Chapter
II-9

Importing and Exporting Data

Importing Data

Most Igor users create waves by loading data from a file created by another program. The process of loading a file creates new waves and then stores data from the file in them. Optionally, you can overwrite existing waves instead of creating new ones. The waves can be numeric or text and of dimension 1 through 4.

Igor provides a number of different routines for loading data files. There is no single file format for numeric or text data that all programs can read and write.

There are two broad classes of files used for data interchange: text files and binary files. Text files are usually used to exchange data between programs. Although they are called text files, they may contain numeric data, text data or both. In any case, the data is encoded as plain text that you can read in a text editor. Binary files usually contain data that is efficiently encoded in a way that is unique to a single program and can not be viewed in a text editor.

The closest thing to a universally accepted format for data interchange is the "delimited text" format. This consists of rows and columns of numeric or text data with the rows separated by carriage return characters (CR - *Macintosh*), linefeed return characters (LF - *Unix*), or carriage return/linefeed (CRLF - *Windows*) and the columns separated by tabs or commas. The tab or comma is called the "delimiter character". The CR, LF, or CRLF characters are called the "terminator". Igor can read delimited text files written by most programs.

FORTRAN programs usually create fixed field text files in which a fixed number of bytes is used for each column of data with spaces as padding between columns. The Load Fixed Field Text routine is designed to read these files.

Text files are convenient because you can create, inspect or edit them with any text editor. In Igor, you can use a notebook window for this purpose. If you have data in a text file that has an unusual format, you may need to manually edit it before Igor can load it.

Text files generated by scientific instruments or custom programs often have "header" information, usually at the start of the file. The header is not part of the block of data but contains information associated with it. Igor's text loading routines are designed to load the block of data, not the header. The Load General Text routine can usually automatically skip the header. The Load Delimited Text and Load Fixed Field Text routines needs to be told where the block of data starts if it is not at the start of the file.

An advanced user could write an Igor procedure to read and parse information in the header using the Open, FReadLine, StrSearch, sscanf and Close operations as well as Igor's string manipulation capabilities. Igor includes an example experiment named Load File Demo which illustrates this.

If you will be working on a Macintosh, and loading data from files on a PC, or vice-versa, you should look at **File System Issues** on page III-400.

The following table lists the data loading routines available in Igor and their salient features.

File Type	Description
Delimited text	Created by spreadsheets, database programs, data acquisition programs, text editors, custom programs. This is the most commonly used format for exchanging data between programs. Row Format: `<data><delimiter><data><terminator>` Contains one block of data with any number of rows and columns. A row of column labels is optional. Can load numeric, text, date, time, and date/time columns. Can load columns into 1D waves or blocks into 2D waves. Columns may be equal or unequal in length. See **Loading Delimited Text Files** on page II-120.

File Type	Description
Fixed field text	Created by FORTRAN programs.
	Row Format: <data><padding><data><padding><terminator>
	Contains one block of data with any number of rows and columns.
	Each column consists of a fixed number of bytes including any space characters which are used for padding.
	Can load numeric, text, date, time and date/time columns.
	Can load columns into 1D waves or blocks into 2D waves.
	Columns are usually equal in length but do not have to be.
	See **Loading Fixed Field Text Files** on page II-127.
General text	Created by spreadsheets, database programs, data acquisition programs, text editors, custom programs.
	Row Format: <number><white space><number><terminator>
	Contains one or more blocks of numbers with any number of rows and columns. A row of column labels is optional.
	Can not handle columns containing non-numeric text, dates and times.
	Can load columns into 1D waves or blocks into 2D waves.
	Columns must be equal in length.
	Igor's Load General Text routine has the ability to automatically skip nonnumeric header text.
	See **Loading General Text Files** on page II-128.
Igor Text	Created by Igor, custom programs. Used mostly as a means to feed data and commands from custom programs into Igor.
	Format: See **Igor Text File Format** on page II-132.
	Can load numeric and text data.
	Can load data into waves of dimension 1 through 4.
	Contains one or more wave blocks with any number of waves and rows.
	Consists of special Igor keywords, numbers and Igor commands.
	See **Loading Igor Text Files** on page II-131.
Igor Binary	Created by Igor, custom programs. Used by Igor to store wave data.
	Each file contains data for one Igor wave of dimension 1 through 4.
	Format: See Igor Technical Note #003, "Igor Binary Format".
	See **Loading Igor Binary Data** on page II-135.
Image	Created by a wide variety of programs.
	Format: Always binary. Varies according to file type.
	Can load JPEG, PNG, TIFF, BMP, Sun Raster graphics files.
	Can load data into matrix waves, including TIFF image stacks.
	See **Loading Image Files** on page II-138.
General binary	General binary files are binary files created by other programs. If you understand the binary file format, it is possible to load the data into Igor.
	See **Loading General Binary Files** on page II-146.

File Type	Description
Excel	Supports the .xls and .xlsx file formats. See **Loading Excel Files** on page II-140.
HDF4	Requires activating an Igor extension. See **Loading HDF Files** on page II-140.
HDF5	Requires activating the HDF5 package. See **Loading HDF Files** on page II-140.
Matlab	See **Loading Matlab MAT Files** on page II-144.
JCAMP-DX	The JCAMP-DX format is used primarily in infrared spectroscopy. See **Loading JCAMP Files** on page II-148.
GIS	Supports a wide variety of GIS file formats including ESRI Shapefiles and GeoTIFF. Requires activating the IgorGIS package. See **Loading GIS Data** on page II-150.
Sound	Supports a variety of sound file formats. See **Loading Sound Files** on page II-150.
TDMS	Loads data from National Instruments TDMS files. Requires activating an extension. Supported on Windows only. See the "TDM Help.ihf" help file for details.
Nicolet WFT	Loads data written by old Nicolet oscilloscopes. Requires activating an extension. See the "NILoadWave Help.ihf" help file for details.
SQL Databases	Loads data from SQL databases. Requires activating an extension and expertise in database programming. See **Accessing SQL Databases** on page II-160.

Load Waves Submenu

You access all of these routines via the Load Waves submenu of the Data menu.

The Load Waves item in this submenu leads to the Load Waves dialog. This dialog provides access to the built-in routines for loading Igor binary files, Igor text files, delimited text files, general text files, and fixed field text files, and provides access to all available options.

The Load Igor Binary, Load Igor Text, Load General Text, and Load Delimited Text items in the Load Waves submenu are shortcuts that access the respective file loading routines with default options. We recommend that you start with the Load Waves item so that you can see what options are available.

The precision of numeric waves created by Data→Load General Text and Data→Load Delimited Text is controlled by the Default Data Precision setting in the Data Loading section of the Miscellaneous Settings dialog.

There are no shortcut items for loading fixed field text or image data because these formats require that you specify certain parameters.

The Load Image item leads to the Load Image dialog which provides the means to load various kinds of image files.

Line Terminators

The character or sequence of characters that marks the end of a line of text is known as the "line terminator" or "terminator" for short. Different computer systems use different terminator.

Mac OS 9 used the carriage-return character (CR).

Unix uses linefeed (LF).

Windows uses a carriage-return and linefeed (CRLF) sequence.

When loading waves, Igor treats a single CR, a single LF, or a CRLF as the end of a line. This allows Igor to load text data from file servers on a variety of computers without translation.

LoadWave Text Encodings

This section applies to loading a text file using Load General Text, Load Delimited Text, Load Fixed Field Text, or Load Igor Text.

If your file uses a byte-oriented text encoding (i.e., a text encoding other than UTF-16 or UTF-32), and if the file contains just numbers or just ASCII text, then you don't need to be concerned with text encodings.

If your file uses UTF-16, UTF-32, or contains non-ASCII text, you may neeed to tell the LoadWave operation which text encoding the file uses. For details, see **LoadWave Text Encoding Issues** on page V-453.

Loading Delimited Text Files

A delimited text file consists of rows of values separated by tabs or commas with a carriage return, linefeed or carriage return/linefeed sequence at the end of the row. There may optionally be a row of column labels. Igor can load each column in the file into a separate 1D wave or it can load all of the columns into a single 2D wave. There is no limit to the number of rows or columns except that all of the data must fit in available memory.

In addition to numbers and text, the delimited text file may contain dates, times or date/times. The Load Delimited Text routine attempts to automatically determine which of these formats is appropriate for each column in the file. You can override this automatic determination if necessary.

A numeric column can contain, in addition to numbers, NaN and [±]INF. NaN means "Not a Number" and is the way Igor represents a blank or missing value in a numeric column. INF means "infinity". If Igor finds text in a numeric or date/time column that it can't interpret according to the format for that column, it treats it as a NaN.

If Igor encounters, in any column, a delimiter with no data characters preceding it (i.e., two tabs in a row) it takes this as a missing value and stores a blank in the wave. In a numeric wave, a blank is represented by a NaN. In a text wave, it is represented by an element with zero characters in it.

Determining Column Formats

The Load Delimited Text routine must determine the format of each column of data to be loaded. The format for a given column can be numeric, date, time, date/time, or text. Text columns are loaded into text waves while the other types are loaded into numeric waves with dates being represented as the number of seconds since 1904-01-01.

There are four methods for determining column formats:

- Auto-identify column type
- Treat all columns as numeric
- Treat all columns as text
- Use the LoadWave /B flag to explicitly specify the format of each column

You can choose from the first three of these methods using the Column Types pop-up menu in the Tweaks subdialog of the Load Waves dialog. To use the /B flag, you must manually add the flag to a LoadWave command. This is usually done in a procedure.

In the "auto-identify column type" method, Igor attempts to determine the format of each column by examining the file. This is the default method when you choose Data→Load Waves→Load Delimited Text. Igor looks for the first non-blank value in each column and makes a determination based on the column's content. In most cases, the auto-identify method works and there is no need for the other methods.

In the "treat all columns as numeric" method, Igor loads all columns into numeric waves. If some of the data is not numeric, you get NaNs in the output wave. For backward compatibility, this is the default method when you use the LoadWave/J operation from the command line or from an Igor procedure. To use the "auto-identify column type" method, you need to use LoadWave/J/K=0.

In the "treat all columns as text" method, Igor loads all columns into text waves. This method may have use in rare cases in which you want to do text-processing on a file by loading it into a text wave and then using Igor's string manipulation capabilities to massage it.

For details on the /B method, see the section **Specifying Characteristics of Individual Columns** on page V-450.

Date/Time Formats

The Load Delimited Text routine can handle dates in many formats. A few "standard" formats are supported and in addition, you can specify a "custom" format (see **Custom Date Formats** on page II-122).

The standard date formats are:

mm/dd/yy	(month/day/year)
mm/yy	(month/year)
dd/mm/yy	(day/month/year)

To use the dd/mm/yy format instead of mm/dd/yy, you must set a tweak. See **Delimited Text Tweaks** on page II-126.

You can also use a dash or a dot as a separator instead of a slash.

Igor can also handle times in the following forms:

[+][-]hh:mm:ss [AM PM]	(hours, minutes, seconds)
[+][-]hh:mm:ss.ff [AM PM]	(hours, minutes, seconds, fractions of seconds)
[+][-]hh:mm [AM PM]	(hours, minutes)
[+][-]hhhh:mm:ss.ff	(hours, minutes, seconds, fractions of seconds)

As of Igor Pro 6.23, Igor also accepts a colon instead of a dot before the fractional seconds.

The first three forms are time-of-day forms. The last one is the elapsed time. In an elapsed time, the hour is in the range 0 to 9999.

The year can be specified using two digits (99) or four digits (1999). If a two digit year is in the range 00 … 39, Igor treats this as 2000 … 2039. If a two digit year is in the range 40 … 99, Igor treats this as 1940 … 1999.

The Load Delimited Text routine can also handle date/times which consist of one of these date formats, a single space or the letter T, and then one of the time formats. To load <date><space><time> as a date/time value, space must not be specified as a delimiter character.

Custom Date Formats

If your data file contains dates in a format other than the "standard" format, you can use Load Delimited Text to specify exactly what date format to use. You do this using the Delimited Text Tweaks dialog which you access through the Tweaks button in the Load Waves dialog. Choose Other from the Date Format pop-up menu. This leads to the Date Format dialog.

By clicking the Use Common Format radio button, you can choose from a pop-up menu of common formats. After choosing a common format, you can still control minor properties of the format, such as whether to use 2 or 4 digits years and whether to use leading zeros or not.

In the rare case that your file's date format does not match one of the common formats, you can use a full custom format by clicking the Use Custom Format radio button. It is best to first choose the common format that is closest to your format and then click the Use Custom Format button. Then you can make minor changes to arrive at your final format.

When you use either a common format or a full custom format, the format that you specify must match the date in your file exactly.

When loading data as delimited text, if you use a date format containing a comma, such as "October 11, 1999", you must make sure that LoadWave operation does not treat the comma as a delimiter. You can do this using the Delimited Text Tweaks dialog.

When loading a date format that consists entirely of digits, such as 991011, you should use the LoadWave/B flag to specify that the data is a date. Otherwise, LoadWave will treat it as a regular number. The /B flag can not be generated from the dialog — you need to use the LoadWave operation from the command line. Another approach is to use the dialog to generate a LoadWave command without the /B flag and then specify that the column is a date column in the Loading Delimited Text dialog that appears when the LoadWave operation executes.

Column Labels

Each column may optionally have a column label. When loading 1D waves, if you read wave names and if the file has column labels, Igor will use the column labels for wave names. Otherwise, Igor will automatically generate wave names of the form wave0, wave1 and so on.

Igor considers text in the label line to be a column label if that text can not be interpreted as a data value (number, date, time, or datetime) or if the text is quoted using single or double quotes.

When loading a 2D wave, Igor optionally uses the column labels to set the wave's column dimension labels. The wave name does not come from column labels but is automatically assigned by Igor. You can rename the wave after loading if you wish.

Igor expects column labels to appear in a row of the form:

```
<label><delimiter><label><delimiter>…<label><terminator>
```

where <column label> may be in one of the following forms:

<label>	(label with no quotes)
"<label>"	(label with double quotes)
'<label>'	(label with single quotes)

The default delimiter characters are tab and comma. There is a tweak (see **Delimited Text Tweaks** on page II-126) for using other delimiters.

