = 2146.603 mean_amplitude = 140.5127 rms_amplitude = 126.1527 2.000000 percentile = 0.5476844 98.00000 percentile = 518.3538 Normal completion. routine extract_data_statistics

where the 98 percentile values 482, 503, and 518 are copied into the (10b, 11b, 12b) *Maximum magnitude* entry for the three axes. Because I have previously flattened the spectrum, I want these three values to be identical in order to evaluate thin-bed tuning. I therefore type in a slightly smaller value of 450 into each of these entries. Executing the program, I obtain the following histogram:



where now I see some values for panel 6. (The peak histogram representing 12% of the data is on panel 2 in bin_r=2, bin_g=2, bin_b=2). The colorbar is the same as before, but now the time slice through the composite data volume at t=1.44 s looks like this:



Changing the color depth (the number of colors)

Although only a few workstation packages allow importing more that 256 colors (and those that do have excellent RGB and CMY color blending tools) you can still generate attributes with greater color depth in the AASPI software. Modern workstations and computer terminals using OpenGL (graphics library) allow 256 levels of R, G, B, and alpha blending, giving 32-bit color. In the next example, I set the *Number of colors along each axis* to be 64. This changes the *Maximum number of colors* to be 64^3 =262,144.



Executing the program for the same three volumes and data ranges, I obtain the following 3D color bar (only three of the 64 panels are shown):



and a more detailed histogram (consisting of 64³=262,144 bins):



Resulting in a corendered image with increased color depth:



Plotting against CMY

To plot against CMY rather than against RGB, I go back to the original GUI and toggle the (0) *Use CMY subtractive color model* option. Then I enter the three volumes I wish to plot against CMY, in this case energy ratio similarity (coherence) computed about 20, 40, and 60 Hz.

Use CMY subtractive color model. Click here to switch to BGB additive color model
Axis 1
Attr. against cyan (*.H): GSB_AAPG/energy_ratio_similarity_GSB_balanced10.020.020.030.0.H Browse
Title of cyan axis: Coherence_at_20_Hz
Minimum magnitude : 0.6 Re-scan
Maximum magnitude : 1
Axis 2
Attr. against magenta (*.H): GSB AAPG/energy ratio similarity GSB balanced 30.040.040.050.0.H Browse
Title of magenta axis: Coherence at 40 Hz
Minimum magnitude : 0.6 Be-scan
Maximum magnitude : 1
Axis 3
Attr. against yellow (*.H): GSB_AAPG/energy_ratio_similarity_GSB_balanced50.060.060.070.0.H Browse
Title of yellow axis: Coherence_at_60_Hz
Minimum magnitude : 0.6 Re-scan
Maximum magnitude : 1
Output File Definition
Unique project name: GSB
Suffix: balanced
Composite Output File (*.H): Energy_ratio_similarity_20_40_60_Hz_GSB.H

Coherence is a little different than most single polarity attributes in that the anomalously low values are the ones that delineate features of interest. I want these low values to plot against strong values of cyan, magenta, and yellow, whereby if all three values are totally saturated, I obtain a black image. To do so, I need to map the minimum values (similarity = 0.6 in the three axes) against the maximum saturation (1) and the maximum values (similarity =1.0 in the three axes) against minimum color saturation (white):

Color intensity to plot against minimum data values: (white = 0.0, fully saturated C, M, or Y=1.0)	1
Color intensity to plot against maximum data values: (white = 0.0, fully saturated C, M, or Y=1.0)	0

Because of this flipping of the axes, the color bar will plot up the same as before (for 64^3 =262,144 colors):



If values of similarity for each attribute are close to 1.0, the voxel will be white. If values of similarity of each attribute are less than or equal to 0.6 (the minimum value), the voxel will be black. The corresponding three panels of the histogram look like this:



Where most the data cluster about similarity=1 for each axis. The values along three left and bottom edges of the first panel correspond to clipped values of similarity < 0.6.

The resulting composite color image at t=1.44 s looks like this:



where we recognize that most of the throughgoing faults have stronger anomalies at the 40 Hz component and appear as magenta (with a smaller subset appearing as black). In contrast, many of the syneresis features change colors, depending on the thickness of the stratigraphic layer cut by this time slice. For this reason, the cyan syneresis features correlate to thicker units tuned about 20 Hz and the yellow correlate to thinner units tuned at 60 Hz.

References

- Guo, H., S. Lewis, and K. J. Marfurt, 2008, Mapping multiple attributes to three- and fourcomponent color models – a tutorial: Geophysics, **73**, W7-W19.
- Marfurt, K. J., 2015, Techniques and best practices in multiattribute display: Interpretation, **3**, 1-24.