HPF Resolution Merge

Use the HPF resolution merge function to combine high-resolution panchromatic data with lower resolution multispectral data, resulting in an output with both excellent detail and a realistic representation of original multispectral scene colors.

This dialog provides an implementation of "HP Resolution Merge," researched and proposed by Ute Gangkofner of Geoville, Inc. and Derrold Holcomb of ERDAS, Inc. The process involves a convolution using a High Pass Filter (HPF) on the high resolution data, then combining this with the lower resolution multispectral data. Read the description of the Algorithm below.

Ensure that your system has sufficient space for not only the output merged image, but also the temporary files written to the directory specified by your User Interface and Session > **Temporary File Directory** preference. Change the preference to a location with sufficient space (preferably on a local hard-drive) if you have problems running a process to completion.

- Dialog Description
- Algorithm
- Dialog Concepts

Dialog Description

This dialog opens when you click **Raster** tab > **Pan Sharpen** > **HPF Resolution Merge**.

High Resolution Input File (*.img) Select the high resolution file that will provide the detail in the output file. Typically, this will be a single-layer panchromatic image.

[file name] Enter the name of the input file, or click the dropdown arrow to open the Recent Files menu.

Click to open the File Selector dialog to navigate to the input file.

Select Layer Type inside the text field, or click the dropdown arrow to select which layer of the input file to use for processing.

Cell Size Reports cell size (ground resolution) for both X & Y direction. The units used to measure the Cell size displays below. You may not edit these values.

Multispectral Input File (*.img) Select the image which will contribute the color aspect of the output image.

[file name] Enter the name of the input file, or click the dropdown arrow to open the Recent Files menu.

Click to open the File Selector dialog to navigate to the input file.

Use Layers Specify the layers of the Multispectral Input File to be used for processing. Use 1,[n],[n] to specify individual layers, or use 1:[n] to specify a range. The default is all layers of the file.

Cell Size Reports cell size (ground resolution) for both X & Y direction. The units used to measure the Cell size displays below. You may not edit these values.

Output File:

[file name] Enter a name and format type for the output file.

Click Open File icon to open the File Selector dialog to choose the format type for the image, and navigate to the directory to store the image, or right-click to open the Recent Files menu.

Files of type In the File Selector, click the dropdown arrow to select the output file format.

Type Select the raster data type for the output image.

Ignore Zero in Stats. When this checkbox is checked, data file values of zero are omitted when statistics are calculated for the output file. It is recommended that you check this option whenever you set an AOI for processing.

R: Resolution Ratio is initially set to the ratio between the **Cell Sizes** (pixel sizes or ground resolution) of the **Multispectral Input File** and the **High Resolution Input File**. The value of Resolution Ratio controls the defaults for all other processing parameters. You can change **R** to enable alternate options for the other processing parameters. **R** should always be greater than 1.

Kernel Size: Size of the High Pass Filter (HPF) convolution kernel to be applied to the **High Resolution Input File**. This number depends on the value of **R**.

Center Value: Center value of the High Pass Filter (HPF) kernel. The rest of the kernel is always -1. The choices of values offered here depends on the value of **R**.

Weighting Factor: This number determines how much “weight” is given to the filtered high resolution input in the final result. Higher numbers result in a very crisp output, while lower numbers will result in a smoother output. The default value results in moderate crispness. The range of values offered here are determined by the value of R.

2 Pass Processing: This option is only enabled when **R** is greater than or equal to 5.5. Select this option to perform the second pass, that is, use a second high pass filter applied to the high resolution data to modify the output.

Center Value Center value of the 2nd Pass High Pass Filter (HPF) kernel. The rest of the kernel is always -1. Select from these options: 24, 28, 32.

Weighting Factor: This number determines the weighting factor for the second pass calculation.

OK Click this button to accept your input into the Modified IHS Resolution Merge dialog and perform the operation.

Batch Click to add this process to Batch Command Editor.

