Chapter III-3

Drawing

Overview

Igor's drawing tools are useful in page layout and graph windows for highlighting material with boxes, circles and arrows and can also be used to create simple diagrams. These drawing tools are object-oriented and optimized for the creation of publication quality graphics.

You can graphically edit a wave's data values when it is displayed in a graph; data points can be deleted, added or modified. You can also create new waves by simply drawing them.

In control panel windows, you can use the drawing tools to create a fancy background for controls.

Like all other aspects of Igor, drawing tools are fully programmable. This allows programmers to create packages of code that add new graph types to Igor's repertoire. Although only programmers can create such packages, everyone can make use of them.

The drawing tools are available only in page layout, graph and control panel windows.

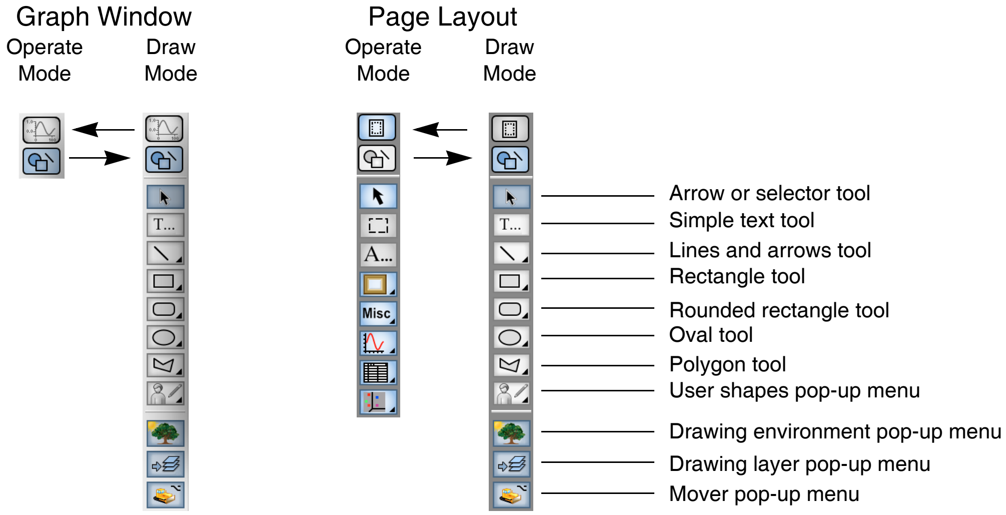
The Tool Palette

To use the drawing tools you first need to invoke the tool palette. In graphs and control panels this is done by the Show Tools menu command in the Graph or Panel menu. This command adds a tool palette along the left edge of the window. The tool palette is always available in page layout windows.

With the exception of Undo, Cut, Copy, Clear, Paste, Select All and Duplicate in the Edit menu, all drawing commands are located in the tool palette.

Once displayed, the tool palette works in two modes:

- **Operate mode:** Click the top (operate) button to enter Operate mode. In this mode, the drawing tool palette is not available, and you interact with the window as normal.
- **Drawing mode:** Click the second (drawing) button to enter Drawing mode. The entire tool palette will then be displayed, and you can add text, arrows, boxes, and other shapes to the window.



The three bottom icons in the tool palette — the Drawing Environment icon (tree and grass), Drawing Layer icon, and the Mover icon (bulldozer) — are pop-up menus. If you press Option (*Macintosh*) or Alt (*Windows*) while clicking the Mover icon, you get a pop-up menu that allows you to retrieve offscreen drawing elements, if any.

The icons above, with the triangle symbol, when clicked, select a mode of operation for creating various shapes using the mouse. If you click them and hold, they present pop-up menus that allow you to invoke dialogs for creating the shapes.

Arrow Tool

Use the arrow tool to select, move and resize one or more drawing objects or user-defined controls.

Selecting, Moving, and Resizing Objects

Click a drawing object once to select it. When selected, small squares called **handles** appear, defining the object's size. You can drag these handles to resize single or multiple objects. By pressing Shift while clicking a handle, an object resize can be constrained to the horizontal, vertical, or diagonal directions depending on how close the cursor is to these directions. By pressing Option (*Macintosh*) or Alt (*Windows*) instead, the resize is constrained to entirely horizontal or entirely vertical, depending on the position of the cursor.

If you click an object and it does not become selected then the object may be in a different drawing layer or it may not in fact be a drawing object at all.

You can select multiple drawing objects by shift clicking additional objects. You can remove an object from a selection by shift clicking a selected object.