Igor expects that the row of column labels, if any, will appear at the beginning of the file. There is a tweak (see **Delimited Text Tweaks** on page II-126) that you can use to specify if this is not the case.

Igor will clean up column labels found in the file, if necessary, so that they are legal wave names using standard name rules. The cleanup consists of converting illegal characters into underscores and truncating long names to the maximum of 31 bytes.

Examples of Delimited Text

Here are some examples of text that you might find in a delimited text file. These examples are tab-delimited.

Simple delimited text

```
ch0         ch1         ch2         ch3         (optional row of labels)
2.97055     1.95692     1.00871     8.10685
3.09921     4.08008     1.00016     7.53136
3.18934     5.91134     1.04205     6.90194
```

Loading this text would create four waves with three points each or, if you specify loading it as a matrix, a single 3 row by 4 column wave.

Delimited text with missing values

```
ch0         ch1         ch2         ch3         (optional row of labels)
2.97055     1.95692                 8.10685
3.09921     4.08008     1.00016     7.53136
            5.91134     1.04205
```

Loading this text as 1D waves would create four waves. Normally each wave would contain three points but there is an option to ignore blanks at the end of a column. With this option, ch0 and ch3 would have two points. Loading as a matrix would give you a single 3 row by 4 column wave with blanks in columns 0, 2 and 3.

Delimited text with a date column

```
Date        ch0         ch1         ch2         (optional row of labels)
2/22/93     2.97055     1.95692     1.00871
2/24/93     3.09921     4.08008     1.00016
2/25/93     3.18934     5.91134     1.04205
```

Loading this text as 1D waves would create four waves with three points each. Igor would convert the dates in the first column into the appropriate number using the Igor system for storing dates (number of seconds since 1/1/1904). This data is not suitable for loading as a matrix.

Delimited text with a nonnumeric column

```
Sample      ch0         ch1         ch2         (optional row of labels)
Ge          2.97055     1.95692     1.00871
Si          3.09921     4.08008     1.00016
GaAs        3.18934     5.91134     1.04205
```

Loading this text as 1D waves would normally create four waves with three points each. The first wave would be a text wave and the remaining would be numeric. You could also load this as a single 3x3 matrix, treating the first row as column labels and the first column as row labels for the matrix. If you loaded it as a matrix but did not treat the first column as labels, it would create a 3 row by 4 column text wave, not a numeric wave.

The Load Waves Dialog for Delimited Text — 1D

The basic process of loading 1D data from a delimited text file is as follows:

1. Choose Data→Load Waves→Load Waves to display the Load Waves dialog.
2. Choose Delimited Text from the File Type pop-up menu.
3. Click the File button to select the file containing the data.
4. Click Do It.

When you click Do It, the LoadWave operation runs. It executes the Load Delimited Text routine which goes through the following steps:

1. Optionally, determine if there is a row of column labels.

2. Determine the number of columns.
3. Determine the format of each column (number, text, date, time or date/time).
4. Optionally, present another dialog allowing you to confirm or change wave names.
5. Create waves.
6. Load the data into the waves.

Igor looks for a row of labels only if you enable the "Read wave names" option. If you enable this option and if Igor finds a row of labels then this determines the number of columns that Igor expects in the file. Otherwise, Igor counts the number of data items in the first row in the file and expects that the rest of the rows have the same number of columns.

In step 3 above, Igor determines the format of each column by examining the first data item in the column. Igor tries to interpret all of the remaining items in a given column using the format that it determines from the first item in the column.

If you choose Load Delimited Text from the Load Waves submenu instead of choosing Load Waves, Igor displays the Open File dialog in which you can select the delimited text file to load directly. This is a shortcut that skips the Load Waves dialog and uses default options for the load. This always loads 1D waves, not a matrix. The precision of numeric waves is controlled by the Default Data Precision setting in the Data Loading section of the Miscellaneous Settings dialog. Before you use this shortcut, take a look at the Load Waves dialog so you can see what options are available.

Editing Wave Names

The "Auto name & go" option is used mostly when you are loading 1D data under control of an Igor procedure and you want everything to be automatic. When loading 1D data manually, you normally leave the "Auto name & go" option deselected. Then Igor presents an additional Loading Delimited Text dialog in which you can confirm or change wave names.

The context area of the Loading Delimited Text dialog gives you feedback on what Igor is about to load. You can't edit the file here. If you want to edit the file, abort the load and open the file as an Igor notebook or open it in a text editor.

Set Scaling After Loading Delimited Text Data

If your 1D numeric data is uniformly spaced in the X dimension then you will be able to use the many operations and functions in Igor designed for waveform data. You will need to set the X scaling for your waves after you load them, using the Change Wave Scaling dialog.

Note: If your 1D data is uniformly spaced it is *very important* that you set the X scaling of your waves. Many Igor operations depend on the X scaling information to give you correct results.

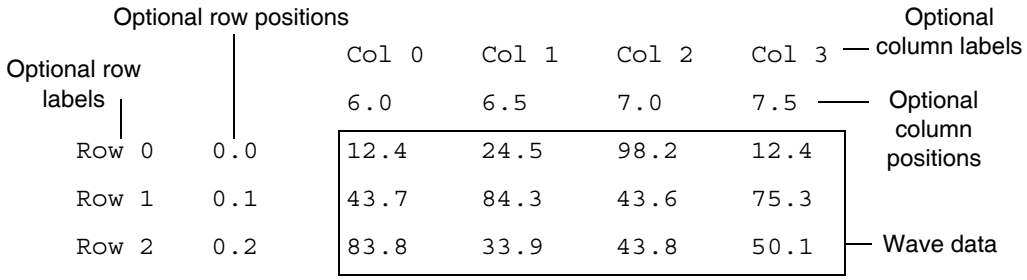
If your 1D data is not uniformly spaced then you will use XY pairs and you do not need to change X scaling. You may want to use Change Wave Scaling to set the data units.

The Load Waves Dialog for Delimited Text — 2D

To load a delimited text file as a 2D wave, choose the Load Waves menu item. Then, select the "Load columns into matrix" checkbox.

When you load a matrix (2D wave) from a text file, Igor creates a single wave. Therefore, there is no need for a second dialog to enter wave names. Instead, Igor automatically names the wave based on the base name that you specify. After loading, you can then rename the wave if you want.

To understand the row/column label/position controls, you need to understand Igor's view of a 2D delimited text file:



In the simplest case, your file has just the wave data — no labels or positions. You would indicate this by deselecting all four label/position checkboxes.

2D Label and Position Details

If your file does have labels or positions, you would indicate this by selecting the appropriate checkbox. Igor expects that row labels appear in the first column of the file and that column labels appear in the first line of the file unless you instruct it differently using the Tweaks subdialog (see **Delimited Text Tweaks** on page II-126). Igor loads row/column labels into the wave's dimension labels (described in Chapter II-6, **Multidimensional Waves**).

Igor can treat column positions in one of two ways. It can use them to set the dimension scaling of the wave (appropriate if the positions are uniformly-spaced) or it can create separate 1D waves for the positions. Igor expects row positions to appear in the column immediately after the row labels or in the first column of the file if the file contains no row labels. It expects column positions to appear immediately after the column labels or in the first line of the file if the file contains no column labels unless you instruct it differently using the Tweaks subdialog.

A row position wave is a 1D wave that contains the numbers in the row position column of the file. Igor names a row position wave "RP_ " followed by the name of the matrix wave being loaded. A column position wave is a 1D wave that contains the numbers in the column position line of the file. Igor names a column position wave "CP_" followed by the name of the matrix wave being loaded. Once loaded (into separate 1D waves or into the matrix wave's dimension scaling), you can use row and column position information when displaying a matrix as an image or when displaying a contour of a matrix.

If your file contains header information before the data, column labels and column positions, you need to use the Tweaks subdialog to specify where to find the data of interest. The "Line containing column labels" tweak specifies the line on which to find column labels. The "First line containing data" tweak specifies the first line of data to be stored in the wave itself. The first line in the file is considered to be line zero.

If you instruct LoadWave to read column positions, it determines which line contains them in one of two ways, depending on whether or not you also instructed it to read column labels. If you do ask LoadWave to read column labels, then LoadWave assumes that the column positions line immediately follows the column labels line. If you do not ask LoadWave to read column labels, then LoadWave assumes that the column positions line immediately precedes the first data line.

Loading Text Waves from Delimited Text Files

There are a few issues relating to special characters that you may need to deal with when loading data into text waves.

By default, the Load Delimited Text operation considers comma and tab characters to be delimiters which separate one column from the next. If the text that you are loading may contain commas or tabs as values rather than as delimiters, you will need to change the delimiter characters. You can do this using the Tweaks subdialog of the Load Delimited Text dialog.

The Load Delimited Text operation always considers carriage return and linefeed characters to mark the end of a line of text. It would be quite unusual to find a data file that uses these characters as values. In the extremely rare case that you need to load a carriage return or linefeed as a value, you can use an escape

sequence. Replace the carriage return value with "\r" (without the quotes) and the linefeed value with "\n". Igor will convert these to carriage return and linefeed and store the appropriate character in the text wave.

In addition to "\r" and "\n", Igor will also convert "\t" into a tab value and do other escape sequence conversions (see **Escape Sequences in Strings** on page IV-13). These conversions create a possible problem which should be quite rare. You may want to load text that contains "\r", "\n" or "\t" sequences which you do not want to be treated as escape sequences. To prevent Igor from converting them into carriage return and tab, you will need to replace them with "\\r", "\\n" and "\\t".

Igor does not remove quotation marks when loading data from delimited text files into text waves. If necessary, you can do this by opening the file as a notebook and doing a mass replace before loading or by displaying the loaded waves in a table and using Edit→Replace.

Delimited Text Tweaks

There are many variations on the basic form of a delimited text file. We've tried to provide tweaks that allow you to guide Igor when you need to load a file that uses one of the more common variations. To do this, use the Tweaks button in the Load Waves dialog.

The Tweaks dialog can specify the space character as a delimiter. Use the LoadWave operation to specify other delimiters as well.

The main reason for allowing space as a delimiter is so that we can load files that use spaces to align columns. This is a common format for files generated by FORTRAN programs. Normally, you should use the fixed field text loader to load these files, not the delimited text loader. If you do use the delimited text loader and if space is allowed as a delimiter then Igor treats any number of consecutive spaces as a single delimiter. This means that two consecutive spaces do not indicate a missing value as two consecutive tabs would.

When loading a delimited file, by default Igor expects the first line in the file to contain either column labels or the first row of data. There are several tweaks that you can use for a file that doesn't fit this expectation.

Lines and columns in the tweaks dialog are numbered starting from zero.

Using the "Line containing column labels" tweak, you can specify on what line column labels are to be found if not on line zero. Using this and the "First line containing data" tweak, you can instruct Igor to skip garbage, if any, at the beginning of the file.

The "First line containing data", "Number of lines containing data", "First column containing data", and "Number of columns containing data" tweaks are designed to allow you to load any block of data from anywhere within a file. This might come in handy if you have a file with hundreds of columns but you are only interested in a few of them.

If "Number of lines containing data" is set to "auto" or 0, Igor will load all lines until it hits the end of the file. If "Number of columns containing data" is set to "auto" or 0, Igor will load all columns until it hits the last column in the file.

The proper setting for the "Ignore blanks at the end of a column" tweak depends on the kind of 1D data stored in the file. If a file contains some number of similar columns, for example four channels of data from a digital oscilloscope, you probably want all of the columns in the file to be loaded into waves of the same length. Thus, if a particular column has one or more missing values at the end, the corresponding points in the wave should contain NaNs to represent the missing value. On the other hand, if the file contains a number of dissimilar columns, then you might want to ignore any blank points at the end of a column so that the resulting waves will not necessarily be of equal length. If you enable the "Ignore blanks at the end of a column" tweak then LoadWave will not load blanks at the end of a column into the 1D wave. If this option is enabled and a particular column has nothing but blanks then the corresponding wave is not loaded at all.

Troubleshooting Delimited Text Files

You can examine the waves created by the Load Delimited Text routine using a table. If you don't get the results that you expected, you can to try other LoadWave options or inspect and edit the text file until it is in a form that Igor can handle. Remember the following points:

- Igor expects the file to consist of numeric values, text values, dates, times or date/times separated by tabs or commas unless you set tweaks to the contrary.
- Igor expects a row of column labels, if any, to appear in the first line of the file unless you set tweaks to the contrary. It expects that the column labels are also delimited by tabs or commas unless you set tweaks to the contrary. Igor will not look for a line of column labels unless you enable the Read Wave Names option for 1D waves or the Read Column Labels options for 2D waves.
- Igor determines the number of columns in the file by inspecting the column label row or the first row of data if there is no column label row.

If merely inspecting the file does not identify the problem then you should try the following troubleshooting technique.

- Copy just the first few lines of the file into a test file.
- Load the test file and inspect the resulting waves in a table.
- Open the test file as a notebook.
- Edit the file to eliminate any irregularities, save it and load it again. Note that you can load a file as delimited text even if it is open as a notebook. Make sure that you have saved changes to the notebook before loading it.
- Inspect the loaded waves again.

This process usually sheds some light on what aspect of the file is irregular. Working on a small subset of your file makes it easier to quickly do some trial and error investigation.

If you are unable to get to the bottom of the problem, email a zipped copy of the file or of a representative subset of it to support@wavemetrics.com along with a description of the problem. Do not send the segment as plain text because email programs may strip out or replace unusual control characters in the file.

Loading Fixed Field Text Files

A fixed field text file consists of rows of values, organized into columns, that are a fixed number of bytes wide with a carriage return, linefeed, or carriage return/linefeed sequence at the end of the row. Space characters are used as padding to ensure that each column has the appropriate number of bytes. In some cases, a value will fill the entire column and there will be no spaces after it. FORTRAN programs typically generate fixed field text files.

Igor's Load Fixed Field Text routine works just like the Load Delimited Text routine except that, instead of looking for a delimiter character to determine where a column ends, it counts the number of bytes in the column. All of the features described in the section **Loading Delimited Text Files** on page II-120 apply also to loading fixed field text.

