



# **IDL Tutorial**

## **Two & Three Dimensional Plots**

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## The IDL Intelligent Tools (iTools)

The IDL Intelligent Tools (**iTools**) are a set of interactive utilities that combine data analysis and visualization with the ability to produce presentation quality graphics. The iTools allow users to continue to benefit from the control of a programming language, while enjoying the convenience of a point-and-click environment. There are 7 primary iTool utilities built into the IDL software package. Each of these seven tools is designed around a specific data or visualization type :

- Two and three dimensional plots (line, scatter, polar, and histogram style)
- Surface representations
- Contours
- Image displays
- Mapping
- Two dimensional vector flow fields
- Volume visualizations

The iTools system is built upon an **object-oriented** component framework architecture that is actually comprised of only a single tool, which adapts to handle the data that the user passes to it. The pre-built *iPlot*, *iSurface*, *iContour*, *iMap*, *iImage*, *iVector* and *iVolume* procedures are simply shortcut configurations that facilitate ad hoc data analysis and visualization. Each pre-built tool encapsulates the functionality (data operations, display manipulations, visualization types, etc.) required to handle its specific data type. However, users are not constrained to work with a single data or visualization type within any given tool. Instead, using the iTools system a user can combine multiple dataset visualization types into a single tool creating a hybrid that can provide complex, composite visualizations.

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## Starting the iPlot Intelligent Tool and Loading Data

Launch the iPlot utility by executing the procedure *iPlot* at the IDL> command prompt :

1. IDL> `iPlot`

A splash screen will appear while the iTools system is launching. The first time the iTools system is launched in any given session of IDL will always be the slowest since the iTools need to be compiled from their ASCII text source code files found in the "*lib/iTools/*" subfolder of the IDL distribution (i.e. the user has access to the source code for the entire iTools system). Once the iTools system is up and running a separate window will come up entitled "*IDL iPlot*". Feel free to minimize the IDLDE window as the next steps of this exercise will involve the *iPlot* utility.

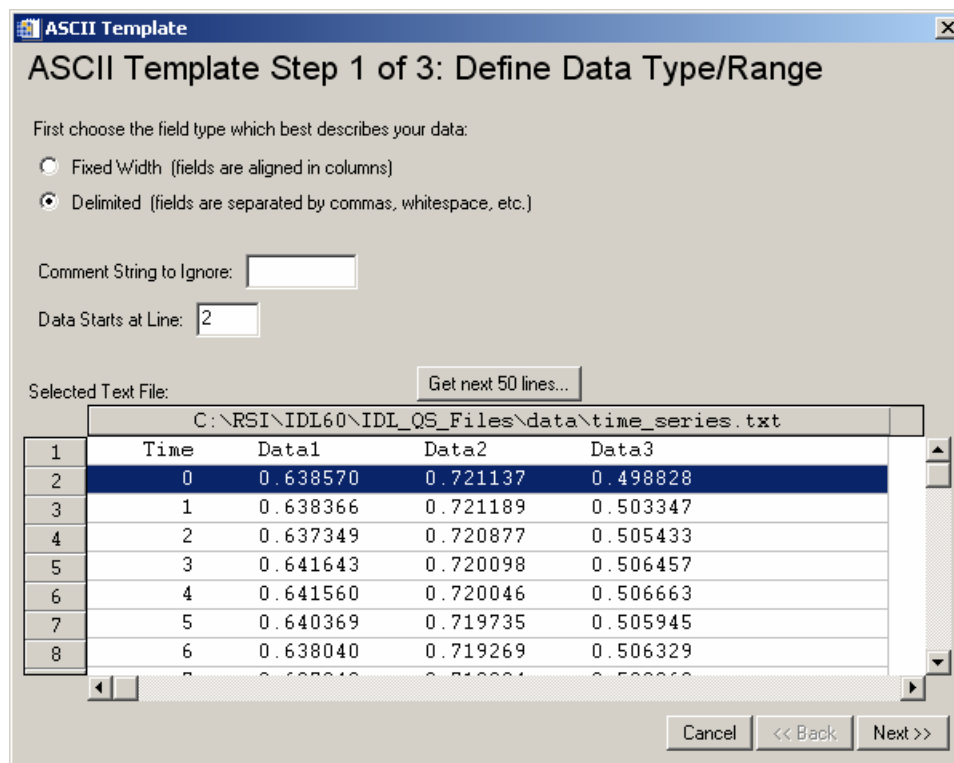
In the following exercise, the time-series data from the example data file "*time\_series.txt*" will be input into the *iPlot* utility. This example data file is located in the "*data*" subfolder.

The file "time\_series.txt" contains standard ASCII text consisting of 4 columns of data separated by whitespace. The first column contains the time-stamp data (independent variable), and the rest of the columns contain various data measurements made at the associated time (dependent variables). Here are the first 4 lines of this ASCII text file :

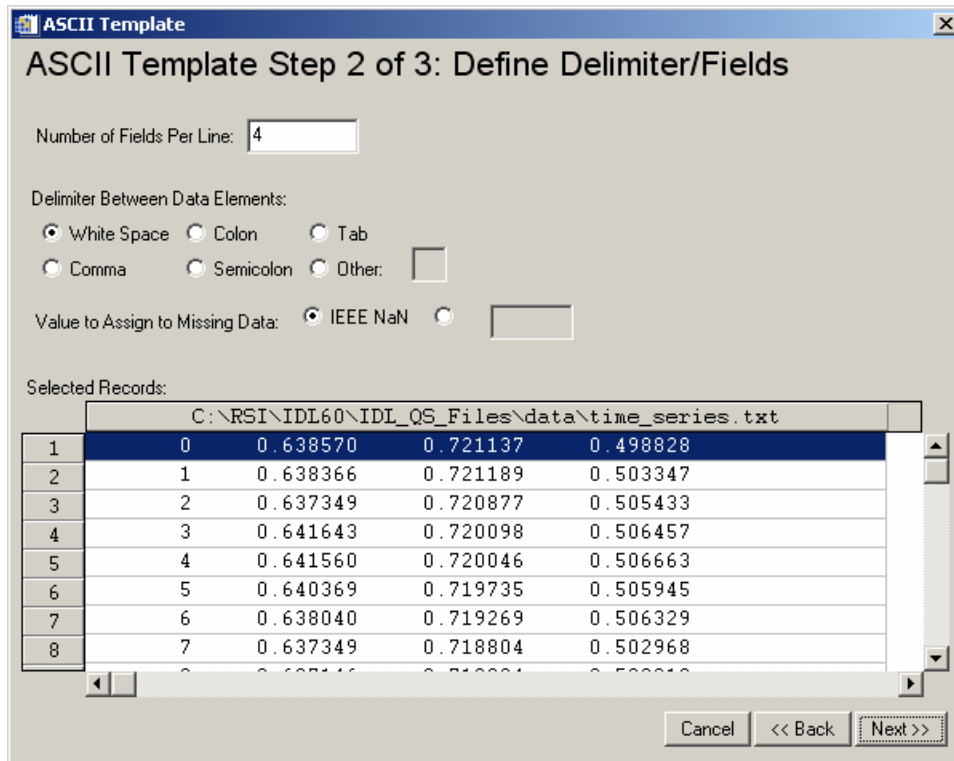
Time	Data1	Data2	Data3
0	0.638570	0.721137	0.498828
1	0.638366	0.721189	0.503347
2	0.637349	0.720877	0.505433

There are a number of different ways to load data into an iTool, and probably the easiest of these is to use the data input utilities built into the iTools system.

2. Select "File > Open..." from the IDL iPlot window.
3. Navigate to the location of the "time\_series.txt" file, select it, and hit "Open".
4. This will launch the *ASCII Template* wizard [Fig. 1] that will guide the user through the steps of defining the layout of the data within the file.
5. Change the "Data Starts at Line:" field to 2 so the first line of column headers is skipped during the read process [Fig. 1].
6. Hit the "Next >>" button to proceed to step 2.
7. In Step 2 of 3 make sure all of the parameters match the default settings illustrated in Fig. 2.
8. Hit the "Next >>" button to proceed to step 3.
9. In Step 3 of 3 change the name of the fields to match the column headers above. This can be accomplished by clicking on the columns in the "Sample Record:" area and typing the appropriate text into the "Name:" field [Fig. 3].
10. Hit "Finish" to complete the *ASCII Template* wizard.



**Figure 1: Step 1 of 3 for the ASCII Template wizard**



ASCII Template Step 2 of 3: Define Delimiter/Fields

Number of Fields Per Line:

Delimiter Between Data Elements:

White Space  
  Colon  
  Tab  
 Comma  
  Semicolon  
  Other:

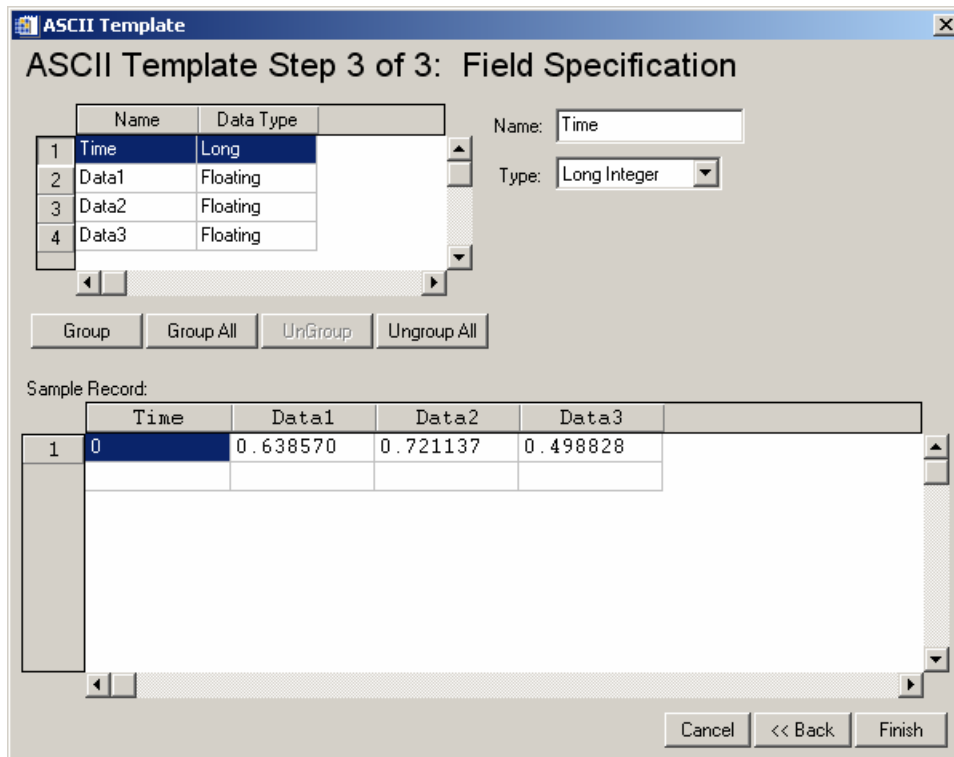
Value to Assign to Missing Data:  IEEE NaN  

Selected Records:

		C:\RSI\IDL60\IDL_QS_Files\data\time_series.txt		
1	0	0.638570	0.721137	0.498828
2	1	0.638366	0.721189	0.503347
3	2	0.637349	0.720877	0.505433
4	3	0.641643	0.720098	0.506457
5	4	0.641560	0.720046	0.506663
6	5	0.640369	0.719735	0.505945
7	6	0.638040	0.719269	0.506329
8	7	0.637349	0.718804	0.502968

Cancel   << Back   Next >>

**Figure 2: Step 2 of 3 for the ASCII Template wizard**



ASCII Template Step 3 of 3: Field Specification

	Name	Data Type
1	Time	Long
2	Data1	Floating
3	Data2	Floating
4	Data3	Floating

Name:

Type:

Group   Group All   UnGroup   Ungroup All

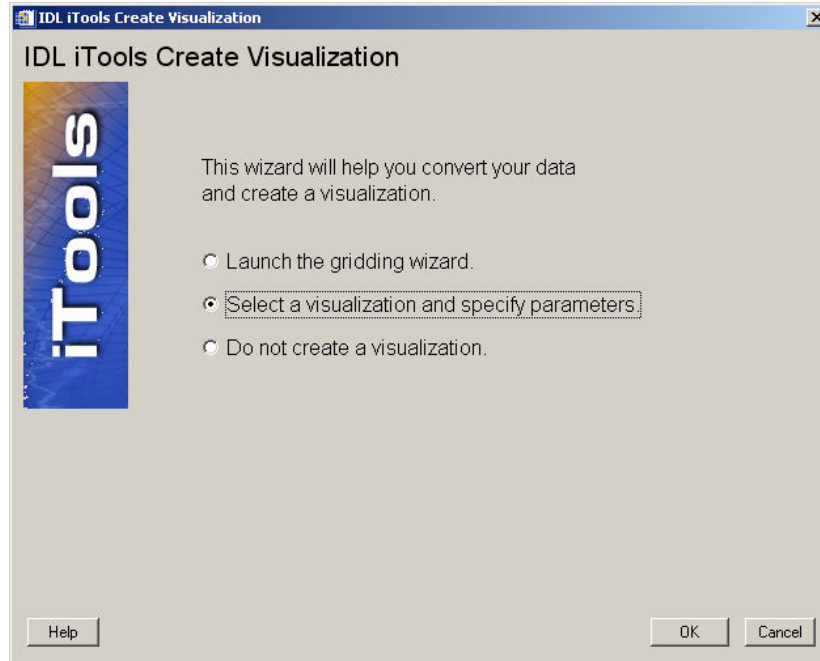
Sample Record:

	Time	Data1	Data2	Data3
1	0	0.638570	0.721137	0.498828

Cancel   << Back   Finish

**Figure 3: Step 3 of 3 for the ASCII Template wizard**

Once the user is finished running the *ASCII Template* wizard the *IDL iTools Create Visualization* dialog will come up [Fig. 4].

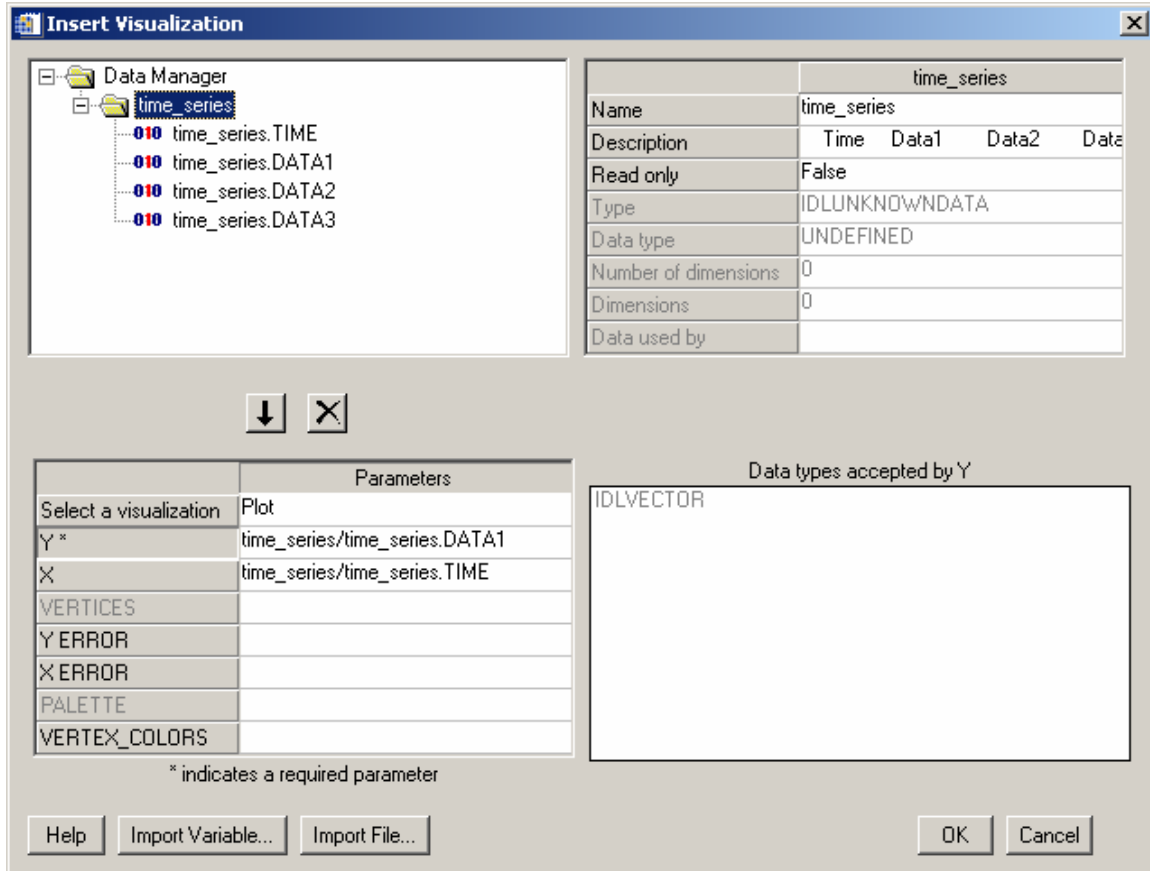


**Figure 4: The IDL iTools Create Visualization dialog**

11. In order to create a line plot visualization out of the time-series data, press "Select a visualization and specify parameters" and hit "OK".


This will bring up the *iTools Insert Visualization* dialog. This tool is used to select the data that is used to create the line plot visualization. In this case, there is one independent variable (X) contained in the field "time\_series.TIME", and 3 dependent variables (Y) that can be plotted as a function of this time.

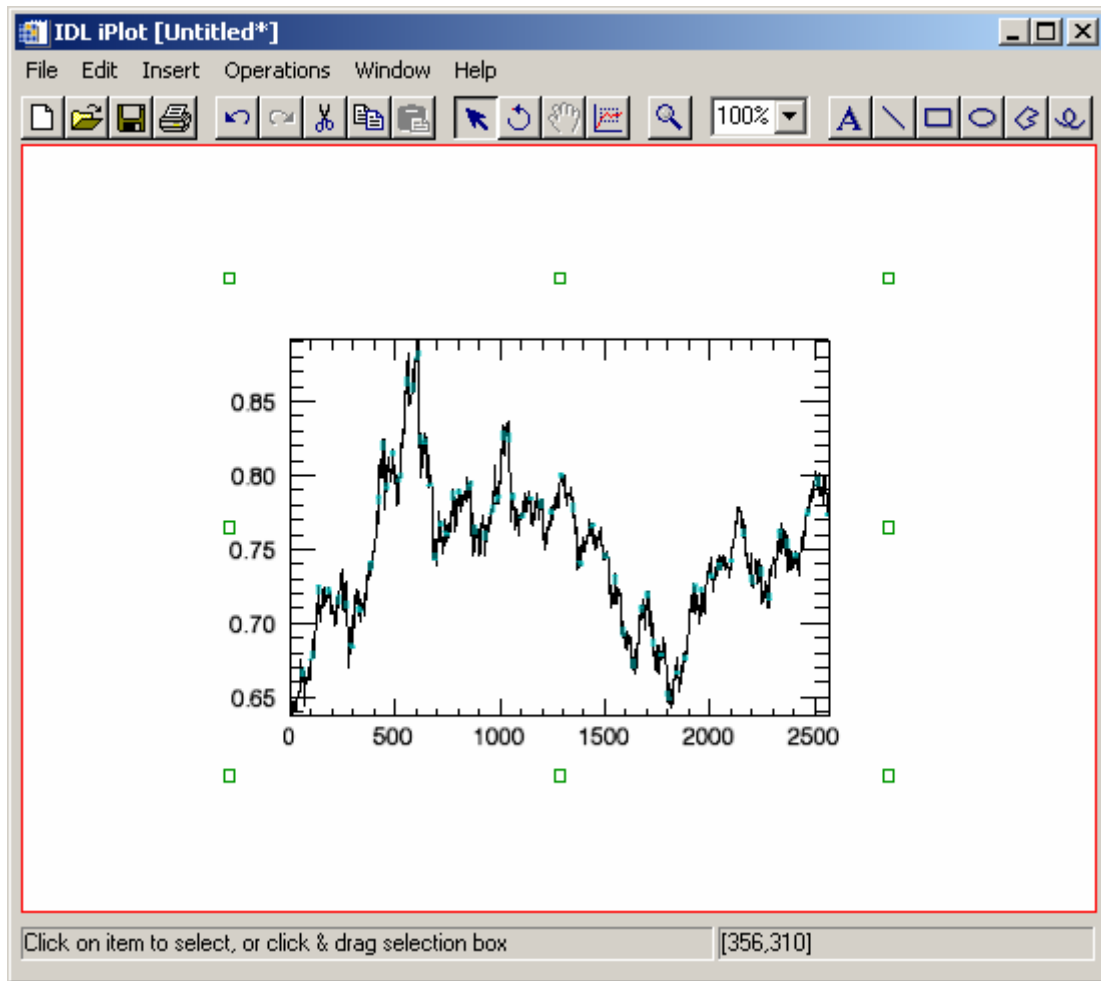
12. Click on the "time\_series" item within the Data Manager panel and expand.
13. Select the "X" row in the lower left table and then double-click the "time\_series.TIME" field from the upper left window to insert the time-stamp data as the independent variable [Fig. 5].
14. Select the "Y" row in the lower left table and then double-click the "time\_series.DATA1" field from the upper left window to insert the first data measurement as the dependent variable [Fig. 5].
15. Once these selections have been made, press "OK".



