Polygon User Manual

1. Introduction

Polygon is a software tool that enables the user to create, edit and export Polygon Reports or to create and show Polygon Presentations. It is mainly intended as a visualisation and report editing tool for gait laboratories, enabling them to quickly and easily create a gait report, analyse the patient and to do research. However, Polygon is intentionally designed as a generic tool which can be used for a variety of biomechanical purposes, such as sports, ergonomics, motor control research and rehabilitation studies.

Polygon integrates with both the Vicon Workstation software and the Vicon BodyBuilder software. The motion captured data processed through either of these two application can be read and analysed using Polygon. Furthermore, Polygon will read the output files from the Vicon Clinical Manager (VCM) and this provides backwards compatibility for users who wish to upgrade from the VCM gait analysis package to Polygon.

Polygon also incorporates the new data management tool called Eclipse from build 100 onwards. This is a hierarchical data tree structure that presents the users of Polygon and Workstation with a common interface to their data storage. See the Eclipse user manual for instructions on how to use and configure Eclipse.

Up to date with: Polygon Release Version 2.1 (Build 109)

2. Getting Started

2.1 The Dialog Bars

When launching Polygon for the first time you will be met by an application that should fill the whole screen. To the left and to the bottom of the screen you should see *dialog bars* - these are described in detail below. Additionally, you will see *tool bars* and a *menu bar* at the top of the screen.

*If this description doesn't match what you're seeing, please press the function keys F5-F11, all of which toggle the bars as described in the following sections. Alternatively, press **Ctrl-F5** to toggle ALL the bars at the same time.*

2.1.1 The Data Bar

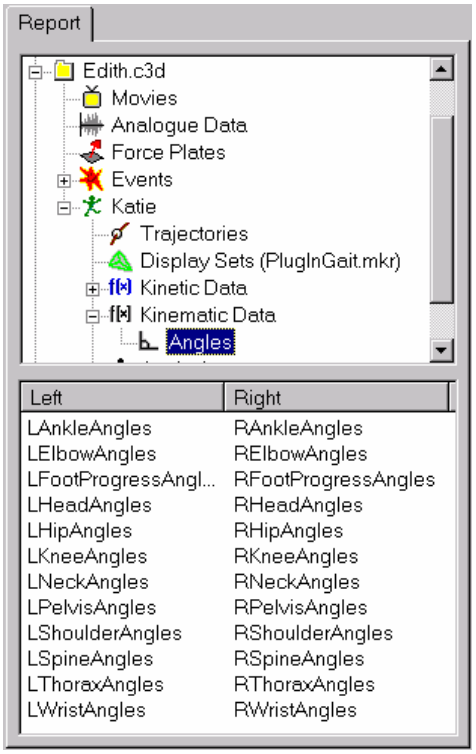


Figure 1 : The Data Bar

The bar at the left hand side of the screen is called the *data bar*. The data bar is split into two sections, the tree (or folder) view at the top and the list (or data object) view at the bottom.

The tree view is hierarchical, the hierarchy being determined by the data files that you have imported into Polygon. The interface is similar to the standard "Windows Explorer" application that allows you to browse your hard disk. Any node with a little "+" box next to it can be expanded, and highlighting any node will display the data objects associated with that particular node.

The data objects are sorted according to the *context* that is associated with it. In the figure above, there are two contexts, Left and Right, and the data objects have been sorted accordingly. In addition to this the data objects are sorted alphabetically from top to bottom.

If you select an object from the data list, you will find that you automatically select the corresponding object from all the context columns. If you would like to select a particular data object from one context only you have to click on the column header of your chosen context (for example, "Left" in the figure above). This will remove the columns of the other contexts. To get the other contexts back, simply click on the column header again.

F7 Toggles the Data Bar on/off.

2.1.2 The Time Bar

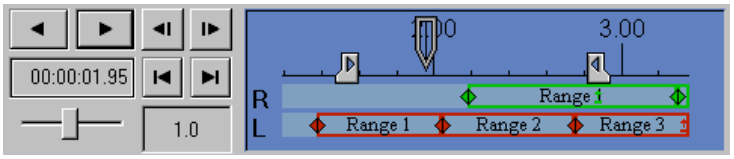


Figure 2 : The Time Bar

The time bar extends across the lower part of your screen and joins the data bar in the lower left hand corner. The time bar is intended for everything that has to do with time and synchronisation. At the left hand side of the time bar there are some buttons which, when relevant data is displayed, will allow you to play, pause, play backwards, step forwards/backwards and change the replay speed.

The main part of the time bar contains a ruler and two *context bars*. The ruler will display the current time range, and the context bars will display the events contained in the context(s) that are currently in use (for gait analysis, these will typically be foot contact and foot off events of the Left and Right contexts). Furthermore, between the events, the time bar displays rectangles which are known as *normalisation ranges*. These usually correspond to gait cycles (foot contact event to foot contact event) for gait analysis, but could be used more generally to normalise graphs according to different types of events.
F8 toggles the Time Bar on/off

2.1.3 The Tool Bar

Figure 3 : The Main Tool Bar

The tool bar contains buttons with icons (little pictures) on them. These enable the user to perform various tasks that are central to Polygon. If a button is greyed out, it means that that particular operation is not available.

The buttons above enable the user to (from left to right):

1. Create new, blank Report.
2. Create a new Report based on a Template.
3. Create a new text pane
4. Toggle the Eclipse Data Management Window on/off.
5. Display the latest error message.
6. Connect to the Real Time Engine
7. Open existing Report
8. Import data into Report
9. Save Report
10. Cut
11. Copy
12. Paste
13. Undo last operation
14. Redo last operation
15. Move pane in pane layout
16. Remove pane from pane layout
17. Change background colour of pane
18. Go back (i.e. go back to what the report was like before the last hyperlink was clicked)
19. Go forward (after a go back operation)
20. Create Global Hyperlink (a hyperlink to a configuration of panes)

21. Create Hyperlink to text pane
22. Toggle presentation mode
23. Toggle workspace view overlay draw mode
24. Move subject in workspace
25. Rotate subject in workspace
26. Toggle thumbnail graph view on/off
27. Display about box

In addition, there may be a number of buttons to the right of the rightmost button described above. These are *script buttons*, buttons that have been assigned to execute a user defined script. They can either have a "normal" background colour or a "marked" background colour. The marked background colour (blue-grey) ones haven't got a script assigned to them, whereas the normal colour ones do.

F10 toggles the Tool Bar on/off

2.1.4 The Format Bar

Figure 4 : The Format Bar

The format bar contains a few buttons and two drop-down list boxes. These are for the text view and will only be active when the text view has the focus (i.e. the text view's caret is flashing). The controls enable the user to change the current font and font size, to change the font colour and whether to use italics, bold or underline, as well as to do simple paragraph formatting, add bullet points and increase/decrease the current indentation.

F9 toggles the Format Bar on/off

2.1.5 The Status Bar

This bar can be found at the very bottom of the screen, below the time bar. The bar will display status messages and sometimes display a progress bar which will give an idea of how long a certain process (such as loading a file) will take.

F11 toggles the Status Bar on/off

2.2 Importing Data

You can import the following data file types:

- C3D files
- PXD files. These are Polygon eXternal Data files, and are files that can only be saved and re-loaded by Polygon.
- GCD files (the output files from the Vicon Clinical Manager, VCM).
- OBJ files. These are 3D Mesh files output by applications like "3D Studio Max", which can be imported and displayed in the Polygon 3D workspace.
- MKR files. These are the Vicon marker files that describe marker sets. It is necessary to highlight a *subject node* before importing an MKR file.
- MPG files. These are movie files, either captured in conjunction with the trial or from elsewhere.
- AVI files. These are also movie files.

- HTM, JPG and GIF files. These are called “multimedia” files, and are either picture files or HTML format files.
- RTF files. These are Rich Text Format files, in other words formatted text files which among other things can be created using Microsoft Word or Wordpad.

To import files into a Polygon report, either press toolbar button 7 () or choose “Import File” from the file menu, after a report has been created. This will result in a dialog box appearing which will instruct you to choose which file to import. You can choose the file type filter at the bottom of the dialog by selecting a file type from the drop-down list. Choosing a file and selecting “OK” will import a file to Polygon.

It is also possible to import a file directly from the Eclipse Data Manager by double-clicking the relevant file symbol.

If you choose to import a file it will appear in the data bar and will be a part of the report. You can now browse the contents of the file you have imported by extending or collapsing the items in the tree view at the top of the data bar. Selecting a tree view item by clicking it will display any data items in the bottom half of the data bar.

Note that from Polygon v2.0 you can also import files directly from the Eclipse interface, which may save you a lot of tedious browsing on the hard disk. Please refer to the Eclipse manual for more details.

2.3 Events and Contexts

Time dependent data that is imported into Polygon may or may not have information that enables Polygon to *normalise* the data. The normalising information is *events* and they are stored in a *context*. A typical example of an event is “Foot Contact”, and the context could be “Left” which together specifies that it’s a left foot contact we’re talking about.

IMPORTANT: Polygon will automatically assign a context to a data object if the first character of the data object’s name matches the first character of the context name. This is case-sensitive. For example, a data object called “LHipAngle” will automatically be associated with a context named “Left”, if such a context exists, but not with contexts named “head” or “left”. The algorithm that does the assigning will search for a matching context up to the “imported file” level in the data tree. This means that if you import multiple files, the data objects in one file *will not* be assigned to a context from another file.

If you look at normalised variables in a graph and they don’t look as you’d expect they should chances are that the variable has been assigned to the wrong context. This can happen if you define events in Workstation only for the Left or the Right context. If you do this, only one context will be stored in the C3D file, called either “Left” or “Right”. When the automatic context assignment algorithm cannot match for example a “LHipAngle” data object to a “Left” context (because there is no Left context), the algorithm will assign the Right context instead, and the trace will thus be normalised to the right side events.

2.4 Preferences

Polygon allows you to customise the application to a great extent. It is very useful to set up some preferences at an early stage.

To set preferences, choose “Preferences” from the “File” menu. A big dialog box will appear, with multiple tabs up in the top left hand corner. The first time you bring the preferences up, the “System” tab will be visible, subsequently the last tab that was visible when you closed the dialog the last time will appear in front.

2.4.1 The System Tab

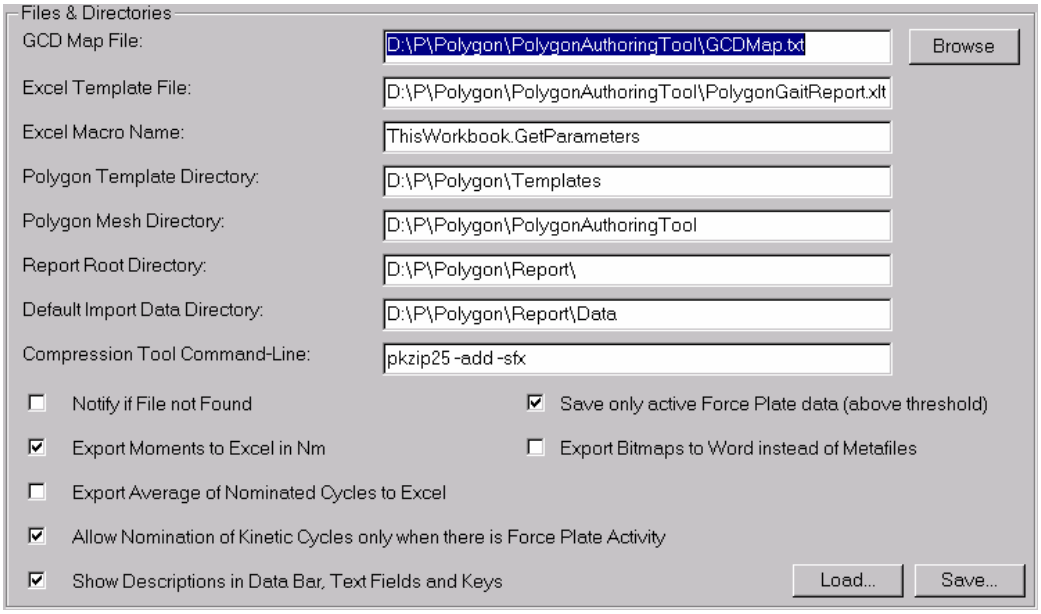


Figure 5 : The System Tab Preference Dialog

First there's two button in the lower right hand corner labelled "Load" and "Save". These buttons enable you to save or retrieve all the preferences from a file. Polygon saves all the preferences in the Windows Registry by default, but these enable you to save copies of the preferences to a file. This can be handy if you want to ensure that all the users on a multi-user Windows machine have the same preferences - just save a "Master Copy" and ensure that all the users load this file.

The System Tab contains the following preferences:

- **GCD Map File**. This file is necessary when Polygon reads GCD files as it maps the contents of the GCD to Polygon's data structures. The GCDMap.txt file is provided with Polygon and should be situated in the same folder as the Polygon executable.
- **Excel Template File**. This file is used by Polygon when exporting data to Excel. A default template called "PolygonGaitReport.xlt" is supplied and can be found in the same folder as the Polygon executable.
- **Excel Macro Name**. This is a macro contained in the file mentioned above, which Polygon will execute automatically after exporting the data to Excel. The default corresponds to the name of the macro in the provided Excel template file mentioned above.
- **Polygon Template Directory**. This is the default folder for Polygon template report files (*.tpl).
- **Polygon Mesh Directory**. Contains the mesh files used by the Polygon Workspace. When you set the appearance of the bones, Polygon will look in this particular directory for <MeshName>.OBJ files.
- **Report Root Directory**. This is the directory which will be the default when using the "Open Report", "New Report" and "Save Report" commands - setting this allows you to choose a specific location on your hard drive or network where all the reports will be stored.