The Load Waves Dialog for Fixed Field Text

To load a fixed field text file, invoke the Load Waves dialog by choosing Data→Load Waves→Load Waves. The dialog is the same as for loading delimited text except for three additional items.

In the Number of Columns item, you must enter the total number of columns in the file. In the Field Widths item, you must enter the number of bytes in each column of the file, separated by commas. The last value that you enter is used for any subsequent columns in the file. If all columns in the file have the same number of bytes, just enter one number.

If you select the All 9's Means Blank checkbox then Igor will treat any column that consists entirely of the digit 9 as a blank. If the column is being loaded into a numeric wave, Igor sets the corresponding wave value to NaN. If the column is being loaded into a text wave, Igor sets the corresponding wave value to "" (empty string).

Loading General Text Files

We use the term "general text" to describe a text file that consists of one or more blocks of numeric data. A block is a set of rows and columns of numbers. Numbers in a row are separated by one or more tabs or spaces. One or more consecutive commas are also treated as white space. A row is terminated by a carriage return character, a linefeed character, or a carriage return/linefeed sequence.

The Load General Text routine handles numeric data only, not date, time, date/time or text. Use Load Delimited Text or Load Fixed Field Text for these formats. Load General Text can handle 2D numeric data as well as 1D.

The first block of data may be preceded by header information which the Load General Text routine automatically skips.

If there is a second block, it is usually separated from the first with one or more blank lines. There may also be header information preceding the second block which Igor also skips.

When loading 1D data, the Load General Text routine loads each column of each block into a separate wave. It treats column labels as described above for the Load Delimited Text routine, except that spaces as well as tabs and commas are accepted as delimiters. When loading 2D data, it loads all columns into a single 2D wave.

The Load General Text routine determines where a block starts and ends by counting the number of numbers in a row. When it finds two rows with the same number of numbers, it considers this the start of a block. The block continues until a row which has a different number of numbers.

Examples of General Text

Here are some examples of text that you might find in a general text file.

Simple general text

```
ch0         ch1         ch2         ch3         (optional row of labels)
2.97055     1.95692     1.00871     8.10685
3.09921     4.08008     1.00016     7.53136
3.18934     5.91134     1.04205     6.90194
```

The Load General Text routine would create four waves with three points each or, if you specify loading as a matrix, a single 3 row by 4 column wave.

General text with header

```
Date: 3/2/93
Sample: P21-3A
ch0         ch1         ch2         ch3         (optional row of labels)
2.97055     1.95692     1.00871     8.10685
3.09921     4.08008     1.00016     7.53136
3.18934     5.91134     1.04205     6.90194
```

The Load General Text routine would automatically skip the header lines (Date: and Sample:) and would create four waves with three points each or, if you specify loading as a matrix, a single 3 row by 4 column wave.

General text with header and multiple blocks

```
Date: 3/2/93
Sample: P21-3A
ch0_1       ch1_1       ch2_1       ch3_1       (optional row of labels)
2.97055     1.95692     1.00871     8.10685
3.09921     4.08008     1.00016     7.53136
3.18934     5.91134     1.04205     6.90194

Date: 3/2/93
Sample: P98-2C
ch0_2       ch1_2       ch2_2       ch3_2       (optional row of labels)
2.97055     1.95692     1.00871     8.10685
3.09921     4.08008     1.00016     7.53136
```

```
3.18934     5.91134     1.04205     6.90194
```

The Load General Text routine would automatically skip the header lines and would create eight waves with three points each or, if you specify loading as a matrix, two 3 row by 4 column waves.

Comparison of General Text, Fixed Field and Delimited Text

You may wonder whether you should use the Load General Text routine, Load Fixed Field routine or the Load Delimited Text routine. Most commercial programs create simple tab-delimited files which these routines can handle. Files created by scientific instruments, mainframe programs, custom programs, or exported from spreadsheets are more diverse. You may need to try these routines to see which works better. To help you decide which to try first, here is a comparison.

Advantages of the Load General Text compared to Load Fixed Field and to Load Delimited Text:

- It can automatically skip header text.
- It can load multiple blocks from a single file.
- It can tolerate multiple tabs or spaces between columns.

Disadvantages of the Load General Text compared to Load Fixed Field and to Load Delimited Text:

- It can not handle blanks (missing values).
- It can not tolerate columns of non-numeric text or non-numeric values in a numeric column.
- It can not load text values, dates, times or date/times.
- It can not handle comma as the decimal point (European number style).

The Load General Text routine *can* load missing values if they are represented in the file explicitly as "NaN" (Not-a-Number). It can not handle files that represent missing values as blanks because this confounds the technique for determining where a block of numbers starts and ends.

The Load Waves Dialog for General Text — 1D

The basic process of loading data from a general text file is as follows:

1. Choose Data→Load Waves→Load Waves to display the Load Waves dialog.
2. Choose General Text from the File Type pop-up menu.
3. Click the File button to select the file containing the data.
4. Click Do It.

When you click Do It, Igor's LoadWave operation runs. It executes the Load General Text routine which goes through the following steps:

1. Locate the start of the block of data using the technique of counting numbers in successive lines. This step also skips the header, if any, and determines the number of columns in the block.
2. Optionally, determine if there is a row of column labels immediately before the block of numbers.
3. Optionally, present another dialog allowing you to confirm or change wave names.
4. Create waves.
5. Load data into the waves until the end of the file or a until a row that contains a different number of numbers.
6. If not at the end of the file, go back to step 1 to look for another block of data.

Igor looks for a row of column labels only if you enable the "Read wave names" option. It looks in the line immediately preceding the block of data. If it finds labels and if the number of labels matches the number of columns in the block, it uses these labels as wave names. Otherwise, Igor automatically generates wave names of the form wave0, wave1 and so on.

If you choose the Load General Text item from the Load Waves submenu instead of the Load Waves item, Igor displays the Open File dialog in which you can select the general text file to load directly. This is a shortcut that skips the Load Waves dialog and uses default options for the load. This will always load 1D waves, not a matrix.

The precision of numeric waves is controlled by the Default Data Precision setting in the Data Loading section of the Miscellaneous Settings dialog. Before you use this shortcut, take a look at the Load Waves dialog so you can see what options are available.

Editing Wave Names for a Block

In step 3 above, the Load General Text routine presents a dialog in which you can change wave names. This works exactly as described above for the Load Delimited Text routine except that it has one extra button: "Skip this block".

Use "Skip this block" to skip one or more blocks of a multiple block general text file.

Click the Skip Column button to skip loading of the column corresponding to the selected name box. Shift-click the button to skip all columns except the selected one.

The Load Waves Dialog for General Text — 2D

Igor can load a 2D wave using the Load General Text routine. However, Load General Text does not support the loading of row/column labels and positions. If the file has such rows and columns, you must load it as a delimited text file.

The main reason to use the Load General Text routine rather than the Load Delimited Text routine for loading a matrix is that the Load General Text routine can automatically skip nonnumeric header information. Also, Load General Text treats any number of spaces and tabs, as well as one comma, as a single delimiter and thus is tolerant of less rigid formatting.

Set Scaling After Loading General Text Data

If your 1D data is uniformly spaced in the X dimension then you will be able to use the many operations and functions in Igor designed for waveform data. You will need to set the X scaling for your waves after you load them, using the Change Wave Scaling dialog.

Note: If your data is uniformly spaced it is *very important* that you set the X scaling of your waves. Many Igor operations depend on the X scaling information to give you correct results.

If your 1D data is not uniformly spaced then you will use XY pairs and you do not need to change X scaling. You may want to use Change Wave Scaling to set the waves' data units.

General Text Tweaks

The Load General Text routines provides some tweaks that allow you to guide Igor as it loads the file. To do this, use the Tweaks button in the Load Waves dialog.

The items at the top of the dialog are hidden because they apply to the Load Delimited Text routine only. Load General Text always skips any tabs and spaces between numbers and will also skip a single comma. The "decimal point" character is always period and it can not handle dates.

The items relating to column labels, data lines and data columns have two potential uses. You can use them to load just a part of a file or to guide Igor if the automatic method of finding a block of data produces incorrect results.

Lines and columns in the tweaks dialog are numbered starting from zero.

Igor interprets the "Line containing column labels" and "First line containing data" tweaks differently for general text files than it does for delimited text files. For delimited text, zero means "the first line". For general text, zero for these parameters means "auto".

Here is what "auto" means for general text. If "First line containing data" is auto, Igor starts the search for data from the beginning of the file without skipping any lines. If it is not "auto", then Igor skips to the specified line and starts its search for data there. This way you can skip a block of data at the beginning of the file. If "Line containing column labels" is auto then Igor looks for column labels in the line immediately preceding the line found by the search for data. If it is not auto then Igor looks for column labels in the specified line.

If the "Number of lines containing data" is not "auto" then Igor stops loading after the specified number of lines or when it hits the end of the first block, whichever comes first. This behavior is necessary so that it is possible to pick out a single block or subset of a block from a file containing more than one block.

If a general text file contains more than one block of data and if "Number of lines containing data" is "auto" then, for blocks after the first one, Igor maintains the relationship between the line containing column labels and first line containing data. Thus, if the column labels in the first block were one line before the first line containing data then Igor expects the same to be true of subsequent blocks.

You can use the "First column containing data" and "Number of columns containing data" tweaks to load a subset of the columns in a block. If "Number of columns containing data" is set to "auto" or 0, Igor loads all columns until it hits the last column in the block.

Troubleshooting General Text Files

You can examine the waves created by the Load General Text routine using a table. If you don't get the results that you expected, you will need to inspect and edit the text file until it is in a form that Igor can handle. Remember the following points:

- Load General Text can not handle dates, times, date/times, commas used as decimal points, or blocks of data with non-numeric columns. Try Load Delimited Text instead.
- It skips any tabs or spaces between numbers and will also skip a single comma.
- It expects a line of column labels, if any, to appear in the first line before the numeric data unless you set tweaks to the contrary. It expects that the labels are also delimited by tabs, commas or spaces. It will not look for labels unless you enable the Read Wave Names option.
- It works by counting the number of numbers in consecutive lines. Some unusual formats (e.g., 1,234.56 instead of 1234.56) can throw this count off, causing it to start a new block prematurely.
- It can not handle blanks or non-numeric values in a column. Each of these cause it to start a new block of data.
- If it detects a change in the number of columns, it starts loading a new block into a new set of waves.

If merely inspecting the file does not identify the problem then you should try the technique of loading a subset of your data. This is described under **Troubleshooting Delimited Text Files** on page II-127 and often sheds light on the problem. In the same section, you will find instructions for sending the problem file to WaveMetrics for analysis, if necessary.

Loading Igor Text Files

An Igor Text file consists of keywords, data and Igor commands. The data can be numeric, text or both and can be of dimension 1 to 4. Many Igor users have found this to be an easy and powerful format for exporting data from their own custom programs into Igor.

The file name extension for an Igor Text file is ".itx". Old versions of Igor used ".awav" and this is still accepted.

Examples of Igor Text

Here are some examples of text that you might find in an Igor Text file.

Simple Igor Text

```
IGOR
WAVES/D unit1, unit2
BEGIN
      19.7  23.9
      19.8  23.7
      20.1  22.9
END
X SetScale x 0,1, "V", unit1; SetScale d 0,0, "A", unit1
X SetScale x 0,1, "V", unit2; SetScale d 0,0, "A", unit2
```

Loading this would create two double-precision waves named unit1 and unit2 and set their X scaling, X units and data units.

Igor Text with extra commands

```
IGOR
WAVES/D/O xdata, ydata
BEGIN
      98.822      486.528
      109.968     541.144
      119.573     588.21
      133.178     654.874
      142.906     702.539
END
X SetScale d 0,0, "V", xdata
X SetScale d 0,0, "A", ydata
X Display ydata vs xdata; DoWindow/C TempGraph
X ModifyGraph mode=2,lsize=5
X CurveFit line ydata /X=xdata /D
X Textbox/A=LT/X=0/Y=0 "ydata= \\{W_coef[0]}+\\{W_coef[1]}*xdata"
X PrintGraphs TempGraph
X DoWindow/K TempGraph              // kill the graph
X KillWaves xdata, ydata, fit_ydata // kill the waves
```

Loading this would create two double-precision waves and set their data units. It would then make a graph, do a curve fit, annotate the graph and print the graph. The last two lines do housekeeping.

Igor Text File Format

An Igor Text file starts with the keyword **IGOR**. The rest of the file may contain blocks of data to be loaded into waves or Igor commands to be executed and it must end with a blank line.

A block of data in an Igor Text file must be preceded by a declaration of the waves to be loaded. This declaration consists of the keyword **WAVES** followed by optional flags and the names of the waves to be loaded. Next the keyword **BEGIN** indicates the start of the block of data. The keyword **END** marks the end of the block of data.

A file can contain any number of blocks of data, each preceded by a declaration. If the waves are 1D, the block can contain any number of waves but waves in a given block must all be of the same data type. Multidimensional waves must appear one wave per block.

A line of data in a block consists of one or more numeric or text items with tabs separating the numbers and a terminator at the end of the line. The terminator can be CR, LF, or CRLF. Each line should have the same number of items.

You can't use blanks, dates, times or date/times in an Igor Text file. To represent a missing value in a numeric column, use "NaN" (not-a-number). To represent dates or times, use the standard Igor date format (number of seconds since 1904-01-01).

There is no limit to the number of waves or number of points except that all of the data must fit in available memory.

The WAVES keyword accepts the following optional flags:

Flag	Effect
/N=(…)	Specifies size of each dimension for multidimensional waves.
/O	Overwrites existing waves.
/R	Makes waves real (default).
/C	Makes waves complex.
/S	Makes waves single precision floating point (default).

Flag	Effect
/D	Makes waves double precision floating point.
/I	Makes waves 32 bit integer.
/W	Makes waves 16 bit integer.
/B	Makes waves 8 bit integer.
/U	Makes integer waves unsigned.
/T	Specifies text data type.

Normally you should make single or double precision floating point waves. Integer waves are normally used only to contain raw data acquired via external operations. They are also appropriate for storing image data.