You can also select multiple drawing objects by dragging a selection rectangle around a set of drawing objects. Unless you first press Option (*Macintosh*) or Alt (*Windows*), only objects that are completely enclosed by the selection rectangle are included in the selection. With Option (*Macintosh*) or Alt (*Windows*) pressed, objects that are merely touched by the selection rectangle are included. You can append additional objects to a selection by pressing Shift before dragging out a selection rectangle.

You can select all objects in the current layer with the Select All item in the Edit menu.

Rotating Objects

You can rotate draw objects by clicking just beyond a selection's visible resizing handles.

When the mouse is over an invisible rotation handle, the cursor changes shape, indicating that you can rotate the object. Click and drag the invisible rotation handle to rotate it.

Duplicating Objects

You can duplicate selected drawing objects using the Duplicate command found in the Edit menu. If, right after duplicating an object, you reposition the duplicated object and duplicate again then the new object will be offset from the last by the amount you just defined.

Deleting Objects

You can delete selected drawing objects by pressing Delete.

Modifying Objects

Double-clicking a drawing object displays a dialog for that object. You can then change any of the settings available in the dialog. Click the Do it button to apply the changes.

Simple Text Tool

The text tool is usually used to create a single line of simple text with the same font, size, style and rotation. You can also create formatted text using multiple lines and all the escape codes supported by annotations - see **Annotations** on page III-33.

The text tool is the only way to add text to control panel windows.

To create a line of text, click the simple text icon. The cursor will change shape to a text entry vertical line. Then move the cursor to the location in the window where you want the text origin, and click there to invoke the Create Text dialog.

Casual users can ignore the Anchor pop-up menu. It is used mainly by programmers to ensure that text is aligned properly about the numeric origin (X0,Y0). Any rotation is applied first and then the rotated text is aligned relative to the origin as specified by the anchor setting.

To edit or change a text object, double-click the object with the Arrow tool.

Lines and Arrows Tool

You can use the Lines tool to draw lines by clicking at the desired starting point and then dragging to the desired ending point. Press Shift while drawing to constrain the line to be vertical or horizontal.

If you click and hold on the Lines icon, you get a pop-up menu that takes you to a dialog where you can specify the line numerically. You see a similar dialog if you use the arrow tool to double-click a line. It allow you to change the properties of the line.

The dash pattern pop-up palette is the same as the one used for graph traces. You can adjust the dash patterns by use of the Dashed Lines command in the Misc menu.

The arrow fatness parameter is the desired ratio of the width of the arrow head to its length.

The line thickness and arrow length parameters are specified in terms of points and may be fractional.

Line start and end coordinates depend on the chosen coordinate system. See **Drawing Coordinate Systems** on page III-67 for detailed discussion. Programmers should note that the ends of a line are *centered* on the start and end coordinates. This is more obvious when the line is very thick.

Rectangle, Rounded Rectangle, Oval

The Rectangle, Rounded Rectangle, and Oval tools create objects that are defined by an enclosing rectangle. Click and hold on the appropriate icon to invoke a dialog where you can specify the object numerically. You see a similar dialog if you use the arrow tool to double-click the object.

Press Shift while initially dragging out the object to create a square or circle. If you press Shift while resizing the object with the arrow tool, you constrain the object in the horizontal, vertical, or diagonal directions depending on how close the cursor is to one of these directions. Thus, when you Shift-drag along a diagonal the sides are constrained to equal length, but if you Shift-drag along a horizontal or vertical direction, the object is resized along only one of these directions. If instead you hold down Option (*Macintosh*) or Alt (*Windows*), dragging along a diagonal resizes the object proportionally.

The Erase fill mode functions by filling the area with the current background color of the window. The fill background color is used only when a fill pattern other than Solid or Erase is chosen.

An object is always drawn *inside* the mathematical rectangle defined by its coordinates no matter how thick the lines. This differs from straight lines which are centered on their coordinates.

To adjust the corners of a rounded rectangle, double-click the object and edit the RRect Radius setting in the resulting dialog. Units are in points.

Arcs and Circles

To draw an arc or a circle by center and radius, click and hold on the Oval icon and choose Draw Arc from the resulting pop-up menu. Click and drag to define the center and the radius or start angle. Click again without moving the mouse to create a circle or move and click to define the stop angle for an arc. A variety of click and click-drag methods are supported and experimentation is encouraged.

To edit an arc, click and hold on the Oval icon in the draw tool panel and then choose Edit Arc from the resulting pop-up menu. If necessary, click on an arc to select it. You can then drag the origin, radius, start angle, and stop angle.

To change the appearance of an arc, double click to get to the Modify Arc dialog. Unlike Ovals, Arcs honor the current dash pattern and arrowhead setting in the same way as polygons and Beziers. The center of an arc or circle can be in any coordinate system (see **Drawing Coordinate Systems** on page III-67) but the radius is always in points.