- **Default import Data Directory**. Polygon will by default look in this directory for data to import. However, if you've browsed to a different directory, Polygon will continue from there the next time you choose to import.
- **Compression Tool Command-Line**. Polygon can export reports in a single file by using a compression tool to combine all the report files. The compression tool must have a command line interface, and this is where you specify what command to use.
- **Notify if file not found**. If this is ticked, Polygon will notify you if a C3D file cannot find associated files such as marker set (MKR) and movie (MPG) files.
- **Export moments to Excel in Nm**. Ticking this will override the currently used moment unit and export all moments to Excel using the unit Newtonmetres (Nm).
- **Export Average of Nominated Cycles to Excel**. This specifies whether to use the first nominated normalisation cycle or the average of all nominated cycles when exporting to Excel.
- **Allow Nomination of Kinetic Cycles only when there is Force Plate Activity**. If this is ticked, Polygon will only allow you to nominate a cycle for kinetics if there is force plate activity during the cycle. A force plate is defined as being active when at least 90% of the cycle contains force plate data that is above the force plate threshold. You can set this threshold in the Workspace tab - see below.
- **Show Descriptions in Data Bar, Text Fields and Keys**. If you tick this preference, Polygon will show the description as well as the name of the data objects in the data bar and when the data is displayed as text fields (e.g. temporal parameters) or shown in the key of a thumbnail graph pane.
- **Save only active Force Plate data (above threshold)**. If you tick this, Polygon will assume that all force plate data that is below the threshold is zero. In fact, the data won't be zero because of measured noise from the force plate, but in general this noise is not interesting. Assuming zero, Polygon will only save force plate data from the portion of the cycle where the plate is active - this is usually only a fraction of the total time of the trial and the data files will therefore be smaller.
- **Export Bitmaps to Word instead of Metafiles.** The default is to export graphs to Word as Metafiles. Metafiles are, in general, more scaleable, versatile and better looking than bitmaps but if you should prefer the latter you'll need to tick this preference.

2.4.2 The Workspace Tab

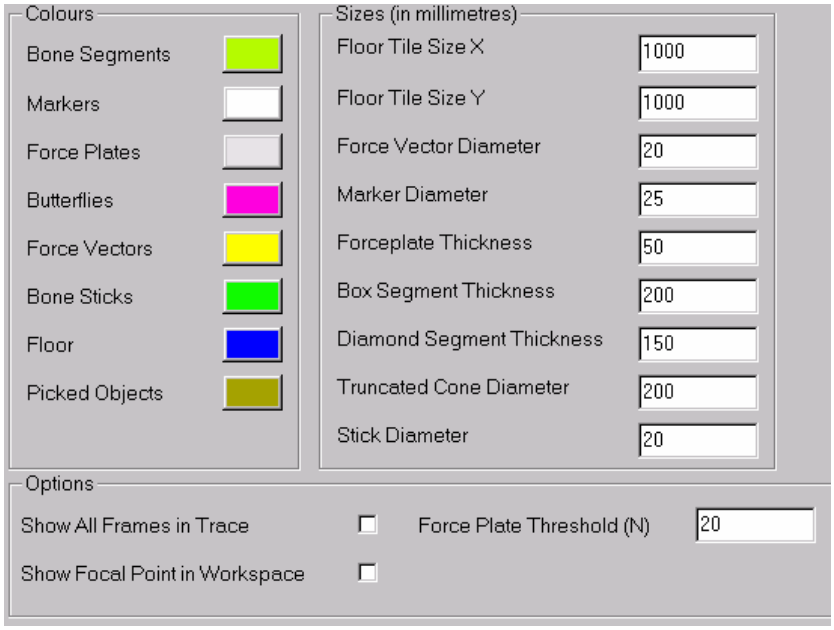


Figure 6 : The Workspace Tab

These preferences should be quite self-explanatory. To set the colours, click any of the coloured buttons and select a new colour. Note that the sizes are all in "virtual millimetres", i.e. millimetres in the workspace as captured by Vicon.

The "Show All Frames in Trace" option is explained later. The Force Plate Threshold sets a minimum threshold for when to display a force vector in the workspace. Remember than one Newton is approximately 0.1 kilograms under normal gravitational circumstances, so a setting of 20 Newtons basically means that the force plate has to have at least 2 kilograms on it before a vector is displayed in the workspace.

Show Focal Point in Workspace toggles whether to display a little symbol representing the focal point of the virtual camera (your view point) in the workspace.

2.4.3 The Text & Graphs Tab

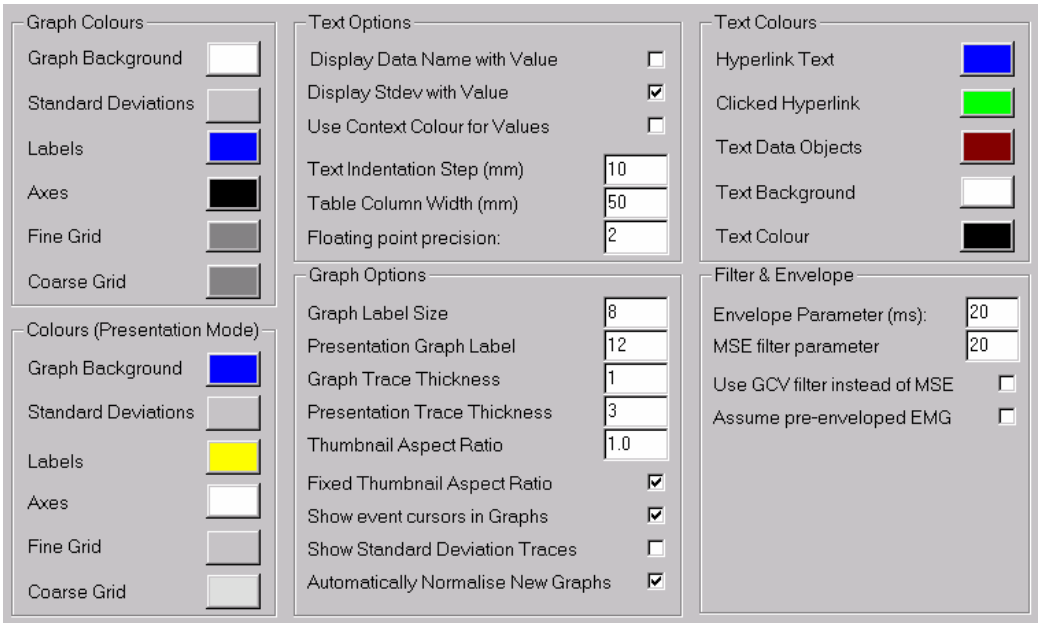


Figure 7 : The Text & Graphs Tab

The options under this tab relate to the appearance of the text and graph panes. Most of the options are colours and sizes, and should be quite self-explanatory. Note that you can set the colours of the graph pane separately for normal and presentation mode - this allows you to have different default colours (as well as trace and label sizes) for presentation mode (for example, blue is often a much better background colour than white when using a projector for a presentation, whereas white is good for a personal screen).

Here are some details for the perhaps not so self-explanatory ones:

- Display Data Name with Value. This applies when you're display data in the text view, for example single-value data objects such as "Step Length". If this option is ticked, the data object's name is dumped to the text view with the value, if the option is not ticked, only the value will be dumped.
- Display Stdev with Value. Toggles whether to display the standard deviation (if it exists) when outputting numbers as text.
- Use Context Colour for Values. If this is selected, the colour of the context associated with the text data object being displayed will be used when outputting the value in the text view.
- Fixed Thumbnail Aspect Ratio. Ticking this will ensure that the thumbnail graphs (see section 4.3.7) will keep their aspect ratio constant (i.e. the ratio of the width to the height of the graph).
- Show event cursors in graphs. If this option is ticked and you're displaying normalised graphs in the graph view, a cursor will be displayed if an event of a different type than the one used to define the normalisation range is found inside the range. In other words, if you're normalising on "Foot Contact" events, and there is a "Foot Off" event between the two foot contacts that define the range, a vertical line will be displayed in the graph view where the event occurs.
- Show Standard Deviation Traces. This toggles whether to display the actual traces that represent the standard deviation. If this is not ticked, Polygon will output a trace with a standard deviation using the stdev colour only (in other words, you will not see the trace representing the average, nor the top and bottom traces of the stdev area).

- Automatically normalise new graphs. Toggles whether Polygon will try to normalise new graphs by default.
- Envelope Parameter. This is the width of the analogue data envelope used when enveloping EMG data. In general, a wider envelope means more smoothing and a narrower envelope means that the enveloped curve will be closer to the raw EMG data.
- MSE filter parameter. This is a parameter used by the filtering algorithm when you're plotting filtered angles or trajectories in the graph view. The higher the value, the more smoothing will occur.
- Use GCV filter instead of MSE. GCV stands for General Cross-Validating filter, whereas MSE stands for Mean Squre Error filter. Both filters are capable of smoothing and differentiating, and Polygon will use GCV if this option is ticked and MSE otherwise. Note that *only MSE uses the filter parameter* specified above. If GCV is chosen, the parameter is disregarded.
  These filters are exactly the same ones that are used in the Vicon Workstation Wolthring filter plug-in. In general the MSE filter smoothes the data more than the GCV filter, which may or may not be a good thing - if you plot the velocity of a trajectory using MSE filtering you may find that the top speed is lower than if you had been using the GCV filter. On the other hand, if the data is noisy the GCV filter may give very noisy curves, especially if you plot velocities and accelerations.
- Assume pre-enveloped EMG. Ticking this option will make Polygon assume that EMG data has been enveloped by the time it is imported, and Polygon will never attempt to do any enveloping again.

2.5 Variable Ranges

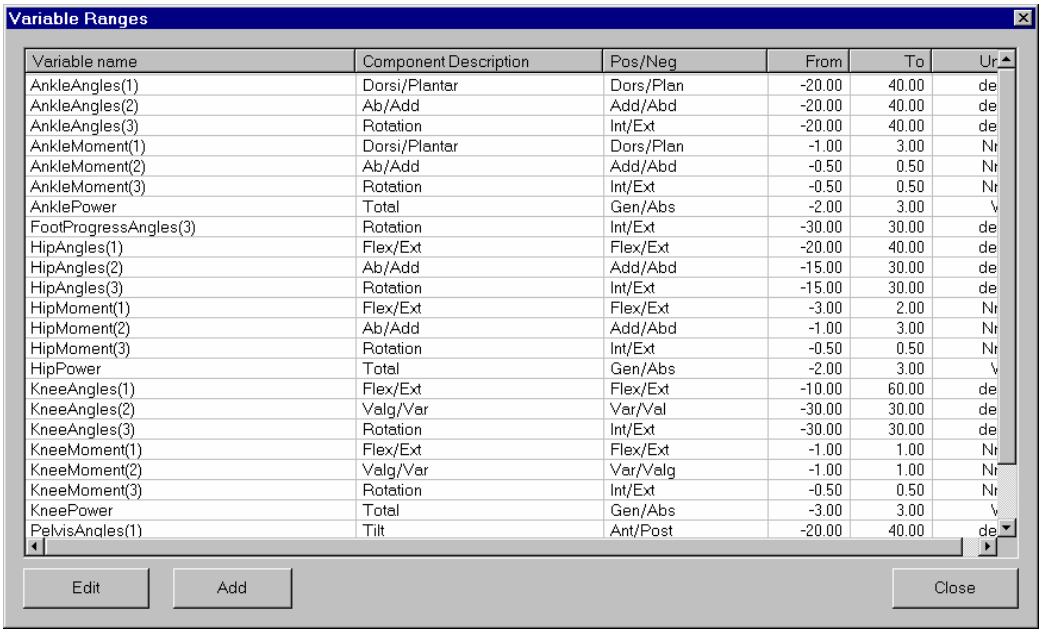


Figure 8 : The Variable Range Dialog

When graphing data it is often desirable to use the same vertical range every time a particular variable is graphed. For example, if you are often graphing the variables LHipAngles and RHipAngles, you may want the range of the vertical axis to be (-40, 40) degrees every time you display such a graph. That way, you get an instantaneous impression of the scale of the data without having to study the vertical axis in detail.

To set vertical ranges for different variables, choose the "Variable Ranges" option in the "File" menu. This will bring up a big dialog box (Figure 1Figure 8). You can either edit the variable

ranges that are already there by selecting the range from the list and clicking “Edit”, or you can add a new one by clicking “Add”.

Either of these operations will bring up yet another dialog box (Figure 9). The naming of the variable is important. You can either type the entire name of the variable (e.g. LHipAngles), or you can skip the prefix. If you skip the prefix, and type in “HipAngles” only, Polygon will apply that range to every variable that has the name “HipAngles” after the prefix.

