Multivariate Histogram Analysis User’s Guide

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Preface

About this Guide

This Multivariate Histogram Analysis User’s Guide is written to provide procedure for the calculation and analysis of multivariate histograms within DigitalMicrograph. This Guide assumes the user is familiar with image manipulation within DigitalMicrograph and only addresses those features specific to the Multivariate Histogram Analysis package.

Preview of this Guide

The Multivariate Histogram Analysis User’s Guide includes the following chapters:

Chapter 1, “Introduction” summarizes the purpose and applicability of the Multivariate Histogram Analysis software and notes the software and hardware requirements.

Chapter 2, “Performing Multivariate Histogram Analysis” provides an overview to the multivariate histogram calculation and analysis process using DigitalMicrograph.
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1 Introduction

Multivariate histogram analysis, also known as scatter plot analysis, provides an effective mechanism for exploring the spatial correlations of the intensity distributions of multiple spatially aligned images. When the source images are chemical distribution images, for example EELS jump-ratio or background extrapolated maps, the intensity correlations within the resultant multivariate histogram reveals information regarding the spatial correlation of the represented elemental species. Discrete, or semi-discrete, ‘clusters’ of intensity within the histogram plots indicate the presence of phases with distinct chemical composition or stoichiometry. Isolating these clusters and retrieving their corresponding spatial representations, a process termed ‘intercorrelative partitioning’, yields chemical-phase specific maps. Such maps can reveal unique information regarding the spatial distribution of the chemical phases present, can provide a convenient means for data reduction, and can also be used as spatially selective masks allowing phase-specific spectroscopy to be performed on spectrum-image datasets.

1.1 Multivariate Histogram Analysis Summary

A number of tools for the calculation and analysis of multivariate histograms are contained in the MULTIVARIATE HISTOGRAM ANALYSIS hierarchical sub-menu, located within the ANALYSIS menu. These tools enable both bivariate and trivariate histograms to be generated, using two or three spatially aligned source images, respectively. Utilities for partitioning histogram regions, and trace-back algorithms for the retrieval of the corresponding chemical phase maps, are also included, as well as commands for performing phase-specific spectroscopy on spectrum-image datasets. This tutorial will describe the use of each sub-menu item in the context of both bi- and trivariate histogram analysis, describing in detail the routine procedures where appropriate. For an introduction on the principles and practical application of histogram analysis of chemical specific maps, please refer to the following reference:

1.2 Requirements

1.2.1 Microscope Requirements

No microscope is required for performing multivariate histogram analyses. However, a microscope equipped with appropriate hardware is required for the acquisition of the datasets to be analyzed. Please refer to the appropriate hardware documentation for details.

1.2.2 Computer Requirements

Multivariate Histogram Analysis runs as part of the Gatan Microscopy Suite (GMS), and hence the minimum and recommended computer requirements are as specified for running the GMS. Please refer to the GMS Installation Guide for specific details.

1.3 Software Installation

The Multivariate Histogram Analysis software plug-in is installed as part of the Gatan Microscopy Suite (GMS). Providing your Gatan Software License Disk contains an appropriate license configuration, the Multivariate Histogram Analysis software plug-in will be configured automatically on installation of the GMS. Please refer to the GMS Installation Guide for installation details.
2 Performing Multivariate Histogram Analysis

This section gives a step-by-step guide to generating and using multivariate histogram plots within the context of analyzing multiple EELS or energy-filtered TEM chemical maps. The principles described, however, can equally be applied to other types of imaging, for example, EDX mapping, or indeed to any images with complementary intensity distributions. The menu items in the MULTIVARIATE HISTOGRAM ANALYSIS sub-menu, shown in Figure 2-1, are ordered sequentially in the logical order one would normally follow when performing such analyses. Accordingly, the following sub-sections are ordered sequentially following the menu structure.

Figure 2-1

The MULTIVARIATE HISTOGRAM ANALYSIS sub-menu.