Polygon Tool

The polygon tool creates or edits drawing objects called polygons and, in graphs, it can create or edit waves.

A polygon is an open or closed shape with one or more line segments, or edges. Polygons can be filled with a color and pattern and can have arrow heads attached to the start or end.

Although you may create a closed polygon by making the beginning and ending points the same, Igor does not recognize it as a closed shape. You can thus open the Polygon by moving either the beginning or ending points. This is subject to change in a future release.

Creating a New Polygon

You can create a polygon in one of two ways:

- **Segment Mode:** Each click defines a new vertex.
- **Freehand Mode:** Igor adds new vertices as you sweep out a smooth curve.

To create a polygon using segment mode, click the polygon icon once. Then click at the desired location for the beginning of the polygon. As you move the cursor, you create a line segment. A second click anchors the first line segment, and begins the second. You can keep drawing line segments until the polygon is finished.

Stop drawing by double-clicking to define the last vertex or by clicking at the first vertex. You then automatically enter edit mode, the cursor changes to ⌖ , and vertices are marked with square handles. In edit mode, you can reshape the polygon. To exit edit mode click the arrow tool.

To create a polygon using freehand mode, to edit an existing polygon, or to draw or edit a Bezier curve, click and hold on the polygon icon until the pop-up menu appears. Then choose one of these items:

- **Draw Poly:** Enters the create-segmented-polygon mode in which a click starts a new segmented polygon. This is identical to a single click on the icon.
- **Freehand Poly:** Enters create-freehand-polygon mode in which a click starts a freehand polygon. Click and drag to sweep out a smooth curve as long as you press the mouse button. When you release the mouse button, you automatically enter edit mode, where you can change the shape.
- **Edit Poly:** Enters edit-polygon mode for editing an existing polygon as described in the next section.
- **Draw Bezier:** Enters create-Bezier-polygon mode in which a click starts a Bezier polygon. Click and drag to define anchor and control points. Click on the first point to close the curve.
- **Edit Bezier:** Enters edit-Bezier-polygon mode for editing an existing Bezier polygon as described in the next section. You may need to click on a Bezier curve to select it.

Editing a Polygon

To enter edit mode, click and hold on the polygon icon, and choose Edit Poly from the pop-up menu. Then click the polygon object you want to edit.

While in edit mode you can move, add, and delete vertices, and move line segments:

- **Move a vertex:** Click and drag the vertex to move it and stretch the associated edges.
- **Create a new vertex:** Click between vertices in a line segment.
- **Delete vertices:** Press Option (*Macintosh*) or Alt (*Windows*) and click the vertex you want to delete.
- **Offset pairs of vertices:** Press Command (*Macintosh*) or Ctrl (*Windows*), click a line segment, and drag.

There are a number of operations you can perform to edit a Bezier curve:

- **Move an anchor point:** Click and drag the anchor point to move it and stretch the associated curves.
- **Move a control point:** Click and drag it. If an anchor point has two control points, this move both.
- **Move one of two control points associated with an anchor point:** Click the control point, then press Option (*Macintosh*) or Alt (*Windows*), and drag the control point.
- **Create a new anchor point:** Click the curve between anchor points.
- **Delete an anchor point:** Press Option (*Macintosh*) or Alt (*Windows*) and then click the anchor point.

Pressing Shift while dragging constrains movement to horizontal or vertical directions.

Exit edit mode by clicking the arrow tool.

After exiting edit mode, you can use the environment icon to adjust the other attributes of the polygon. You can even add arrows to the start or end of the polygon. Or you can double-click a polygon to invoke the Modify Polygon dialog.

The X0 and Y0 settings determine the location of the first point.

You can change the size of the polygon by modifying the Xscale and Yscale parameters in the dialog. For example, enter 0.5 for both settings to shrink the polygon to half its normal size.

Drawing and Editing Waves

In a graph, you can use the polygon tool to create or edit waves using the same techniques just described for drawing polygons. Click and hold on the polygon tool. Igor displays a pop-up menu containing, in addition to the usual polygon and Bezier commands, the following wave-drawing commands:

```
Draw Wave
Draw Wave Monotonic
Draw Freehand Wave
Draw Freehand Wave Monotonic
Edit Wave
Edit Wave Monotonic
```

The first four commands create and add a pair of waves with names of the form W_XPoly*nn* and W_YPoly*nn* where *nn* are digits chosen to ensure the names are unique. Draw Wave and Draw Freehand Wave work exactly like the corresponding polygon drawing described above. The monotonic variants prevent you from backtracking in the X direction. As with polygons, you enter edit mode when you finish drawing.

