

## CHAPTER

## 3

## Adjusting Data with Filters

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### Introduction

After loading data, you can apply a data filter to smooth or sharpen data. Data filtering is optional, but applying one can remove drastic changes in neighboring response values or clean out false data. Applying a data filter can also highlight or exaggerate the differences between adjacent response values.

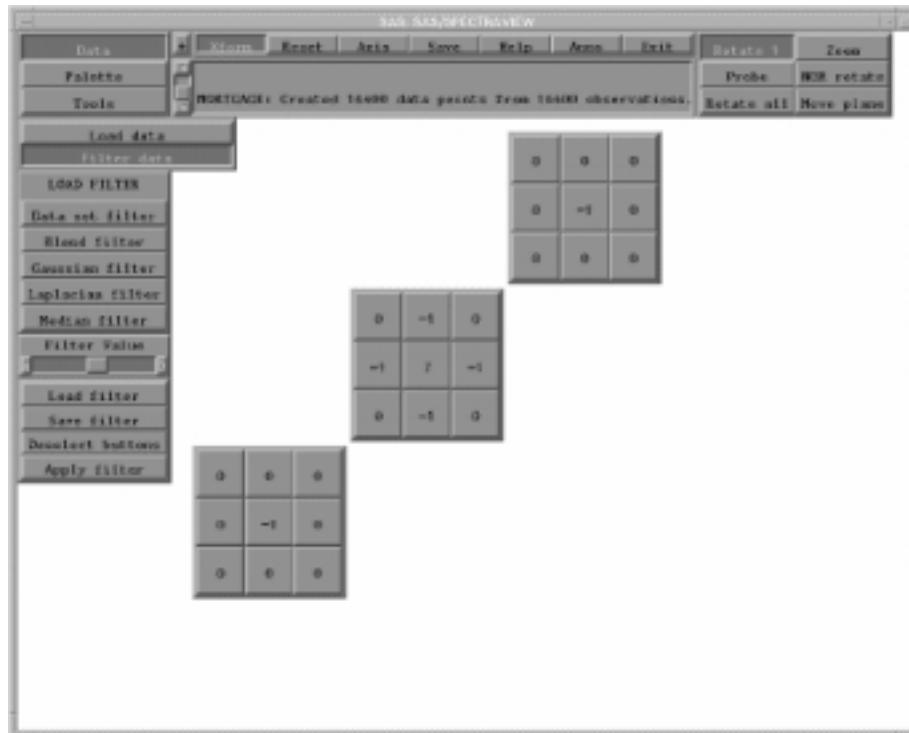
For example, suppose you have measurement values from an instrument that has some degree of noise associated with its measurements:

$$\text{measure value} = \text{real value} \pm \text{instrument noise}$$

To assist in analysis, you could smooth out the noise by applying a smoothing filter, like the Blend filter. Another example would be a data set representing a CT scan that you want smoothed or enhanced.

When you apply a data filter, the software adjusts the value for each response value in the data by performing a mathematical operation. In general, the operation replaces the response value being operated on by multiplying and averaging its value with the values of adjacent response values. Missing response values are ignored.

When you specify a filter, the software displays three pads of buttons that represent a 3x3 matrix. Each button (element) represents a response value location, with the center element representing the response value being operated on. For example, Display 3.1 on page 40 shows the matrix of preset values for the Laplacian filter (provided with the software), which sharpens data.

**Display 3.1** Laplacian Filter Matrix of Preset Values

When you apply the Laplacian filter, the software does the following for each response value in the data:

- 1 The response value being operated on is multiplied by 7, which weights (increases) it.
- 2 Adjacent (surrounding) response values are multiplied by -1, which pulls down (decreases) their values.
- 3 The resulting values are then averaged, and the average replaces the value for the response value being operated on.

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## Using the Filters Provided with the Software

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### Understanding the Filters

SAS/SPECTRAVIEW provides four filters:

**Blend filter**

smooths by averaging without weighting the response value.