<table>
<thead>
<tr>
<th>Multivariate Histogram Analysis</th>
<th>Histogram Setup…</th>
</tr>
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<tbody>
<tr>
<td>Create Bivariate Histogram</td>
<td></td>
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<tr>
<td>Create Trivariate Histogram</td>
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<td>Extract Single Phase Image</td>
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</table>

2.1 Setting up the histogram parameters

The HISTOGRAM SETUP... item initiates the Histogram Setup dialog, as shown in Figure 2-2. This dialog allows a number of the basic properties of the generated two or three-dimensional histograms to be defined, namely histogram resolution and display properties. The dialog contains the following parameter fields;
Setting up the histogram parameters

**Histogram resolution (pixels)** - This value determines the resolution (in pixels) of the generated histogram. In the case of a bivariate histogram, the generated plot will be square with side length equal to this value. In the trivariate case, the resultant histogram will be an equilateral triangle of base length equal to this value. The optimal histogram resolution will depend on both the intensity distribution and the quantity of pixels within the source images. A lower resolution is favored for source images containing a low number of pixels, and vice-versa. Lowering the histogram resolution will produce a coarser looking histogram. Raising this value will increase the sampling density, but at the expense of mean counts per pixel within the histogram.

**Source survey technique** – This pop up menu contains the available intensity survey techniques for determining the minimum and maximum intensities of the source images that will be considered in the histogram generation process. Hence, the technique selected in this field determines the intensity range of each histogram axis. The first four survey methods, cross-wire, whole image, sparse and reduction, are the default contrast survey methods provided and used by Digital Micrograph; please refer to your Digital Micrograph manual for a full account of the surveying criteria these techniques apply. Selecting one of these survey methods will result in an automatic determination of the histogram intensity range, and experimentation is often required to establish the most suitable for a particular dataset. The fifth survey technique, source display, applies the intensity range of the source images as displayed in their respective image-windows. Hence, by adjusting the source image-display intensity ranges using, for example, the Histogram floating window, the minimum and maximum values can be specified giving the user complete control over the histogram range.

**Histogram color table** – This option determines the color table used for the multivariate histogram display. The available options are taken from the Digital Micrograph default color tables; the choices are grayscale and temperature.

**Composite phase-map color table** – The choice in this pop-up menu determines the color table applied to the generated composite phase-maps, described later in this section. The color tables are based on the identically titled Digital Micrograph defaults, with the choice of grayscale, temperature and rainbow.
Creating a bivariate histogram plot

The default values will give satisfactory results in the majority of cases, though it is recommended you become familiar with the effects of these parameters, particularly the histogram resolution and survey technique settings, in order to optimize your histogram plots. Further histogram display attributes may also be adjusted; please refer to the advanced notes in Section 2.8 for further details.

2.2 Creating a bivariate histogram plot

Selecting the Create Bivariate Histogram sub-menu item initiates the bivariate histogram calculation. The routine proceeds by requesting you to specify two source images, which should be spatially aligned and also have dimensions of equal sizes. If the two source images are spatially misaligned, the accuracy of the generated histogram will be compromised. Alternatively, if the images have incompatible dimensionalities then the procedure will not proceed and you will be alerted with a suitable error message. In either case, ensure that the above criteria are met by cropping the source images if necessary.

Once the source images have been specified, the procedure determines for each the intensity range to be considered in the histogram calculation, applying the specified survey method as described in the previous section. Once the minimum and maximum intensities are established, the histogram is generated using a sampling width $w$ determined by the histogram resolution $r$ (as specified in the histogram setup dialog) following, for an image $A$,

$$w_A = \frac{\text{max}_{\text{survey}}(A) - \text{min}_{\text{survey}}(A)}{r}$$

Please note that the sampling density is calculated for each axis of the histogram, resulting in an equal number of samples for each source image and, hence, a square histogram. Additionally, note that pixels with intensity values outside the survey range are not excluded from the histogram analysis; these pixels are clipped to have values at the corresponding intensity limit, and will therefore be included in the histogram at the extremes of the range covered.

The histogram is generated by comparison of the intensities contained within the two source images subject to the minimum and maximum values (as determined by the survey technique specified) and the corresponding sampling width (governed by the histogram resolution). Each pixel in source image $A$ will have a corresponding pixel at the same spatial co-ordinate $(x,y)$ in source image $B$. Representing the associated pixel intensities as $a$ and $b$ for source images $A$ and $B$ respectively, each corresponding pixel pair will have a contribution of unity to the histogram at co-ordinate $(a, b)$. The resultant value of the histogram at co-ordinate $(a, b)$ therefore represents the total number of pixel pairs in $A$ and $B$ with intensities $a$ and $b$ respectively, within the sampling widths $w_a$ and $w_b$ defined as above.
An example of creating a bivariate histogram is described as follows. The two source images, shown in Figure 2-3, are chemical distribution maps taken from a sample consisting of gold particles on an amorphous carbon support film. The carbon and gold maps shown were calculated using the jump-ratio method, from energy-filtered images taken across the C K and Au N edges respectively. The procedure for generating a bivariate histogram is as follows:

To create a bivariate histogram

1. Ensure the two source images are of similar size and are spatially aligned. If the images are incompatible sizes, they will have to be cropped to a common size. To check if the images are spatially aligned, perform a cross-correlation (e.g. using the MEASURE RELATIVE DRIFT option in the FILTER menu). If the images are not spatially aligned, then they should be cropped accordingly. (Hint: to crop an image, place a rectangular ROI on the region of interest, copy the contents using Ctrl+C, then paste the region into a new image window using Ctrl+Alt+V.)

2. Enter the desired options in the histogram setup dialog, initiated by selecting the HISTOGRAM SETUP sub-menu item. For the example, a histogram resolution of 256 pixels was specified (a resolution comparable to the source image side length), the Source Display survey technique was selected, and Temperature histogram color table was used.

3. If the Source Display survey technique is selected, specify the maximum and minimum intensity levels by either highlighting the desired range using the Histogram floating window, or by entering the values directly in the appropriate fields via dialog the IMAGE DISPLAY…. dialog option found under OBJECT.
4. Select **CREATE BIVARIATE HISTOGRAM** from the **MULTIVARIATE HISTOGRAM ANALYSIS** sub-menu, and specify the two source images in the pop-up menu dialog.

5. The bivariate histogram will be calculated and displayed in a new image window. If the displayed intensity range is not to your liking, repeat steps 2-4 using a different survey technique or alternatively, if the Source Display survey technique is specified, select a more appropriate intensity range.

---

**Figure 2-4**

A bivariate histogram calculated from the two source images shown in Figure 2-3.

The calculated histogram is shown in Figure 2-4. It is sometimes possible for a few intense regions to dominate the histogram image display intensity range, causing regions of low value to appear black. If this happens, adjust the image-display intensity range as appropriate. For a bivariate histogram calculated in this way, the axes are linear and represent the sampled intensity range of the source images in their calibrated intensity units. The value of the pixel at the intersection of the two red lines gives the number of pixels in the Au and C maps with jump-ratio values of 0.59 and 1.7 respectively. It should be noted that the histogram shown consists of two well-defined clusters, with a relatively high carbon jump-ratio and the other with a higher gold jump-ratio, joined by an intermediate branch of intensity. As will be demonstrated in Section 4.5, this is indicative of two well-defined chemical phases / species, with a small degree of spatial overlap.

### 2.3 Creating a trivariate histogram plot

A trivariate histogram may be generated from three spatially aligned images following a similar procedure as described in the previous section for a bivariate histogram. In the same way that a one-dimensional histogram is
Creating a trivariate histogram plot

represented by a line-plot and a bivariate histogram may be represented as a rectangular plot, a trivariate histogram can be represented as a cuboid. However, manipulating a three-dimensional form on a two-dimensional computer screen poses many problems in terms of visualization and manipulation, especially when performing intercorrelative partitioning of phases as described later in Section 2.4. A more practical and intuitive way of performing trivariate histogram analysis is by means of a triangular histogram in a similar style to a tertiary phase diagram. In the case where an equal number of samples are taken of the source images the resultant trivariate histogram plotted in this way is an equilateral triangle.

Figure 2-5

Source images for the trivariate histogram in Figure 2-6.

A tertiary phase diagram can be displayed as a two-dimensional plot since the sum of the (three) constituents always adds up to 100%. However, this is not necessarily the case for a trivariate histogram plot from three chemical distribution maps; there could well be other constituent elements present, or alternatively the source images may be generated using a qualitative, but not quantitative, mapping technique such as jump-ratio imaging. To accommodate this, the intensities are plotted as a fraction $F$ of the total sum of intensities for each pixel from the three source images $A$, $B$ and $C$ following