The /N flag is needed only if the data is multidimensional but the flag is allowed for one-dimensional data, too. Regardless of the dimensionality, the dimension size list must always be inside parentheses. Examples:

```
WAVES/N=(5) wave1D
WAVES/N=(3,3) wave2D
WAVES/N=(3,3,3) wave3D
```

Integer waves are signed unless you use the /U flag to make them unsigned.

If you use the /C flag then a pair of numbers in a line supplies the real and imaginary value for a single point in the resulting wave.

If you specify a wave name that is already in use and you don't use the overwrite option, Igor displays a dialog so that you can resolve the conflict.

The /T flag makes text rather than numeric waves. See **Loading Text Waves from Igor Text Files** on page II-135.

A command in an Igor Text file is introduced by the keyword **X** followed by a space. The command follows the X on the same line. When Igor encounters this while loading an Igor Text file it executes the command.

Anything that you can execute from Igor's command line is acceptable after the X. Introduce comments with "X //". There is no way to do conditional branching or looping. However, you can call an Igor procedure defined in a built-in or auxiliary procedure window.

Commands, introduced by X, are executed as if they were entered on the command line or executed via the Execute operation. Such command execution is not thread-safe. Therefore, you can not load an Igor text file containing a command from an Igor thread.

Setting Scaling in an Igor Text File

When Igor writes an Igor Text file, it always includes commands to set each wave's scaling, units and dimension labels. It also sets each wave's note.

If you write a program that generates Igor Text files, you should set at least the scaling and units. If your 1D data is uniformly spaced in the X dimension, you should use the SetScale operation to set your waves X scaling, X units and data units. If your data is not uniformly spaced, you should set the data units only. For multidimensional waves, use SetScale to set Y, Z and T units if needed.

The Load Waves Dialog for Igor Text

The basic process of loading data from an Igor Text file is as follows:

1. Choose Data→Load Waves→Load Waves to display the Load Waves dialog.
2. Choose Igor Text from the File Type pop-up menu.
3. Click the File button to select the file containing the data.

4. Click Do It.

When you click Do It, Igor's LoadWave operation runs. It executes the Load Igor Text routine which loads the file.

If you choose the Load Igor Text item from the Load Waves submenu instead of the Load Waves item, Igor displays the Open File dialog in which you can select the Igor Text file to load directly. This is a shortcut that skips the Load Waves dialog.

Loading MultiDimensional Waves from Igor Text Files

In an Igor Text file, a block of wave data is preceded by a WAVES declaration. For multidimensional data, you must use a separate block for each wave. Here is an example of an Igor Text file that defines a 2D wave:

```
IGOR
WAVES/D/N=(3,2) wave0
BEGIN
      1     2
      3     4
      5     6
END
```

The "/N=(3,2)" flag specifies that the wave has three rows and two columns. The first line of data (1 and 2) contains data for the first row of the wave. This layout of data is recommended for clarity but is not required. You could create the same wave with:

```
IGOR
WAVES/D/N=(3,2) wave0
BEGIN
      1     2     3     4     5     6
END
```

Igor merely reads successive values and stores them in the wave, storing a value in each column of the first row before moving to the second row. All white space (spaces, tabs, return and linefeed characters) are treated the same.

When loading a 3D wave, Igor expects the data to be in column/row/layer order. You can leave a blank line between layers for readability but this is not required.

Here is an example of a 3 rows by 2 columns by 2 layers wave:

```
IGOR
WAVES/D/N=(3,2,2) wave0
BEGIN
      1     2
      3     4
      5     6

      11    12
      13    14
      15    16
END
```

The first 6 numbers define the values of the first layer of the 3D wave. The second 6 numbers define the values of the second layer. The blank line improves readability but is not required.

When loading a 4D wave, Igor expects the data to be in column/row/layer/chunk order. You can leave a blank line between layers and two blank lines between chunks for readability but this is not required.

If loading a multidimensional wave, Igor expects that the dimension sizes specified by the /N flag are accurate. If there is more data in the file than expected, Igor ignores the extra data. If there is less data than expected, some of the values in the resulting waves will be undefined. In either of these cases, Igor prints a message in the history area to alert you to the discrepancy.

Loading Text Waves from Igor Text Files

Loading text waves from Igor Text files is similar to loading them from delimited text files except that in an Igor Text file you declare a wave's name and type. Also, text strings are quoted in Igor Text files as they are in Igor's command line. Here is an example of Igor Text that defines a text wave:

```
IGOR
WAVES/T textWave0, textWave1
BEGIN
      "This"      "Hello"
      "is"        "out"
      "a test"    "there"
END
```

All of the waves in a block of an Igor Text file must have the same number of points and data type. Thus, you can not mix numeric and text waves in the same block. You can have any number of blocks in one Igor Text file.

As this example illustrates, you must use double quotes around each string in a block of text data. If you want to embed a quote, tab, carriage return or linefeed within a single text value, use the escape sequences \", \t, \r or \n. Use \\ to embed a backslash. For less common escape sequences, see **Escape Sequences in Strings** on page IV-13.

Loading Igor Binary Data

This section discusses loading Igor Binary data into memory.

Igor stores Igor Binary data in two ways: one wave per Igor Binary file in unpacked experiments and multiple waves within a packed experiment file.

When you open an experiment, Igor *automatically* loads the Igor Binary data to recreate the experiment's waves. The main reason to *explicitly* load an Igor Binary file is if you want to access the same data from multiple experiments. The easiest way to load data from another experiment is to use the Data Browser (see **The Data Browser** on page II-106).

Warning: You can get into trouble if two Igor experiments load data from the same Igor Binary file. See **Sharing Versus Copying Igor Binary Files** on page II-137 for details.

There are a number of ways to load Igor Binary data into the current experiment in memory. Here is a summary. For most users, the first and second methods — which are simple and easy to use — are sufficient.

Method	Loads	Action	Purpose
Open Experiment	Packed and unpacked files	Restores the experiment to the state in which it was last saved.	To restore experiment.
Data Browser	Packed and unpacked files	Copies data from one experiment to another. See **The Browse Expt Button** on page II-108 for details.	To collect data from different sources for comparison.
Desktop Drag and Drop	Unpacked files only	Copies data from one experiment to another or shares between experiments.	To collect data from different sources for comparison.
Load Waves Dialog	Unpacked files only	Copies data from one experiment to another or shares between experiments.	To create a LoadWave command that can be used in an Igor procedure.
LoadWave Operation	Unpacked files only	Copies data from one experiment to another or shares between experiments. See **LoadWave** on page V-443 for details.	To automatically load data using an Igor Procedure.

Method	Loads	Action	Purpose
LoadData Operation	Packed and unpacked files	Copies data from one experiment to another. See **LoadData** on page V-437 for details.	To automatically load data using an Igor Procedure.

The Igor Binary File

The Igor Binary file format is Igor's native format for storing waves. This format stores one wave per file very efficiently. The file includes the numeric contents of the wave (or text contents if it is a text wave) as well as all of the auxiliary information such as the dimension scaling, dimension and data units and the wave note. In an Igor packed experiment file, any number of Igor Binary wave files can be packed into a single file.

The file name extension for an Igor Binary file is ".ibw". Old versions of Igor used ".bwav" and this is still accepted. The Macintosh file type code is IGBW and the creator code is IGR0 (last character is zero).

The name of the wave is stored *inside* the Igor Binary file. It does not come from the name of the file. For example, wave0 might be stored in a file called "wave0.ibw". You could change the name of the file to anything you want. This does not change the name of the wave stored in the file.

The Igor Binary file format was designed to save waves that are part of an Igor experiment. In the case of an unpacked experiment, the Igor Binary files for the waves are stored in the experiment folder and can be loaded using the LoadWave operation. In the case of a packed experiment, data in Igor Binary format is packed into the experiment file and can be loaded using the LoadData operation.

Some Igor users have written custom programs that write Igor Binary files which they load into an experiment. Igor Technical Note #003, "Igor Binary Format", provides the details that a programmer needs to do this. See also Igor Pro Technical Note PTN003.

The Load Waves Dialog for Igor Binary

The basic process of loading data from an Igor Binary file is as follows:

1. Choose Data→Load Waves→Load Waves to display the Load Waves dialog.
2. Choose Igor Binary from the File Type pop-up menu.
3. Click the File button to select the file containing the data.
4. Check the "Copy to home" checkbox.
5. Click Do It.

When you click Do It, Igor's LoadWave operation runs. It executes the Load Igor Binary routine which loads the file. If the wave that you are loading has the same name as an existing wave or other Igor object, Igor presents a dialog in which you can resolve the conflict.

Notice the "Copy to home" checkbox in the Load Waves dialog. It is very important.

If it is checked, Igor will disassociate the wave from its source file after loading it into the current experiment. When you next save the experiment, Igor will store a new copy of the wave with the current experiment. The experiment will not reference the original source file. We call this "copying" the wave to the current experiment.

If "Copy to home" is unchecked, Igor will keep the connection between the wave and the file from which it was loaded. When you save the experiment, it will contain a *reference* to the source file. We call this "sharing" the wave between experiments.

We strongly recommend that you copy waves rather than share them. See **Sharing Versus Copying Igor Binary Files** on page II-137 for details.

If you choose the Load Igor Binary item from the Load Waves submenu instead of the Load Waves item, Igor displays the Open File dialog in which you can select the Igor Binary file to load directly. This is a short-

cut that skips the Load Waves dialog. When you take this shortcut, you lose the opportunity to set the "Copy to home" checkbox. Thus, during the load operation, Igor presents a dialog from which you can choose to copy or share the wave.

The LoadData Operation

The LoadData operation provides a way for Igor programmers to automatically load data from packed Igor experiment files or from a file-system folder containing unpacked Igor Binary files. It can load not only waves but also numeric and string variables and a hierarchy of data folders that contains waves and variables.

The Data Browser's Browse Expt button provides interactive access to the LoadData operation and permits you to drag a hierarchy of data from one Igor experiment into the current experiment in memory. To achieve the same functionality in an Igor procedure, you need to use the LoadData operation directly. See the **LoadData** operation (see page V-437).

LoadData, accessed from the command line or via the Data Browser, has the ability to overwrite existing waves, variables and data folders. Igor automatically updates any graphs and tables displaying the overwritten waves. This provides a very powerful and easy way to view sets of identically structured data, as would be produced by successive runs of an experiment. You start by loading the first set and create graphs and tables to display it. Then, you load successive sets of identically named waves. They overwrite the preceding set and all graphs and tables are automatically updated.

Sharing Versus Copying Igor Binary Files

There are two reasons for loading a binary file that was created as part of another Igor experiment: you may want your current experiment to *share* data with the other experiment or, you may want to *copy* data to the current experiment from the other experiment.

There is a potentially serious problem that occurs if two experiments share a file. The file can not be in two places at one time. Thus, it will be stored *with* the experiment that created it but *separate from* the other. The problem is that, if you move or rename files or folders, the second experiment will be unable to find the binary file.

Here is an example of how this problem can bite you.

Imagine that you create an experiment at work and save it as an unpacked experiment file on your hard disk. Let's call this "experiment A". The waves for experiment A are stored in individual Igor Binary files in the experiment folder.

Now you create a new experiment. Let's call this "experiment B". You use the Load Igor Binary routine to load a wave from experiment A into experiment B. You elect to share the wave. You save experiment B on your hard disk. Experiment B now contains a *reference* to a file in experiment A's home folder.

Now you decide to use experiment B on another computer so you copy it to the other computer. When you try to open experiment B, Igor can't find the file it needs to load the shared wave. This file is back on the hard disk of the original computer.

A similar problem occurs if, instead of moving experiment B to another computer, you change the name or location of experiment A's folder. Experiment B will still be looking for the shared file under its old name or in its old location and Igor will not be able to load the file when you open experiment B.

Because of this problem, we recommend that you *avoid file sharing* as much as possible. If it is necessary to share a binary file, you will need to be very careful to avoid the situation described above.

The Data Browser always copies when transferring data from disk into memory.

For more information on the problem of sharing files, see **References to Files and Folders** on page II-22.

Loading Image Files

You can load JPEG, PNG, TIFF, BMP, and Sun Raster image files into Igor Pro using the Load Image dialog.

You can load numeric plain text files containing image data using the Load Waves dialog via the Data menu. Check the "Load columns into matrix" checkbox.

You can load images from HDF4 and HDF5 files. See **Loading HDF Files** on page II-140 for details.

You can load other image formats using the IgorGIS package as described under **Loading GIS Data** on page II-150.

You can also load images by grabbing frames. See the **NewCamera** operation.

The Load Image Dialog

To load an image file into an Igor wave, choose Data→Load Waves→Load Image to display the Load Image dialog.

When you choose a particular type of image file from the File Type pop-up menu, you are setting a file filter that is used when displaying the image file selection dialog. If you are not sure that your image file has the correct file name extension, choose “Any” from the File Type pop-up menu so that the filter does not restrict your selection.

The name of the loaded wave can be the name of the file or a name that you specify. If you enter a wave name in the dialog that conflicts with an existing wave name and you do not check the Overwrite Existing Waves checkbox, Igor appends a numeric suffix to the new wave name.

Loading PNG Files

There are two menu choices for the PNG format: Raw PNG and PNG. When Raw PNG is selected, the data is read directly from the file into the wave. When PNG is selected, the file is loaded into memory, an off-screen image is created, and the wave data is set by reading the offscreen image. In nearly all cases, you should choose Raw PNG.

When loading a PNG file, the image data is loaded into a 3D Igor RGB wave containing unsigned byte RGB elements in layers 0, 1, and 2. If the image file includes an alpha channel, the resulting 3D RGBA wave includes an alpha layer.

You can convert a 3D waves containing an RGB image into a grayscale image using the **ImageTransform** operation with the rgb2gray keyword.

Loading JPEG File

When loading a JPEG file, the image data is loaded into a 3D Igor RGB wave containing unsigned byte RGB elements in layers 0, 1, and 2. JPEG does not support alpha.

You can convert a 3D waves containing an RGB image into a grayscale image using the **ImageTransform** operation with the rgb2gray keyword.

Loading BMP Files

When loading a BMP file, the image data is loaded into a 3D Igor RGB wave containing unsigned byte RGB elements in layers 0, 1, and 2. BMP does not support alpha.

