Operations
- Interpolate
- Scan Average
- Krige

What Do I Need?
Use the Interpolate operation on non-continuous data to fill in gaps and voids. Cells with no data should be assigned the value “VOID”. The Interpolate operation works best on semi-continuous data such as contours and remote sensing imagery with gaps. If you have a map layer with sparse data points, use the Krige operation to interpolate unknown values.

Example
Interpolate Continuous Elevation Data From Contours
Contour map layers do not provide sufficient detail about surface elevation to perform some types of raster analysis based on elevation related criteria. Certain analyses require a continuous elevation surface. Use the Interpolate operation to create a continuous surface from a discontinuous one such as this contour map:

Here the Interpolate operation is used to generate a continuous elevation map layer with a precision of 0.5m. A mask map layer is used to prevent
cells representing the river network from being used in the interpolation. A search radius of 200 metres is specified. The default grid spacing and weighting method are used. Refer to the Interpolate document for details on these options:

If you were performing this operation from the Script window the statement would be:

```
DEMInterpolated = Interpolate Contour
    In WaterMask To 0.5m
    Within 200m Step 3;
```

The Interpolate operation uses a two pass process. The first pass derives a sparse mesh of values and the second pass fills in the rest of the values. The user is not able to see the first pass, but if it were possible, this is what it would look like for the operation specified above (Note: To reduce the
number of legend entries for this example, the legends have been grouped for the following two figures):

![Legend for FirstPass mfm](image1)

![Legend for DEM mfm](image2)

The final map layer has the values between the original contours completely filled in:

![Final Map Layer](image3)

It is not recommended that you use the **Interpolate** operation to create a continuous data set from map layers with a very low density of data points. The **Interpolate** operation produces the best results when applied to a well defined contour map with good sources of ridge and channel information.

The **Kriging** operation is a better solution for creating a continuous data set from sparse data map layers, such as point data map layers. The **Kriging** operation has been designed specifically for map layers that contain a sparse matrix of data.
**Example**  **Interpolate Continuous Bathymetric Data From Non-continuous Data Using a Mask Map Layer**

You will need a mask map that restricts the interpolation process to specific cells. In this example, a mask map is used to restrict the interpolation to those cells that have elevations below sea level.

Contour maps and spot elevation map layers do not provide sufficient detail about surface elevation. Some analyses require a continuous elevation surface. Use the **Interpolate** operation to create a continuous surface from a discontinuous one such as this contour bathymetry map layer:

![Contour Bathymetry Map Layer](image)

The areas above sea level (i.e., the land surface) have the value “0”. The contours are in metres below sea level. The background “water” cells for which continuous bathymetric values are to be interpolated have the value “VOID”.

The **Interpolate** operation is used to estimate the unknown bathymetric values between the contours. The contours represent known bathymetric values. The precision of the estimated bathymetric values will be half a
metre. To restrict the interpolation to those cells below sea level, a mask map layer is specified:

The mask map layer restricts the interpolation process to those cells with a non-VOID value. In this case, all the “land” cells have the value “VOID” and all the “ocean floor” cells have the value “1”. The following
Interpolate operation is applied to the bathymetric contour map layer named 4003 Contours:

![Interpolate operation interface](image)

If you were performing this operation from the Script window the statement would be:

```
  "4003 DEM" = Interpolate "4003 Contours"
  In "4003 Mask" To 0.5m Step 4
  InverseSquare;
```

Specifying a mask map layer with the Interpolate operation creates a continuous data set map layer from a non-continuous data set map layer.
The mask map layer restricts the interpolation to areas in the mask map layer that have non-VOID values:

![Image of a map with a mask map layer]

**Smoothing to Improve the Results of the Interpolate Operation**

To improve the smoothness of the bathymetric data values, the **Scan** operation with the **Average** modifier could be used.

It is not recommended that you use the **Interpolate** operation to create a continuous data set from map layers with a very low density of data points. The **Interpolate** operation produces the best results when applied to a well defined contour map with good sources of ridge and channel information.

The **Kriging** operation is a better solution for creating a continuous data set from sparse data map layers, such as point data map layers. The **Kriging** operation has been designed specifically for map layers that contain a sparse matrix of data.
**Example**

Interpolate Continuous Elevation Data From Sparse Point Data Using the Krige Method

The **Krige** operation can be used to interpolate a continuous data set from a data set of sparse points separated by cells with the value VOID.