$$F_a = \frac{a}{a + b + c}$$

where $a$ is the pixel intensity at $A(x, y)$ and so on. Note that this normalization is performed after applying the intensity range limits to the source images following the specified survey technique (as described for bivariate analysis), and after rescaling with the minimum intensity set at zero and the maximum at the specified histogram resolution – 1. This rescaling allows the contribution of each source image to be independent of its relative intensity, avoiding maps with high counts dominating the histogram. Hence the computed trivariate histogram does not have linear axes and the plot cannot be regarded to be strictly quantitative as such (to achieve this, a cuboid histogram would have to be used). As a consequence, the axes are not marked with a scale. Therefore the distribution of intensities in the trivariate histogram should be regarded as a qualitative representation of the quantitative distribution, i.e. indicative of the
Creating a trivariate histogram plot

spatial correlation between the constituent images, where clusters of intensity indicate a phase may be present.

An example of a trivariate histogram calculation is described as follows. The three source images are shown in Figure 2-5. These maps were taken from an EELS spectrum-image acquired from a semi-conductor device sample, and calculated using the background extrapolation method for mapping. The procedure for calculating a trivariate histogram is almost identical to the previous procedure for calculating a bivariate histogram;

To create a trivariate histogram

1. Ensure the three source images are spatially aligned and are of equal size. If not, crop accordingly as described in Step 1 above in the bivariate histogram example.

2. Set the desired histogram setup options and intensity ranges (if necessary) following steps 2 and 3 as described above for bivariate histogram calculation.

3. Select Create Trivariate Histogram from the MULTIVARIATE HISTOGRAM ANALYSIS sub-menu and specify the three source images in the pop-up menu dialog.

The trivariate histogram will be calculated and displayed in a new image window. If the displayed intensity ranges require adjustment, repeat steps 2-3 above using different survey technique options.

Figure 2-6

Trivariate histogram (with annotations) of the source images shown in Figure 2-5.
The computed trivariate histogram is shown in Figure 2-6. The convention followed when plotting the histogram is that the fractional contribution to a pixel in the histogram is related to its perpendicular distance from the side opposite the vertex corresponding to the species of interest. That is, clusters with high fractional concentrations of a particular element will be situated closer to the corresponding vertex. Hence in Figure 2-6, the fractional content of oxygen with respect to the sum of the three constituents of all pixels along the white line is related to the ratio of the length of the blue arrow to the red arrow. Note, however, that as scaling is applied to the images before computing the fractional contributions for reasons of display clarity, then this fraction is only qualitative.

It can be seen that a number of clusters are present in the generated trivariate histogram, indicating a number of well-defined chemical phases are present. Extraction of the spatial distribution maps corresponding to these phases is described in the two following sections.

2.4 Extracting a single phase image from a histogram plot

Once a multivariate histogram has been calculated, the next operation one would most likely wish to perform is to extract the corresponding spatial representations of selected histogram regions. This is can be achieved by selecting a portion of the histogram using an ROI tool, and selecting the EXTRACT SINGLE PHASE IMAGE sub-menu item. A trace-back algorithm then extracts the phase-specific map corresponding to the selected histogram region and displays it in a new image window. The phase-specific map is displayed as a binary image, with pixels associated with the selected histogram region set to unity and all other pixels set to zero. Note that to perform this operation, all source images must be loaded into Digital Micrograph; if not, a suitable error message will be posted. Additionally, no functions or transforms should have been carried out on the original source images since histogram calculation (for
example, a mathematical operation via the SIMPLE MATH... menu item), else the trace-back algorithm employed will produce erroneous results.

An example of extracting a single phase-specific map from the bivariate histogram generated in the previous section is shown in Figure 2-7 above. The procedure for extracting a single phase-map is as follows;

**To extract a single phase map from a multivariate histogram plot**

1. Choose any ROI tool from the ROI Tools floating window, and highlight the region of interest on the histogram plot.
2. Select the Extract Single Phase Image item in the Multivariate Histogram Analysis sub-menu.
3. The corresponding phase image is then extracted and displayed in a new image-window

As shown in Figure 2-7, once the phase map has been extracted the ROI is displayed as a continuous line, indicating it has been made non-deletable (that is, it is not deleted when another ROI is drawn, though you may delete it explicitly), and labeled with a number corresponding to the title of the extracted phase map. ROI placement is a somewhat arbitrary affair, and as a rule it is best to select well-defined clusters using the closed loop tool. It can be seen in the bivariate histogram example that the selected cluster of intensity is associated with the carbon rich regions in the carbon map; this is consistent with the cluster having high carbon and low Au jump-ratio values in the histogram plot. Any number of phase maps may be extracted from a single histogram by repeating the procedure outlined above.