**Gaussian filter**

smooths by averaging and weights the response value.

**Laplacian filter**

sharpens the data.

**Median filter**

smooths by using the median value.

The filters are provided as templates and are preset with values that the software uses to multiply the response values. The templates differ only in their values, which you can use or modify to suit your needs. The Median filter does not provide values and cannot be modified.

Note that you can also create your own data filter, which is explained in “Creating and Applying Your Own Filter” on page 44.

## Blend Filter

The Blend filter, which is the default, gently smooths data by averaging the response value with the values of adjacent response values. (In comparison, the Gaussian filter smooths by averaging and also weights the response value.) The Blend filter uses the following preset values, which you can modify:

```
1 1 1   1 1 1   1 1 1
1 1 1   1 1 1   1 1 1
1 1 1   1 1 1   1 1 1
```

Each element in the matrix has a value of 1. The multiplication does not change any values, so the response values are simply averaged to arrive at the replacement response value.

## Gaussian Filter

The Gaussian filter smooths data by averaging and also weights the response value. (In comparison, the Blend filter smooths by averaging but does not raise the response value.) The Gaussian filter uses the following preset values, which you can modify:

```
0 0 0   0 1 0   0 0 0
0 1 0   1 4 1   0 1 0
0 0 0   0 1 0   0 0 0
```

The response value being operated on is multiplied by 4, which increases (weights) it. Adjacent response values are multiplied by 1, so they are not changed. The resulting values are then averaged, with the average replacing the response value being operated on. *Note that the Gaussian filter is useful to smooth out spikes in CAT scan data.*

## Laplacian Filter

The Laplacian filter sharpens data by weighting the response value and pulling down the adjacent response values. The Laplacian filter uses the following preset values, which you can modify:

```
0 0 0   0-1 0   0 0 0
0-1 0   -1 7-1   0-1 0
0 0 0   0-1 0   0 0 0
```

The response value being operated on is multiplied by 7, which increases (weights) it. Adjacent response values are multiplied by -1, which decreases (pulls down) their values. The resulting values are then averaged, with the average replacing the response value being operated on. *Note that the Laplacian filter is helpful for sharpening contrast in data.*

## Median Filter

The Median filter smooths data by using a median (middle) value. The Median filter is not a template. There are no values in the matrix; only asterisks, which cannot be changed.

The Median filter sorts the response value being operated on with surrounding response values in order, selects the median value, then replaces the response value being operated on with the median value. The median value is the value in the sorted list that has the same number of values below it as above it. All 27 values, except missing values, are included in each operation.

## Combining Filters

You can apply multiple filters to the data to both smooth and sharpen data. For example:

- apply the Laplacian filter along with the Gaussian filter
- apply the Gaussian filter or Median filter along with the Laplacian filter
- apply the Laplacian filter along with the Median filter.

Note that the order in which you apply filters affects the result. That is, if you apply a Laplacian filter, then a Gaussian filter, the result will be different than if you apply the Gaussian filter first, then the Laplacian filter.

## Applying a Filter Provided with the Software

The following instructions apply a data filter provided with SAS/SPECTRAVIEW :

- 1 Load the appropriate data set.
- 2 Select **Data**, then **Filter data**.
- 3 Specify the filter you want to load by selecting one of the following. The default is the Blend filter.
  - Blend filter** smooths by averaging without weighting the response value.
  - Gaussian filter** smooths by averaging and weights the response value.
  - Laplacian filter** sharpens the data.
  - Median filter** smooths by using the median value.
- 4 Select **Apply filter** to apply the filter to all response values in the data.