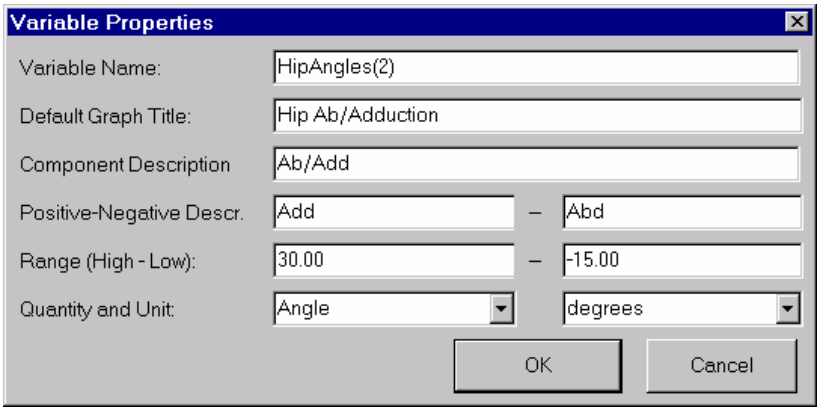


Figure 9 : Setting the Variable Range

If the variable is a vector, you will have to add a paranthesis describing which component you’re dealing with directly after the variable name. For example, if the HipAngle is, in fact, a vector when it’s imported into Polygon, make sure that you add either “(1)”, “(2)” or “(3)” *directly* after the name, i.e. no space in between.

You can specify the default title for a graph containing this particular variable in the "Default Graph Title" field. This means that whenever you visualise this variable, the title you specify here will be used instead of the one that otherwise would have been automatically generated by Polygon.

If you’d like to apply your own name convention to variable components you can enter your preference in the “Component Descr.” field. Say you have a “KneeAngle” variable, imported into Polygon as a vector. The first component is the flexion/extension component, and if you use for example “FlexExt” as the component description, “FlexExt” will appear whenever you graph that component later (instead of “1”). Similarly you can name the valgus/varus and the rotation component of the knee angle.

Furthermore, you can specify positive and negative descriptors for the different variables. These will be displayed on the vertical ruler in the graph view whenever the variable is plotted (if multiple variables having conflicting positive and negative descriptors are plotted in the same graph, nothing will be displayed). A positive descriptor could be “Flex” and a negative “Ext” for the knee angles, or “int” and “ext” for rotation.

You should also choose a range, and a default unit for the variable (e.g. degrees or radians for angles).

It may seem to you that setting up all these ranges is a lot of work, but remember, you’ll only have to do it once, since Polygon saves your settings. After you have done it, Polygon will display all the variables you have specified ranges for in a consistent and recognisable manner.

NB! Polygon 2.1 and later allows you to specify normalised units for the kinetic variables, i.e. “Nm/kg”, “Nmm/kg”, “W/kg”. To get the correct units on the graphs, specify the units in your variable ranges.

2.6 Temporal Parameters

Temporal parameters are very frequently used in Gait Analysis. Polygon will calculate the most commonly used of these for you, and allow you to choose some settings and which units to use.

The values that are calculated by Polygon are:

- Cadence. The number of steps or strides per minute.
- Single Support. The time or the percentage of the gait cycle where the current foot supports the subject.
- Double Support. The time or the percentage of the gait cycle where both feet are on the ground
- Opposite Foot Contact. The time or the point as a percentage of the gait cycle where the opposite foot hits the ground.
- Opposite Foot Off. The time or the point as a percentage of the gait cycle where the opposite foot leaves the ground.
- Step time. The time or the percentage of the gait cycle from current foot off to current foot contact.
- Step Length. The distance along the line of progression from opposite foot contact to current foot contact.
- Step Width. This is the distance between the chosen foot marker (defaults to TOE marker) and the same marker on the opposite foot when the foot down event occurs, and *normal* to the line of progression.
- Limp Index. The total support (single + double) for this foot divided by the total support for the opposite foot. Will be exactly one for a symmetric walk.
- Stride time. The time from current foot contact to the next foot contact, i.e. the time taken for the foot to do a full gait cycle.
- Stride length. The distance along the line of progression from current foot contact to the next current foot contact.
- Walking speed. The speed of the current foot based on the stride time and stride length.

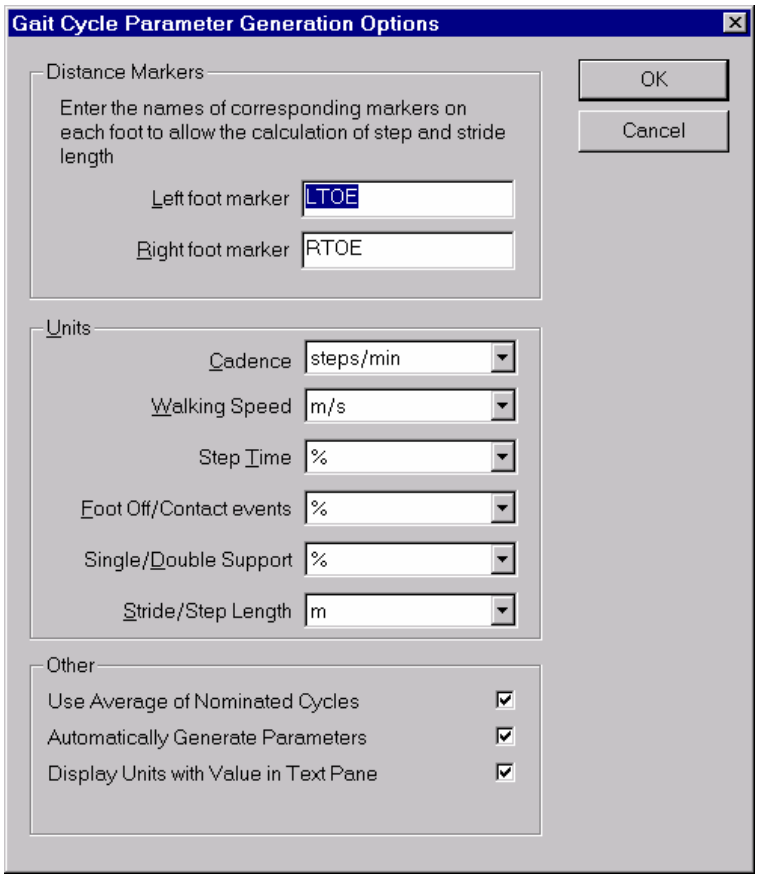
All of these are calculated for both the left and the right context, so when I am talking about the current foot it means the left foot for “Left Cadence”, “Left Single Support” etc. and vice versa.

Some of these parameters are not strictly speaking dependent on which foot we are talking about. Cadence and walking speed are examples of parameters where the Left and Right contexts don’t really make sense since your cadence and walking speed are a measure of your walking in general.

However, since the layout of tables and the structure of the data objects are nicer when the same criteria are applied to all the parameters it has been decided to keep the Left and Right separate also for Cadence and Walking Speed. The correct “independent” value will be the average of the left and the right values.

2.6.1 Setting up the properties

You can set the properties of the Temporal Parameters from the shortcut menu of the “Analysis” node in the data bar. Expand a C3D file until you see a node named “Analysis” (usually found under the Subject node) and select this with the right hand mouse button, then choose “Properties” from the shortcut menu. The following dialog box will appear:



This dialog box enables you to choose the marker trajectories on which to base the distance calculations (step length, stride length). Usually, the toe markers will be appropriate but you are free to choose any marker you may wish to use.

You can also choose units for the different temporal parameters, both metric and imperial are provided as appropriate.

In the bottom group in the dialog you can choose whether to base the calculation of the parameters on the first nominated gait cycle or the average of the nominated gait cycles (See Chapter 4.7.2 Nominating Normalisation Ranges for details).

You can also choose whether to automatically regenerate the temporal parameters whenever something that would affect them happens (such as the user nominating/denominating a gait cycle or an event being moved on time bar). Any temporal parameter being displayed on the screen will automatically be updated if this option is ticked.

Finally you can choose whether to display the units with the values when outputting them to the text pane.

2.7 Creating a new Report

Creating a new report is done by clicking toolbar button 1 (🗋) or by selecting the “New (Blank)” option from the “File” menu. This will bring up a dialog which asks you to name a directory in which to create the report.

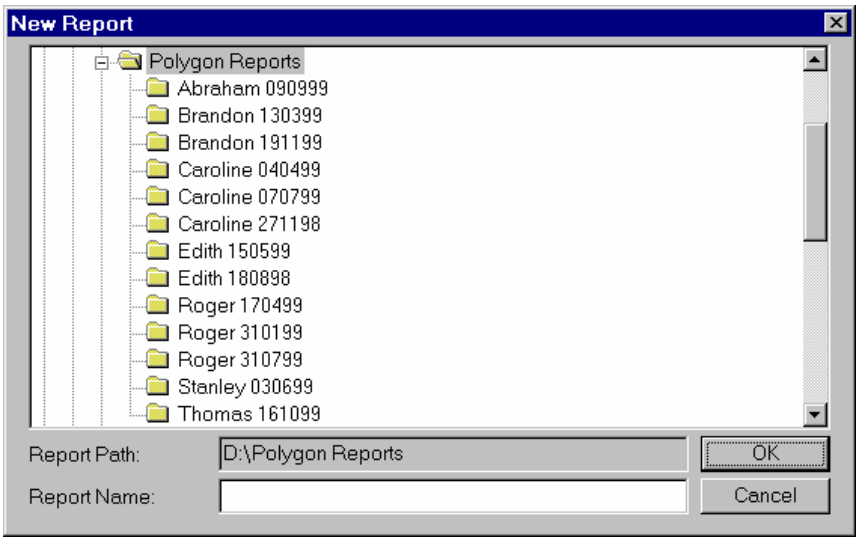


Figure 10 : New Report Dialog

Polygon uses an entire directory for each report. This is because there are potentially a lot of data files associated with each report. You have to choose a directory for the report, and the name of the directory will be the name of the report.

Browse to the directory which you'd like to be the parent directory of the report. Type the report name into the field marked "Report Name" (observe that the report path changes as you do this) and hit OK - this will create a new Polygon report for you.

Alternatively, you can create a report directly from the **Eclipse Data Manager**. This is the recommended way to do it since it keeps the report integrated in the Vicon Eclipse data hierarchy.

2.8 Visualising Data in the report

If you have both created a new report and imported some suitable data, you can start visualising data in the report. This can be done in several ways.

- 3D data will be visualised in a workspace view
- Time-dependant one-dimensional data will be visualised in a graph view
- Movie data will be visualised in a movie view.
- Pictures, Web pages and HTML will be visualised in a HTML view.
- Power Point presentations can be viewed as full-screen presentations.

Data can be visualised by clicking data objects in the bottom half of the data bar (see Figure 1) using the right hand mouse button. This will bring up a *shortcut menu.* This menu allows you to quickly and effortlessly select what you want to do with the data.

The options that will be available in the shortcut menu depend on what type of data object you have selected. If the selected object is a trajectory, the options will be:

- Components. Selecting this one will bring up another nested menu, which will present the options X, Y, Z, All and Separate. Selecting X, Y or Z will add a single graph to the graph view (and add a graph view if necessary) containing the X, Y or Z trace. Selecting All will add a single graph containing the three X, Y and Z traces in the same graph. Selecting Separate will add three separate graphs each containing one of the traces. **This is the default.**
  Note that if you have both the Left and the Right column active in the data bar and click a data object you automatically select both the Left and the Right object (if both are available). If you, when having both selected like this, choose the "Separate" option, three graphs will

be added each containing one of the X, Y or Z component from *both* the Left and the Right data object.

- Filtered. Selecting this option will bring up a nested menu allowing you to display filtered positions, velocities or accelerations. The filter type and parameter can be set in the preferences. The velocities and accelerations are calculated by the filter by differentiating the positional data.
  There are two types of filter: General Cross-Validating filter (GCV) and Mean Square Error filter (MSE). Both are also used in the Plug-in Gait (PiG) plug-in for the Vicon Workstation software. The GCV filter ignores the parameter in the preferences whereas the MSE filter uses the parameter - generally, the higher the parameter the smoother the data after filtering.
  WARNING! Filtering changes the appearance of the data, and especially the MSE filter will remove spikes which may be significant. For example, if you plot the speed of a marker which has been moved very suddenly (say the marker was at the end of a golf club), the filtered graph may indicate a lower speed than the real one. The best advice is to experiment a little with the GCV and MSE filters and not use too high a parameter value when using the MSE filter.
- Show Object. This will open a workspace view in the report and display the trajectory as a marker moving through space.
- Display as text. This will dump all the data to the text view, which can be a lot of text if there are many sample points in the trajectory. This option is there so that you can look at the actual data in a written form if you want to.

If the data object you have selected is a one-dimensional time series object (such as EMG data) the options available will be:

- Graph Variable. This will dump the data straight to a graph.
- Enveloped Graph. This will apply an advanced mathematical function to the data before visualising, which will represent the general shape of the data (especially useful for fast-varying data such as EMG). For the interested reader: the algorithm uses a parameter from the preferences (given in milliseconds) to establish an envelope around every sample point in the data. The algorithm will then search for the peak in the ahead part and the behind part of the envelope and adjust the sample point to lie on the line between these two points (if the sample point is the peak it will, of course, remain unchanged). When this has been done for all the sample points, a standard running average algorithm will be applied to all the samples using the same envelope. The end result is that, subject to the correct parameter setting (around 100 ms seems to work), the general shape of fast-varying data is represented well.