**Figure 2-8**

Extracting a phase-specific map (right) from a trivariate histogram.

Similarly, a single phase may be extracted from a trivariate histogram following the same procedure, as illustrated in Figure 2-8. In this example, the selected phase is positioned close to the titanium vertex, suggesting that the phase is titanium rich. However, a comparison of the extracted phase-specific map and comparison with the titanium source image reveals that the phase-map contains
regions of both high and low titanium content. The reason for this somewhat ambiguous result is that the selected cluster of intensity corresponds to regions of high titanium content, but also to other regions of low oxygen and aluminum signal. As the plot displays intensities relative to the other constituents, the two phases are combined in the same cluster of intensity. This example is a good illustration of the qualitative nature of the trivariate histogram method implemented, where the normalization procedure employed gives rise to well-defined and well-separated clusters of intensity, useful when extracting phase specific maps, but at the expense of quantitative information. As a result, a little caution and thought should be applied when interpreting trivariate histogram plots quantitatively.

Figure 2-9 Generating a composite phase image (bottom) from a bivariate histogram (left). The color-encoded ROI map is shown right with ICP palette overlaid.

2.5 Extracting a composite phase image

In addition to extracting single phase-specific images from histogram plots, you may also generate composite phase images built up from multiple phase-specific maps. Composite phase maps are color (or grayscale) encoded for clarity, using the color table specified by the selected COMPOSITE PHASEMAP
COLOR TABLE option in the HISTOGRAM SETUP... dialog. Selecting EXTRACT COMPOSITE PHASE IMAGE from the MULTIVARIATE HISTOGRAM ANALYSIS sub-menu initiates the INTERCORRELATIVE PARTITIONING floating palette, as shown in Figure 2-9. To extract a phase map from the multivariate histogram when in this mode, place an ROI on the region of interest and select EXTRACT PHASE on the palette. The corresponding phase map will then be displayed, color encoded, in a new image-window. In addition, an ROI Map will also be displayed, showing the selected histogram region encoded with the same color or grayscale (see Figure 2-9). The composite phase map is built up by extracting successive phase images from different regions of the histogram, with each phase image being displayed in a different color. Note when in this mode, the selected ROI region is removed from the source histogram display after each successive calculation, preventing a histogram region contributing twice to the composite phase map through overlapping ROI’s. If a mistake is made, or alternatively if you wish to alter your choice of region, select the UNDO STEP button to undo the previous phase extraction. To complete the analysis, select FINISH on the palette to end the mode and restore the histogram to its original state.

An example of a composite phase map with the corresponding ROI Map is shown in Figure 2-10. In the example shown, it can be seen that the gold and carbon abundant phases correspond to the intensity clusters shown as green and blue respectively in the composite ROI map, while the intermediate branch joining the two discrete clusters corresponds to regions of overlap between the edges of the gold particles and the surrounding carbon film as a consequence of the particle’s spherical form. In this example, the two chemical distribution maps have been reduced to a single image, with phases represented by three distinct colors.

In summary, the procedure for calculating a composite phase image is as follows:
To extract a composite phase map from a multivariate histogram plot

1. Specify the desired color table in the COMPOSITE PHASEMAP COLOR TABLE pull down menu in the HISTOGRAM SETUP... dialog.

2. With the multivariate histogram of interest front-most, select EXTRACT COMPOSITE PHASE in the MULTIVARIATE HISTOGRAM ANALYSIS sub-menu to initiate the INTERCORRELATIVE PARTITIONING floating palette.

3. Select the histogram region of interest using an ROI from the ROI TOOLS floating palette, and extract the corresponding phase (and ROI) map by selecting EXTRACT PHASE on the floating palette.

4. Repeat step 3 to add additional phase maps. If you wish to undo one or more steps, click on UNDO STEP.

5. When complete, select the FINISH button on the floating dialog to leave the analysis mode and restore the original histogram.

It should be noted that each composite phase map color table has a maximum number of available colors; when this limit is reached, an appropriate message will be posted and no additional phase maps may be added to the composite map.