You can edit an existing wave, or pair of waves if displayed as an XY pair, by choosing one of the Edit Wave commands and then clicking the wave trace you wish to edit. Again, the monotonic variant prevents backtracking in the X direction. If you edit a wave that is not displayed in XY mode then you can not adjust the X coordinates since they are calculated from point numbers.

You can use the **GraphWaveDraw** and **GraphWaveEdit** operations as described in **Programmatic Drawing** on page III-69 to start wave drawing or editing.

The User Shapes Tool

This tool creates drawing objects defined by procedure code written by you or another Igor user. For details see the **DrawUserShape** operation and for examples choose File→Example Experiments→Programming→User Draw Shapes.

Drawing Environment Pop-Up Menu

TheDrawing Environment icon allows you to change properties such as line thickness, color, fill pattern, and other visual attributes.

You can change the attributes of existing objects, or you can change the default attributes of objects you are yet to create.

To change the attributes of existing objects, first select them. Then use the Drawing Environment pop-up menu to modify the attributes.

To change the default attributes of objects yet to be created, make sure no objects are selected. Then use the Drawing Environment pop-up menu to change attributes. From that point on, all new objects will have the new attributes, until you change them again.

The items in the menu do not affect all types of objects. The Fill Mode and Fill Color commands affect only enclosed shapes. The Line Dash and Line Arrow commands do not affect rectangles and ovals.

You can invoke the Modify Draw Environment dialog to change multiple attributes by choosing All from the Drawing Environment pop-up menu or by double-clicking an object.

Double-clicking multiple selected objects or groups of object with the selector tool also invokes the Modify Draw Environment dialog. In this case, the properties shown are those of the *first* selected object but if you change a property then all selected objects are affected.

Double-clicking a single drawing object with the selector tool invokes a specific dialog for objects of that type.

Drawing Layer Pop-up Menu

The Drawing Layer pop-up menu selects the active drawing layer. You can create and edit drawing objects in the active drawing layer only. See **Drawing Layers** on page III-68 for details.

Mover Pop-Up Menu

The Mover pop-up menu performs various actions:

- Changing the front-to-back relationship of drawing objects in a given layer
- Aligning drawing objects or controls to each other
- Distributing the space between drawing objects or controls
- Grouping and ungrouping drawing objects
- Retrieving drawing objects or controls that are off screen

Use the Bring to Front, Send to Back, Forward and Backward commands to adjust the drawing order within the current drawing layer.

The Align command adjusts the positions of all the selected drawing objects relative to the first selected object. This works on controls as well as drawing objects.

The Distribute command evens up the horizontal or vertical spacing between selected objects. The original order is maintained. This operation is especially handy when working with buttons or other controls in a user-defined panel. This works on controls as well as drawing objects.

The Retrieve command is used to bring offscreen objects back into the viewable area. You can retrieve an offscreen object by selecting it from the Retrieve submenu of the Mover pop-up menu. Alternatively, if you press Option (*Macintosh*) or Alt (*Windows*) and select an object from the resulting pop-up menu, Igor selects the object and displays the Properties dialog. Use this to set the numeric coordinates for an object to bring it back onscreen. Or you can cancel out of the dialog and then press Delete to remove the object. Retrieve works on controls as well as drawing objects.

The Grid submenu provides options for controlling the grid. See **Drawing Grid** on page III-66 for details.

Drawing Grid

You can display a grid and force objects to snap to the grid, it is visible or not. You do this using the Mover pop-up menu Grid submenu.

The default grid is in inches with 8 subdivisions. The grid origin is the top-left corner of the window or subwindow. Use the **ToolsGrid** to set grid properties. You can independently specify the X and Y grids and set the origin, major grid spacing, and number of subdivisions.

When grid snap is on, you can turn it off temporarily by engaging Caps Lock.

When dragging an object, the corner nearest to where you clicked to start dragging the object is the corner that will be snapped to the grid. You can also snap existing objects to the grid by selecting the Align to Grid from the Mover popup menu.

Set Grid from Selection

If a single object is selected, Set Grid from Selection will set the grid origin at the top left corner of the object. It two objects are selected, the origin will be set to the top left corner of the first object and the major grid spacing will be defined by the distance to the top left corner of the second object. If either the horizontal or vertical separation is small then a uniform (equal X and Y) grid is defined by the larger distance. Otherwise the horizontal and vertical grids are set from the corresponding distances.

Grid Style Function

The Style Function submenu allows you use to create a style function or to run one that you previously created. Style functions are created in the main procedure window with names like *MyGridStyle00*. You can edit these to provide more meaningful names.