View... Click to open a spatial modeler diagram which is representative of the Modified IHS Resolution Merge dialog. You can use the tools in the Spatial Modeler to modify the rules in the spatial modeler by hand. This is a very powerful means to modify the default technique.

Save any changes to the model to your own file; that is, do not overwrite the existing graphical model (.gmd) file.

AOI... Click to select a specific area of interest for use in resolution merge. The Choose AOI dialog opens. The AOI you select will be considered in creating the output file only insofar as it overlaps both the high-resolution and the multispectral image. It is highly recommended to choose the “Ignore Zero in Stats” option for the output file when an AOI is specified.

Cancel Click to cancel resolution merge and discard your edits in the dialog.

Help Click to open this On-Line Help document.

Algorithm

Research into improving our wavelet-based Resolution Merge functionality led to advancement of the High Pass Filter (HPF) add-back method to the level at which it yields results comparable to redundant wavelets but with much smaller computation time and data space requirements.

The general algorithm is:

- Read pixel sizes from Image files and calculate R, the ratio of multispectral cell size to high-resolution cell size.
- Apply the High-pass filter to the high spatial resolution image.
- Resample the multispectral image to the pixel size of the high-pass image.
- Add the HPF image to each multispectral band. The HPF image is weighted relative to the global standard deviation of the multispectral band.
- Stretch the new multispectral image to match the mean and standard deviation of the original (input) multispectral image.

Calculate R

The Pixel Sizes (Cell Size) are automatically extracted from the Image Metadata for each image. These values then populate the **Cell Size** fields in the dialog. R is calculated as the ratio between the cell size of the multispectral input and the cell size of the high resolution input. For example, for Landsat TM imagery, R=2.

High-Pass Filter

This operation produces the high-pass filtered image (HPF). A high pass convolution filter kernel (HPK) is created and used to filter the high-resolution input data. The size of the high-pass kernel (HPK) is a function of the relative input pixel sizes, R. Table 1 shows how the size of HPK is determined based on R.

Table 1: HPK size based on values of R

R Value	HPK Size
1 < R < 2.5	5x5
2.5 <= R < 3.5	7x7
3.5 <= R < 5.5	9x9
5.5 <= R < 7.5	11x11
7.5 <= R < 9.5	13x13
R >= 9.5	15x15

All values of the kernel are set to –1 except the center value. There are three possible values for the kernel center value, as shown in Table 2. The lowest of the three values for each kernel size is the default.

Table 2: Center value options based on HPK

HPK (Kernel) Size	Center Value		
	Default Value	Optional Values	
5x5	24	28	32
7x7	48	56	64
9x9	80	93	106

11x11	120	150	180
13x13	168	210	252
15x15	336	392	448

Resample the Multispectral Image

The low spatial resolution image is resampled to the pixel size of the high resolution image using a Bilinear algorithm (4 nearest neighbors). The resulting HPF image will, therefore, have the same pixel size as the high resolution image.

Add the HPF Image

The HPF image is weighted relative to the global standard deviation of the multispectral bands and is also a function of R.

The value of the weight applied to the HPF image, prior to addition to the multispectral image, depends on both R and the standard deviations (SD) of both the HPF image and multispectral band it is being merged with. In addition, the weight is allowed to vary so you can adjust the crispness of the result. The range of weighting is constrained within reasonable limits.

The weighting (W) is determined by the formula:

W = (SD(MS) / SD(HPF) x M)

Where:

W = weighting multiplier for HPF image value.

SD(MS) = standard deviation (SD) of the MS band to which the HPF image is being added.

SD(HPF) = standard deviation (SD) of the HPF image.

M = modulating factor to determine the crispness of the output image. This factor is user-adjustable. The min, max, and default value for M depend on R, as shown in Table 3.