Composite phase maps may be extracted from trivariate histograms in an identical way. This is illustrated in Figure 2-11, where a composite phase map and corresponding ROI map have been calculated from the trivariate histogram generated in Section 2.3. As shown, the numerous clusters of intensity within the trivariate histogram correspond to distinct, well-defined phases as shown in the composite phase image. In this way, the information within the three elemental maps has been reduced to a single image that suggests that a small number of distinct phases exist in the dataset. These phase maps may be used to extract phase-specific information from the source images or dataset; functions incorporated to help do this are discussed in the following two sections.
2.6 Extracting a single phase image from a composite map

After generating a composite phase image, it is often desirable to extract one or more of the constituent phases as a single image. The extracted single phase-specific map could be used, for example, as a spatially specific mask to selectively integrate regions in one or more elemental maps for performing spatially specific atomic-ratio calculations or, alternatively, to perform phase specific spectroscopy on a spectrum-image dataset as described in the following section.

To extract a single phase-map from a composite, select the **EXTRACT SINGLE PHASE MAP FROM COMPOSITE** option from the **MULTIVARIATE HISTOGRAM ANALYSIS** sub-menu with the composite phase map front-most. A dialog will request you to specify which number phase you want to extract, as shown in Figure 2-12. Each phase in the composite image has a value corresponding to the sequence in which it was added (the first phase selected has a value of 1, the second phase a value of 2, and so on). By placing the cursor on the desired phase within the composite, the associated value can be viewed in the **IMAGE STATUS** floating window. After specifying the desired phase for extraction, the single phase will be displayed in a new image window. In summary;

To extract a single phase image from a composite phase map

1. With the multivariate histogram front-most, select **EXTRACT SINGLE PHASE MAP FROM COMPOSITE** in the **MULTIVARIATE HISTOGRAM ANALYSIS** sub-menu and enter the number corresponding to the phase you wish to extract.
2. The extracted phase map will be displayed in a new image-window.

It should be noted that the a binary phase map is extracted, with the value of the pixels associated with the extracted phase set at unity (and zero for all other pixels), regardless of its (non-zero) value in the composite phase image.

2.7 Performing phase-specific spectroscopy on a spectrum-image

A phase-specific map provides an effective filter (or mask) for performing phase-specific spectroscopy on a spectrum-image dataset. To carry out this operation, generate a single phase map by either directly from a multivariate histogram plot as described in Section 4.4 or, alternatively, by extracting a single plane from a composite phase map as shown in the previous section. Selecting **Extract Phase-Specific Spectrum from SI Using Mask** in the **Multivariate Histogram Analysis** sub-menu initiates a dialog asking you to specify the spectrum-image and phase-map to be used for this operation, as shown in Figure 2-13.

It should be noted that the spectrum image and phase map should have identically sized spatial dimensions to perform this operation; if there is an incompatibility, an appropriate error message will be given. Once the appropriate information is entered, the procedure checks the images are compatible for the operation before multiplying each image plane in the spectrum-image by the binary phase image. The filtered spectrum-image is then summed in the spatial directions, and the resulting phase-specific spectrum is plotted in a new image-window as shown in Figure 2-14.
2.8 Advanced notes

To extract a phase-specific spectrum from a spectrum-image using a phase-map

1. Select **EXTRACT PHASE-SPECIFIC SPECTRUM FROM SI USING MASK** in the MULTIVARIATE HISTOGRAM ANALYSIS sub-menu, and specify the spectrum-image and (single) phase image in the appropriate fields.

2. The phase-specific spectrum will be computed and displayed in a new image-window.

The default preference settings for the Multivariate Histogram procedure are contained in the global information tags. In addition to the parameters accessible via the **HISTOGRAM SETUP...** dialog, additional items such as font size and style for the trivariate histogram and histogram display sizes are contained here. These values may be viewed and edited via the Global Info dialog box, initiated by selecting the **GLOBAL INFO...** menu item in the File menu. The multivariate histogram preferences are found in **TAGS** under MULTIVARIATE HISTOGRAM ANALYSIS, as shown in Figure 2-15.
To alter the value of a preference tag, simply highlight the item, click EDIT and enter the new preference. To revert a preference to its default (factory) setting, delete the entry from the PREFERENCES group by highlighting it and selecting REMOVE, and the default entry will be generated next time the histogram routine requires it.
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