Drawing Coordinate Systems

A unique feature of Igor's drawing tools is the ability to choose different coordinate systems. You can choose different systems on an object-by-object basis and for X and Y independently. This capability is mainly for use in graphs to allow your drawings to adjust to changes in window size or to changes in axis scaling.

You specify the coordinate system using pop-up menus found in the drawing Modify dialogs. The available coordinate systems are:

- Absolute
- Relative
- Plot Relative
- Axis

Absolute

In absolute mode, coordinates are measured in points relative to the top-left corner of the window. Positive x is toward the right and positive y is toward the bottom. In this mode the position and size of objects are unaffected by changes in window size. This is the default and recommended mode in page layouts and control panels.

If you shrink a window, it is possible that some objects will be left behind and may find themselves outside of the window (offscreen). In addition, if you copy an object with absolute coordinates from one window and then paste it in another smaller window it will be placed where the coordinates specify, even if it is offscreen. If you think this has happened, use the Mover pop-up menu to retrieve any offscreen objects or expand the window until the stray objects are visible.

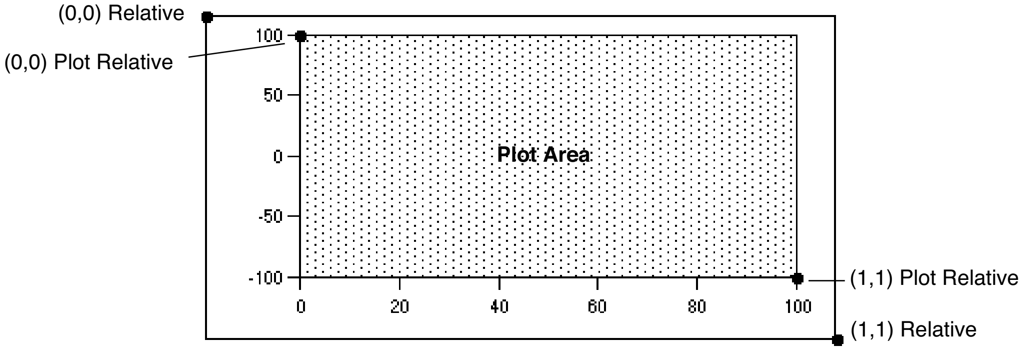
Relative

In this mode, coordinates are measured as fractions of the size of the window. Coordinate values x=0, y=0 represent the top-left corner while x=1,y=1 corresponds to the bottom-right corner. Use this mode if you want your drawing object to remain in the same relative position as you change the window size.

This mode will produce near but not exact WYSIWYG results in graphs. This is because the margins of a graph depend on many factors and only loosely on the window size. This mode gives good results for objects that don't have to be positioned precisely, such as an arrow pointing from near a trace to near an axis. It would not be suitable if you want the arrow to be positioned precisely at a particular data point or at a particular spot on an axis. For that you would use one of the next two coordinate systems.

Plot Relative (Graphs Only)

This system is just like Relative except it is based on the plot rectangle rather than the window rectangle. The plot rectangle is the rectangle enclosed by the default left and bottom axes and their corresponding mirror axes. The coordinates x=0, y=0 represent the top-left corner while x=1,y=1 corresponds to the bottom-right corner. This is the default and recommended mode for graphs.



The Plot Relative system is ideal for objects that should maintain their size and location relative to the axes. A good example is cut marks as used with split axes. In most cases, Plot Relative is a better choice than the more complex axis-based system discussed next.

Axis-Based (Graphs Only)

The pop-up menu for the X coordinate system includes a list of the horizontal axes and the pop-up menu for the Y coordinate includes a list of the vertical axes. When you choose an axis coordinate system, the position on the screen is calculated just as it is for wave data plotted against that axis, with the exception that drawing object coordinates are not limited to the plot area. This mode is ideal when you want an object to stick to a feature in a wave even if you zoom in and out.

Axes are treated as if they extend to infinity in both directions. For this reason along with the fact that axis ranges can be very dynamic, it is very easy to end up with objects that are offscreen. You can use the Mover pop-up menu Retrieve submenu to retrieve objects or, if you press Option (*Macintosh*) or Alt (*Windows*) before clicking the Mover icon, you can edit the numerical coordinates of each offscreen object. You can also end up with objects that are huge or tiny. It is best to have the graph in near final form before using axis-based drawing objects.

Axis-based coordinates are of particular interest to programmers but are also handy for a number of interactive tasks. For example you can easily create a rectangle that shades an exact area of a plot. If you use axis coordinate systems then the rectangle remains correct as the graph is resized and as the axis ranges are changed. You can also create precisely positioned drop lines and scale (calibrator) bars.