## An Example Using the Blend Filter

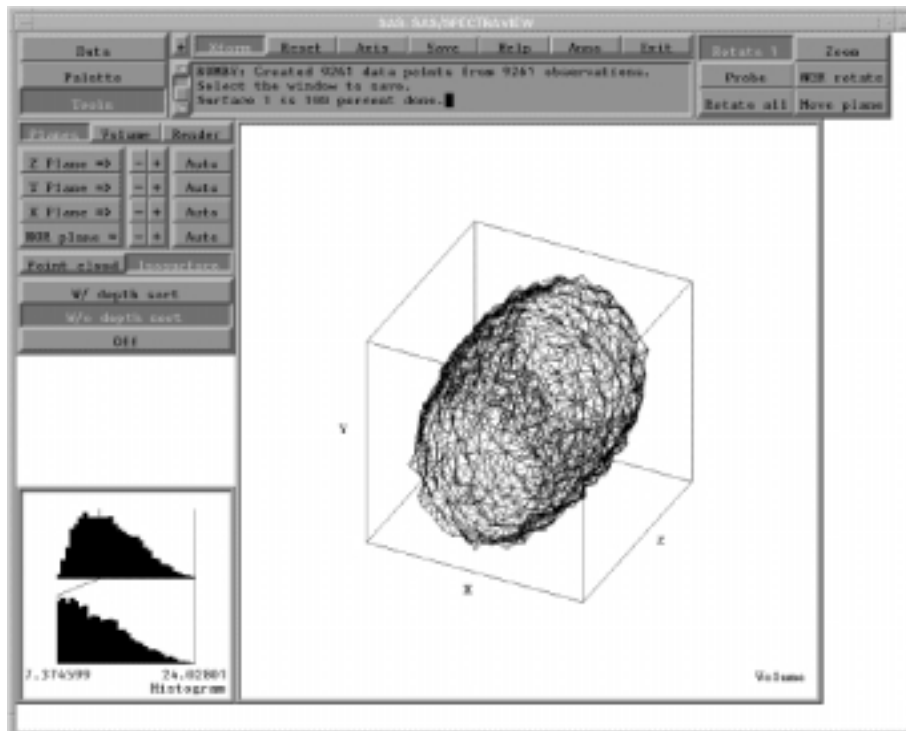
The following steps illustrate the effects of applying the Blend filter:

- 1 Issue the following DATA step code to create a SAS data set named BUMPY, which produces a series of ellipses with additional random noise added to the response values:

```
data bumpy;
  do x = -5 to 5 by 0.5;
    do y = -5 to 5 by 0.5;
      do z = -5 to 5 by 0.5;
        response = (x*x*0.5 + y*y*0.3 + z*z*0.1) + 2.0*ranuni(-1);
        output;
      end; end; end;
run;
```

- 2 Load the data set into SAS/SPECTRAVIEW .
- 3 Create an isosurface, which represents one response value:
  - a Select **Tools**, then **Isosurface**.
  - b To specify the response value, use the left mouse button and drag the histogram's left white line to a desired value. (The histogram appears at the bottom left of the interface.)
  - c Then select **W/ depth sort**. The isosurface looks something like a football that is rather bumpy.