**Figure 5: The iTools Insert Visualization dialog**

A simple line plot of the "Time" data (X axis) versus the "Data1" data (Y axis) will appear within the *IDL iPlot* window [Fig. 6]. Notice that both the X and Y axes have been automatically scaled to display the full data range of the respective variables. Currently the size of the *IDL iPlot* window should be the default when it was first launched, which makes it difficult to visualize the features within the line plot graphic. Consequently, use the following steps to maximize the visual area for the graphics window :

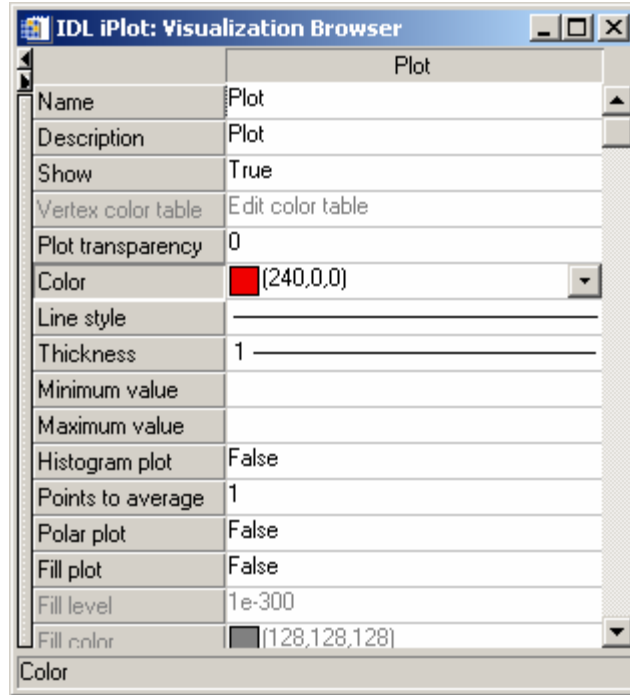
16. From the *IDL iPlot* window menu select "Window > Zoom on Resize".
17. Hit the maximize button  in the upper-right hand corner of the window.



**Figure 6: The IDL iPlot window displaying graphic of time-series data**

Currently the line plot should be displayed with the default black color. Furthermore, the *iPlot* tool should be in selection mode with the line plot automatically selected (graphic will be surrounded by 8 small squares and highlighted with cyan color markers). If the line plot is not selected simply click on the line in any location so it appears as displayed in Fig. 6. In order to differentiate the line plot from the axes (and the other data variables which will soon be plotted) change the color to red by following these steps :

18. Right-click on the lineplot in order to see the standard iTools context menu.
19. Select "Properties...".
20. Within the *IDL iPlot: Visualization Browser* window, click on the box to the right of the "Color" property and select bright red [Fig. 7].
21. Once the desired change has been made, close the *IDL iPlot: Visualization Browser* window.



**Figure 7: The IDL iPlot: Visualization browser window (property sheet)**

Now that the line plot for the first dataset has been changed in color to red, the two remaining dependent data variables can be imported and overplotted within the existing visualization :

22. From the *IDL iPlot* window menu system, select "Insert > Visualization...".
23. Select the "Y" row in the lower left table and this time double-click the "time\_series.DATA2" field from the upper left window to insert the second data measurement as the dependent variable.
24. Once this has been accomplished, hit "OK".

This will automatically insert a new lineplot within the existing data space and axes. Once again the line is plotted with the default black color, so use the following steps to change the color of this line to blue :

25. Select the new black line plot if it is not already (it should be selected by default).
26. Right-click, select "Properties...", and change the "Color" property to blue.
27. Close the *IDL iPlot: Visualization Browser* window.

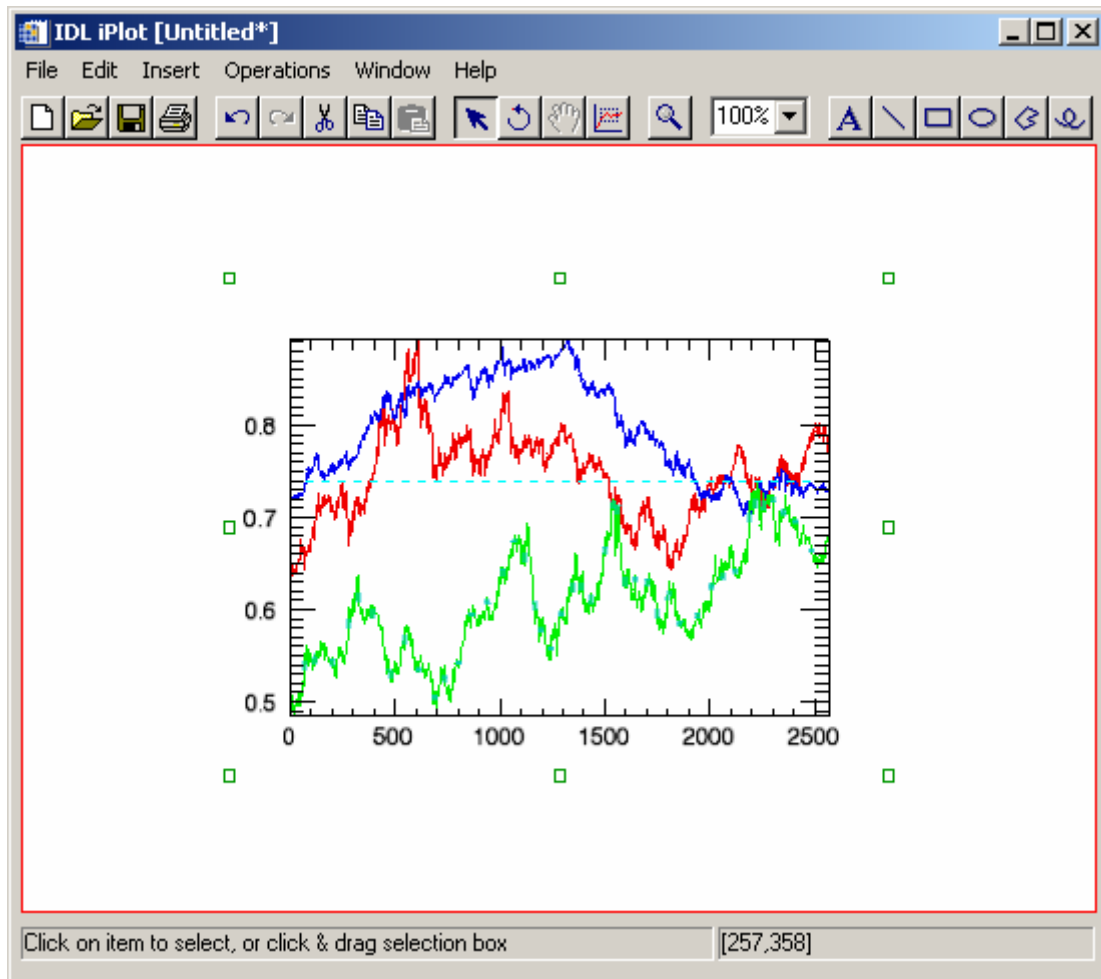
Next, plot the third and final data variable and change its line color to green :

28. From the *IDL iPlot* window menu system, select "Insert > Visualization...".
29. This time select the "Y" row in the lower left table and then double-click the "time\_series.DATA3" field from the upper left window to insert the second data measurement as the dependent variable.
30. Once this has been accomplished, hit "OK".
31. Select the new black line plot.
32. Right-click, select "Properties...", and change the "Color" property to green.



33. Close the *IDL iPlot: Visualization Browser* window.

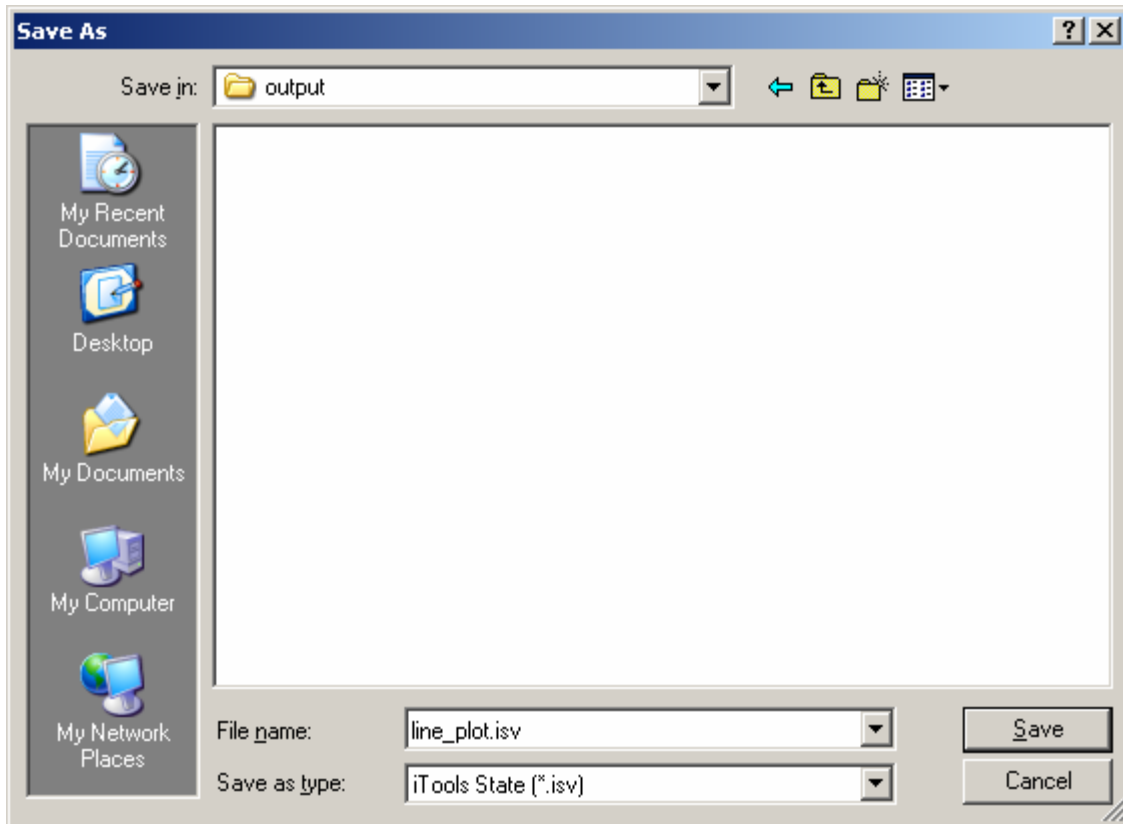
Notice that when this final data variable was plotted, the scaling of the Y axis automatically changed in order to display the full data range of all 3 time-series measurements. In addition, dashed lines that are cyan in color will be displayed when a specific line plot is selected, which mark the minimum and maximum Y data range for that dataset. The line plot visualization should now look like Fig. 8.



**Figure 8: The line plot visualization of all 3 time-series datasets**

Now that all 3 time-series datasets have been loaded and plotted, it is a good idea to save the current **state** of the *iPlot* visualization utility. When an *iTool* is saved, the state of the utility in its entirety is output to a file on disk, and this state includes the layout of the current graphical visualizations, their properties, and the data itself. Use the following steps to save the current *iTool* state :

34. From the *IDL iPlot* window, select "File > Save As...".
35. Save the *iTools* state to a new file named "*line\_plots.isv*".
36. Press the "Save" button.



**Figure 9: Saving the iTool state to a file on disk**

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## Selection of Objects, Undo/Redo, and Manipulation


The iTools graphical system is based on an object-oriented architecture where each element (graphic, display window, axes, annotations, etc.) have individual **objects** associated with them. These objects each have their own individual **properties**, such as the color of the line plots that were modified in the previous exercise. The power of an object-oriented architecture is that separate objects can be built into a **hierarchy** that provides the ability to create complex graphical visualizations.

There are three ways to select separate or multiple objects within the iTools system :


- Using the **Select/Translate** arrow manipulator
- Using the *Visualization Browser* window
- Selecting "*Edit > Select All*" from the iTool menu system

Experiment with selecting separate graphical objects or groups of objects using the Select/Translate arrow :

1. If necessary, click the Select/Translate arrow button  on the toolbar to enter the object selection and translation manipulator mode.