You can convert a 3D waves containing an RGB image into a grayscale image using the **ImageTransform** operation with the rgb2gray keyword.

Loading TIFF Files

A TIFF file can store one or more images in many formats. The most common formats are:

- Bilevel

- Grayscale
- Palette color
- Full color (RGB, RGBA, CMYK)

A bilevel image consists of one plane of data in which each pixel can represent black or white. Igor loads a bilevel image into a 2D wave.

A grayscale image consists of one plane of data in which each pixel can represent a range of intensities. Igor loads a grayscale image into a 2D wave.

A palette color image is like a grayscale but includes a color palette. Igor loads the grayscale image into a 2D wave and also creates a colormap wave named with the suffix "_CMap".

RGB, RGBA, and CMYK images are loaded into 3D waves with 3 or 4 layers. Each layer stores the pixels for one color component.

TIFF files that contain multiple images are called TIFF stacks. There are two options for loading them:

- Load the images into a single 3D wave.

  This works with grayscale images only. Each grayscale image is loaded into a layer of the 3D output wave.
- Load each image into its own wave.

  This works with any kind of image. Each grayscale image is loaded into its own 2D wave. Each RGB, RGBA, or CMYK image is loaded into its own 3D wave.

You can specify a particular image, or range of images, to be loaded from a multi-image TIFF file. In the Load Image dialog, enter the zero-based index of the first image to load and the number of images to load from the TIFF stack.

You can display TIFF images using the NewImage operation and convert image waves into other forms using the ImageTransform operation.

You can convert a 3D waves containing an RGB image into a grayscale image using the **ImageTransform** operation with the rgb2gray keyword.

You can convert a number of 2D image waves into a 3D stack using the **ImageTransform** operation with the stackImages keyword.

Loading Sun Raster Files

Sun Raster files are loaded as 2D waves.

If the Sun Raster file includes a color map, Igor creates, in addition to the image wave, a colormap wave, named with the suffix "_CMap".

Loading Row-Oriented Text Data

All of the built-in text file loaders are column-oriented — they load the columns of data in the file into 1D waves. There is a row-oriented format that is fairly common. In this format, the file represents data for one wave but is written in multiple columns. Here is an example:

```
350         2.97        1.95        1.00        8.10        2.42
351         3.09        4.08        1.90        7.53        4.87
352         3.18        5.91        1.04        6.90        1.77
```

In this example, the first column contains X values and the remaining columns contain data values, written in row/column order.

Igor Pro does not have a file-loader extension to handle this format, but there is a WaveMetrics procedure file for it. To use it, use the Load Row Data procedure file in the “WaveMetrics Procedures:File Input

Output" folder. It adds a Load Row Data item to the Macros menu. When you choose this item, Igor presents a dialog that offers several options. One of the options treats the first column as X values or as data. If you specify treating the column as X values, Igor will use it to determine the X scaling of the output wave, assuming that the values in the first column are evenly spaced. This is usually the case.

Loading HDF Files

HDF stands for "Hierarchical Data Format". HDF is a complex and powerful format and you will need to understand it as well as the structure of your HDF files to conveniently use it. Information on HDF is available via the World Wide Web from:

<http://www.hdfgroup.org/>

Igor Pro includes an HDF5XOP that can read and write HDF5 files. HDF5XOP is documented in the "HDF5 Help.ihf" file in "Igor Pro 7 Folder:More Extensions:File Loaders". An HDF5 browser is also provided and documented in the help file.

Igor Pro also includes an older XOP that supports HDF version 3 and version 4 files. This HDF Loader XOP is documented in "HDF Loader Help.ihf" file in the same folder.

Loading Excel Files

You can load data from Excel files into Igor using the **XLLoadWave** operation directly or by choosing Data→Load Waves→Load Excel File which displays the Load Excel File dialog.

XLLoadWave loads numeric, text, date, time and date/time data from Excel files into Igor waves. It can load data from .xls and .xlsx files. It does not support .xlsb (binary format for large files) files.

On Macintosh, it is possible to have a worksheet open in Excel and to use XLLoadWave to load the worksheet into Igor at the same time. When you do this, Igor loads the most recently saved version of the worksheet. On Windows, you must close the worksheet in Excel before loading it in Igor.

Some programs unfortunately save tab-delimited or other non-Excel type files using the ".xls" extension. If you try to load one of these files, XLLoadWave will tell you that it is not an Excel binary file.

What XLLoadWave Loads

A worksheet can be very simple, consisting of just a rectangular block of numbers, or it can be very complex, with blocks of numbers, strings, and formulas mixed up in arbitrary ways. XLLoadWave is designed to pick a rectangular block of cells out of a worksheet, converting the columns into Igor waves.

XLLoadWave can load both numeric and text (string) data. An Excel column can contain a mix of numeric and text cells. An Igor wave must be all numeric or all text. When you load an Excel column into an Igor wave, you need to decide whether to load the data into a numeric wave or into a text wave. XLLoadWave can also load date, time, and date/time data into numeric waves.

Column and Wave Types

XLLoadWave provides the following methods of determining the type of wave that it will create for a given column. These methods are presented in the Load Excel File dialog and are controlled by the /C and /COLT flags of the XLLoadWave command line operation.

Treat all columns as numeric

This is the default method. If you have a simple block of numbers that you want to load into waves, this is the method to use, and you can forget about the others.

XLLoadWave creates a numeric wave for each Excel column that you are loading. If the column contains numeric cells, their values are stored in the corresponding point of the wave. If the column contains text cells, XLLoadWave stores NaNs (blanks) in the corresponding point of the wave.

Treat all columns as date

This is the same as the preceding method except that XLLoadWave converts the numeric data from Excel date/time format into Igor date/time format. See Excel Date/Time Versus Igor Date/Time for details.

When XLLoadWave creates a numeric wave that is to store dates or times, it always creates a double-precision wave, because double precision is required to accurately store dates. Also, XLLoadWave sets the data units of the wave to "dat". Igor recognizes "dat" as signifying that the wave contains dates and/or times when you use the wave in a graph as the X part of an XY pair.

In this method, when XLLoadWave displays the wave in a table, it uses date/time formatting for the table column. You can change the column format to just date or just time using the ModifyTable operation.

Treat all columns as text

XLLoadWave loads all columns into text waves.

If you load a column containing numeric cells into a text wave, Igor converts the numeric cell value into text and stores the resulting text in the wave.

Deduce from row

This is a good method to use for loading a mix of columns of different types (numeric and/or date and/or text) into Igor.

You tell XLLoadWave what row to look at. XLLoadWave examines the cells in that row. For a given column, if the cell is numeric then XLLoadWave creates a numeric wave and if the cell is text then XLLoadWave creates a text wave.

If a numeric cell uses an Excel built-in date, time, or date/time format, XLLoadWave converts the numeric data from Excel date/time format into Igor date/time format. XLLoadWave can not deduce date and time formatting for cells that are governed by custom cell formats. In this case, see Excel Date/Time Versus Igor Date/Time for details on manually conversion.

When XLLoadWave deduces the column type using this method, it sets the Igor table column format for date/time waves to either date, time or date/time, depending on the built-in cell format for the corresponding column in the Excel file.

Use column type string

Use this method if you have a mix of columns of different types (numeric and/or date and/or text) and the "deduce from row" method does not make the correct deduction. For example, in some files there may be no single row that is suitable for deducing the column type.

In this method, you provide a string that identifies the type of each column to be loaded. For example, the string "1T1D3N" tells XLLoadWave that the first column loaded is to be loaded into a text wave, the next column is to be loaded into a numeric date/time wave, and the next three columns are to be loaded into numeric waves. If you load more columns than are covered by the string, extra columns are loaded as numeric. Also, the string "N" means all columns are numeric, the string "D" means all columns are numeric date/time, and the string "T" means all columns are text. The string must not contain any blanks or other extraneous characters.

Here are examples of suitable strings:

"N"	All columns are numeric.
"T"	All columns are text.
"1T1D3N"	One text column followed by one numeric date/time column followed by three or more numeric columns.
"1T1N3T25N"	One text column followed by one numeric column followed by three text columns followed by 25 or more numeric columns.

When loading numeric columns, the "use column type string" method differs from the "treat all columns as numeric" method in one way. In the "Treat all columns as numeric" method, any text cells in the numeric column are treated as blanks. This behavior is compatible with previous versions of XLLoadWave. In the "use column type string" method, if XLLoadWave encounters a text cell in a numeric column, it converts the text cell into a number. If the text represents a valid number (e.g., "1.234"), this will produce a valid number in the Igor wave. If the text does not represent a valid number (e.g., "January"), this will produce a blank in the Igor wave. This is useful if you have a file that inadvertently contains a text cell in a numeric column.

XLLoadWave and Wave Names

As you can see in the Load Excel File dialog, XLLoadWave uses one of three ways to generate names for the Igor waves that it creates. First, it can take wave names from a row that you specify in the worksheet. In this case XLLoadWave expects that the row contains string values. Second, it can generate default wave names of the form ColumnA, ColumnB and so on, where the letter at the end of the name indicates the column in the worksheet from which the wave was created. Third, XLLoadWave can generate wave names of the form wave0, wave1 and so on using a base name, "wave" in this case, that you specify.

XLLoadWave supports a fourth wave naming method that is not available from the dialog: the /NAME flag. This flag allows you to specify the desired name for each column using a semicolon-separated string list.

There are several situations, described below, in which XLLoadWave changes the name of the wave that it creates from what you might expect. When this happens, XLLoadWave prints the original and new names in Igor's history area. After the load, you can use Igor's Rename operation to pick another name of your choice, if you wish.

If a name in the worksheet is too long, XLLoadWave truncates it to a legal length. If a name contains characters that are not allowed in standard Igor wave names, XLLoadWave replaces them with the underscore character.

If two names in the worksheet conflict with each other, XLLoadWave makes the second name unique by adding a prefix such as “D_” where the letter indicates the Excel column from which the wave is being loaded.

If a name in the worksheet conflicts with the name of an existing wave, XLLoadWave makes the name of the incoming wave unique by adding one or more digits unless you use the overwrite option. With the overwrite option on, the incoming data overwrites the existing wave.

If XLLoadWave needs to add one or more digits to a name to make it unique and if the length of the name is already at the limit for Igor wave names, XLLoadWave removes one or more characters from the middle of the name.

It is possible that a name taken from a cell in the worksheet might conflict with the name of an Igor operation, function or macro. For example, Date and Time are built-in Igor functions so a wave can not have these names. If such a conflict occurs, XLLoadWave changes the name and prints a message in Igor's history area showing the original and the new names.

XLLoadWave Output Variables

XLLoadWave sets the standard Igor file-loader output variables, V_flag, S_path, S_fileName, and S_waveNames. In addition it sets S_worksheetName to the name of the loaded worksheet within the workbook file.

Excel Date/Time Versus Igor Date/Time

Excel stores date/time information in units of days since January 1, 1900 or January 1, 1904. 1900 is the default on Windows and 1904 is the default on Macintosh. Igor stores dates in units of seconds since January 1, 1904.

If you use the Treat all columns as date, Deduce from row, or Use column type string methods for determining the column type, XLLoadWave automatically converts from the Excel format into the Igor format. If you use the Treat all columns as numeric method, you need to manually convert from Excel to Igor format.

If the Excel file uses 1904 as the base year, the conversion is:

```
wave *= 24*3600                // Convert days to seconds
```

If the Excel file uses 1900 as the base year, the conversion is:

```
wave *= 24*3600                // Convert days to seconds
wave -= 24*3600*365.5*4        // Account for four year difference
```

The use of 365.5 here instead of 365 accounts for a leap year plus the fact that the Microsoft 1900 date system represents 1/1/1900 as day 1, not as day 0.

When displaying time data, you may see a one second discrepancy between what Excel displays and what Igor displays in a table. For example, Excel may show "9:00:30" while Igor shows "9:00:29". The reason for this is that the Excel data is just short of the nominal time. In this example, the Excel cell contains a value that corresponds to, "9:00:30" minus a millisecond. When Excel displays times, it rounds. When Igor displays times, it truncates. If this bothers you, you can round the data in the Igor wave:

```
wave = round(wave)
```

In doing this rounding, you eliminate any fractional seconds in the data. That is why XLLoadWave does not automatically do the rounding.

Loading Excel Data Into a 2D Wave

XLLoadWave creates 1D waves. Here is an Igor function that converts the 1D waves into a 2D wave.

```
Function LoadExcelNumericDataAsMatrix(pathName, fileName, worksheetName,
                        startCell, endCell)
   String pathName         // Name of Igor symbolic path or "" to get dialog
   String fileName         // Name of file to load or "" to get dialog
   String worksheetName
   String startCell        // e.g., "B1"
   String endCell          // e.g., "J100"

   if ((strlen(pathName)==0) || (strlen(fileName)==0))
      // Display dialog looking for file.
      Variable refNum
      String filters = "Excel Files (*.xls,*.xlsx,*.xlsm):.xls,.xlsx,.xlsm;"
      filters += "All Files:.*;"
      Open/D/R/P=$pathName /F=filters refNum as fileName
      fileName = S_fileName         // S_fileName is set by Open/D
      if (strlen(fileName) == 0)    // User cancelled?
         return -2
      endif
   endif

   // Load row 1 into numeric waves
   XLLoadWave/S=worksheetName/R=($startCell,$endCell)/COLT="N"/O/V=0/K=0/Q fileName
   if (V_flag == 0)
      return -1                     // User cancelled
   endif

   String names = S_waveNames       // S_waveNames is created by XLLoadWave
   String nameOut = UniqueName("Matrix", 1, 0)
   Concatenate /KILL /O names, $nameOut   // Create matrix and kill 1D waves
```

```
   String format = "Created numeric matrix wave %s containing cells %s to %s in
                        worksheet \"%s\"\r"
   Printf format, nameOut, startCell, endCell, worksheetName
End
```

Loading Matlab MAT Files

The MLLoadWave operation loads Matlab MAT-files into Igor Pro. You can access it directly via the MLLoadWave operation or by choosing Data→Load Waves→Load Matlab MAT File which displays the Load Matlab MAT File dialog.