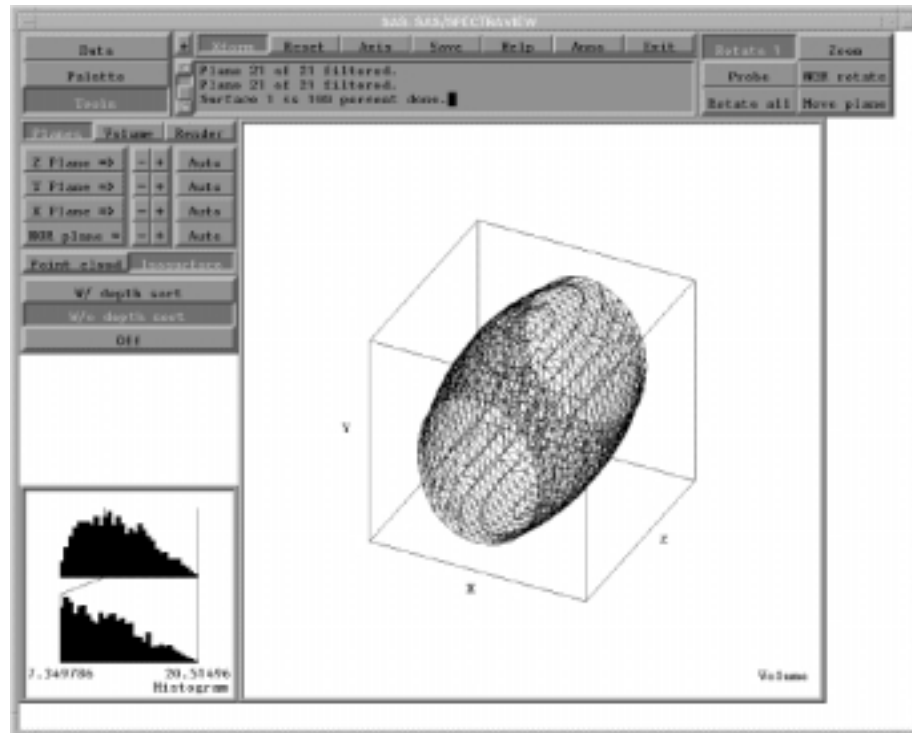
**Display 3.2** Bumpy Isosurface



- 4 Next, smooth the data by applying a data filter:
  - a Select **Data**, then **Filter data**.
  - b Select **Blend filter**.
  - c Select **Apply filter**.
- 5 Follow the same instructions as in Step 3 to re-create the isosurface.
 

The result is that removing the noise in the data displays a much smoother surface, which can help in viewing overall trends in data.

Display 3.3 Smoother Isosurface



## Creating and Applying Your Own Filter

To create a filter to suit your own needs, you can customize a supplied filter by modifying its preset values, or you can define a filter using SAS DATA step code.

### Customizing a Filter

The following steps create a filter by modifying the preset values of a filter provided with SAS/SPECTRAVIEW:

- 1 Load the appropriate data set.
- 2 Select **Data**, then **Filter data**.
- 3 Specify the filter template you want to customize by selecting one of the following. You cannot customize the Median filter.
  - Blend filter** smooths by averaging without weighting the response value.
  - Gaussian filter** smooths by averaging and weights the response value.
  - Laplacian filter** sharpens the data.
- 4 Select the filter element(s) that you want to have the same value, and adjust the slider under **Filter Value** to set the value.
- 5 Select **Deselect buttons** to release the selected elements.
- 6 If needed, adjust more element values.
- 7 Select **Apply filter** to apply the customized filter to all response values in the data.
- 8 To reuse the customized filter, store it in a SAS data set by selecting **Save filter** and specifying a one- or two-level SAS data set name in the text window.

---

## Creating a Filter with SAS DATA Step Code

Using SAS DATA step code, you can create a SAS data set containing a filter, which can then be loaded into SAS/SPECTRAVIEW. The following restrictions apply:

- The data set must contain exactly four numeric variables, named as follows and in this order: FILTER\_X, FILTER\_Y, FILTER\_Z, FILTER.
  - FILTER\_X, FILTER\_Y, and FILTER\_Z are the indices of the filter for X, Y, and Z. The valid range for these values is 1, 2, and 3.
  - FILTER is the value for a given set of indices. Its range of values is -16 to 16, inclusive.
- All values must be integers or are converted to integers when read in. The data set must have at least 27 values, one for each location in the filter. More than 27 values produces a warning message. Incomplete filters are aborted. The data set cannot contain missing values.

The following DATA step code creates a SAS data set named BLEND, which contains a valid filter:

```
data blend;
  do filter_x = 1 to 3;
    do filter_y = 1 to 3;
      do filter_z = 1 to 3;
        filter = 1; output;
      end; end; end;
run;
```

---

## Applying a Filter Stored in a Data Set

The following instructions apply a filter stored in a SAS data set:

- 1 Load the appropriate data set.
- 2 Select **Data**, then **Filter data**.
- 3 Select **Load filter** and enter the data set name in the text window.
- 4 Select **Data set filter** to display the filter matrix.
- 5 Select **Apply filter** to apply the filter to all response values in the data.





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