2. Position the mouse cursor pointer over one of the line plots and click with the left mouse button. The line plot object will be highlighted with cyan markers, and a selection box will appear around the data space.
3. To select additional line plots, hold down the *Shift* key on the keyboard while clicking them.
4. The arrow button manipulator also provides translation functionality. While at least one of the line plots is selected, click and hold down the left mouse button while moving the mouse to re-position the data space within the view window. The mouse pointer changes to the translation pointer .
5. In addition to being able to select and move the line plots, the axes are also their own individual objects. Click on one of the axes to select it, then hold down the left mouse button to move it within the view window. Each axis can be moved in a plane perpendicular to its direction.
6. Also experiment with the ability to click-and-drag an object selection box. This can be accomplished by clicking in the white area outside of the data space, holding down the mouse button, and dragging a rectangular box. Once the mouse button is released, any objects that fall within the selected region in their entirety will be selected and highlighted.

If at any time an action is taken within an iTool that the user wishes to reverse, they can utilize the built-in Undo/Redo system. There are two ways to access the Undo/Redo mechanism within any given iTool :

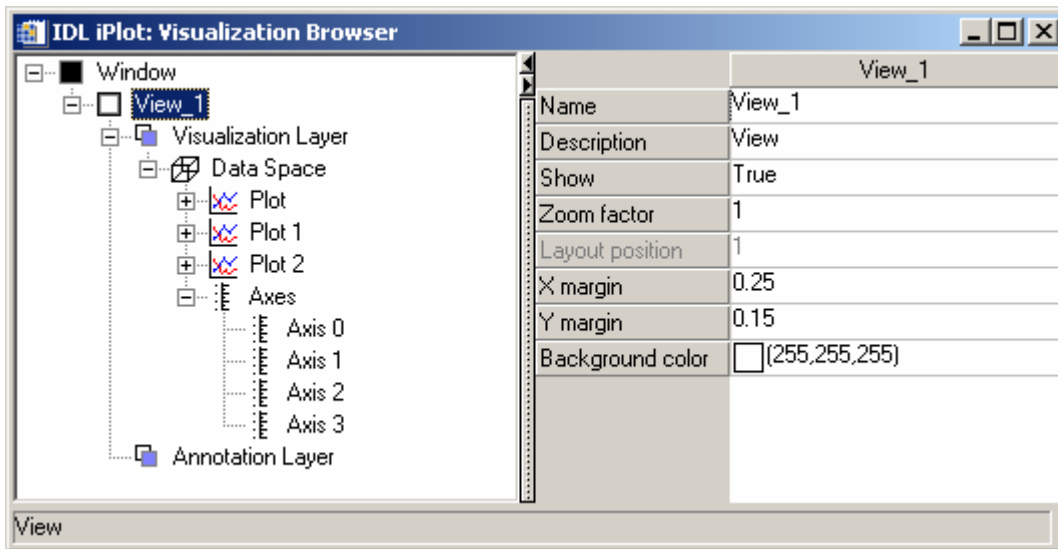
- Using the Undo/Redo  buttons on the toolbar
  - From the *Edit* menu system
7. Experiment with the Undo/Redo system using both the toolbar buttons and the *Edit* menu system items in order to retrace and repeat the steps that have been performed within the current *IDL iPlot* utility.
  8. Using the Select/Translate arrow or the Undo/Redo system, setup the current visualization in its previous appearance with the data space centered within the view window.
  9. While in Select/Translate mode, click in an area outside of the data space so that no object appears selected.
  10. Open the *Visualization Browser* window by selecting "*Window > Visualization Browser...*" from the menu system.

The *Visualization Browser* window displays the object-oriented hierarchy of the current graphical visualization for the iTool on the left-hand side, and the property sheet for the currently selected object on the right-hand side [Fig. 10]. Currently the main view object named "*View\_1*" should be selected, which is the white graphics area within the *IDL iPlot* window.

11. Experiment with selecting various objects on the left-hand side of the *Visualization Browser* window.

Notice how the objects are once again highlighted within the *IDL iPlot* utility window when they are selected. In addition, notice how the property sheet on the right-hand side of the *Visualization Browser* window updates to reflect the properties of the currently selected object.


Currently the 3 line plot graphical objects that are contained within the iTool are named "Plot", "Plot 0", and "Plot 1" by default [Fig. 10]. These line plot objects can be given more appropriate names that help associate them with the data they are displaying.



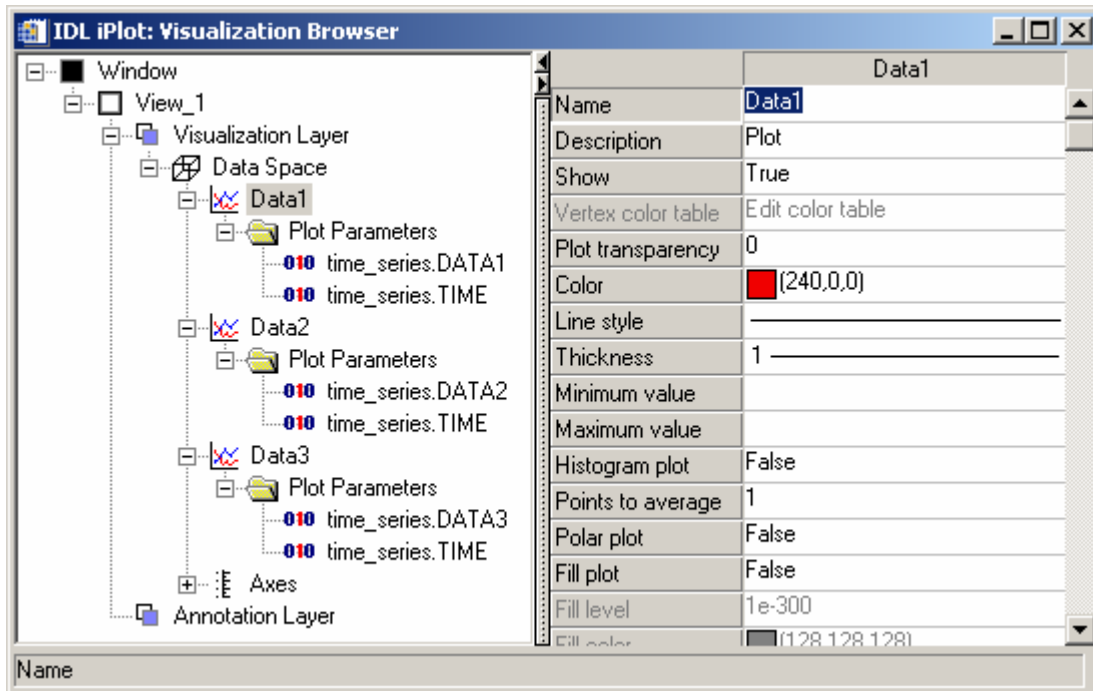
**Figure 10: The Visualization Browser window**

12. Click on the first line plot object named "Plot" within the *Visualization Browser* window.
13. On the right-hand side, change the "Name" property to the appropriate time-series field name from the original dataset "Data1". It may help to expand the plot object tree to look at the parameters (data) that define the graphical object [Fig. 11].
14. Make sure to hit the *Enter* key on the keyboard after modifying the "Name" property so the change takes effect.
15. Repeat this process for the other 2 line plot objects, changing "Plot 0" to "Data2", and "Plot 1" to "Data3" [Fig. 11].
16. The final state of the *Visualization Browser* window should look like Fig. 11. Once this has been accomplished close the *Visualization Browser* window.

In addition to the translation manipulator mode accessed via the Select/Translate arrow button, there is also **Rotate**, **View Zoom**, **Scaling**, and **Data Range** manipulators that can be accessed using their respective buttons on the toolbar :



17. From the *IDL iPlot* window menu system, select "Edit > Select All".
18. Click the Rotate  button to enter rotation manipulator mode.
19. Experiment with arbitrarily rotating the current graphic by clicking on it, holding down the mouse button, and moving the mouse.
20. Notice how the arrow keys on the keyboard can also be used to rotate the graphic (after it has been rotated by the mouse). Furthermore, notice how using the *Shift* and *Ctrl* keys in conjunction with the arrow keys will rotate the graphic by specific amounts.

21. Since the rotation of line plot graphics is usually not appropriate, use either the Ctrl-arrow button single degree rotation or the Undo button to restore the visualization to its original horizontal orientation.



**Figure 11: Changing the Name properties of the 3 line plot objects**

The size of the graphics area can also be made smaller / larger in relation to the display canvas by using the View Zoom manipulator :



22. Click the Zoom  button to enter View Zoom manipulator mode.
23. Position the mouse pointer over the viewplane. The pointer will change to a zoom pointer.
24. The view zoom manipulator works by clicking-and-dragging with the mouse cursor. Dragging the zoom pointer towards the top of the window (upwards direction) will enlarge the graphics. Dragging the zoom pointer towards the bottom of the window (downwards direction) will make the graphics area smaller.
25. Restore the graphics area (approximately) to its original size, and click on the Select/Translate  arrow button in order to leave View Zoom mode.

In addition to using the View Zoom manipulator tool, the size of the graphics area can also be made smaller / larger using the constrained and unconstrained scaling available when using the Select/Translate arrow mode. Constrained scaling permits changing the size of only one dimension while preserving the size of the other dimensions. In contrast, unconstrained rotation allows the user to scale all dimensions of an object in an arbitrary fashion.

26. While using the Select/Translate arrow mode, click on one of the line plots within the graphics area.

27. In addition to the selected line plot being highlighted with cyan color markers, the 8 green selection boxes will appear around the graphics area.
28. To perform constrained scaling, position the mouse cursor over one of the four selection boxes found midway along each side of the graphics area. The mouse cursor will change to a double-headed ↔ arrow.
29. Click-and-drag with the mouse to scale the graphics in the desired direction.
30. To perform unconstrained scaling, position the mouse cursor over one of the four selection boxes found in the corners of the graphics area. The mouse cursor will change to a four-headed ↗↘↙↕ arrow.
31. Click-and-drag with the mouse to scale the graphics in an unconstrained fashion.
32. Restore the graphics area (approximately) to its original shape and size.

Finally, the Data Range tool allows the user to zoom into the data space itself, instead of simply resizing the graphics area within the viewplane. This allows users to adjust the range displayed within the current graphics area, and zoom into the data space to get a better look at features at a smaller scale.