Drawing Layers

Layers allow you to control the front-to-back layering of drawing objects relative to other window components. For example, if you want to demarcate a region of interest in a graph, you can draw a shaded rectangle into a layer behind the graph traces. If you drew the same rectangle into a layer above the traces then the traces would be covered up.

Each window type supports a number of separate drawing layers. For example, in graphs, Igor provides three pairs of drawing layers. You can see the layer structure for the current window and change to a different layer by clicking the layer icon. The current layer is indicated by a check mark.

Drawing layers have names. This table shows the names of the layers and which window types support which layers:

Graphs	Page Layouts	Control Panels
ProgBack	ProgBack	ProgBack
UserBack	UserBack	UserBack
ProgAxes		
UserAxes		

ProgFront	ProgFront	
UserFront	UserFront	
Overlay	Overlay	Overlay

Drawing layers come in pairs named ProgSomething and UserSomething. User layers are provided for interactive drawing while Prog layers are provided for Igor programmers. This usage is just a recommended convention and is not enforced. The purpose of the recommendation is to give Igor procedures free access to the Prog layers. If you were to draw into a Prog layer and then ran a procedure that used that layer then your drawing could be damaged or erased.

The top layer is the Overlay layer. It is provided for programmers who wish to add user-interface drawing elements without disturbing graphic elements. It is not included when printing or exporting graphics. This layer was added in Igor Pro 7.00.

Only drawing objects in the current layer can be selected. If you find you can not select a drawing object then it must be in a different drawing layer. You will have to try the other layers until you find the right one.

To move an object between layers you have to cut, switch layers and then paste.

Drawing Exporting and Importing

Copy/Paste Within Igor

You can use the Edit menu to cut, copy, clear and paste drawing objects just as you would expect.

Drawn objects retain all of their Igor properties as long as they are not modified by any other program. If, however, you export an Igor drawing to a program and then copy it back to Igor, the picture will no longer be editable by Igor, even if you made no changes to the picture.

When selected drawing objects are copied to the clipboard and then pasted, they retain their coordinates. However, this can cause the pasted objects to be placed offscreen if the object's coordinates don't fall within the displayed portion of the coordinate systems.

If you find that pasting does not yield what you expected, perhaps it is because some objects were pasted off-screen. You can use the Mover icon to examine or retrieve any of these offscreen objects.

Pasting a Picture Into a Drawing Layer

Pasting a picture from a drawing program may work differently than you expect. Igor does not attempt to take the picture apart to give you access to the component objects. Instead, Igor treats the entire picture as a single object that you can move and resize but not otherwise adjust.

You can change the scale of a pasted picture by either dragging the handles when the object is selected or by double-clicking the object and then setting the x and y scale factors in the resulting dialog.

Programmatic Drawing

All of the drawing capabilities in Igor can be used from Igor procedures. This section describes drawing programming in general terms and provides strategies for use along with example code.

The programmable nature is especially useful in creating new graph types. For example, even though Igor does not support polar plots as a native graph type we were able to create a polar plot package that produces high-quality polar graphs. (To see a demo of the package, choose File→Example Experiments→Graphing Techniques→New Polar Graph Demo.) Nonprogrammers can use the package as-is while programmers can modify the code to suit their purposes or can extract useful code snippets for their own projects.

You can get a quick start on a drawing programming project by first drawing interactively and then asking Igor to create a recreation macro for the window (click the close button and look in the Procedure window). You can then extract useful code snippets for your project. Frequently all you will have to do is replace literal coordinate values with calculated values and you are in business.

Drawing Operations

Here is a list of operations related to drawing.

DrawAction	**DrawArc**	**DrawBezier**	**DrawLine**
DrawOval	**DrawPICT**	**DrawPoly**	**DrawRect**
DrawRRect	**DrawText**	**DrawUserShape**	**GraphNormal**
GraphWaveDraw	**GraphWaveEdit**	**HideTools**	**SetDashPattern**
SetDrawEnv	**SetDrawLayer**	**ShowTools**	**ToolsGrid**

SetDrawLayer Operation

Use **SetDrawLayer** to specify which layer the following drawing commands will affect. If you use the /K flag then the current contents of the given drawing layer are deleted. See **Drawing Programming Strategies** on page III-72 for considerations in the use of SetDrawLayer and the /K flag.

SetDrawEnv Operation

This is the workhorse command of the drawing facility. It is used to specify the characteristics for a single object, to specify the default drawing environment for future objects, and to create groups of objects.