MLLoadWave relies on dynamic libraries provided by the Matlab application. You must have Matlab installed on your machine to use MLLoadWave.

The MLLoadWave operation was incorporated into Igor for Igor Pro 7.0. In earlier versions it was implemented as an XOP. The XOP was originally created by Yves Peysson and Bernard Saoutic.

Finding Matlab Dynamic Libraries

MLLoadWave dynamically links with libraries supplied by The Mathworks when you install Matlab. You will need to tell Igor where to look as follows:

1. Choose Data→Load Waves→Load Matlab MAT File.

   This displays the Load Matlab MAT File dialog.
2. Click the Find 32-bit Matlab Libraries button or the Find 64-bit Matlab Libraries button.

   The button title depends on whether you are running IGOR32 or IGOR64. Clicking it displays the Find Matlab dialog.
3. Click the Folder button to display a Choose Folder dialog.
4. Navigate to your Matlab folder and select it.

   This will be something like:

   ```
   C:\Program Files\MATLAB\<version>                  // 64-bit Windows
   C:\Program Files (x86)\MATLAB\<version>            // 32-bit Windows
   /Applications/MATLAB_<version>.app/bin/maci64      // 64-bit Macintosh
   /Applications/MATLAB_<version>.app/bin/maci        // 32-bit Macintosh
   ```

   where <version> is your Matlab version, for example, R2015a.
5. Click the Choose button.

   Igor searches your Matlab folder to find the required dynamic libraries. If found, Igor attempts to load them. If the search and loading succeeds, the Accept button is enabled. If the search and loading fails, the Accept button is disabled. The search will fail if Igor can not find the required Matlab dynamic libraries or if the system can not find other dynamic libraries required by the Matlab dynamic libraries.

   If you have selected a valid Matlab folder but the Accept button remains disabled, see **Matlab Dynamic Library Issues**.
6. Click the Accept button.

   Igor records the location of the Matlab dynamic libraries in preferences for use in future sessions.

If you call MLLoadWave before you specify the Matlab dynamic library locations, MLLoadWave displays the Find Matlab dialog. Follow the steps above to locate your Matlab installation.

Matlab Dynamic Library Issues

NOTE: MLLoadWave requires Matlab dynamic libraries built for the same architecture as your version of Igor Pro. IGOR32 (32-bit Igor Pro) requires the 32-bit Matlab libraries, while IGOR64 (64-bit Igor Pro) requires the 64-bit Matlab libraries.

Matlab Dynamic Library Issues on Macintosh

On Macintosh, MLLoadWave has been verified to work with Matlab version 2010b and 2015b. It should work with later versions. It may or may not work with earlier versions.

For Matlab 2010b, you need to create an alias to the libraries as described next. Matlab 2015b does not require the alias. We do not know whether the alias is necessary for versions between 2010b and 2015b.

On Macintosh it sometimes happens that you point Igor to valid Matlab dynamic libraries but Igor still can't link with them. This occurs when the dynamic libraries to which Igor directly links cannot find other dynamic libraries which they require. To address this problem, create an alias pointing to the Matlab libraries directory as follows:

1. In the Finder, open the Applications folder and locate the Matlab application.
2. Right click on the Matlab application and open it by selecting "Show Package Contents".
3. Inside the Matlab package, navigate to the folder containing your Matlab dynamic libraries. This will be one of the following:

   ```
   /Applications/MATLAB_<version>.app/bin/maci     // 32-bit Macintosh
   /Applications/MATLAB_<version>.app/bin/maci64   // 64-bit Macintosh
   ```

   where <version> is your Matlab version, for example, R2010b.
4. Right click the maci or maci64 folder and select Make Alias.
5. Rename the alias as MLLoadWave32Support or MLLoadWave64Support.
6. Move the alias to your Applications folder.
7. Restart Igor and try Finding Matlab Dynamic Libraries again.

Matlab Dynamic Library Issues on Windows

Prior to Igor Pro 7.02, it was required that the path to the Matlab dynamic libraries directory be in the Windows PATH environment variable. As of 7.02, this should no longer be necessary.

However, we can not test with all versions of Matlab and future versions may behave differently. If you follow the steps listed under **Finding Matlab Dynamic Libraries** on page II-144 but Igor is still unable to link with the Matlab dynamic libraries, try adding the Matlab libraries path to your Windows PATH environment variable. Remember that IGOR32 requires 32-bit Matlab libraries and IGOR64 requires 64-bit Matlab libraries. Restart Igor before re-testing.

Supported Matlab Data Types

MLLoadWave can load 1D, 2D, 3D and 4D numeric and string data. MLLoadWave can not load data of dimension greater than 4.

When loading Matlab string data into an Igor wave, the Igor wave will be of dimension one less than the Matlab data set. This is because each element in a Matlab string data set is a single byte whereas each element in an Igor string wave is a string (any number of bytes).

MLLoadWave does not support loading of the following types of Matlab data: cell arrays, structures, sparse data sets, objects, 64 bit integers.

Numeric Data Loading Modes

The Load Matlab MAT File dialog presents a popup menu that controls how numeric data is loaded into Igor. The items in the menu are:

Load columns into 1D wave	Each column of the Matlab matrix is loaded into a separate 1D Igor wave.
Load rows into 1D wave	Each row of the Matlab matrix is loaded into a separate 1D Igor wave.

Load matrix into one 1D wave	The entire Matlab matrix is loaded into a single 1D Igor wave.
Load matrix into matrix	The Matlab matrix is loaded into an Igor matrix.
Load matrix into transposed matrix	The Matlab matrix is loaded into an Igor matrix but the rows and columns are transposed.

When loading data of dimension 3 or 4, the first three modes treat each layer (“page” in Matlab terminology) as a separate matrix. For 3D Matlab data, this gives the following behavior:

Load columns into 1D wave	Each column of each layer of the Matlab data set is loaded into a separate 1D Igor wave.
Load rows into 1D wave	Each row of each layer of the Matlab data set is loaded into a separate 1D Igor wave.
Load matrix into one 1D wave	The layer of the Matlab data set is loaded into a 1D Igor wave.
Load matrix into matrix	The Matlab 3D data set is loaded into an Igor 3D wave.
Load matrix into transposed matrix	The Matlab 3D data set is loaded into an Igor 3D wave but the rows and columns are transposed.

When loading 3D or 4D data sets, the term "matrix" in the last two modes is not really appropriate. MLLoadWave loads the entire 3D or 4D data set into a 3D or 4D Igor wave.

Loading General Binary Files

General binary files are binary files created by other programs. If you understand the binary file format, it is possible to load the data into Igor. However, you must understand the binary file format *precisely*. This is usually possible only for relatively simple formats.

There are two ways to load data from general binary files into Igor:

- Using the **FBinRead** operation
- Using the **GBLoadWave** operation

Using FBinRead is somwhat more difficult and more flexible than using GBLoadWave. It is especially useful for loading data stored as structures into Igor. For details, see **FBinRead**. This section focuses on using the GBLoadWave operation.

GBLoadWave loads data from general binary files into Igor waves. "GB" stands for "general binary".

You can invoke the GBLoadWave operation directly or by choosing Data→Load Waves→Load General Binary File which displays the Load General Binary dialog.

You need to know the format of the binary file precisely in order to successfully use GBLoadWave. Therefore, it is of use mostly to load binary files that you have created from your own program. You can also use GBLoadWave to load third party files if you know the file format precisely.

Files GBLoadWave Can Handle

GBLoadWave handles the following types of binary data:

- 8 bit, 16 bit, 32 bit, and 64 bit signed and unsigned integers
- 32 and 64 bit IEEE floating point numbers
- 32 and 64 bit VAX floating point numbers

In addition, GBLoadWave handles high-byte-first (Motorola) and low-byte-first (Intel) type binary numbers.

GBLoadWave currently can not handle IEEE or VAX extended precision values. See **VAX Floating Point** for more information.

GBLoadWave can create waves using any of numeric data types that Igor supports (64-bit and 32-bit IEEE floating point, 64-bit, 32-bit, 16-bit and 8-bit signed and unsigned integers). The data type of the wave does not need to be the same as the data type of the file. For example, if you have a file containing integer A/D readings, you can load that data into a single-precision or double-precision floating point wave.

In general, it is best to load waves as floating point since nearly all Igor operations work faster on floating point. One exception is when you are dealing with images, especially stacks of images. For example, if you have a 512x512x1024 byte image stack in a file, you should load it into a byte wave. This takes one quarter of the memory and disk space of a single-precision floating point wave.

GBLoadWave knows nothing about Igor multi-dimensional waves. It knows about 1D only. The term "array", used in the GBLoadWave dialog, means "1D array". However, after loading data as a 1D wave, you can redimension it as required.

GBLoadWave can load one or more 1D arrays from a file. When multiple arrays are loaded, they can be stored sequentially in the file or they can be interleaved. Sequential means that all of the points of one array appear in the file followed by all of the points of the next array. Interleaved means that point zero of each array appears in the file followed by point one of each array.

GBLoadWave And Very Big Files

Most data files are not so large as to present major issues for GBLoadWave or Igor. However, if your data file approaches hundreds of millions or billions of bytes, size and memory issues may arise.

If you want GBLoadWave to convert the type of the data, for example from 16-bit signed to 32-bit floating point, this requires an extra buffer during the load process which takes more memory.

When dealing with extremely large files, you may need to load part of your data file into Igor at a time using the GBLoadWave /S and /U flags.

The Load General Binary Dialog

When you choose Data→Load Waves→Load General Binary File, Igor displays the Load General Binary dialog. This dialog allows you to choose the file to load and to specify the data type of the file and the data type of the wave or waves to be created.

A few of the items in the dialog require some explanation.

The Number of Arrays in File textbox and the Number of Points in Array textbox are both initially set to 'auto'. Auto means that GBLoadWave automatically determines these based on the number of bytes in the file.

If you leave both on auto, GBLoadWave assumes that there is one array in the file with the number of points determined by the number of bytes in the file and the data length of each point.

If you set Number of Arrays in File to a number greater than zero and leave Number of Points in Array on auto, GBLoadWave determines the number of points in each array based on the total number of bytes in the file and the specified number of arrays in the file.

If you set Number of Points in Array to a number greater than one and leave Number of Arrays in File on auto, GBLoadWave determines the number of arrays in the file based on the total number of bytes in the file and the specified number of points in each array.

You can also specify the number of arrays in the file and the number of points in each array explicitly by entering a number in place of 'auto' for each of these settings.

GBLoadWave creates one or more 1D waves and gives the waves names which it generates by appending a number to the specified base name. For example, if the base name is "wave", it creates waves with names like wave0, wave1, etc.

If the Overwrite Existing Waves checkbox is checked, GBLoadWave uses names of existing waves, overwriting them. If it is unchecked, GBLoadWave skips names already in use.

Checking the Apply Scaling checkbox allows you to specify an offset and multiplier so that GBLoadWave can scale the data into meaningful units. If this checkbox is unchecked, GBLoadWave does no scaling.

VAX Floating Point

GBLoadWave can load VAX "F" format (32 bit, single precision) and "G" format (64 bit, double precision) numbers.

Do not use the GBLoadWave byte-swapping feature (/B flag) for VAX data. This does Intel-to-Motorola byte swapping, also called little-endian to big-endian. VAX data is byte-swapped relative to the way Igor stores data, but not in the same sense. Specifically, each 16-bit word is big-endian but each 8-bit byte is little-endian. When you specify that the input data is VAX data, using /J=2, GBLoadWave does the swapping required for VAX data.

GBLoadWave can not currently read VAX "D" (another 64 bit format). However, VAX D format is the same as F with an additional 4 bytes of fraction. This makes it possible to load VAX D format as F format, throwing away the extra fractional bits. Here is an example:

```
GBLoadWave/W=2/V/P=VAXData/T={2,2}/J=2/N=temp "VAX D File"
KillWaves temp1
Rename temp0, VAXDData_WithoutExtraFractBits
```

The /W=2 flag tells GBLoadWave that there are two arrays in the file. The /V flag tells it that they are interleaved. The first four bytes of each data point in the file wind up in the temp0 wave. The seconds four bytes, which contain the extra fractional bits in the D format, wind up in temp1 which we discard.

Loading JCAMP Files

Igor can load JCAMP-DX files using the **JCAMPLoadWave** operation. The JCAMP-DX format is used primarily in infrared spectroscopy. It is a plain text format that uses only ASCII characters.

You can invoke the JCAMPLoadWave operation directly or by choosing Data→Load Waves→Load JCAMP-DX File which displays the Load JCAMP-DX File dialog.

JCAMPLoadWave understands JCAMP-DX file headers well enough to read the data and set the wave scaling appropriately. Because JCAMP-DX is intended primarily for evenly-spaced data, a single wave is produced for each data set. The wave's X scaling is set based on information in the JCAMP-DX file header. The header information is optionally stored in the wave note, and optionally in a series of Igor variables. If you choose to create these variables, there will be one variable for each JCAMP-DX label in the header.

Files JCAMPLoadWave Can Handle

JCAMPLoadWave can load one or more waves from a single file. The JCAMP-DX standard calls for each new data set to start with a new header. Each header should start with the ##TITLE= label. As far as we can tell, most spectrometer systems write only one data set per file.

In addition, the JCAMP-DX standard includes simple optional compression techniques which JCAMPLoadWave supports. Files that do not use compression are human-readable.

We believe that JCAMPLoadWave should load most files stored in standard JCAMP-DX format. If you have a JCAMP-DX file that does not load correctly, please send it to support@wavemetrics.com.

Some systems produce a hybrid format in which the data itself is stored in a binary file, accompanied by an ASCII file that contains just a JCAMP-DX style header. We know that certain Bruker NMR spectrometers do this. To accomodate these systems, it is possible to select an option to load the header information only. You would then have to load the data separately, most likely using **GBLoadWave**.

Loading JCAMP Header Information

JCAMPLoadWave provides two mechanisms to load the header information into Igor:

- Storing all header text in the wave note
- Creating one Igor variable for each JCAMP label encountered in the header

In the Load JCAMP-DX File dialog, checking the Make Wave Note checkbox invokes the /W flag which stores the entire header in the wave note.