If the selected data object or objects represent single values, such as temporal parameters in gait analysis (cadence etc), the options are:

- Display All. This will just dump the data to the text view without any formatting.
- Insert Table. If you select this (only available when multiple data objects have been selected), a formatted table of the selected data will be inserted in your text view. Note that you can set the column width in the preferences.
- Add to Graph. This will add the single value data object as a vertical line in the graph view. This vertical line will be inserted at the position corresponding to the data object's value. For example, if the data object has the value 55%, the vertical line will appear at the 55% spot on the horizontal ruler in the graph view (if the graph is not normalised, i.e. the variable is plotted against time, the vertical line will not appear).

You will notice that one of the options in every shortcut menu in the data bar is in bold. This is the *default option*. The default option will be invoked if you double-click the data object. For trajectories, the default option is to show the object in the workspace, so this is what will happen if you double-click a trajectory in the data bar.

The shortcut menus also allow you to cut, copy, paste and delete data. These options should be used with extreme caution. They are NOT undoable so if you have removed a data object (or a

whole tree node) by deleting or cutting it, you cannot get it back except by re-importing the data! The most useful aspect of the cut/copy/paste/delete functions is that you can delete a whole imported file if you realise that you don't need it. Just highlight it in the data tree and choose "delete" from the shortcut menu. Note that the "delete" option will be disabled if data from the subtree of what you're trying to delete is currently being visualised. This includes events on the time bar, so if you're trying to delete an entire C3D file and aren't allowed to do it, chances are that its events are displayed on the time bar.

The C3D file can contain events, and these can be visualised as well, but only on the time bar. You can either visualise them individually by choosing "Show Events" from the data list shortcut menu, or by choosing "Show Context" from the shortcut menu that will appear if you right-click a context item (looks like a wrapped present) in the data tree. A context is a container for events, and for gait analysis this will typically be "Left" and "Right" events. Additionally, Polygon will automatically display relevant contexts when doing normalised graphs.

2.9 Exporting a Report

2.9.1 Exporting to hard disk

Once you've created a report which you'd like to distribute or send to someone there are two ways Polygon can prepare it to send to other people. You can either export the whole report in compressed form as a single file or you can export a whole directory containing the relevant files uncompressed. The latter is good if you'd like to burn the information on to a CD since the target machine can the run the report straight off the CD. If you export the report in a compressed file the report needs to be uncompressed on the target machine, thus requiring disk space. However, if you'd like to email the report to someone, sending it in a single compressed file is clearly the best option.

To export a compressed report, select "File", then "Export Report" then "Compressed". A file dialog will appear, asking you to specify a name for the target file and a location. Do not worry about the file extension as this will be automatically appended by the compression tool.

The compression tool is separate from Polygon, and ***you will require a separate licence for it***. One tool suitable for use with Polygon is PkZip version 2.5, obtainable from http://www.pkware.com. This is shareware - read the licence agreement carefully. If you do decide to purchase such a compression tool, the licence agreement is between you and the compression tool vendor and does in no way involve Oxford Metrics and Vicon Motion Systems.

The compression tool will need to have a command-line interface which means that you cannot use the standard WinZip tool directly from Polygon (you can, however, export uncompressed and then manually add all the files to a zip archive).

You can set up the command-line command and arguments in the Polygon preferences.

If you select to export uncompressed, Polygon will bring up a dialog asking you to specify a target directory. You can specify a non-existing directory by typing its name, and Polygon will create it for you. Once this is done, all the files that are necessary to run a report will be copied to this directory.

2.9.2 Exporting to Microsoft Excel

This is described in Chapter 5.10, Using Excel to Create Report.

2.9.3 Exporting to Microsoft Word

Polygon enables you to export a report to Word from where you can print. Due to the interactive nature of a Polygon report, the exported one is very limited. However, if a hard copy is needed for whatever purpose, this is the most straightforward way to obtain it.

The function is available from the "File" menu - choose the "Export to Word" option. You will now be presented with the following dialog:

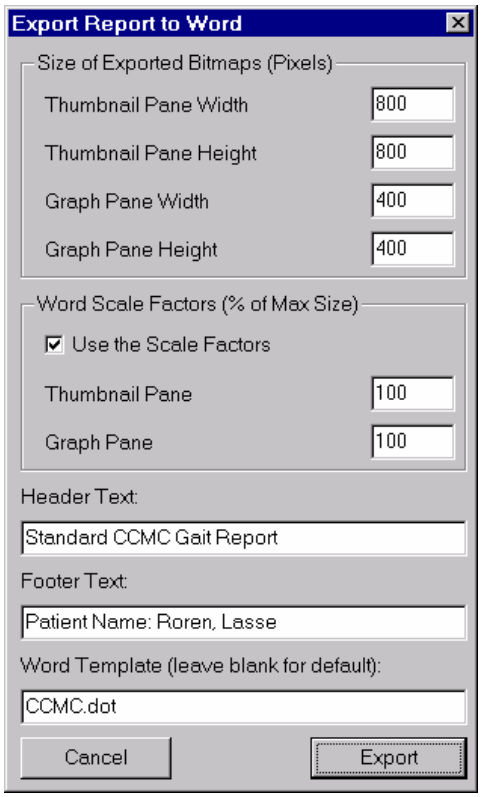


Figure 11 Export To Word Dialog

This dialog makes more sense if you have an understanding of what Polygon will actually do when exporting to Word. It is fairly simple to explain - first, Polygon will copy the contents of the *currently open* text pane to Word. Then, Polygon will go through all the hyperlinks in this particular text pane and copy any graph panes that the links may reference to Word as well. The method used to copy the graph panes to Word is to save the graph as a *Metafile* which is pasted to the Word document or to paint the graph pane to an offscreen bitmap and then paste the bitmap. The bitmap or Metafile will be added to the Word document at *the end of the paragraph where the link is situated.* Furthermore, Polygon will add a caption using the text from the hyperlink.

The dialog above refers to the offscreen Metafile or bitmaps used when exporting the graph panes to Word. There are two main types of graph panes - thumbnails and normal panes. Often, the thumbnails will contain quite a number of graphs and it is nice to use a bigger offscreen surface (a bigger surface will, of course, contain more detail) than for the individual graph panes.

The selection bar which enables you to choose which graph to display will not be exported to Word.

Word will *scale* the bitmaps and metafiles to fit the screen. If, for example, you choose an enormous offscreen surface of, say 3000 by 2000 pixels for the thumbnails, Word will still fit graph to the document. However, at such a size the labels and rulers of the graphs will be very small compared to the size of the traces. This is because the size of the labels and rulers are static in terms of the number of pixels they use. In other words, if you choose a 300 by 200 bitmap the label will be, say, 12 pixels tall, but it will still be 12 pixels tall in the 3000 by 2000 example. When Word has scaled the latter graph to fit the page, the labels will look very small indeed.

IMPORTANT: It is possible to set the sizes of the exported bitmaps of the graphs individually. The sizes specified in this dialog are the sizes used if this hasn't been done. See Chapter 4.3 about the Graph View for more information.

The best piece of advice is to experiment a little bit, and perhaps use the values in the dialog above as a starting point. Remember, if you'd like the labels and rulers to appear bigger in the Word document, you need to make the offscreen bitmaps smaller and vice versa.

Next we have the Word Scale Factor. This is a scale factor which is applied *after* Word has fitted the graphs to the page. If you choose a scale factor of 50 the bitmap will be scaled down to 50% of the page width in Word. This is handy especially for normal graph panes since these typically will look too big if they fill the width of the page. You can also set this scaling factor in Word manually, as well as edit the Word document to your heart's content, of course.

Furthermore, you can specify text to go in the header and the footer of the document.

You can also specify a Word template file (*.dot) to use when exporting. Leave this field blank to use the default template, which is the one that Word uses to create a default document when you start Word.

NOTE ABOUT THE VERSION OF WORD: You will need Word 2000 or later.

3. Using Polygon

After you have created a report, imported some data and visualised a bit you will probably want to start using Polygon for something useful. The main purpose of Polygon is to create a report. The report is basically some text that contains *hyperlinks*. Hyperlinks allow the user to jump from reading the text to looking at visualisations of data by clicking on them using the mouse pointer in the text view. The mouse cursor will change when the pointer is above a hyperlink to indicate that it's hovering above a hyperlink.

WARNING: Depending on the amount of information and data that the hyperlink instructs Polygon to visualise, the process could take a few seconds, depending on the speed of your computer and peripherals.

3.1 Hyperlinks

As mentioned above, hyperlinks are the backbone of Polygon. They connect the written report and the visualisation of data together. The author of a report will create them, and the reader of a report will click them in order to see what the author wanted to visualise in the report.

A hyperlink will always re-create the appearance of the report when the link was created. There are two main types of hyperlinks:

- Link to a single view (called a *local hyperlink*)
- Link to a view configuration (called a *global hyperlink*)

Clicking local hyperlink will result in a new view being created. This will either be a text view, a graph view, a movie view, a workspace view or a multimedia view. If such a view already exists, the existing one will be replaced with the new one. If no such view exists, the new one will be inserted by splitting the biggest existing pane either horizontally or vertically.

Clicking global hyperlink will result in all the existing views being destroyed and the whole view pane configuration that was present when the link was created being restored. If the size available has changed (for example because the screen resolution has changed or the data bar has been resized), the link will restore the sizes of the panes so that they are proportionally the same as they were when the link was created.

3.1.1 Creating a link

Before creating a hyperlink you need to make sure that the cursor in the text view is at the place where you want the link to be inserted. Alternatively you can select some text by using the mouse before creating the link, and the link will be created using that text.

If you would like to create a local link, right-click the mouse button in the pane that you want to link to. This will bring up a shortcut menu, and one of the options will be "Create

Hyperlink". Select this option. This will not work in the Multimedia view and it won't work in the Movie view unless you right-click *outside* the movie but inside the view (which, of course, is not possible if the movie fills the whole view).

You can also create a local link by using the view-specific menu. As you may have noticed, the menu next to the "help" menu on the main menu bar changes depending on the type of view that is currently active (a view becomes active when you click in it). Thus, the menu will either be called "Text View", "Workspace View", "Movie View", "Graph View" or "Multimedia View". In either case, the menu will contain an option to create a local link, usually "Create Local Link" but "Create Text Link" for the text view.

Once you have chosen to create a local link, if you haven't marked any text in the text view, a little dialog box will appear. The box will ask you to type in the hyperlink text, otherwise you will notice that the appearance of the currently marked text will change to look like a hyperlink. The default is blue colour and underlined (the current version the text control, from Riched20.dll v5.3 hard-codes the hyperlink appearance to blue and underlined. This is a control supplied by Microsoft so at the time of writing, you cannot choose a different appearance).

You can set the hyperlink colour as well as the "hyperlink having been clicked once" colour, the default text colour and default text view background colour in the preferences.

If you want to create a global link, set up the view panes as you want them and click the icon on the toolbar that looks like two circles joined together (). If, when you are creating a global link, the configuration doesn't include a text pane the global link button will stay "down" after you have pressed it. This means that the link has been created, but it's textual bit hasn't because there's nowhere to stick it. Re-opening a text view and pressing the button again will dump the hyperlink into the text view.

There are some rules that you have to obey when creating a hyperlink:

- You cannot create a hyperlink inside another
- You cannot have overlapping hyperlinks
- A hyperlink must be at least two characters long, not including space characters.

3.1.2 Copying, Editing and Deleting a Link

You can edit the text of a hyperlink just as you edit normal text. However, you cannot click to set the inserting point inside the link without actually activating it. If you'd like to edit the text in a link without activating it, you can use the cursor keys to move the insertion point inside the link and then edit to your heart's content without activating anything.

You can also edit the link itself (as opposed to the text that represents the link). You do this by clicking the link, rearranging the target view and then choosing "Replace Link" from the shortcut menu which appears when you right-click the hyperlink text.

The simplest way to delete a hyperlink is to right-click it (this action should highlight the link) and choose "delete" from the shortcut menu. You can also highlight the area which includes the hyperlink and hit the backspace key or delete key.

It is possible to copy a hyperlink from one report to another, or within the same report. This is quite simple - right click the link and choose "Copy Link" from the shortcut menu. This will enable you to paste the link to another report or to another place in the same report.

If you choose to copy a link from one report to another you have to be aware that the hyperlink usually references some data. For example, the link may refer to a specific kinematic data variable from the second file in the data bar. If the report you're pasting the link into doesn't have enough data imported or have different data files, the link may not work properly.

3.1.3 Creating a link from one text view to another

It is possible to create a link to a specific point in a text file. This text file can be the same one as the one that contains the link (for example if you'd like a "back to top" link at the bottom of a long text file), or it can be a different one.

All the links mentioned in the previous sections are inserted at the current cursor position. This strategy is not good enough if you want the link to bring the text view to a different cursor position. The way to do this is by using the text link toolbar button which can be found on the tool bar between the "global link" button and the "presentation" button and it has this symbol: .

1. Place the cursor at the point in the text file to which you want the hyperlink to move the cursor.
2. Press the text hyperlink button. This will create the hyperlink, but not yet insert it in the text. The button will look like it's pressed, indicating that a hyperlink has been created.
3. Move to the text pane and position where you want the actual hyperlink to be inserted.
4. Press the text hyperlink button again, and the link will be inserted there.

3.1.4 Link Error Reporting

Most hyperlinks in Polygon will reference data that you have imported. For example, a graph may refer to the "LKneeAngle" and "RKneeAngle" data objects from an imported C3D file.

Some times the link may not be able to locate these data variables. In earlier versions of Polygon, this used to cause an error message and a link failure. This has, from build 072, been replaced by an error reporting mechanism. The link will still work, but if the data cannot be found you will not see what you'd expect to see in the resultant view.