You can issue several SetDrawEnv commands in sequence; their effect is cumulative. By default, the group of SetDrawEnv commands affects only the next drawing command. Drawing commands that follow the first will use the default settings that were in effect before the SetDrawEnv commands were issued. For instance, these SetDrawEnv commands change the font and font size for only the first of the two DrawText commands:

```
SetDrawEnv fname="Courier New"
SetDrawEnv fsize=18     // 18 point Courier New, commands accumulate
DrawText 0,1,"This is in 18 point Courier New"
DrawText 0,0,"Has font and size in use before SetDrawEnv commands"
```

Use the save keyword in the SetDrawEnv specification to make the settings permanent. The usual use of the save keyword is at the end of the last SetDrawEnv command in a series. The permanent settings allow you to draw a number of objects all with the same characteristics without having to reissue SetDrawEnv commands before each object.

To create a grouping of objects, simply bracket a group of drawing commands with SetDrawEnv commands using the gstart and gstop keywords. Grouping is purely a user interface concept. Objects are drawn exactly the same regardless of grouping.

Draw<*object*> Operations

These operations, along with SetDrawEnv, operate differently depending on whether or not drawing objects are selected in the target window. If, for example, a rectangle is selected in the target window and a DrawRect command is executed then the *selected* rectangle is changed. If, on the other hand, no rectangle is selected then *a new* rectangle is created. This behavior exists to support interactive drawing and is not useful to Igor programmers, since there is no programmatic way to select a drawing object. Normally, you will be creating new objects rather than modifying existing objects.

As you can see from the format of the commands, generally all you specify in the commands themselves are the coordinates. Properties such as color and line thickness are specified by SetDrawEnv commands preceding the Draw<*object*> commands. The exception is DrawText where you specify the text to be drawn.

DrawPoly and DrawBezier Operations

The **DrawPoly** operation on page V-155 and **DrawBezier** operation on page V-153 come in the following two types:

- **Literal:** You can specify the vertices or control points with a set of literal numbers. (Polygons and bezier curves created interactively are always of the literal variety.)
- **Wave:** You can use waves to define the vertices or control points.

Because polygons and bezier curves can be of unlimited length, the /A flag allows object definitions to extend over multiple lines.

It is legal to specify a polygon with only a single point. Use this to set up a loop to append vertices to the origin vertex. Note that if you fail to add vertices and leave the polygon with just one vertex then the user will not be able to see or select the polygon.

Literal Versus Wave

As a programmer, you must choose either the literal or the wave polygon type when creating a polygon or bezier curve. This section explains the differences between the two.

The advantage of the literal method is that it does not clutter the experiment with numerous waves that may be distracting to the user. It also has the advantage that all such objects are independent of one another.

With the wave method, objects are not independent. If the user duplicates an object, or runs a window recreation macro several times, then all the objects would be linked via the wave. If the user then edits one of the objects, those edits would affect all of the associated objects; this could also be considered an advantage of the method.

A disadvantage of the literal method is that when Igor creates a recreation macro for a window containing literal method objects then all of the vertices or control points have to be specified in text. This can create huge macros that take a lot of time to create and to run. Because Igor uses the recreation macro technique when saving and restoring experiments, the use of large literal method objects can dramatically lengthen experiment save and restore time.

Wave method objects do not have this disadvantage. One nifty feature of the wave method is that you can read back the vertices or control points after the user has edited the object. Another advantage of the wave method is that you can calculate new vertices or control points at any time and the dependent objects will be automatically updated.

Screen Representation

It is important to note that the value of the first polygon vertex does not determine the location of the first vertex on the screen. The location is specified by the *xOrg*, *yOrg* parameters. Effectively the value of the first vertex is *subtracted* from all the vertices and then the value of the origin is *added* to all vertices. Thus the following commands create the exact same representation on the screen:

```
DrawPoly 120,50,1,1,{0,0,20,40,60,15}
DrawPoly 120,50,1,1,{200,300,220,340,260,315}
```

When programming, the first vertex is usually `0,0`. The *hScaling*, *vScaling* parameters are probably not of any interest to programmers; use 1 for both values.

GraphWaveDraw, GraphWaveEdit, and GraphNormal

These operations relate to graph modes that are only tangentially related to drawing.

- **GraphWaveDraw** puts the graph in a mode where the user can draw a wave using the same user interface as polygon drawing.
- **GraphWaveEdit** allows the user to edit a wave using the same user interface as polygon editing.
- **GraphNormal** puts the user into normal operation mode, and is the equivalent of clicking the top icon in the tool palette.

These operations are provided so a program can allow the user to sketch a region in a graph. The program can then read back what the user did. Unlike the other drawing modes, these wave drawing and edit modes allow user-defined buttons to be active. This is so you can provide a “done” button for the user. The button procedure should call GraphNormal to exit the drawing or edit mode.