Checking Set JCAMP Variables invokes the /V flag which creates one Igor variable for each JCAMP label encountered in the header. This is explained in the next section.

Variables Set By JCAMPLoadWave

JCAMPLoadWave sets the standard Igor file-loader output variables: S_fileName, S_path, V_flag and S_waveNames. These are described in the JCAMPLoadWave reference documentation.

If you use the /V flag, which corresponds to the the Set JCAMP Variables checkbox in the dialog, it also sets "header variables". Header variables are variables that contain data which JCAMPLoadWave gleans from the JCAMP header.

When JCAMPLoadWave is called from a macro, it creates the header variables as local variables. When it is called from the command line or from a user-defined function, it creates the header variables as global variables. The section **Using Header Variables From a Function** on page II-150 explains this in more detail.

The header variable names are set based on the JCAMP label with a prefix of "SJC_" for string variables or "VJC_" for numeric variables. Thus, when it encounters the ##TITLE label, JCAMPLoadWave creates a string variable named SJC_TITLE which contains the label.

Certain JCAMP labels are parsed for numeric information and a numeric variable is created. Numeric variables that might be created include:

VJC_NPOINTS	Set to the number of points in the data set. This is set from the header information. If the actual number of data points in the file is different, this variable will not reflect this fact.
VJC_FIRSTX	Set to the X value of the first data point in the data set.
VJC_LASTX	Set to the X value of the last data point in the data set.
VJC_DELTAX	Set to the interval between successive abscissa values. This is calculated from (VJC_LASTX -VJC_FIRSTX)/ (VJC_NPOINTS - 1), and so might be slightly different from the value given by the ##DELTAX=label.
VJC_XFACTOR	Set to the multiplier that must be applied to the X data values in the file to give real-world values.
VJC_YFACTOR	Set to the multiplier that must be applied to the Y data values in the file to give real-world values.
VJC_MINY	Set to the minimum Y value found in the data set.
VJC_MAXY	Set to the maximum Y value found in the data set.

If you are loading Fourier domain data, these variables may be created to reflect the fact that the data represent optical retardation and amplitude: VJC_FIRSTR, VJC_LASTR, VJC_DELTR, VJC_RFACTOR, VJC_AFACTOR.

Any other labels found in the header result in a string variable with name SJC_<label> where <label> is replaced with the name of the JCAMP label. For instance, the ##YUNITS label results in a string variable named SJC_YUNITS.

Since successive data sets in a single file have the same standard labels, the contents of the variables are set by the last instance of a given label in the file.

Using Header Variables From a Function

If you execute JCAMPLoadWave from a user-defined function and tell it to create header variables via the /V flag, the variables are created as global variables in the current data folder. To access these variables, you must use **NVAR** and **SVAR** references. These references must appear *after* the call to JCAMPLoadWave. For example:

```
Function LoadJCAMP()
   JCAMPLoadWave/P=JCAMPFiles "JCAMP1.dx"
   if (V_Flag == 0)
      Print "No waves were loaded"
      return -1
   endif

   NVAR VJC_NPOINTS
   Printf "Number of points: %d\r", VJC_NPOINTS

   SVAR SJC_YUNITS
   Printf "Y Units: %s\r", SJC_YUNITS

   return 0
End
```

The code above assumes that the header contains the ##NPOINTS label from which the variables VJC_NPOINTS and SJC_YUNITS are created. If you can't guarantee that the file contains such a label, then you must use **NVAR**/Z and **NVAR_Exists** to test for the existence of the variable before using it.

If you need to determine which variables were created at runtime, use the **GetIndexedObjName** function and test each name for the SJC_ or VJC_ prefix.

Another problem with header variables in functions is that they leave a lot of clutter around. You can clean up like this:

```
KillVariables/Z VJC_NPOINTS
KillStrings/Z SJC_YUNITS
```

Loading GIS Data

GIS stands for “geographic information system”.

The IgorGIS package reads and writes various GIS files including shapefiles, GeoTIFF and many others. It also supports transformations between spatial reference systems and creating underlay images from vector data for use in fills.

For details see the “IgorGIS Help.ihf” file.

Loading Sound Files

The **SoundLoadWave** operation, which was added in Igor Pro 7, loads data from various sound file formats.

The SndLoadSaveWave XOP loads a variety of sound files on Macintosh and Windows. It adds the SndLoadWave, SndSaveAIFF and SndSaveWAV operations. However it works with IGOR32 only, not with IGOR64, and is considered obsolete. For new applications, use **SoundLoadWave** and **SoundSaveWave** instead.

On Windows you must install QuickTime to use the SndLoadSaveWave XOP but this is not recommended as Apple is phasing out QuickTime.

See the SndLoadSaveWave help file in the More Extensions:File Loaders folder for details.

See **Sound** on page IV-230 for general information on Igor's sound-related features.

Loading Waves Using Igor Procedures

One of Igor's strong points is that it you can write procedures to automatically load, process and graph data. This is useful if you have accumulated a large number of data files with identical or similar structures or if your work generates such files on a regular basis.

The input to the procedures is one or more data files. The output might be a printout of a graph or page layout or a text file of computed results.

Each person will need procedures customized to his or her situation. In this section, we present some examples that might serve as a starting point.

Variables Set by File Loaders

The LoadWave operation creates the numeric variable V_flag and the string variables S_fileName, S_path, and S_waveNames to provide information that is useful for procedures that automatically load waves. When used in a function, the LoadWave operation creates these as local variables.

Most other file loaders create the same or similar output variables.

LoadWave sets the string variable S_fileName to the name of the file being loaded. This is useful for annotating graphs or page layouts.

LoadWave sets the string variable S_path to the full path to the folder containing the file that was loaded. This is useful if you need to load a second file from the same folder as the first.

LoadWave sets the variable V_flag to the number of waves loaded. This allows a procedure to process the waves without knowing in advance how many waves are in a file.

LoadWave also sets the string variable S_waveNames to a semicolon-separated list of the names of the loaded waves. From a procedure, you can use the names in this list for subsequent processing.

Loading and Graphing Waveform Data

Here is a very simple example designed to show the basic form of an Igor function for automatically loading and graphing the contents of a data file. It loads a delimited text file containing waveform data and then makes a graph of the waves.

This example uses an Igor symbolic path. If you are not familiar with the concept, see **Symbolic Paths** on page II-21.

In this function, we make the assumption that the files that we are loading contain three columns of waveform data. Tailoring the function for a specific type of data file allows us to keep it very simple.

```
Function LoadAndGraph(fileName, pathName)
   String fileName      // Name of file to load or "" to get dialog
   String pathName      // Name of path or "" to get dialog

   // Load the waves and set the local variables.
   LoadWave/J/D/O/P=$pathName fileName
   if (V_flag==0)       // No waves loaded. Perhaps user canceled.
      return -1
   endif
```

```
   // Put the names of the three waves into string variables
   String s0, s1, s2
   s0 = StringFromList(0, S_waveNames)
   s1 = StringFromList(1, S_waveNames)
   s2 = StringFromList(2, S_waveNames)

   Wave w0 = $s0                  // Create wave references.
   Wave w1 = $s1
   Wave w2 = $s2

   // Set waves' X scaling, X units and data units
   SetScale/P x, 0, 1, "s", w0, w1, w2
   SetScale d 0, 0, "V", w0, w1, w2

   Display w0, w1, w2             // Create a new graph

   // Annotate graph
   Textbox/N=TBFileName/A=LT "Waves loaded from " + S_fileName

   return 0                       // Signifies success.
End
```

s0, s1 and s2 are local string variables into which we place the names of the loaded waves. We then use the $ operator to create a reference to each wave, which we can use in subsequent commands.

Once the function is entered in the procedure window, you can execute it from the command line or call it from another function. If you execute

```
   LoadAndGraph("", "")
```

the LoadWave operation displays an Open File dialog allowing you to choose a file. If you call LoadAndGraph with the appropriate parameters, LoadWave loads the file without presenting a dialog.

You can add a “Load And Graph” menu item by putting the following menu declaration in the procedure window:

```
Menu "Macros"
   "Load And Graph...", LoadAndGraph("", "")
End
```

Because we have not used the “Auto name & go” option for the LoadWave operation, LoadWave displays another dialog in which you can enter names for the new waves. If you want the procedure to be more automatic, use /A or /N to turn “Auto name & go” on. If you want the procedure to specify the names of the loaded waves, use the /B flag. See the description of the **LoadWave** operation (see page V-443) for details.

To keep the function simple, we have hard-coded the X scaling, X units and data units for the new waves. You would need to change the parameters to the SetScale operation to suit your data. For more flexibility, you would add additional parameters to the function.

It is possible to write LoadAndGraph so that it can handle files with any number of columns. This makes the function more complex but more general.

For more advanced programmers, here is the more general version of LoadAndGraph.

```
Function LoadAndGraph(fileName, pathName)
   String fileName      // Name of file to load or "" to get dialog
   String pathName      // Name of path or "" to get dialog

   // Load the waves and set the variables.
   LoadWave/J/D/O/P=$pathName fileName
   if (V_flag==0)       // No waves loaded. Perhaps user canceled.
      return -1
   endif

   Display              // Create a new graph
```

```
   String theWave
   Variable index=0
   do                    // Now append waves to graph
      theWave = StringFromList(index, S_waveNames) // Next wave
      if (strlen(theWave) == 0)              // No more waves?
            break                            // Break out of loop
      endif
      Wave w = $theWave
      SetScale/P x, 0, 1, "s", w             // Set X scaling
      SetScale d 0, 0, "V", w                // Set data units
      AppendToGraph w
      index += 1
   while (1)          // Unconditionally loop back up to "do"

   // Annotate graph
   Textbox/A=LT "Waves loaded from " + S_fileName

   return 0           // Signifies success.
End
```

The do-loop picks each successive name out of the list of names in S_waveNames and adds the corresponding wave to the graph. S_waveNames will contain one name for each column loaded from the file.

There is one serious shortcoming to the LoadAndGraph function. It creates a very plain, default graph. There are four approaches to overcoming this problem:

- Use preferences
- Use a style macro
- Set the graph formatting directly in the procedure
- Overwrite data in an existing graph

Normally, Igor does not use preferences when a procedure is executing. To get preferences to take effect during the LoadAndGraph function, you would need to put the statement "Preferences 1" near the beginning of the function. This turns preferences on just for the duration of the function. This will cause the Display and AppendToGraph operations to use your graph preferences.

Using preferences in a function means that the output of the function will change if you change your preferences. It also means that if you give your function to a colleague, it will produce different results. This dependence on preferences can be seen as a feature or as a problem, depending on what you are trying to achieve. We normally prefer to keep procedures independent of preferences.

Using a style macro is a more robust technique. To do this, you would first create a prototype graph and create a style macro for the graph (see **Graph Style Macros** on page II-262). Then, you would put a call to the style macro at the end of the LoadAndGraph macro. The style macro would apply its styles to the new graph.

To make your code self-contained, you can set the graph formatting directly in the code. You should do this in a subroutine to avoid cluttering the LoadAndGraph function.

The last approach is to overwrite data in an existing graph rather than creating a new one. The simplest way to do this is to always use the same names for your waves. For example, imagine that you load a file with three waves and you name them wave0, wave1, wave2. Now you make a graph of the waves and set everything in the graph to your taste. You now load another file, use the same names and use LoadWave's overwrite option. The data from the new file will replace the data in your existing waves and Igor will automatically update the existing graph. Using this approach, the function simplifies to this:

```
Function LoadAndGraph(fileName, pathName)
   String fileName      // Name of file to load or "" to get dialog
   String pathName      // Name of path or "" to get dialog

   // load the waves, overwriting existing waves
   LoadWave/J/D/O/N/P=$pathName fileName
```

```
   if (V_flag==0)       // No waves loaded. Perhaps user canceled.
      return -1
   endif

   Textbox/C/N=TBFileName/A=LT "Waves loaded from " + S_fileName

   return 0             // Signifies success.
End
```

There is one subtle change here. We have used the /N option with the LoadWave operation, which auto-names the incoming waves using the names wave0, wave1, and wave2.

You can see that this approach is about as simple as it can get. The downside is that you wind up with uninformative names like wave0. You can use the LoadWave /B flag to provide better names.

If you are loading data from Igor Binary files or from packed Igor experiments, you can use the LoadData operation instead of LoadWave. This is a powerful operation, especially if you have multiple sets of identically structured data, as would be produced by multiple runs of an experiment. See **The LoadData Operation** on page II-137 above.

Loading and Graphing XY Data

In the preceding example, we treated all of the columns in the file the same: as waveforms. If you have XY data then things change a bit. We need to make some more assumptions about the columns in the file. For example, we might have a collection of files with four columns which represent two XY pairs. The first two columns are the first XY pair and the second two columns are the second XY pair.

Here is a modified version of our function to handle this case.

```
Function LoadAndGraphXY(fileName, pathName)
   String fileName   // Name of file to load or "" to get dialog
   String pathName   // Name of path or "" to get dialog

   // load the waves and set the globals
   LoadWave/J/D/O/P=$pathName fileName
   if (V_flag==0)    // No waves loaded. Perhaps user canceled.
      return -1
   endif

   // Put the names of the waves into string variables.
   String sx0, sy0, sx1, sy1
   sx0 = StringFromList(0, S_waveNames)
   sy0 = StringFromList(1, S_waveNames)
   sx1 = StringFromList(2, S_waveNames)
   sy1 = StringFromList(3, S_waveNames)

   Wave x0 = $sx0                   // Create wave references.
   Wave y0 = $sy0
   Wave x1 = $sx1
   Wave y1 = $sy1

   SetScale d 0, 0, "s", x0, x1     // Set wave data units
   SetScale d 0, 0, "V", y0, y1

   Display y0 vs x0                 // Create a new graph
   AppendToGraph y1 vs x1

   Textbox/A=LT "Waves loaded from " + S_fileName  // Annotate graph

   return 0          // Signifies success.
End
```

The main difference between this and the waveform-based LoadAndGraph function is that here we append waves to the graph as XY pairs. Also, we don't set the X scaling of the waves because we are treating them as XY pairs, not as waveforms.