Sometimes this doesn't matter at all. For example, if a link was created to a workspace view containing a skeleton and three force plates and this was used to create a template. If, at a later stage, this template is used to create a report based on a data file which has only got two force plates in it, the link will still work - but you'll see only two force plates, of course.

If Polygon fails to locate data, it will provide you with an error message which you may or may not choose to have a look at. The message is available by clicking on tool bar button number 5 ( ). However, if you clicked a link and everything went smoothly, this button will be greyed out, indicating that the link located all the data without problems.

3.2 Presentation Mode

Polygon has the ability to create a presentation. This means that you can set up hyperlinks not in the text, but in a list that can be used sequentially.

To start the presentation mode, press the toolbar icon that is meant to look like an overhead projector (number 21,). The toolbar button will stay down, indicating that you're now in presentation mode.

Any hyperlink you create now will not appear in the text view. You can create hyperlinks to any configuration of views, also to configurations without text views. The links you create in presentation mode will go into a *presentation list* sequentially. Once you have finished creating the list of hyperlinks, you can start the presentation by going to the start of the list and pressing the hyperlink backwards/forwards button (and) to navigate through it.

To start at an arbitrary point in the list, or to edit it, go to the "Edit" menu and choose the "Presentation" item. This will only be available when you are in presentation mode, so make sure that you have pressed the toolbar button first!

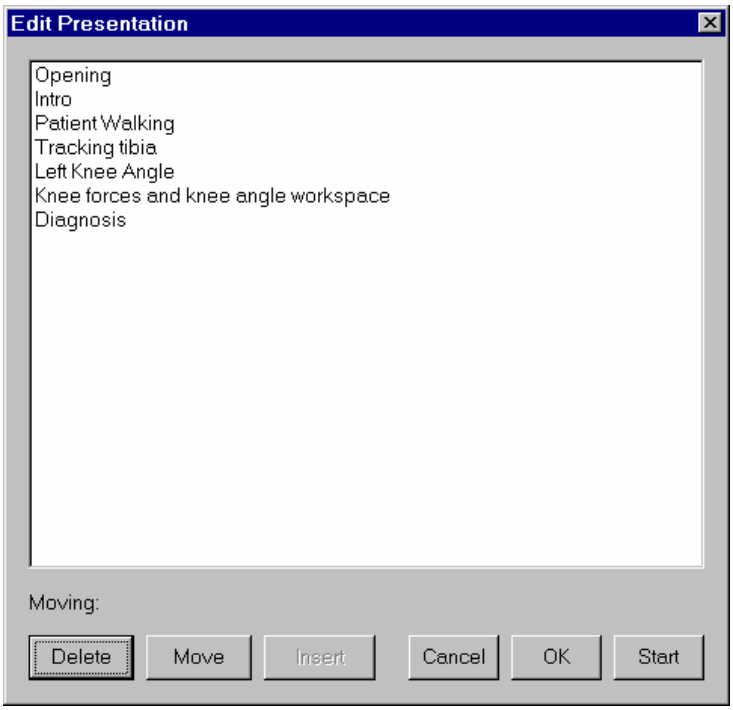


Figure 12 : The Presentation Dialog

Selecting this item will bring up a dialog box where all the links you have created are displayed. You can now highlight the link at which point you want to start the presentation and click "Start". This will remove the dialog box, activate the link and allow you to navigate from there by pressing hyperlink forward (key F4) or backward (key F3). If you want full screen appearance you can hide all dialog bars and the system title bar and menu by pressing the keys between F5 and F11.

You can also rearrange the links using the presentation dialog box. Select a link and press "Delete" to delete it. Select a link and press "Move", then select another link and press "Insert" to move the first link to the position *before* the one you selected last.

The final thing to say about the presentation mode is that you can edit the link itself by selecting it in the dialog box, pressing "Start" to activate it and changing the aspects you want to change. After you have done this, re-create the link just as when you created it the first time and Polygon will ask you if you want to replace, select "Yes" to confirm.

3.3 Polygon Templates

Polygon allows you to write a template if you don't feel like starting from scratch every time you want to write a report. The idea behind a template is to keep all the visualisation that can be set up through the hyperlinks, but to change the underlying data each time it is used. This way, you can create a standard report to use for routine work and just import the most recently captured data.

3.3.1 Creating a template

Polygon allows you to save a report as a template by selecting the "Save As Template" option in the "File" menu. This will bring up a dialog box asking you to choose a name for the template file, the extension ".tpl" is automatically applied. The default template directory will be the one that initially appears (this can be set in the Preferences).

Selecting a name and confirming will bring up yet another dialog box. The purpose of this box is to select which nodes from the report data tree should be placeholders and which should not.

A placeholder is a node where the actual data is left out, and into which new data can be imported when the template is used at a later stage to create a new report. A non-placeholder node in a template will save the data in the node with the template.

It is very important to understand how this works. For example, if Joe Gait wants to create a report template for comparing gait patients to some normal data which he has collected, he could create a report with nice hyperlinks to graphs where he has plotted the relevant data together. Then, when he saves the report as a template, he can select the patient data to be placeholders and the normal data to be non-placeholders. This way, the next time the template is used, the new patient will be compared to the same normal data.

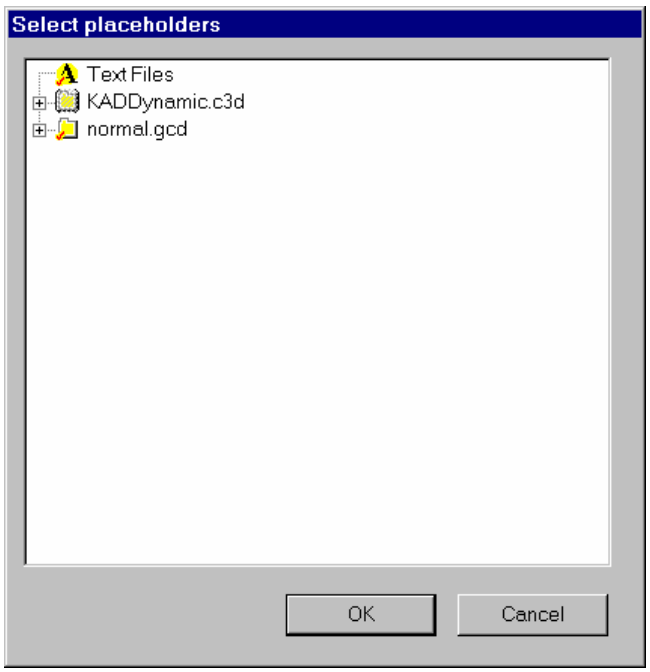


Figure 13 : Select Placeholders Dialog

The dialog box contains a mirror image of the report's data tree. By clicking the individual tree nodes, you will see that the appearance of the icon changes from having a little tick by it to having square brackets around it.

Square brackets means the node is a placeholder. A tick means the node is *not* a placeholder, and data objects of this node will be saved with the template.

There are two simple rules that applied when selecting placeholders:

- All the child nodes of a placeholder must be placeholders.
- All the parent nodes of a non-placeholder must be non-placeholders.

These rules are automatically applied by Polygon, so you cannot violate them no matter how hard you try. However, in the vast majority of case you will want to choose entire C3D files as placeholders and not just parts of them, so expanding the nodes should not be necessary.

Once you're satisfied, you click "OK" to continue. Now Polygon will ask you to name the first-level data nodes in your data tree. This allows you to name the nodes more sensibly than the default Polygon suggests. For example, if you're basing your template on three trials where you have a good left force plate strike and three trials where you have a good right strike you could name the former nodes "Good Left 1", "Good Left 2" etc. and the latter ones "Good Right 1" etc. When the template is being used at a later stage it will be immediately obvious which C3D files should be applied to which place holders.

After this step has been completed, the template has been saved successfully.

From Polygon build 072 it is also possible to save a text file as a place holder in the template. This is useful for example if you have some facility that automatically generates a rich text format file containing information about, say, the patient's clinical examination or general information. To designate a text file as a place holder, expand the "Text Files" node and choose the place holders.

Note that if you want a templated hyperlink to a placeholder RTF to work, you need to import an RTF file with the same name when you use the template. For example, if the RTF used when you created the template was called "ClinicalExamination.rtf", the one you apply to the placeholder needs to have the same name.

Note that you can now change the name of an RTF data object by clicking the object in the data bar and choosing "New RTF Name" from the shortcut menu.

3.3.2 Using a template

You create a template report by selecting the "New (Template)" option from the "File" menu or toolbar button number 2 ( ).

After you have chosen to create a report based on a template, you will first be asked to select one of the existing templates. The initial directory in the "File Open" dialog will be the one that you can set up in the Preferences. A Polygon template has the extension ".tpl".

Next you'll be asked to select a name for the report in exactly the same way as when you're creating a new report from scratch.

Once this has been done, Polygon will display the new report. At this stage, however, all the placeholders are still empty, i.e. they have no data in them.

What you need to do is import data to the template. You do this in the normal way by choosing the "import" button from the toolbar ( ) or from the "File" menu. Alternatively, if your Polygon installation includes the Eclipse Data Management tool, you can import directly from this interface by double-clicking on the relevant file symbols. See the Eclipse manual for more information.

Once Polygon has successfully imported the data file, you will be asked where it should end up - either in a placeholder or at the end of the data tree.

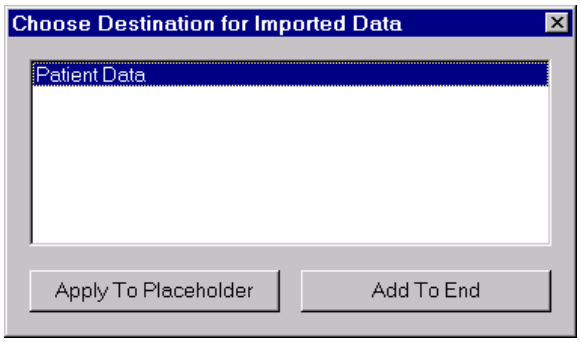


Figure 14 Data Destination Dialog

The dialog contains a list of the available place holders in your template and you can highlight one of these and hit the "Apply To Placeholder" button (or simply double-click on the placeholder). Alternatively, you can choose to add the new data to the end of the data bar list of data if you don't want to use the data in the template.

When you apply a data file to a placeholder, Polygon will go through the template data tree and copy data objects from the imported file's tree where there is a match between them. However, if there are hyperlinks in the template that reference data objects that aren't in the data you applied to the template, the hyperlink will of course fail to find the data and not work properly. It is important that the data used to create the template in the first place match the data that you will later apply to the template.

More likely than not, when using a template the whole process is a routine one and the data files applied to the template will have been generated in the same way as the one(s) used to create the template in the first place. However, if they should differ there is no way Polygon can guess what has happened, so the hyperlinks may fail to produce the desired results.

4. Visualisation

Polygon can visualise data in five different views, as well as on the time bar. The views are:

- The Graph View
- The Workspace View
- The Movie View
- The Text View
- The Multimedia View

Of these, both the graph view and the workspace view allow the user to interact with the objects inside the view in order to change the way the data is viewed.

4.1 The Text View

You can have as many text views as you like associated with a Polygon report, but you can only have one open for editing at the time (you can have a second read only text pane, see below). A list of all the text view will appear in the data bar if you click the "Text Files" tree item in the tree view part of the data bar. Double-clicking a data object will insert that text file into the pane view, replacing the current one if there's one there. The contents of a text view that is automatically removed in this way is always saved.

If you'd like to insert a new blank text view, press tool bar button number 3 (). The data object corresponding to this view will be automatically named "Text Pane X" where X is a number making the name unique. You can change this name by right-clicking the text object in the data bar and choosing "New RTF Name" from the shortcut menu. This can be a good idea if you are creating a report with many text panes since a descriptive name will make it easier to locate the correct RTF file.

The text view will respond to right hand mouse clicks by displaying a shortcut menu. The menu presented to the user depends on whether the user right-clicked a hyperlink or just ordinary text. If the user clicked just ordinary text, the standard editing commands "Copy", "Cut", "Delete" and "Paste" will be available. If the user right-clicked a link, however, the following options are available:

- **Cut, Paste, Delete**. Same as above
- **Copy Link**. This copies both the text of the link and the link itself so that you can paste it into another report or to another position in the same report.
- **Replace Link**. This option is available only if the link can be replaced, which is usually when it has just been clicked. This is what you should do if you'd like to edit a link. First click the link, then modify the view that the link linked you to, then choose this option from the shortcut menu.
  Say for example that you have created a link to a workspace view but that you'd like to change the camera angle a bit. Instead of redoing the whole link, you can simply click the link, modify the camera angle and choose "Replace Link" from the shortcut menu and the link will be updated.
- **Properties**. If you choose this option you will be presented with a tiny window containing information about the hyperlink.

In the "Edit" menu are the two standard Find/Replace commands - these work on the text view and provides the user with the opportunity to search for words and phrases and to replace words as well.

From build 076, OLE is supported in the text pane. OLE stands for Object Linking and Embedding and means that you can embed objects normally associated with other applications in the text view (for example bitmaps or Microsoft Word equations).

4.1.1 The Read-Only Text View

From build 076 it is possible to add a second text pane to the pane layout (to be displayed simultaneously with the first text pane). This is a read-only text pane so you cannot edit the text, but hyperlinks and OLE will work fine. You can also create local and global hyperlinks to the read-only view.