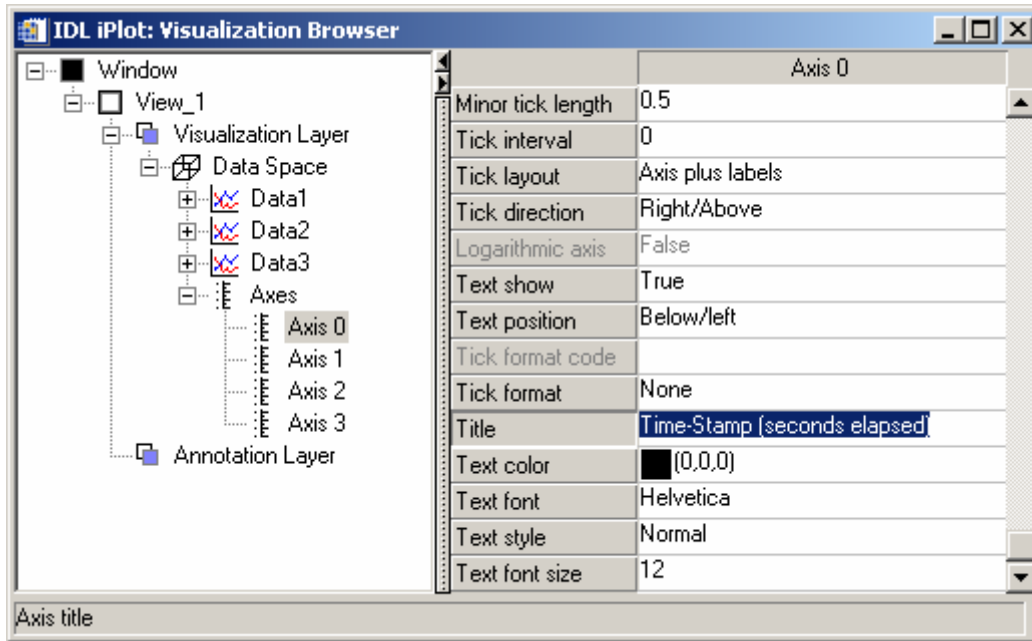
33. While one or all of the line plots are selected, click the Data Range  button to enter data range manipulator mode.
34. Both the X and Y axes will be labeled with green translation arrows and zoom symbols ("+" and "-"). Clicking on these will change the range and location of the respective axis.
35. In addition, position the mouse cursor within the graphics area containing the line plots. The mouse cursor will change to a cross-hair.
36. Click-and-drag to define a rectangular box within the graphics area, and once the box has been defined release the mouse button to zoom into the corresponding data range.
37. Select/Translate  arrow button in order to leave Data Range mode.
38. In order to reset the data range to the original full extent of all 3 data variables, select "Window > Reset Dataspace Ranges" from the IDL iPlot window menu system.

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## Labeling Axes, Annotation, and Inserting a Legend

Currently the line plots for the 3 time-series data variables are displayed with different colors, but there are no annotations present within the visualization window that describe the contents of the graphic. In order to label the axes and change the direction of the tick marks, utilize the *Visualization Browser* window :


1. Select "Window > Visualization Browser...".
2. Expand the Axes group to see the 4 separate axis objects.
3. Select the first axis object named "Axis 0". Notice that the bottom X-axis within the *iPlot* window is highlighted.
4. Scroll down the property sheet on the right-hand side and locate the "Title" property. Change the "Title" property for this axis to "Time-Stamp (seconds elapsed)" and hit *Enter* on the keyboard to complete the change [Fig. 12].



**Figure 12: Modification of the Title property for the X axis**


5. Next, select the second axis object named "Axis 2". This selects the Y axis along the left-hand side of the graphics area.
6. Find the "Tick direction" property, click within the setting box, and change the droplist to "Left/Below".
7. Once again, scroll down and change the "Title" property to "Data Values".
8. Finally, select the last axis named "Axis 3" and change the "Tick direction" property to "Right/Above".
9. Once these tasks have been accomplished, close the *Visualization Browser* window.
10. An axis may still be selected, so click in the white viewplane outside of the graphics area to unselect all graphical objects.

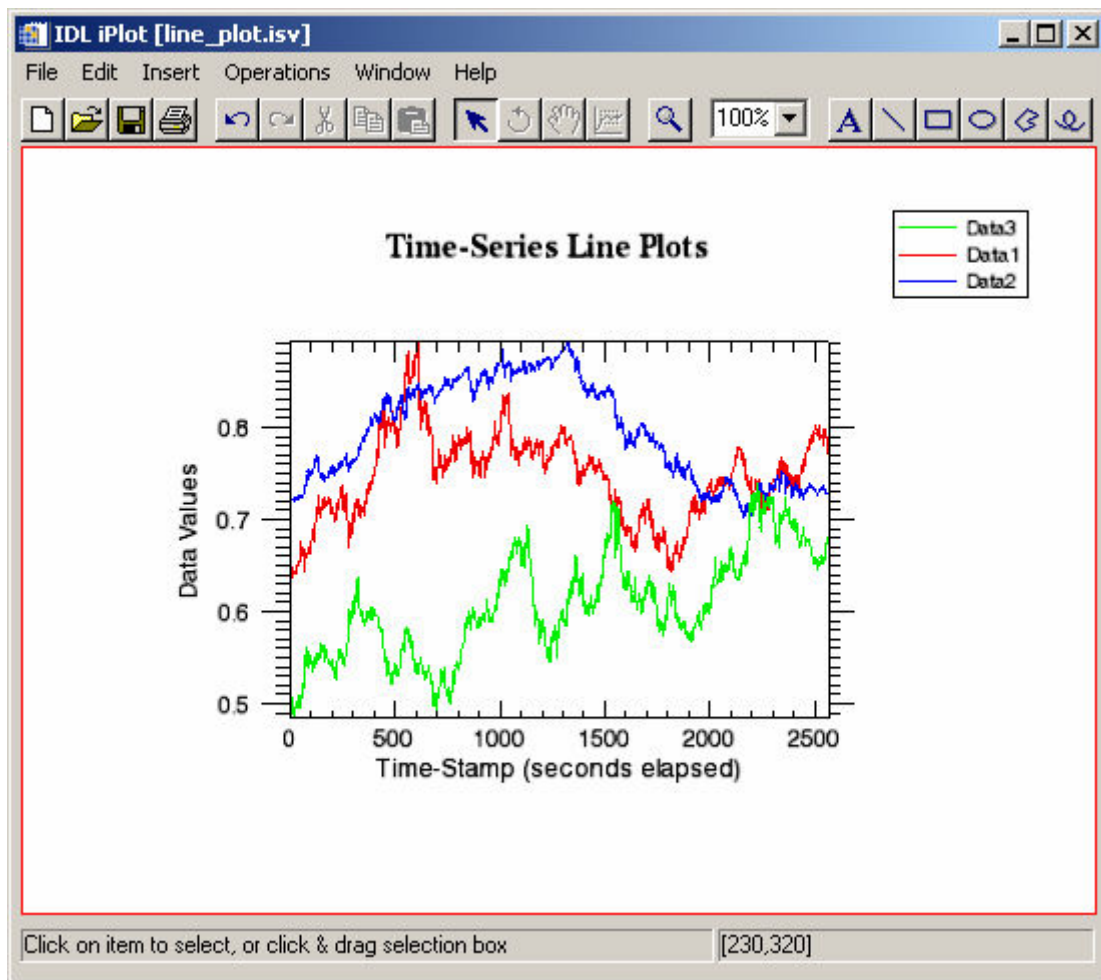
It may also be appropriate to provide a title for the overall visualization, and this can be inserted into the visualization using the Text annotation tool :

11. Click the Text  annotation button to enter text insertion mode.
12. Once the mouse cursor is moved over the viewplane, the pointer will change to a standard text selection cursor.
13. Click on a location outside and above the graphics area. A cursor is inserted into the annotation layer and text insertion mode is initiated.
14. Using the keyboard, enter the text "Time-Series Line Plots". Once finished typing this text, hit the *Enter* key to complete the text annotation.
15. While this text annotation object is highlighted, right-click on it and select "Properties..." from the context menu.
16. The font properties of this text annotation can be modified to make it appear like a legitimate graphics title. In the *Visualization Browser* window, change the "Text font" property to "Times".
17. Change the "Text style" property to "Bold".

18. Change the "Text font size" to "16", hit *Enter*, and close the *Visualization Browser* window.
19. Re-position the text annotation so it is centered above the graphics area.

Finally, a legend can be inserted into the *iPlot* visualization window in order to label the line plots with the names that were previously defined :

20. Click on one of the line plots, hold down the Shift key, and click on the remaining two so that all 3 line plots are selected and highlighted.
21. From the menu system, select "*Insert > New Legend*".
22. Position the legend in the desired location in the upper-right hand corner of the viewplane.
23. Click in a blank white area of the viewplane outside all graphical objects in order to deselect all objects.
24. At this point, it may be a good idea to re-save the current state of the *iPlot* utility. This can be accomplished by selecting "*File > Save*" from the menu system or hitting the Save  button.
25. The current state of the *IDL iPlot* window should look similar to Fig. 13.



**Figure 13: The current state of the time-series line plot visualization**




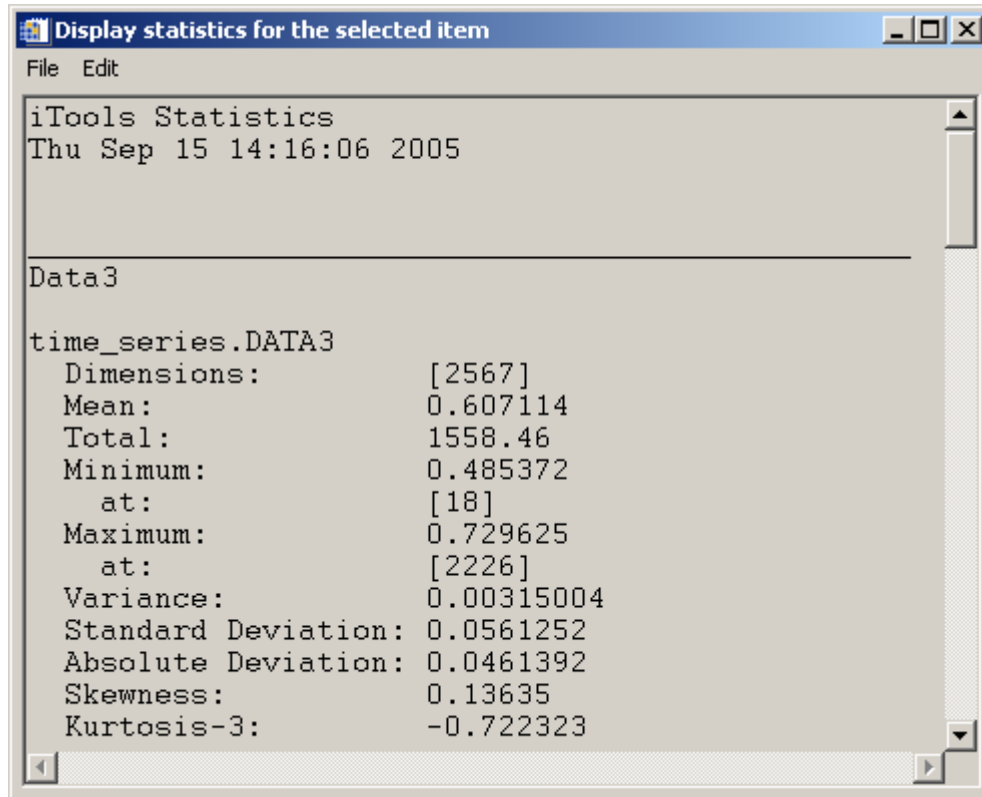
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## Operations, Graphical Output, and Printing

So far the exercises in this chapter have demonstrated the data input, graphics creation, manipulation, undo/redo, and annotation capabilities of the iTools system. In addition to this standard functionality the iTools system also includes **operations**, which are data analysis and processing tools. Any given iTool will contain a suite of the most common operations for the data type and visualization style that the utility was designed for.