Use the **Krige** operation on map layers of sparse data points (<1000) for which you wish to create a continuous data set. Continuously varying data such as soil type, population density, or topography is often collected as a set of discontinuous, unevenly spaced data points using Global Positioning System (GPS) units or other field data collection methods. The non-data cells in the input map layer should be assigned the value “VOID”. For contour data or incomplete data sets, such as remote sensing images with data gaps, use the **Interpolate** operation to interpolate unknown values.

**Recommendation**

We strongly recommend that you have an understanding of the Kriging method of data interpolation and its inherent problems before using the results of this operation for critical applications. You should be aware that data interpolation leads to the potential for error since the interpolated values may not reflect the true values.

Also, the choice of interpolation method is dependent on the nature of the data. We recommend that you have a good understanding of the variability, trend, and spatial correlation of the phenomena you are mapping before using the **Krige** operation.

Use the **Krige** operation only if you have a high degree of confidence in the exactness of the original data. For data of low confidence, use the **Interpolate** operation followed by the **Scan Average** operation to smooth the results. Use the **Krige** operation when there is a finite range at which a point no longer has any influence over the values of the unknown points; when the influence of any point is not a function of distance but rather a function of the complexity/smoothness of the surface. The degree of smoothness of the data is important to the choice. Therefore you should have knowledge of the behaviour of the surface being modelled.

If you do not have knowledge of the nature of the data to be estimated and the strengths and weaknesses of the Krige method, we recommend that you obtain professional training in the field related to the data you are analyzing and that you either consult a statistician familiar with the Krige method or obtain training in spatial statistical analysis before using the results of the **Krige** operation in critical applications.

An excellent review of the Krige method can be found in Myer, D.E., 1991, “Interpolation and estimation with spatially located data”, Chemometrics
and Intelligent Laboratory Systems, 11, pp. 209-228, and in Bonham-Carter, G.F., 1994, *Geographic Information Systems for Geoscientists: Modelling with GIS*, Pergamon/Elsevier Science Inc. Some of the notes for this document are based on these works.

**Processing Speed**

Speed of processing is also a consideration when choosing which interpolation method to use. Some researchers suggest that the choice of an interpolation method should be made on the basis of ease of computation since there is very little difference among the results of the various methods, and all produce equally suspect results. Others argue that Kriging provides a marginal advantage that, when multiplied against dollars of return based on the accuracy of the predictions, offsets the disadvantages of the slower processing speed.

**Kriging and Data Interpolation**

Kriging is a regression based interpolation method that is used to predict unknown values from irregularly spaced known values. It was originally developed for mapping in the fields of Geology and Geophysics, mining, and photogrammetry.

Kriging takes into account the interdependency of samples that are close to each other while allowing for a certain independence of the sample points. It avoids the building of a surface based on trends with introduced randomness. Kriging is based on the structural characteristics and behaviour of spatially located data. Samples taken closer together are expected to be more alike than samples taken farther apart because points that are close together tend to be strongly correlated whereas, points that are far apart tend not to be correlated.

The weights applied to the known values are obtained from a system of linear equations in which the coefficients are the values of variograms or covariance functions. The functions calculate the correlation between known points or known and unknown points. To obtain the function, the variance error must be minimized. The variogram yields the size of the zone of influence, the isotropic nature of the variable, and the continuity of the variable through space.
Interpolate Continuous Elevation Data From Sparse Point Data Using the Krige Method

A set of elevation data was collected at several locations over the area represented by the map layer named **Point Map**:

![Point Map](image)

The **Krige** operation is used to produce a map layer that estimates the non-measured values of a sparse data map layer to a precision of 0.5m:

![Krige](image)

If you were performing this operation from the **Script window** the statement would be:
Surface = Krige “Point Map” To 0.5m
Spherical Range 171;

A map layer of continuous surface data is generated from the non-VOID cells in the input map layer named **Point Map**. The data of the output map layer will be expressed in metre units with 1 decimal place of floating point precision:

Using the Exponential equation would result in a smoother appearing surface map. Using a smaller range value would result in a more complex surface.

See the example **Interpolate Continuous Bathymetric Data From Non-continuous Data Using a Mask Map Layer** for an example of how to use mask map layers in interpolation-type operations.