Table 3: Range and default for M based on R

R Value	M Values		
	Max	Default	Min
1<R < 2.5	0.3	0.25	0.20
2.5<= R<3.5	0.65	0.50	0.35
3.5<= R<5.5	0.65	0.50	0.35
5.5<= R<7.5	1.0	0.65	0.50
7.5<= R<9.5	1.4	1.0	0.65
R>=9.5	2.0	1.35	1.0

The calculation for each band of the input image will then be:

Pixel (out) = [Pixel (in)] + [HPF x W]

In the dialog, the weighting factor WF is presented as an integer which is equal to 20 * M.

For example, for R = 4, M ranges from .35 to .65, therefore 20*.35 <= WF <= 20*.65, or 7 <= WF <= 13.

So, in the example above, you can select WF between 7 and 13.

M is calculated as:

M= WF / 20

For large values of R, it is sometimes preferable to perform two sequential HPF add-back operations using different parameters. For large value of R (>=5.5) the **2-Pass Processing** option is enabled. If you select this checkbox, two sequential HPF add-back operations are performed. The first pass parameters are identical to those used when only one pass is used. The center of the 2nd pass HPK has a default of 28, and optional values 24 and 32.

The modulating factor M for the second pass has the range:

Table 4: Optional 2-Pass M values

R Value	2-Pass M Values		
	Max	Default	Min
R >=5.5	0.5	0.35	0.25

As in the first pass, the dialog shows the weighting factor (WF) for the second pass as an integer which is equal to 20 * M. So for the second pass:

20*.25 <= WF <= 20*.5, or

5 <= WF <= 10.

Linear Stretch

A linear stretch is performed as the last step of this algorithm. The linear stretch rescales the output so that the mean and standard deviation of the final output match the mean and standard deviation of each layer of the input multispectral image. This allows the final output image to have the same data type as the input multispectral image. Typical data types include Unsigned 8 bit or Unsigned 16 bit.

Dialog Concepts

Input Files

There are two Input Files:

- Single layer “high resolution” (spatial) image
- Multispectral “low resolution” (spectral) image

Use the Multispectral Input File Selector to select any or all of the input layers. For each input image, the pixel sizes and units are shown.

Calculate Resolution Ratio

Once both of these fields are properly populated, **R** (resolution ratio) is calculated and entered into the appropriate field. This parameter is calculated from the input pixel sizes. You have the option to change R if you wish to experiment with different parameters.

Raster Data Type of Output File

The **Output File** contains the same number of layers as are chosen from the **Input File**. The data type of the output file is the same as for the multispectral input file. The conversion from the processing format (Float) to the final data type (commonly Unsigned 8 or 16-bit) is accomplished by the Linear Stretch step.

First High Pass Kernel

The first **High Pass Kernel** is defined by three parameters:

Kernel Size The kernel size for the first high pass is determined by **R**. This value is calculated using the relative pixel sizes of the two input images. Thus, the default value will be as seen in Table 1 This is a non-editable parameter, but can be indirectly varied by changing **R** above.

Center Value This parameter is shown in Table 2. Note that there are three options, a default value and two optional values.

Weighting Factor The range for this parameter is calculated based on R as in Table 3. Note that the value selected here is divided by 20 to get the value for M in Table 3. The higher number yields a greater HPF add-back which results in a crisper output.

Second High Pass Kernel

2-Pass Processing This is a checkbox; the default is Off (that is, one-pass processing), so this area is grayed out and not active unless R >= 5.5. Once checked, the **Second High Pass Options** becomes active.

2-pass processing is an option only for R >= 5.5.

The **Second High Pass Kernel** is defined by three parameters. Only the Weighting Factor may be changed.

Kernel Size This parameter is always 5 (that is, a 5 X 5 high-pass kernel).

Center Value Note that there are three options, a default value (28) and two optional values (24 and 32).

Weighting Factor The range for this parameter is based on M as in Table 4. Note that the value selected here is divided by 20 to get the value for M in Table 4. The higher number yields a greater second pass HPF add-back which results in a crisper output.