In the case of visualizing line plots of time-series data, one common operation that is performed in signal processing analysis is the application of a smoothing filter that will help eliminate some of the high-frequency noise contained within the data. In addition, the user may be interested in obtaining mathematical statistics on the time-series datasets :

1. Make sure the Select/Translate  arrow button is selected.
2. Click on one of the line plots, hold down the Shift key, and click on the remaining two so that all 3 line plots are selected and highlighted.
3. From the menu system, select "*Operations > Filter > Smooth*". A separate dialog window entitled "Smooth" will appear.
4. This operation will apply a smoothing filter using a boxcar average over an area of a specified width. Change the value for the "Width" field to "7" and press the "OK" button in the Smooth window. Notice that the line plots are smoothed.
5. Click within the white viewplane outside the graphics area in order to deselect all objects.
6. Experiment with the Undo/Redo buttons to visualize the effect that the smoothing operation had on the line plot graphics.
7. Reselect the three line plots by clicking on each while holding down the Shift key. From the menu system, select "*Operations > Statistics...*". This will launch a separate window that displays the standard iTools statistics for each of the 3 line plot datasets [Fig. 14].
8. Once finished viewing the statistical information, close the iTools Statistics window.




**Figure 14: Statistics for the time-series datasets**

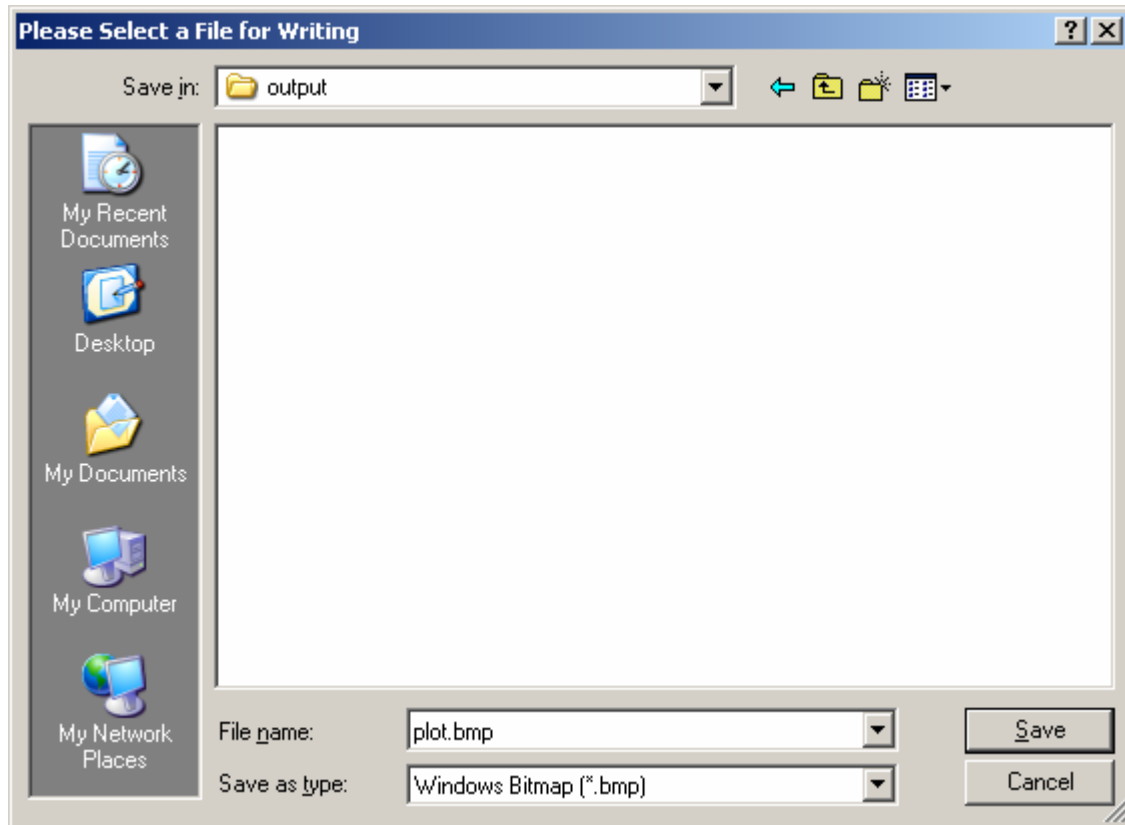
At this point, it may be necessary to obtain a softcopy or hardcopy version of the current *iPlot* visualization. There are a number of ways of exporting the current graphical visualization to the clipboard, image files on disk, or a printer :

9. Make sure the Select/Translate  arrow button is selected. Click on an area outside the plot and drag a rectangle around the entire plot.
10. Select "*Edit > Copy*". This will copy the current viewplane window to the native operating system clipboard so that it can be pasted into other software applications.
11. If running on a Windows computer with Microsoft Office installed, open either Word or PowerPoint and paste the graphic into this separate application.

In addition to the standard clipboard operations, the *iTools* system also offers the ability to export the current visualization to a wide variety of generic image formats :

12. From the menu system, select "*File > Export...*". This will launch the *IDL Data Export Wizard*.
13. In Step 1 of 3, select the "*To a File*" option for the export destination and hit the "*Next >>*" button.
14. In Step 2 of 3, the user can select individual graphical objects to specify either the entire visualization or individual data items to export. In this case, in order to output the entire visualization select the "*Window*" object and hit "*Next >>*".
15. In step 3 of 3 the output "*File Type:*" should be set to *Windows Bitmap* by default. If this is not the case, select *Windows Bitmap* now.

16. Click the file selection  button and specify an output filename of "plot.bmp".



**Figure 15: Specifying an output filename for Windows Bitmap format**

17. Once this is accomplished, hit the "Save" button in order to return to the *IDL Data Export Wizard*.
18. The full path to the output file specified will be displayed within the "File Name:" field.
19. Once this output filename is satisfactory, hit "Finish".

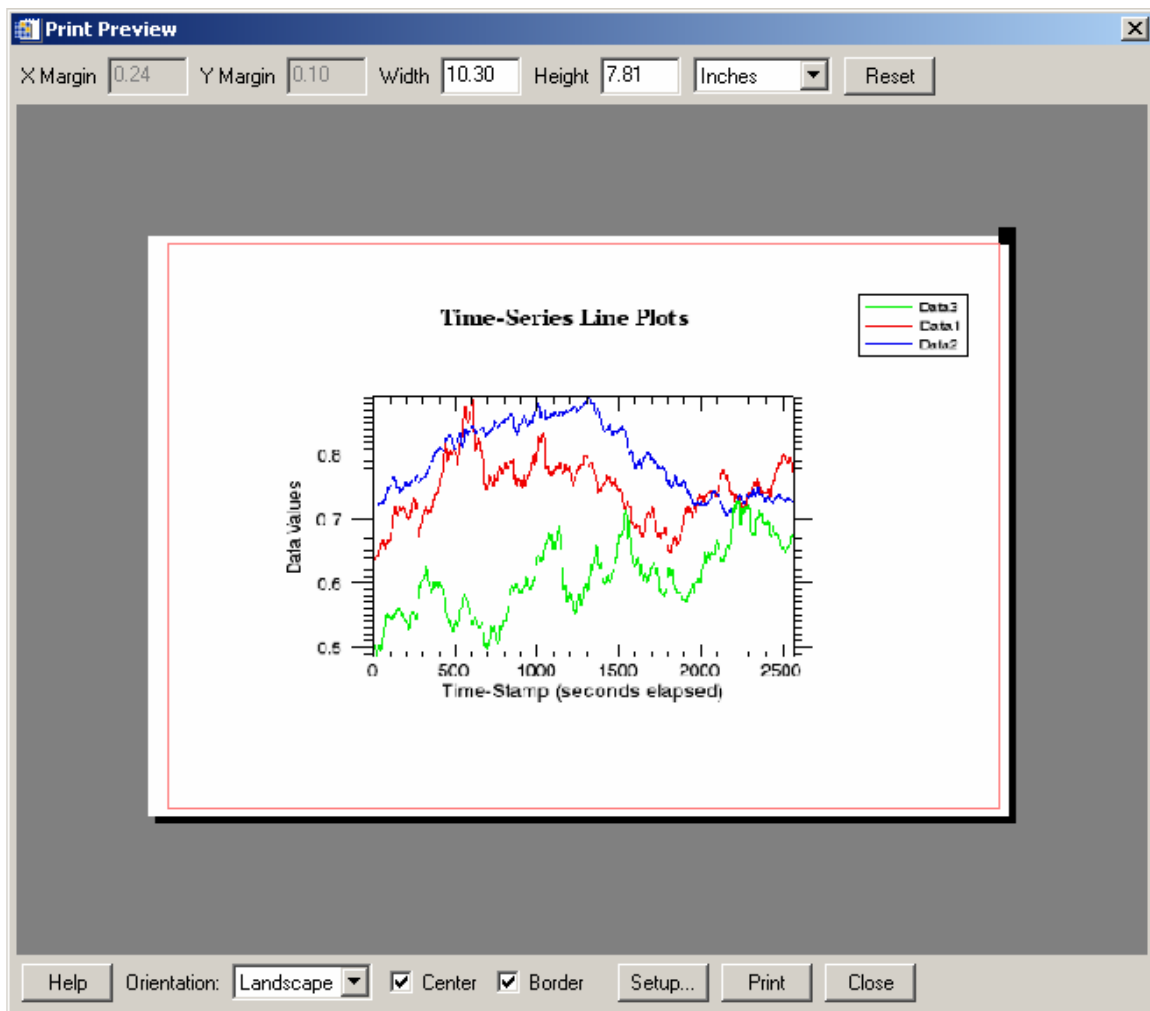
Looking within the output directory for the bitmap file that was just exported from the *iPlot* utility, the user should find a new file named "plot.bmp". Looking at this file in any standard image visualization software that can read and display bitmap files will display the contents of the *iPlot* visualization as it currently appears.

The current *iPlot* visualization can also be sent directly to a printer for hardcopy output :


20. Select "File > Print Preview..." from the main menu system.

A separate *Print Preview* window will be displayed [Fig. 16]. This tool allows the user to control the layout of the *iTools* viewplane window in relation to a standard 8.5" x 11" piece of paper. Within the *Print Preview* window pane are horizontal and vertical offset bars, along with a scaling box.

21. Change the orientation droplist to "Landscape".
22. Click on the scaling box in the upper-right corner and move up or down to make the size of the graphic larger or smaller, respectively.
23. Check the "Center" checkbox to automatically adjust the horizontal and vertical offsets so the graphic is centered within the page. The user can also manually move the individual offset bars.
24. If the computer being used is configured with a printer connection, the "Setup..." button can be pressed to obtain the standard printer selection / configuration dialog.
25. In addition, if the computer being used is configured with a printer connection, the "Print" button can be pressed to direct output to the selected printer.



**Figure 16: The iTools Print Preview tool**

26. Once finished working with the *Print Preview* tool, press "Close".
27. At this point, the *IDL iPlot* window containing the time-series visualizations can be closed as it is no longer used from this point forward. This can be accomplished by selecting "File > Exit" from the menu system or hitting the Close  button in the upper-right hand corner.