The GraphWaveEdit command operates a little differently depending on whether or not you specify a wave with the command. If you do specify a wave then only that wave can be edited by the user. If you let the user choose a wave then he or she can switch to a new trace by clicking it.

Drawing Programming Strategies

There are three distinct ways you can structure your drawing program:

- **Append:** You can append the contents of one or more layers.
- **Replace Layer:** You can replace the contents of the layers.
- **Replace Group**: You can replace the contents of a named group.

The Replace Layer Method

Use this method when you want to maintain a fairly complex drawing completely under program control. For example you may want to extend Igor by adding a new axis type or a new display method or you may want to create a completely new kind of graph. The Polar Graphs package mentioned above utilizes the replace method.

The key to the replace method is the use of the /K flag with the SetDrawLayer command. This “kills” (deletes) the entire contents of the specified layer. After clearing out the layer you must then redraw the entire contents. To do this you will usually have to maintain some sort of data structure to hold all the information required to maintain the drawing.

For example if you are creating an artificial axis package, you will need to maintain user settings similar to those you see in Igor’s modify axis dialog. In many cases setting up a few global variables or waves in a data folder will be sufficient. As an example, see the Drawing Axes procedure file in the WaveMetrics Procedures folder.

The Replace Group Method

With named groups created with the SetDrawEnv gname keyword, you can use DrawAction to delete the group or to set the insertion point for new drawing commands. See the **DrawAction** operation on page V-151 for an example.

The Append Method

Use this method to provide convenience features that automate creation of simple drawings. You add a small drawing, such as a drop line, calibration bar, or shading rectangle, to any existing drawing objects in a given layer when the user runs a procedure or clicks a button. Such drawings are often small and modular — .

Generally, the drawing will be something the user could have done manually and may want to modify. If you need to specify a layer at all it should be a User layer. Often there will be no need to set the drawing layer at all — just use the current layer.

You may, however, need to set the layer for specific circumstances. A shading rectangle is an example of an object that should go in a specific layer, since it must be below the traces of a graph. In this case, if you use the SetDrawLayer operation, then you should set the current layer back with “SetDrawLayer UserTop”.

If you are using the append method, you should avoid using the Prog layers. This is because they are intended for use where the entire layer is to be replaced under program control.

Another consideration is whether or not you should set the default drawing environment. In general you should not but instead leave the uer in control. This varies depending on specific objectives.

Grouping

It is a good idea to use grouping for your drawing. This allows the user to move the entire drawing by merely selecting and dragging it.

Example: Drop Lines

In this example, we show a procedure that adds a line from a particular point on a wave, identified by cursor A, to the bottom axis. The procedure assumes that the graph has left and bottom axes and that cursor A is on a trace. For clarity, error checking is omitted.

```
Menu "Graph"
   “Add Drop Line", AddDropLine()
End

Function AddDropLine()
   Variable includeArrow = 2           // 1=No, 2=Yes
   Prompt includeArrow, "Include arrow head?", popup "No;Yes"
   DoPrompt "Add Drop Line", includeArrow
   includeArrow -= 1                   // 0=No, 1=Yes

   Variable xCursorPosition = hcsr(A)
   Variable yCursorPosition = vcsr(A)

   GetAxis/Q left
   Variable axisYPosition = V_min

   SetDrawEnv xcoord=bottom, ycoord=left
   if (includeArrow)
      SetDrawEnv arrow=1, arrowlen=8, arrowfat=0.5
   else
      SetDrawEnv arrow=0
   endif
   DrawLine xCursorPosition,yCursorPosition,xCursorPosition,axisYPosition
End
```

Drawing Shortcuts

Action	Shortcut (*Macintosh*)	Shortcut (*Windows*)
To temporarily invoke the Arrow tool while in Operate mode	Press Command-Option. You can now select an object and move or resize it. This shortcut works even if the tool palette is not showing.	Press Ctrl+Alt. You can now select an object and move or resize it. This shortcut works even if the tool palette is not showing.
To invoke the dialog to modify a control or drawing object while in Operate mode	Press Command-Option and double-click the control or drawing object. This shortcut works even if the tool palette is not showing. Also, if the palette is showing, the Drawing mode's Arrow tool becomes selected after the dialog is dismissed.	Press Ctrl+Alt and double-click the control or drawing object. This shortcut works even if the tool palette is not showing. Also, if the palette is showing, the Drawing mode's Arrow tool becomes selected after the dialog is dismissed.
To nudge a selected drawing object or control	Use the Arrow keys. Press Shift to nudge faster.	Use the Arrow keys. Press Shift to nudge faster.