It is possible to write a more general function that can handle any number of XY pairs. Once again, adding generality adds complexity. Here is the more general version of the function.

```
Function LoadAndGraphXY(fileName, pathName)
   String fileName      // Name of file to load or "" to get dialog
   String pathName      // Name of path or "" to get dialog

   // Load the waves and set the globals
   LoadWave/J/D/O/P=$pathName fileName
   if (V_flag==0)       // No waves loaded. Perhaps user canceled.
      return -1
   endif

   Display              // Create a new graph

   String sxw, syw
   Variable index=0
   do       // Now append waves to graph
      sxw=StringFromList(index, S_waveNames) // Next name
      if (strlen(sxw) == 0)                  // No more?
            break       // break out of loop
      endif
      syw=StringFromList(index+1, S_waveNames)// Next name

      Wave xw = $sxw                   // Create wave references.
      Wave yw = $syw

      SetScale d 0, 0, "s", xw         // Set x wave's units
      SetScale d 0, 0, "V", yw         // Set y wave's units
      AppendToGraph yw vs xw

      index += 2
   while (1)         // Unconditionally loop back up to "do"

   // Annotate graph
   Textbox/A=LT "Waves loaded from " + S_fileName

   return 0          // Signifies success.
End
```

Loading All of the Files in a Folder

In the next example, we assume that we have a folder containing a number of files. Each file contains three columns of waveform data. We want to load each file in the folder, make a graph and print it. This example uses the LoadAndGraph function as a subroutine.

```
Function LoadAndGraphAll(pathName)
   String pathName      // Name of symbolic path or "" to get dialog

   String fileName
   String graphName
   Variable index=0

   if (strlen(pathName)==0)       // If no path specified, create one
      NewPath/O temporaryPath     // This will put up a dialog
      if (V_flag != 0)
         return -1                // User cancelled
      endif
      pathName = "temporaryPath"
   endif
```

```
   Variable result
   do       // Loop through each file in folder
      fileName = IndexedFile($pathName, index, ".dat")
      if (strlen(fileName) == 0)    // No more files?
         break                      // Break out of loop
      endif
      result = LoadAndGraph(fileName, pathName)
      if (result == 0)              // Did LoadAndGraph succeed?
                                    // Print the graph.
         graphName = WinName(0, 1)  // Get the name of the top graph
         String cmd
         sprintf cmd, "PrintGraphs %s", graphName
         Execute cmd    // Explained below.

         DoWindow/K $graphName      // Kill the graph
         KillWaves/A/Z              // Kill all unused waves
      endif
      index += 1
   while (1)

   if (Exists("temporaryPath"))     // Kill temp path if it exists
      KillPath temporaryPath
   endif
   return 0          // Signifies success.
End
```

This function relies on the IndexedFile function to find the name of successive files of a particular type in a particular folder. The last parameter to IndexedFile says that we are looking for files with a ".dat" extension.

Once we get the file name, we pass it to the LoadAndGraph function. After printing the graph, we kill it and then kill all the waves in the current data folder so that we can start fresh with the next file. A more sophisticated version would kill only those waves in the graph.

To print the graphs, we use the PrintGraphs operation. PrintGraphs is one of a few built-in operations that can not be directly used in a function. Therefore, we put the PrintGraphs command in a string variable and call Execute to execute it.

If you are loading data from Igor Binary files or from packed Igor experiments, you can use the LoadData operation. See **The LoadData Operation** on page II-137 above.

Exporting Data

Igor automatically saves the waves in the current experiment on disk when you save the experiment. Many Igor users load data from files into Igor and then make and print graphs or layouts. This is the end of the process. They have no need to explicitly save waves.

You can save waves in an Igor packed experiment file for archiving using the SaveData operation or using the Save Copy button in the Data Browser. The data in the packed experiment can then be reloaded into Igor using the LoadData operation or the Load Expt button in Data Browser. Or you can load the file as an experiment using File→Open Experiment. See the **SaveData** operation on page V-695 for details.

The main reason for saving a wave separate from its experiment is to export data from Igor to another program. To explicitly save waves to disk, you would use Igor's Save operation.

You can access all of the built-in routines via the Save Waves submenu of the Data menu.

The following table lists the available data saving routines in Igor and their salient features.

Saving Waves in a Delimited Text File

To save a delimited text file, choose Data→Save Waves→Save Delimited Text to display the Save Delimited Text dialog.

File type	Description
Delimited text	Used for archiving results or for exporting to another program.
	Row Format: `<data><delimiter><data><terminator>`*
	Contains one block of data with any number of rows and columns. A row of column labels is optional.
	Columns may be equal or unequal in length.
	Can export 1D or 2D waves.
	See **Saving Waves in a Delimited Text File** on page II-156.
General text	Used for archiving results or for exporting to another program.
	Row Format: `<number><tab><number><terminator>`*
	Contains one or more blocks of numbers with any number of rows and columns. A row of column labels is optional.
	Columns in a block must be equal in length.
	Can export 1D or 2D waves.
	See **Saving Waves in a General Text File** on page II-158.
Igor Text	Used for archiving waves or for exporting waves from one Igor experiment to another.
	Format: See **Igor Text File Format** on page II-132 above.
	Contains one or more wave blocks with any number of waves and rows. A given block can contain either numeric or text data.
	Consists of special Igor keywords, numbers and Igor commands.
	Can export waves of dimension 1 through 4.
	See **Saving Waves in an Igor Text File** on page II-158.
Igor Binary	Used for exporting waves from one Igor experiment to another.
	Contains data for one Igor wave.
	Format: See Igor Technical Note #003, "Igor Binary Format".
	See **Saving Waves in Igor Binary Files** on page II-159.
Image	Used for exporting waves to another program.
	Format: TIFF, PNG, raw PNG, JPEG.
	See **Saving Waves in Image Files** on page II-159.
HDF4	Requires activating an Igor extension.
	See **Saving HDF Files** on page II-159.
HDF5	Requires activating the HDF5 package.
	See **Saving HDF Files** on page II-159.
GIS	Supports a wide variety of GIS file formats including ESRI Shapefiles and GeoTIFF.
	Requires activating the IgorGIS package.
	See **Saving GIS Files** on page II-159.
Sound	Used for exporting waves to another program.
	Format: AIFC, WAVE.
	See **Saving Sound Files** on page II-159.
TDMS	Saves data to National Instruments TDMS files.
	Requires activating an extension.
	Supported on Windows only.
	See the "TDM Help.ihf" help file for details.

File type	Description
SQL Databases	Writes data to SQL databases. Requires activating an extension and expertise in database programming. See **Accessing SQL Databases** on page II-160.

* <terminator> can be carriage return, linefeed or carriage return/linefeed. You would use carriage return for exporting to a Macintosh program, carriage return/linefeed for Windows systems, and linefeed for Unix systems.

The Save Delimited Text routine writes a file consisting of numbers separated by tabs, or another delimiter of your choice, with a selectable line terminator at the end of each line of text. When writing 1D waves, it can optionally include a row of column labels. When writing a matrix, it can optionally write row labels as well as column labels plus row and column position information.

Save Delimited Text can save waves of any dimensionality. Multidimensional waves are saved one wave per block. Data is written in row/column/layer/chunk order. Multidimensional waves saved as delimited text can not be loaded back into Igor as delimited text because the Load Delimited Text routine does not support multiple blocks. They can be loaded back in as general text. However, for data that is intended to be loaded back into Igor later, the Igor Text, Igor Binary or Igor Packed Experiment formats are preferable.

The order of the columns in the file depends on the order in which the wave names appear in the Save command. This dialog generates the wave names based on the order in which you select waves in the Source Waves list.

By default, the Save operation writes numeric data using the "%.15g" format for double-precision data and "%.7g" format for data with less precision. These formats give you up to 15 or 7 digits of precision in the file.

To use different numeric formatting, create a table of the data that you want to export. Set the numeric formatting of the table columns as desired. Be sure to display enough digits in the table because the data will be written to the file as it appears in the table. In the Save Delimited Text dialog, select the "Use table formatting" checkbox. When saving a multi-column wave (1D complex wave or multi-dimensional wave), all columns of the wave are saved using the table format for the first table column from the wave.

The **SaveTableCopy** and **wfprintf** operations can also be used to save waves to text files using a specific numeric format.

The Save operation is capable of appending to an existing file, rather than overwriting the file. This is useful for accumulating results of a analysis that you perform regularly in a single file. You can also use this to append a block of numbers to a file containing header information that you generated with the fPrintf operation. The append option is not available through the dialog. If you want to do this, see the discussion of the **Save** operation (see page V-691).

Saving Waves in a General Text File

Saving waves in a general text file is very similar to saving a delimited text file. The Save General Text dialog is identical to the Save Delimited Text dialog.

All of the columns in a single block of a general text file must have the same length. The Save General Text routine writes as many blocks as necessary to save all of the specified waves. For example, if you ask it to save two 1D waves with 100 points and two 1D waves with 50 points, it will write two blocks of data. Multidimensional waves are written one wave per block.

Saving Waves in an Igor Text File

The Igor Text format is capable of saving not only the data of a wave but its other properties as well. It saves each wave's dimension scaling, units and labels, data full scale and units and the wave's note, if any. All of this data is saved more efficiently as binary data when you save as an Igor packed experiment using the SaveData operation.

As in the general text format, all of the columns in a single block of an Igor Text file must have the same length. The Save Igor Text routine handles this requirement by writing as many blocks as necessary.

Save Igor Text can save waves of any dimensionality. Multidimensional waves are saved one wave per block. The /N flag at the start of the block identifies the dimensionality of the wave. Data is written in row/column/layer/chunk order.

Saving Waves in Igor Binary Files

Igor's Save Igor Binary routine saves waves in Igor Binary files, one wave per file. Most users will not need to do this since Igor automatically saves waves when you save an Igor experiment. You might want to save a wave in an Igor Binary file to send it to a colleague.

The Save Igor Binary dialog is similar to the Save Delimited Text dialog. There is a difference in file naming since, in the case of Igor Binary, each wave is saved in a separate file. If you select a single wave from the dialog's list, you can enter a name for the file. However, if you select multiple waves, you can not enter a file name. Igor will use default file names of the form "wave0.ibw".

When you save an experiment in a packed experiment file, all of the waves are saved in Igor Binary format. The waves can then be loaded into another Igor experiment using **The Data Browser** (see page II-106) or **The LoadData Operation** (see page II-137).

Saving Waves in Image Files

To save a wave in TIFF, PNG, raw PNG, or JPEG format, choose Data→Save Waves→Save Image to display the Save Image dialog.

JPEG uses lossy compression. TIFF, PNG and raw PNG use lossless compression. To avoid compression loss, don't use JPEG.

JPEG supports only 8 bits per sample.

PNG supports 24 and 32 bits per sample. Raw PNG supports 8 and 16 bits per sample.

The extended TIFF file format supports 8, 16, and 32 bits per sample and you can use image stacks to export 3D and 4D waves.

See the **ImageSave** operation on page V-348 for details.

Saving HDF Files

Igor Pro includes an HDF5XOP that can read and write HDF5 files. HDF5XOP is documented in the "HDF5 Help.ihf" file in "Igor Pro 7 Folder:More Extensions:File Loaders". An HDF5 browser is also provided and documented in the help file.

Igor Pro also includes an older XOP that supports HDF version 3 and version 4 files. This HDF Loader XOP is documented in "HDF Loader Help.ihf" file in the same folder.

Saving GIS Files

GIS stands for "geographic information system".

The IgorGIS package reads and writes various GIS files including shapefiles, GeoTIFF and many others. It also supports transformations between spatial reference systems and creating underlay images from vector data for use in fills.

For details see the "IgorGIS Help.ihf" file.

Saving Sound Files

You can save waves as sound files using the **SoundSaveWave** operation.

You can save waves as sound files using the SndLoadSaveWave XOP. However it works with IGOR32 only, not with IGOR64, and is considered obsolete. For new applications, use **SoundSaveWave** instead. For further information on SndLoadSaveWave, see the SndLoadSaveWave help file in the More Extensions:File Loaders folder.

Exporting Text Waves

Igor does not quote text when exporting text waves as a delimited or general text file. It does quote text when exporting it as an Igor Text file.

Certain special characters, such as tabs, carriage returns and linefeeds, cause problems during exchange of data between programs because most programs consider them to separate one value from the next or one line of text from the next. Igor Text waves can contain any character, including special characters. In most cases, this will not be a problem because you will have no need to store special characters in text waves or, if you do, you will have no need to export them to other programs.

When Igor writes a text file containing text waves, it replaces the following characters, when they occur within a wave, with their associated escape codes:

Character	Name	ASCII Code	Escape Sequence
CR	carriage return	13	\r
LF	linefeed	10	\n
tab	tab	9	\t
\	backslash	92	\\

Igor does this because these would be misinterpreted if not changed to escape sequences. When Igor loads a text file into text waves, it reverses the process, converting escape sequences into the associated ASCII code.

This use of escape codes can be suppressed using the /E flag of the **Save** operation (see page V-691). This is necessary to export text containing backslashes to a program that does not interpret escape codes.

At present, the Save operation always uses the UTF-8 text encoding when writing text files. If your waves contain non-ASCII text, and if you need to import into a program that does not support UTF-8, you will need to convert the file's text encoding after saving it. You can do this by opening the file as a notebook, changing the text encoding, and saving it again, or using an external text editor.

Exporting MultiDimensional Waves

When exporting a multidimensional wave as a delimited or general text file, you have the option of writing row labels, row positions, column labels and column positions to the file. Each of these options is controlled by a checkbox in the Save Waves dialog. There is a discussion of row/column labels and positions under **2D Label and Position Details** on page II-125.

Igor writes multidimensional waves in column/row/layer/chunk order.

Accessing SQL Databases

Igor Pro includes an XOP, called SQL XOP, which provides access to relational databases from IGOR procedures. It uses ODBC (Open Database Connectivity) libraries and drivers on Mac OS X and Windows to provide this access.

For details on configuring and using SQL XOP, open the SQL Help file in "Igor Pro 7 Folder:More Extensions:Utilities".