28. Restore the IDL Development Environment window so the IDL> command prompt can be accessed.

---

## Scatter, Histogram, Polar, and 3-Dimensional Plots

In addition to standard 2-Dimensional line plots, IDL also has the capability to display X-Y scatter plots, histograms, polar plots, and 3-D line plots. The iTools utilities can be launched with data automatically loaded using the **arguments** to the appropriate iTool procedure call. Furthermore, the properties of the graphical objects can be controlled by using the **keywords** to the iTool procedure. For example, create two 50 element vectors of uniformly-distributed, floating-point, pseudo-random numbers by using the *RANDOMU* function :

1. IDL> x = RANDOMU (s, 50)
2. IDL> y = RANDOMU (s, 50)

The *RANDOMU* function returns two variables "x" and "y" that contain data values ranging from 0 → 1.0 that are created by a random number generator. To visualize these two vectors in a **X-Y scatter plot**, simply load the variables as arguments to the *IPlot* procedure and set the appropriate keywords in order to control the properties of the plot object. In this example, the *SCATTER* keyword is set in order to change the graphic style from the default line plot to scatter plot mode, the *SYM\_INDEX* keyword is set to the symbol index for small rectangular boxes, and the *COLOR* keyword is set to a RGB triplet for the color red :

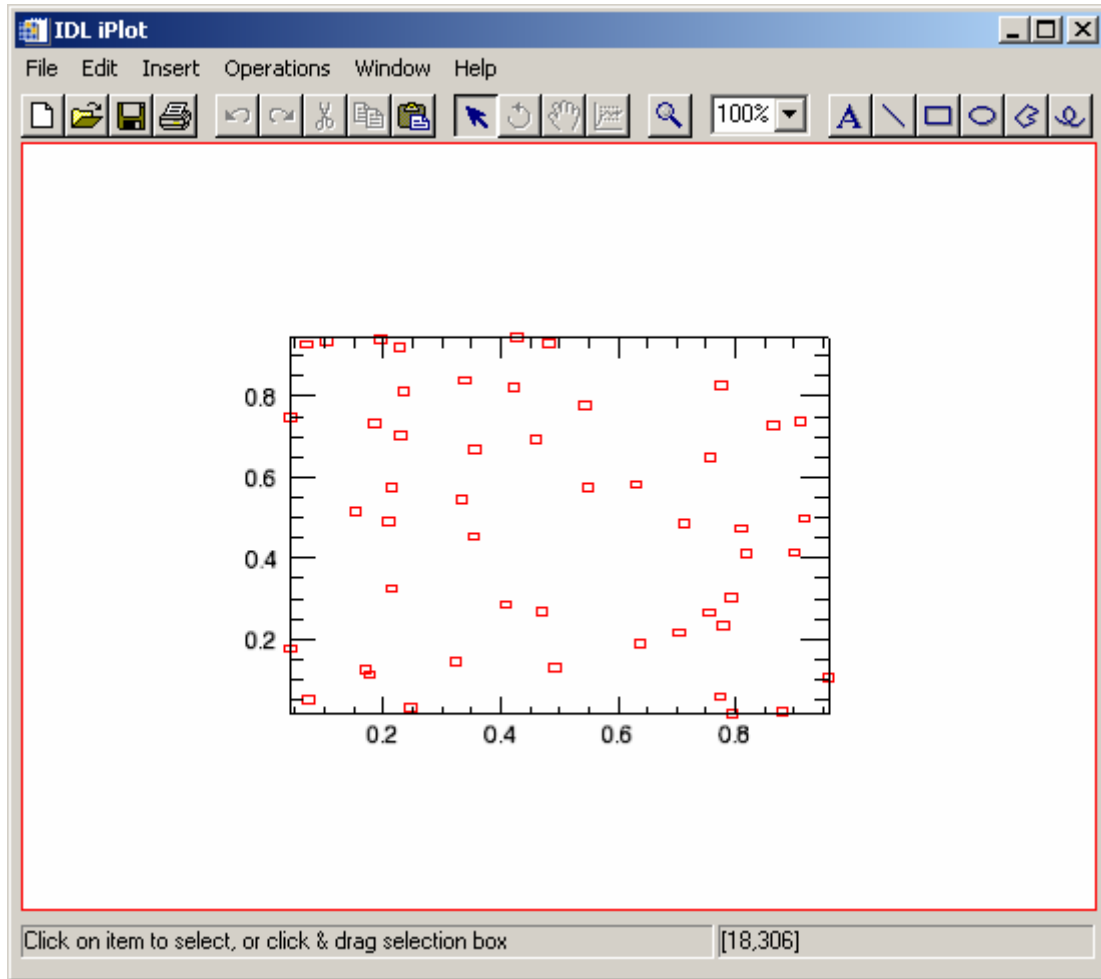
3. IDL> iPlot, x, y, /SCATTER, SYM\_INDEX=6, COLOR=[255,0,0]

This will launch a new *IDL iPlot* window containing a X-Y scatter plot of the random data values plotted as small red rectangles [Fig. 17].

4. It may help to click in the white viewplane outside of the graphics area to deselect the scatter plot object in order to remove the cyan selection markers.

**Note:** The appearance of the X-Y scatter plot that results may differ slightly from what appears in Fig. 17 since the random numbers that are generated by the *RANDOMU* function will always be different.

5. Once finished viewing the X-Y scatter plot, close the *IDL iPlot* window.



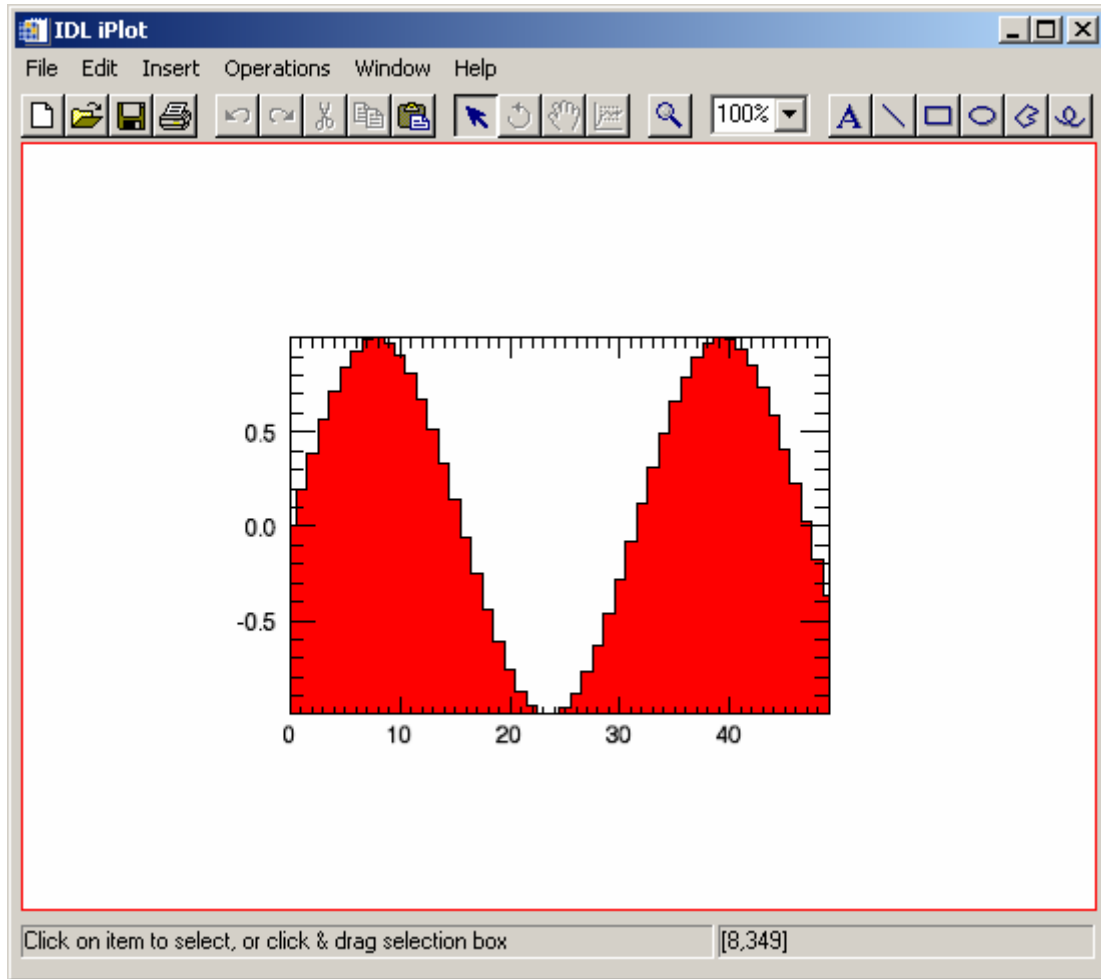
**Figure 17: An X-Y scatter plot of the randomly generated numbers**

A **histogram** can also be useful for visualizing 2-Dimensional signals or a density plot showing a distribution of data values. In a histogram plot, only horizontal and vertical lines are used to connect the plotted points. For example, plot a simple sine wave using a histogram style plot :

6. IDL> sine = SIN (FINDGEN (50) / 5)
7. IDL> iPlot, sine, /HISTOGRAM, /FILL\_BACK, FILL\_COLOR=[255,0,0]

The resulting *IDL iPlot* visualization window should look like Fig. 18.

8. Once finished viewing the histogram plot, close the *IDL iPlot* window.



**Figure 18: A histogram style plot of a sine wave**

So far all of the data that has been plotted is in a standard Cartesian (X-Y) coordinate system. In some cases, the data may use a **polar** coordinate system, which involves **radius** distances measured at various angles (**theta**) that are expressed in units of radians. For example, create a vector named "theta" that stores angles which encompass a full 360 degrees in 15° increments, and create a vector named "radius" that contains distances which range from 0 → 24 :