If you'd like to add a read-only view to your pane layout, highlight a text data object in the data bar, click the right mouse button and select "Insert Read-Only" from the shortcut menu.

4.2 The Movie View

The movie is mainly controlled from the time bar. From here you can start, stop, pause, change the speed and move the current position of the movie.

The Movie View menu in the main menu bar will appear if you click in the movie view. This menu contains the following options:

- **Fill View**. This determines if the movie will fill all the available space in the view or whether to restrict the size to its original size. If your computer has limited resources you may want to limit the size since the algorithm that enlarges the movie requires some.
- **Keep Aspect Ratio**. Determines if the movie should always keep its aspect ratio or not.
- **Create Local Link**.
- **Background Colour**.

You can also create a local link to a movie by right-clicking in an area of the movie view that is not occupied by the movie.

4.3 The Graph View

The graph view allows the user to create graphs of time-dependent data. Currently it is not possible to plot two variables against each other (parametric plots).

The way you interact with the graph view depends on what part of the view you are focusing.

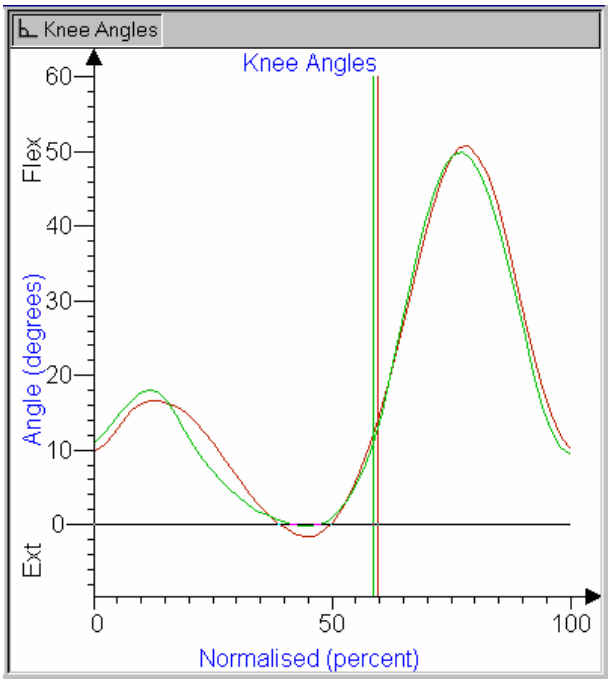


Figure 15 : The Graph View

4.3.1 The Rulers and Axes

The rulers and axes are found at the left hand and bottom edges of the view. The rulers indicate the scale of the data that is being plotted. The rulers also have labels indicating the units that are being used on the horizontal and vertical axes.

There are two main ways of interacting with the ruler - through a shortcut menu or by using the mouse directly.

The direct ways of manipulating the ruler are:

- Clicking and dragging the mouse will highlight a part of the ruler. This is intended to be a region for later zooming on the axis (see the shortcut menu description below).
- Double-clicking with the left button will set the default range of the ruler. The default range depends on the traces that are currently plotted (see chapter 2.5 Variable Ranges).
- Hitting the space bar while the focus is on the graph view (i.e. you have clicked in the graph view without clicking in another view afterwards) will change the horizontal ruler between the normalised (percent) and full time range setting.

If you right-click while the mouse pointer is over one of the rulers you will get a shortcut menu. The menu has the following options:

- **Zoom in**. This will be greyed out if there is no zoom range (which you can set by clicking and dragging, see above). Selecting this will change the scale of the ruler, and thus the traces, to the new range.
- **Zoom out**. This will double the range covered by the ruler.
- **Set Range**. Brings up a little dialog box which allows you to directly type in the range of the ruler as well as changing the units.
- **Full Range**. Same as double-clicking, sets the default range of the ruler.
- **Set Replay Loop**. This option is available if the horizontal ruler has a time unit (it will be greyed out if the ruler displays normalised data). Selecting this will set the replay loop of the time bar equal to the current range of the ruler.

- **Stick to Replay Loop**. This option is also available only when the ruler uses a time unit. Selecting this option will synchronise the horizontal ruler's range with the current replay loop on the time bar. If you subsequently change the replay loop on the time bar, the horizontal ruler of the graph view will continuously update (and the traces as well).
- **Units**. This is a nested shortcut menu which brings up another menu when selected. In this menu, the units that are currently on offer are listed. If, for example, you are plotting an angle against time, you will get the option to change between degrees and radians on the vertical ruler or to change between normalised units and samples on the horizontal axis.

4.3.2 The Graph Traces

The traces represent the actual data, and are scaled to the current rulers (unless you have overlayed graphs, see below). The colour of the traces will match the colour of the relevant context (i.e. if the "left" context has colour red, any trace that is normalised using the left context will have default colour red when it's being plotted). If the trace has no context, for example because it's averaged data, Polygon will assign a colour from a list of colours.

A trace can be "picked". Picking is done by placing the mouse cursor on or near a trace and clicking the left mouse button. The trace, if picked, will double its thickness to show that it is picked. Clicking again will unpick the trace, and picking another trace will also unpick the currently picked one.

If you pick a trace and hold the *shift* key down at the same time, a little window will pop up which displays some useful information about the trace, such as the name of the data object and the data file from which it originated, the number of sample points, averaged population if it was averaged etc.

Multiple picking is also possible using the control key. If the control key is held down while doing picking, any currently picked trace will stay picked when you pick a new one.

Right clicking in the trace area (which is above the horizontal and to the right of the vertical ruler) will bring up another shortcut menu. This items contained in this menu will depend on whether there are none, one or more than one picked traces.

At the top of the menu there will be an item labelled "Grid". This controls the background grid of the graph, and selecting it will bring up a nested menu giving you the choice of "No Grid", "Fine Grid" or "Coarse Grid". The colour of the grid lines can be set in the Preferences.

If you have picked one trace, a menu item will appear below the "Grid" item labelled "Trace". This is also a nested menu which will bring up the following options:

- **Remove**. Removes the trace from the graph view.
- **Expand**. Changes the ranges of the rulers so that the entire trace is visible.
- **Show stdev**. If the trace has standard deviation because it's averaged data, this will allow you to turn the standard deviation display on or off.
- **Choose Context**. This only available if the data object has a context assigned to it. If there are one or more contexts, these will appear in a popup menu allowing you to choose one. If the trace is already associated with one of the contexts, this will be indicated by a tick mark next to the menu entry.
- **Context Setting** (For more info about contexts, see 4.7.1.) This is greyed out unless the graph trace has been associated with a context, either manually or automatically. When not greyed out, it is a popup menu giving the user the following options: "Current", "All", "Average" and "Side by Side".
  Selecting any of these only makes a difference if the context has *multiple normalisation cycles*. If so, the "current" option will always use the *nominated normalisation cycle* that is closest to the current time as set on the time bar. In other words, if you move the current time forwards, the graph trace will always show data normalised to the current nominated cycle, and the appearance of the trace may change when changing from one cycle to the next.

The “all” option will display one trace for each of the nominated cycles. Any label will point to the current one, though.
The “average” option will average the traces of the nominated cycles and display the average trace with its standard deviation as a shaded area.
NEW: The “Side by Side” option will display all nominated cycles side by side, i.e. one after the other. The horizontal ruler will, of course, be expanded to reflect the number of currently nominated cycles, e.g. it will display 0-300% if there are three cycles. Note that if you have normalised data such as the EMG bars or averaged data displayed at the same time, this data will be repeated once for each cycle when the horizontal ruler is expanded.

- **Add Numeric Label**. This will add a label showing the numerical values of the current time and the corresponding trace value. *If the current time is outside the current range of the horizontal ruler, the label will appear off screen, and will not be visible until the current time has been moved to within the range of the horizontal ruler.*
- **Add Key Label**. This will add a label containing the name of the trace at the middle of the trace as it’s currently displayed.
- **Add Text Label**. As above but will pop up a dialog asking you to write the label text.
- **Apply Filter Twice**. This option is only available when you display filtered data such as the velocities or accelerations of positional data (trajectories). Choosing this will apply the filter twice, but the second time without performing any differentiation.
- **Appearance**. This will bring up a dialog box enabling you to set the colour and the pen style of the graph. If the graph is normalised, setting the colour will have no effect since the graph will use the colour of the normalising range set on the time bar.
- **Information**. This will bring up a little window telling you some useful information about the underlying data, such as the data file it originated from. **NB!** Picking with the shift key pressed triggers the same operation.

If you have picked multiple traces, a menu item will appear below the “Grid” item labelled “Traces”. This nested menu has fewer options than the single-picked one, but will allow you to remove all the picked traces, expand all the picked traces and add numerical as well as key labels to all of them.

Double-clicking a graph trace will expand it.

4.3.3 The Graph Cursors

The graph cursors are single-value data objects that have been visualised in the graph. These could, for example, correspond to a certain event such as the one defined by the “Left Opposite Foot Contact” data object from the “Analysis” node in a C3D file.

The graph cursors can be shown with or without their standard deviation (if standard deviation is available).

If you pick a graph cursor by right-clicking on it you will see that a “Cursor” submenu has appeared in the shortcut menu. This menu contains the following options.

- **Remove.** Removes the cursor.
- **Information.** Displays a little box with some information about the cursor such as the data object and data file it originates from. The same box is displayed if you hold the shift key down whilst left mouse button picking the cursor.
- **Appearance.** Allows you to change the colour and pen style of the cursor, but only if it’s not showing the standard deviations. Any cursor show standard deviations will be shown using the standard deviation colour as set up in the preferences.
- **Show Stdev.** Toggles the standard deviation display (if available) on and off.
- **Alignment.** Allows you to select whether to align the cursor with the top of the graph view, the bottom or if you’d prefer it to span the entire height of the view.

- **Size.** Affects a top or bottom aligned cursor only - allows you to increase or decrease the size of the cursor.

4.3.4 The Graph Labels

The procedure for adding a graph label is described above. Once you have added one or more of these labels you can interact with it as follows:

- Left button down and moving the mouse will move the label but keep it pointing to the same spot on the trace. This allows you to move it to a place where it doesn't obscure any other information.
- Right button down and moving the mouse will move the spot where the label points at the trace leftwards or rightwards. If the label is numerical and has not been detached (see below to find out how to do this), it is synchronised to the current time and cannot be moved in this fashion.
- Left button double-click will allow you to change the label's text. Does not work for numerical labels.
- Right button click will bring up the familiar shortcut menu with an additional menu item below the "Grid" and (if a trace has been picked) "Trace" items, labelled "Label".

The label's shortcut menu has the following options:

- **Stick**. Only works for numerical labels. This will stick the label to the same place in the view even when the current time changes. In other words, as the current time changes, only the pointer will move to indicate the position on the trace, the actual label will stay in the same place.
- **Detach**. Only works for numerical labels. If you don't want a numerical label to be attached to the current time you can detach it. After you have done this, the label will not move when the current time changes. You can move it along the trace by right mouse button dragging (see above).
- **Delete**. This will remove the label.
- **Show Units**. Only works for numerical labels and will toggle whether to display the numbers' units inside the label.

4.3.5 The Graph Title

The graph's title is found just over the traces. This title is automatically generated unless the user has chosen to enter a custom title. The automatically generated title tries to create a reasonably sensible title given the traces that are currently on display.

Left double-clicking the title will bring up a dialog box allowing you to enter a new title.

4.3.6 The Selection Bar

At the very top of the graph view, above the graph title, you will see the selection bar. The selection bar allows the user to select the graph that is currently being viewed. It looks a bit like Windows 9x/NT's task bar, and by pressing the buttons using the left mouse button the user can select which graph to view.

The buttons display the graphs' titles as well as a symbol indicating the vertical unit (for example angles, forces, moments). If the titles are too long to fit, the buttons will display only the first few characters of the titles. If even that doesn't provide enough space for the selection bar two arrows will appear at the left and right hand side. Clicking these will allow you to scroll left and right on the bar to see all the available graphs.

The user can also interact with the bar in the following ways:

- Left clicking a non-selected button *while holding the control key down* will overlay the two graphs in question. This allows you to compare the shape of, for example, an angle trace and a moment trace which otherwise cannot be plotted on the same vertical axis. The scale of the rulers will remain unchanged (i.e. correspond to the graph that was

selected before the overlaying was done), so it is *very* important to remember that the rulers do not necessarily describe the ranges of all the visible traces anymore!!

- Pressing the left button and dragging will allow you to drag and drop one graph onto another. This can only be done if the two graphs you want to combine have compatible units. The mouse cursor will indicate whether the operation is legal or not. The operation is undoable (only one level of undo though) through the shortcut menu.
- Right button click will display the shortcut menu, which will allow you to delete the entire graph corresponding to the button you right-clicked (*not* the one that is currently selected). If you have recently combined two graphs as described above there will be a shortcut opion to undo that operation.