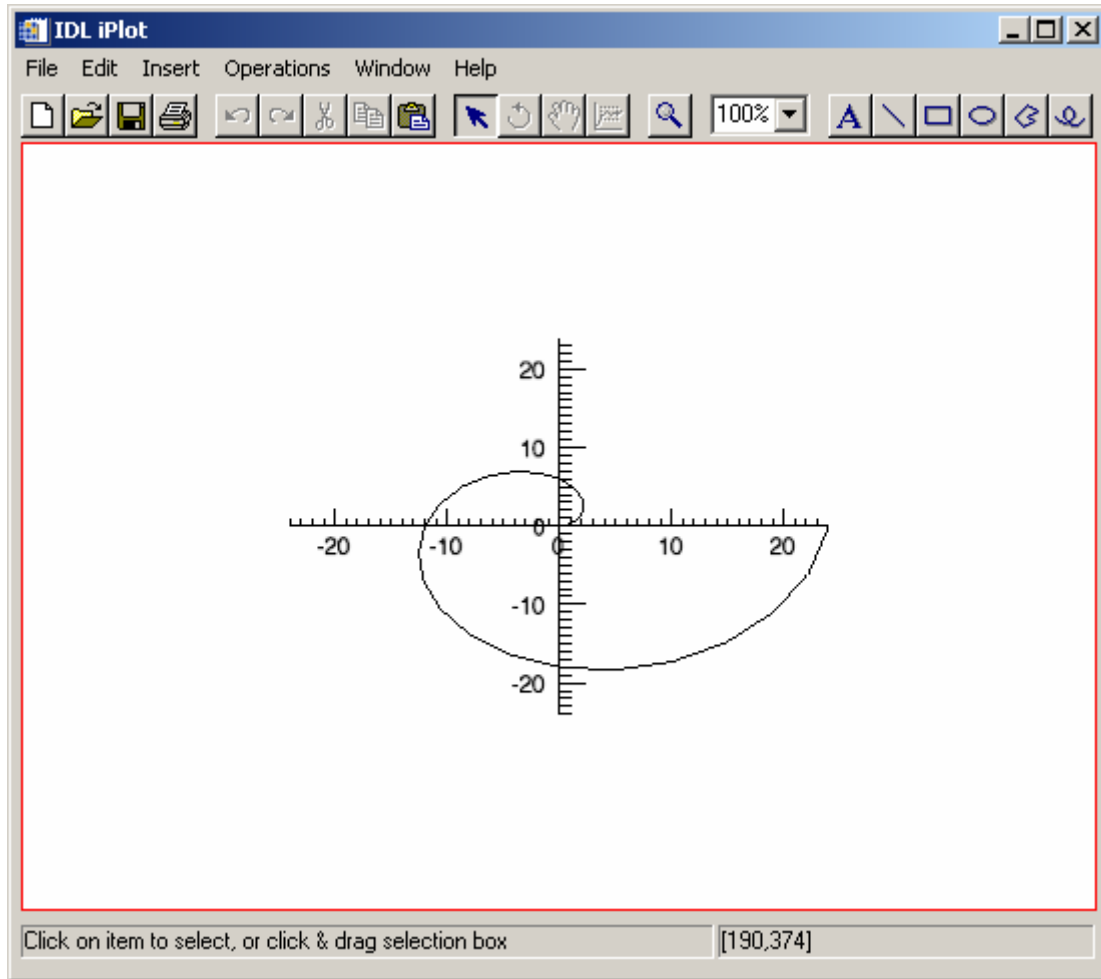
```

9. IDL> theta = INDGEN (25) * 15 * !DTOR
10.IDL> radius = FINDGEN (25)
11.IDL> iPlot, radius, theta, /POLAR, XRANGE=[-24,24], $
    YRANGE=[-24,24]

```

The resulting *IDL iPlot* visualization window should look like Fig. 19.

12. Once finished viewing the polar plot, close the *IDL iPlot* window.



**Figure 19: A polar line plot of radius values that increase incrementally**

Finally, the *iPlot* utility is not limited to two dimensions, and quite often it is necessary to visualize datasets that have 3 variables (X, Y, Z) in three dimensions. For example, consider the flight test data that is stored in the file "*flight\_test.txt*". This example data file is located in the "*data*" subfolder.


The file "*flight\_test.txt*" contains standard ASCII text consisting of 3 columns of data separated by whitespace. The first column contains longitude location in units of decimal degrees, the second column contains latitude position, and the third column contains the altitude of the aircraft. Here are the first 2 lines of this ASCII text file :

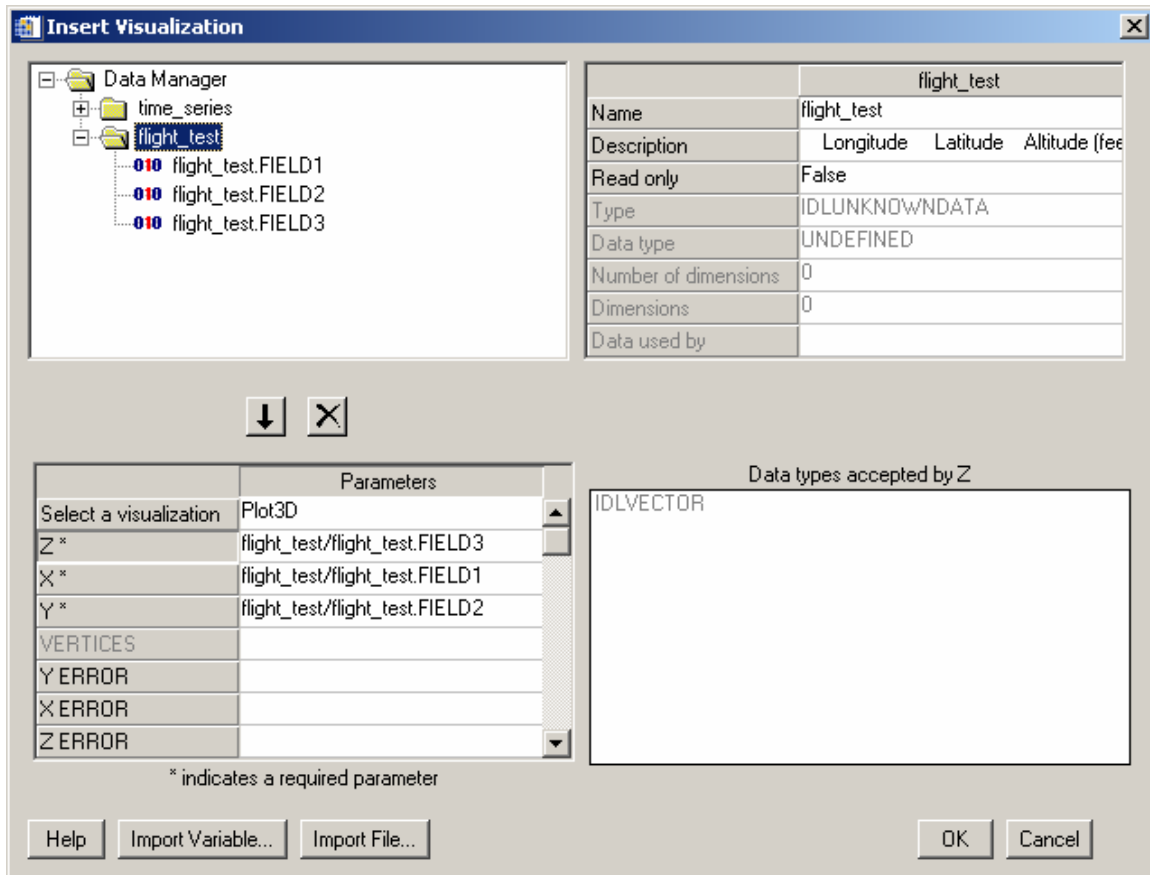
Longitude	Latitude	Altitude (feet)
-97.3943	35.4237	798

This flight test data will be loaded into a new *iPlot* utility in the same manner as the time-series data that was used in the previous exercise. Start by launching a new blank *IDL iPlot* window :

13. IDL> `iPlot`
14. Select "*File > Open...*" from the menu system.
15. Select the "*flight\_test.txt*" file and hit "*Open*".

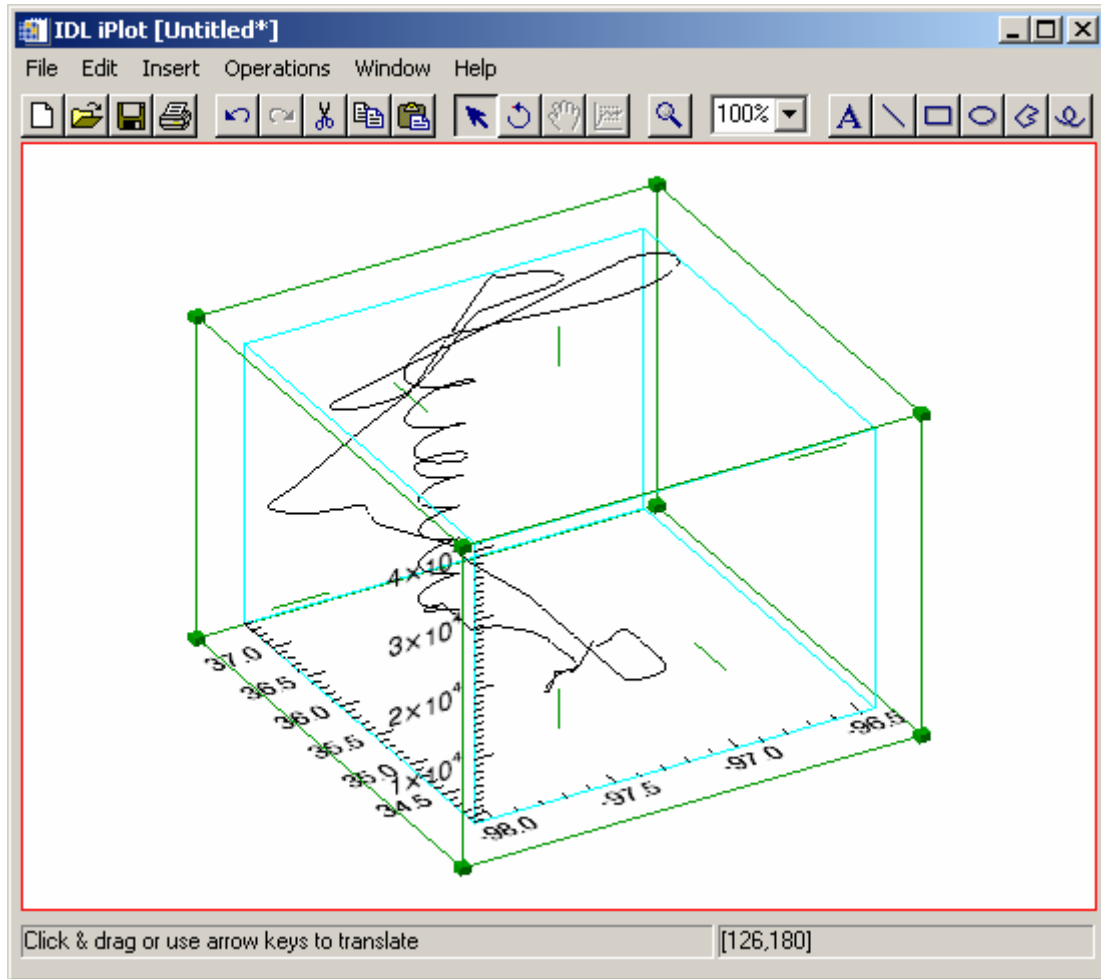


16. In Step 1 of 3 for the *ASCII Template* wizard, make sure to change the "Data Starts at Line:" field to "2".
17. In the remaining steps of the *ASCII Template* wizard, all settings can be left as their defaults. Simply hit "Next >>", followed by "Finish".
18. In the *IDL iTools Create Visualization* dialog, press "Select a visualization and specify parameters" and hit "OK". This will display the *Insert Visualization* dialog.
19. In the *Select a Visualization* row in the lower-left hand corner, click on "Plot" and change the graphic type droplist to "Plot3D" [Fig. 20].
20. Define the X parameter for the Plot3D visualization by clicking on "X" in the table in the lower-left corner, select the "flight\_test.FIELD1" in the upper-left hand corner, then press the  down arrow button. Do the same with "flight\_test.FIELD2" as the Y parameter, and "flight\_test.FIELD3" as the Z parameter [Fig. 20].
21. Once this is accomplished, hit "OK" to load the 3-Dimensional line plot.



**Figure 20: Specifying the parameters for the 3-D line plot**

The resulting *IDL iPlot* window should look like Fig. 21.



**Figure 21: The 3-Dimensional line plot of flight test data**

All of the same translation, rotate, zoom, and scaling manipulators are available within the iTools system when a 3-Dimensional graphic is displayed, although they act in three dimensions.

22. Once finished viewing the 3-Dimensional line plot, close the *IDL iPlot* window.

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