4.3.7 The Thumbnail View

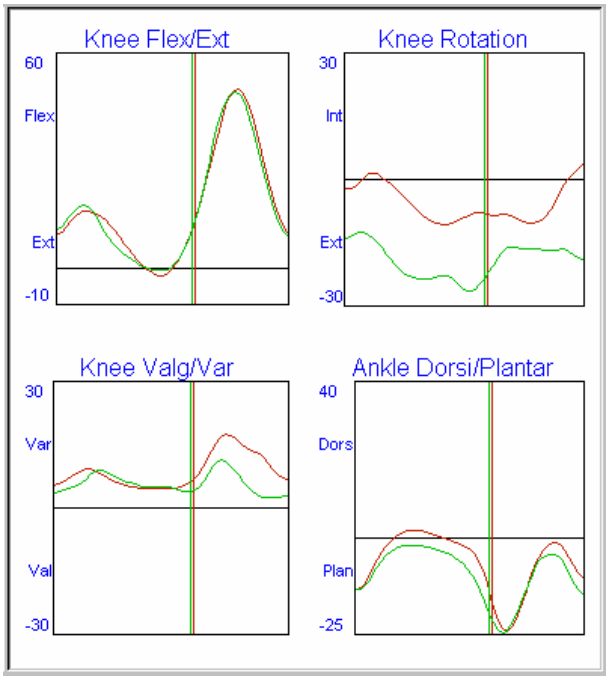


Figure 16 : The Thumbnail View

The thumbnail graph view offers the user a handy way to get an overview of all the graphs in a graph view. The thumbnail will take all the graphs that have an entry on the selection bar and lay them out in a grid pattern using the available space in the pane. The user can choose whether the graphs should have a fixed aspect ratio or a variable one. If a variable one is used, then the graphs will always expand to fill the available space, but this may have some strange effects when the shape of the pane is very narrow or wide. The fixed aspect ratio option will size the horizontal and vertical graph axes so that their relative ratio remains the same. *Whether to use fixed or variable aspect ratio, and the desired aspect ratio can be set in the Preferences.*

There are two ways of toggling between a thumbnail layout and the "normal" graph view with the selection bar: left mouse button double-click on the background area of a graph and Toolbar button 23 () If you double-click in the thumbnail view, the specific graph you double-clicked will appear in the normal view.

There's two other ways of interacting with the thumbnail view: combining graphs and swapping the position of graphs.

Overlaying is the same operation as the one you can do on the selection bar, described above. It's done using the left mouse button to select and drag a graph onto another - the cursor will indicate whether the operation is legal or not. Releasing the left mouse button will (if the operation is legal) combine the two graphs.

Swapping the position of two graphs is done by right mouse button dragging. Select a graph by pressing and holding the right hand mouse button and move the mouse cursor to the position of the graph with which you'd like to swap position. Releasing the mouse button at this stage will trigger the operation.

You can also delete a graph from a thumbnail layout by dragging it off the thumbnail view. A rubbish bin will appear as your cursor with an arrow pointing into it giving you a subtle visual clue as to what will happen with your graph. The operation can be undone, see below.

The thumbnail shortcut menu gives you the following options:

- **Create Hyperlink**. Creates a local hyperlink.
- **Copy to Clipboard**. This copies the entire thumbnail pane *as a bitmap* to the clipboard. From there you can paste it into other applications.
- **Trace Appearance**. This is a nested menu which, when chosen, will give you the choice between all the data sources currently visible in the thumbnail pane. If you choose either of them you can change the appearance of ALL the traces that are from the same data source. For example, if you have plotted traces from both the Left and the Right context of EXAMPLE.C3D you can change the appearance of all the traces associated with the Left or the Right context of this file.
- **Remove All Traces**. This displays the same list of files as the option above, but selecting one will remove all the traces from one particular data source or context.

4.3.8 Undo Last Operation

Polygon allows you to undo the last operation performed on the graph view. For this function to work, the focus needs to be on the graph view, which means that you must have clicked in it at least once. The main menu should display an option called "Graph View" whenever the focus is on the graph view.

The undo mechanism will undo the last addition, removal or combine of graphs. It is available using the normal undo mechanism (toolbar and Ctrl-Z) and it replaces the previous Polygon "Undo Combine" mechanism which would undo combining two graphs only.

Note that changing the appearance of the graphs or traces is not undoable (except by changing back manually, of course).

4.3.9 The Graph View Menu

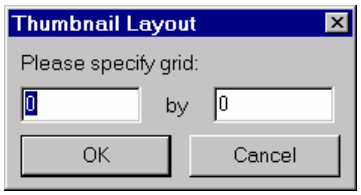


Figure 17 Thumbnail Layout Dialog

The Graph View menu is available from the main menu bar whenever the focus is on the graph view. It contains the following options:

- **Average Traces**. Selecting this will turn all the visible traces to "average" mode, which means they will be displayed as the average of all the currently nominated ranges on the time bar (see 4.7.2 Nominating Normalisation Ranges for further information on nominating and denominating ranges)
  This option has the same effect as manually picking each and every trace and selecting "Average" from the "Context Setting" submenu.
- **Thumbnail View**. Toggles between normal graph view and thumbnail view.
- **Thumbnail Layout**. If you select this the dialog in Figure 17 will appear. This dialog will allow you to specify the exact layout of your thumbnail view. Specify the number

of columns in the left edit field and the number of rows in the right field and press OK. If you have specified more spaces than there are graphs Polygon will insert "white" rectangles as placeholders. On the other hand, if you have specified less spaces than there are graphs Polygon will revert to the default layout algorithm.

- **Thumbnail Tick Marks.** This allows you to specify little tick marks along the horizontal ruler of the thumbnail graphs. The spacing, in percent, between the marks can be specified in the dialog box that appears. For example, if you enter "25", a tick mark will appear for every 25% along the bottom of the thumbnail graphs. Furthermore, if the thumbnails span more than one gait cycle, a line from the top to the bottom of the graph will appear where the 100% marks are, i.e. where the previous cycle ends and the next one starts.
- **Fixed Aspect Ratio.** This allows you to specify on a thumbnail by thumbnail basis whether you'd like the graphs to have a fixed aspect ratio or not. The default can be set in the preferences.
- **Normalise Graph**. Toggles between normalised and full time range horizontal ruler for all the visible graphs.
- **Hide Selection Bar**. This hides the selection bar if the graph view is the normal view.
- **Axis Colour**. Allows you to choose the colour of the axes and rulers.
- **Label Colour**. Allows you to choose the colour of all the textual labels.
- **Stdev Colour**. Allows you to choose the colour of the standard deviation areas.
- **Increase Trace Width** - increases the trace width of all visible traces by one pixel.
- **Decrease Trace Width** - decreases the trace width of all visible traces by one pixel
- **Use All Kinematic Cycles**. Applies to thumbnail graphs. If you select this option, the graphs in the thumbnail will show the data according to the currently nominated *kinematic* cycles regardless of whether the data is kinetic or kinematic in the graphs.
- **Use Only Kinetic Cycles**. Applies to thumbnail graphs. If you select this, the graphs in the thumbnail will only show data for nominated and valid *kinetic* cycles regardless of whether the data is kinetic or kinematic. Use this option if you want to guarantee that in a thumbnail of mixed kinetic and kinematic graphs you see data from the same cycle.
- **Use Default Cycle**. If you select this, kinematic graphs use kinematic nomination and kinetic graphs use kinetic nominations.
- **Set Pane Size for Export**. This option allows you to specify, in pixels, the exact size Polygon will use for the offscreen bitmap or metafile when exporting this particular graph to Word. This means that if you have some links to 3 by 3 thumbnails and some links to 3 by 4 thumbnails, for example, you can specify different sizes for the export operation so that the individual graphs have consistent sizes.
- **Copy to Clipboard**. Copies the current graph view to the clipboard as a bitmap.
- **Set Clipboard Scale**. Allows you to set a scaling factor for the previous operation. For example, if the scaling factor is 2, the copy operation puts a bitmap which is twice as high and twice as wide on the clipboard.
- **ASCII to Clipboard**. This option will copy all the traces that are currently visible in your Thumbnail view to the clipboard in *text format*. The format is:
  <Variable Name> <Population> <Unit> <1st Sample> <2nd Sample> ... <Last Sample>
  for each trace , the elements are separated by a TAB character. This pastes very nicely into Excel.
- **Set View Title**. This option enables you to type in a title to be displayed on top of the thumbnails.

- **Show Key**. Toggles the display of a simple key at the bottom of the thumbnail view which shows the data source of the traces that are currently visualised (but not the normals).
- **Create Local Link** and **Set Background Colour**.

4.4 The Workspace View

This is where 3D data is visualised. Many different types of data can be visualised here, both time dependant and not. These are the main types:

- Trajectory markers
- Force plates
- Display set segments and sticks
- 3D meshes

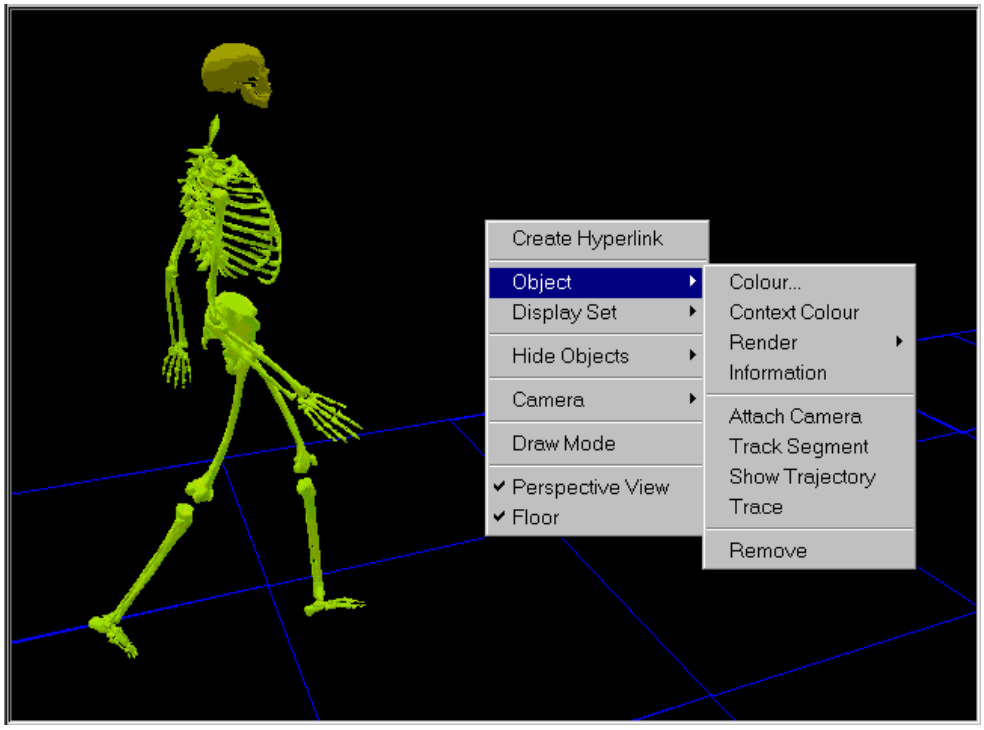


Figure 18 : Workspace View with Shortcut Menu

4.4.1 Interacting

Interaction in the workspace is based on the same mouse handling as interaction in workspaces in other Vicon products such as the Workstation and Bodybuilder. When you visualise something in the workspace, two thing will always be present: a focal point representation and a floor. These are there to help you orient yourself in the 3D space.

Your viewpoint can be interpreted as a camera which “films” the 3D world and displays it on your 2D screen. This camera can be moved around to allow you to look at the world from many different angles.

You can move the camera in the following ways:

- Pressing the left mouse button and moving the mouse will move the camera “around” the focal point. Imagine the focal point as the centre of a sphere and the camera at the surface, pointing towards the centre. Moving the mouse while the left button is pressed moves the camera around the sphere but keeps the distance to the focal point (equivalent to the radius of the sphere) unchanged. It also keeps the camera pointing towards the

middle of the sphere (the focal point) without changing the up direction as perceived by the user.

- Pressing the right mouse button and moving the mouse up and down will dolly the camera. This basically means moving the camera closer or further ways from the focal point (it's similar to zooming, but zooming with a camera means changing the lens properties, not moving it).
- Pressing *both* mouse buttons and moving the mouse moves the camera in the plane which is normal to the current vector pointing from the camera to the focal point. For example, pressing the buttons and moving the mouse upwards will move the camera in the direction that is currently up in the camera's reference frame. The scene will appear to move downwards in the view.

You can also use the mouse to:

- Pick. This is done by pointing at the object you'd like to pick and pressing the left mouse button. If the operation is successful, the object should change colour (you can set the "picked object" colour in the Preferences). Multiple picking is possible by keeping the control key pressed while you pick. If you pick while keeping the shift key down, a window containing information about the object will appear.
- Display shortcut menu. If you have picked one or more or more objects in the workspace and press the right mouse button a shortcut menu will appear. Details below.

The workspace which appears will depend on the type of object you have picked. One item will always appear, either labelled "Object" or "Objects" depending on how many objects that have been picked. This menu contains the following items:

- **Colour**. Brings up a colour dialog box allowing you to set the colour of the picked objects.
- **Context Colour**. If the display set has been assigned to a context, choosing this option will ensure that the object's colour is always the same as the context's current normalisation range's colour. For more info about contexts, see 4.7.1.
- **Information**. Displays a little window containing some information about the picked object, for example its name, which data file it came from and other interesting and/or useful things.
- **Attach Camera**. Only appears if you have picked a single object. This allows the camera to move with an object as it moves in time. The focal point will be moved to the position of the object and if you start playing forwards or backwards the focal point will be moved so that it "sticks" to the object. You can still use the normal workspace mouse interaction to move around the object of interest, even when the animation is playing.
- **Track Segment**. This option will only work when a segment has been picked. Selecting it will attach the camera to the segment and track the segment's moves by changing the orientation as well as the position of the camera. The effect is that the picked segment is seen as being stationary in the workspace while all the other segments move around it.
- **Show Trajectory**. This option will display any relevant trajectories for the object you have picked.
- **Trace**. This option will ensure that whenever the object is moved, the old appearance will not be deleted. The effect is to create an object trace where you can visualise just how the trace has moved through time. *The object will only be traced when it remains picked!!* Un-picking the object will not remove the trace but new ones will not be added. Turn off the trace by picking the same object and selecting the same option (which by now should have a check mark by it) again.
- **Recentre.** This option will affect the *all the trajectories of the trial*. If the user decides to recentre, the current object's origin will be moved in space so that it is always at the origin of the lab space. All other trajectories will be moved the same relative distance so that all the relative distances between the trajectories remain unchanged for all the

frames in the trial. The operation is equivalent to moving the lab origin to always be at the same position as the origin of the picked object. **This operation is not undoable,** except by re-importing the trial.

- **Remove**. Removes the whole object from the workspace. This is irreversible except by re-visualising the object from the data bar.

If you have picked an object that is part of a display set another menu item will be available in the shortcut menu. This menu gives you the following options:

- **Colour**. This allows you to set the colour for the entire display set.
- **Context Colour**. If the display set has a context assigned to it, this will make the colour of all the objects in the display set reflect the colour of the context's current normalisation range.
- **Render**. Selecting this pop-up menu allows you to choose whether the object should be rendered using Gouraud or Flat shading, or if it should be rendered as wireframe or points.
- **Appearance Setting**. This allows you to change the appearance of the whole display set. A dialog box will appear, with two tabs at the top. A display set may contain two different types of objects, sticks and segments. A stick is defined more or less as a line which has a 3D start point and an end point. In other words, it has no information that fixes its orientation around the axis defined by these points. Selecting the "sticks" tab in the dialog will allow you to choose whether to display the sticks as cylinders or ovoids (ellipsoids) and to set their radii.
  The segments page allows you to choose how to display segments, which contrary to the sticks do have an orientation along their length axis. This extra information allows you to choose whether to display the segments in the display set as boxes, diamonds, truncated cones or realistic-looking meshes. Meshes are imported from external files. A drop-down combo box will display the currently available meshes. The directory in which Polygon searches for the meshes can be set in the Preferences.
- **Set Context**. This is a popup menu that lists the available contexts and allows the user to pick a suitable one for the display set.
- **Remove**. This removes all the objects in the display set.

You can also pick force plates. The shortcut menu for these contains:

- **Butterfly**. Toggles whether the butterfly is visible.
- **Force Vector**. Toggles whether the force vector is visible.
- **Set Scale Factor**. Allows you to specify a scale factor for the force vector. If the scale factor is 2 the force vector will be displayed twice as long.

Additionally, the menu contains the following items:

- **Hide Objects**. This is a pop-up menu, selecting this will bring up another menu containing a list of all the graphical primitive *types* currently in the workspace. The menu will contain items like "Display Set Segments", "Display Set Sticks", "Trajectories" and "Markers". Selecting any of these will hide all of the objects of that particular type. Next time you bring up this menu you will see that the object type you chose to hide has been ticked – selecting it again will display all the objects. Say you have displayed dozens of markers in the workspace but don't need them for a while. Instead of removing them one by one, you can turn all the markers off (and on again later) using this menu.
- **Camera**. This nested menu contains options enabling you to align the camera with the x, y and z axes as well as turning the camera 180 degrees around the current focal point. There are accelerator keys for the x, y and z options – Alt-x, Alt-y and Alt-z will do the job if you can't be bothered using the shortcut menu.

- **Draw Mode**. This item does the same thing as the toolbar button (). Draw mode is described below.
- **Perspective View**. This toggles between a perspective view and an orthogonal view. If the item is ticked, the workspace is perspective.
- **Floor**. This toggles whether to display the floor or not. It is especially useful to turn the floor off if you track certain segments that move much in relation to the floor (for example the fibula), otherwise you may get seasick quite quickly!
- **Detach Camera**. If you are tracking a point or a segment with the camera, this option will detach the camera.

4.4.2 Advanced Menu Options

There are also some options which will appear in the shortcut menu only when you have picked certain types of objects.

- **Set Marker Diameter.** Available when one or more markers are picked in the Workspace. Allows you to set the diameter of the markers in millimetres.
- **Create Stick.** Available when two or more markers are picked in the Workspace. Polygon allows you to create a stick between any two markers in the Workspace. It is important that you have picked two or more markers only (press Ctrl for multiple picking), otherwise the option won't appear in the shortcut menu.
  If you have picked more than two markers, Polygon will add a stick between the first and the second marker you picked, then one between the second and the third and so on.
- **Distance Between.** Available when two markers are picked in the Workspace. This option will add a graph to the graph view containing the absolute distance between the two picked markers.
- **Show Angles.** Available when two or three *sticks* are picked in the Workspace (note that you can create sticks between markers, see above). If two sticks are selected, Polygon will graph the angle between the two sticks in the plane which contains both. If three sticks are selected Polygon will graph the angle between the first two sticks *projected into the plane to which the third stick is the normal vector.*

4.4.3 Moving and Rotating Subjects

It is possible using toolbar buttons 21 () and 22 () to rotate and move the position of an entire trial in space. This is useful if you'd like to compare two different trials and their positional data in space overlap.

To do this, pick any object that belongs to a trial in the workspace view (a single bone or trajectory or whatever will do). Press the relevant toolbar button and observe that the cursor has changes when you move the mouse back to the workspace view. Hold down the left mouse button and move the mouse to rotate or move the subject. Note that ALL the positional data for an entire trial will be affected, so all the display sets, force plates etc. will be moved.

4.4.4 Draw Mode

If the workspace is in draw mode all the usual interaction changes to be concerned with an overlay 2D line and scribble facility. The idea is simple – if you'd like to draw some reference lines and/or scribble on top of the display you can use this facility. Also, the system will automatically calculate and display the angle between any two lines you draw.

To scribble: Press left mouse button and hold while moving the mouse.

To draw lines: Click left mouse button to establish starting point for line. Move mouse to end point, a rubber band line should follow the mouse cursor. Click again to draw the line.

To display the shortcut menu: Click the right hand mouse button.

Items in the shortcut menu:

- **Pen Width**. Lets you choose between 4 different pen widths

- **Pen Colour**. Lets you choose between 6 different pen colours
- **Calc Angles**. Toggles whether to calculate the angle between lines automatically
- **Cycle Colours**. Toggles whether to change the colour every time a line has been drawn or to keep the same colour.
- **Clear**. Removes all lines and scribbling.
- **Exit**. Back to normal workspace operation.

4.4.5 The Workspace View Menu

The menu appears on the main menu bar whenever the workspace view is active. The menu contains the following options:

- **Detach Camera**. Does the same thing as the shortcut menu option of the same name.
- **Perspective**. Toggles perspective/orthogonal view.
- **Overlay Mode**. Toggles the overlay mode.
- **Copy to Clipboard**. Copies the workspace view to the clipboard as a bitmap.
- **Create Viewpoint Link.** This will create a hyperlink that changes the position of the Viewpoint only, without affecting the contents of the Workspace. This enables you to create universal hyperlinks that moves the viewpoint to a sagittal, coronal or transverse view regardless of the origin of the data currently visualised in the Workspace.
- **Create Local Link**. Creates a local hyperlink to the workspace view.
- **Background Colour**. Not currently implemented.
- **Set View Title**. Enables you to enter a textual title for the view which will be displayed at the bottom of the workspace.

4.5 Locking Views

Polygon allows you to *lock* views of Workspace, Graph and Movie type. The locking of a view means that that particular view will no longer accept any more data. If a view is not locked it will always accept more data of relevant types.

For example, unless you have locked a Workspace view you can keep on adding more skeletons, force plates, markers etc. However, once a view has been locked nothing more is accepted and if you try to add more a *new view of the relevant type will be created.*

Another way of looking at it is that if you'd like more than one view of the same type, for example two graph views, you can do that by first adding data to the first view, lock it, and then add data to the second view. You can then continue to add new views by locking the ones you're "done" with and continuing with the next one.

So how does one lock a view? The function is available from the shortcut menus of the Workspace, Graph and Movie views and it's called "Lock View". If this option has a tick mark, it means that the view is locked. If not, it's not locked and will accept data. If all views currently on screen are locked, a new view of the relevant type will be created and inserted. If one view is not locked, data will be added to that view. If more than one view are unlocked, the destination view for new data is not defined.

4.6 The Multimedia View

This view is really an integrated web-browser and is able to display HTML formatted files as well as JPG and GIF format picture files. If you'd like to use a URL directly to the World Wide Web you can choose "Insert Web Page" from the "Edit" menu.

If you want to create a local hyperlink to a Multimedia Pane you have to do this through the "Multimedia View" menu which appears on the main menu bar whenever the multimedia view has the focus (click in a view to set the focus to that view).

The shortcut menu that appears whenever you right-click in the multimedia view is an Internet Explorer defined menu and will not be described here.

You can also change the background colour and, if you are displaying a picture, centre it. This is done through the "Multimedia View" menu, and will work only if you are displaying a JPG or a GIF file.

4.7 The Time Bar

The time bar is where time-related information is displayed. There is a ruler and space for two contexts on the two context bars found below the ruler. If you choose to visualise any time-dependant data that have associated contexts, they will automatically appear on the time bar. The range of the time bar will automatically expand or contract to reflect the current time range of the visualised data.

You can interact with the time bar by:

- Left clicking any of the controls on the left hand side of the bar. These control play backwards/forwards, single step backwards/forwards, step backwards/forwards to next event and replay speed.
- Press left and hold on the step backwards/forwards buttons to make the buttons automatically repeat the operation.
- Click the digital clock to toggle between frame rate display and clock display.
- Left clicking the current time cursor and dragging it left or right. This will change the current time, which will be reflected in the graph view (time cursor moves), workspace view (objects move) and movie view.
- Left clicking the replay loop cursors and dragging them left or right will move them. Note that you cannot drag them over the current time cursor. If you cannot see any replay loop cursors, they could either be off the scale of the ruler or they could be disabled. In the first case, zooming out on the ruler will bring them back into view. In the latter case, right click on the time bar and select the "Toggle Replay Loop" option.
- Left clicking in an area of the ruler where there is no cursor and dragging left or right moves the whole ruler left or right.
- Left clicking any event icon on the event bars allow you to drag the event to a new position. Once you have selected a new position and released the mouse button, the current normalisation range will change if you have dragged one of the two events that define a normalisation range. The operation is undoable by pressing ctrl-z (undo) or ctrl-y (redo), or by clicking the relevant toolbar buttons (and).. Note that there are lists for undoing and redoing, depending on what aspect of Polygon you are working on. If the "focus" is on the text view or graph view (the text view has the focus if the caret is visible) the undo/redo will affect the last operation you performed in the text or graph view *regardless of whether you have altered the event bar,* and vice versa.

  If you change the current normalisation range, any visible normalised graphs will automatically update.
- Right clicking on the ruler and dragging left or right zooms in or out on the ruler.
- Right clicking anywhere will display a shortcut menu as usual.

The shortcut menu for the ruler part of the time bar will contain:

- **Full size**. This will restore the ruler to its default state, spanning the current time range of visualised data.
- **Toggle Replay Loop**. This turns the replay loop functionality on or off, displaying or hiding the replay loop cursors.

- **Single Play**. This toggles whether the time cursor will loop whenever it hits the start or end of the replay loop when playing or just top.
- **Show Frames**. If you select this the time bar will show frames instead of seconds. However, since the time bar refers to all the different things that are visualised at the same time, it may reference more than one frame rate (for example, EMG, normal capture and movie capture often have different frame rates). In this case, Polygon will in general show the frames corresponding to the latest entity that was added to the pane layout.

4.7.1 The Time Bar and Contexts

Contexts can be visualised on the time bar, but only two at the time. When you visualise graphs and data in a workspace, the relevant context(s) will automatically appear, you can also manually choose to visualise a context straight from the data bar.

A context can have multiple normalisation ranges. This depends on the data that are read from the C3D files. Events are typically defined using the Vicon Workstation software, and in order to define a normalisation range, two events *of the same type* is needed (there are currently three types of events - *foot down*, *foot off* and *general*). Furthermore, one event can define both the end of one range and the beginning of another. Thus, Polygon automatically creates a range between any two events of the same type - the type of event is by default *foot down*, but you can choose which one to normalise on by right-clicking the context bar and choose the event type from the "Normalise on" entry in the shortcut menu that will appear.

Multiple normalisation ranges are useful to separate different aspects of a captured movement (for example, stance and swing in a gait cycle, or back swing, swing and follow through in a golf swing) or to separate repeated cycles of the same type (for example full gait cycles for walking trials). Each range can have its own colour and name which can be set by right-clicking on the context and choose "Name" or "Colour" from the first entry (named using the current range and context name) in the shortcut menu.

If you do choose different colours for different ranges, both graphs and display sets that are assigned to the context can be made to use the current colour when drawing traces or workspace objects. For example, if you are trying to analyse a golf swing it may be useful to split the motion into separate ranges and assign a different colour to each - then, if you choose to use the context's colour for, say, the club this object would change colour accordingly as the motion entered the different phases of the swing.

4.7.2 Nominating Normalisation Ranges

Polygon allows you to *nominate* ranges. A nominated range is a range which will be taken into account when doing calculation. A denominated range is "dormant", i.e. it's there but won't be used for any calculation or display whatsoever.

This enables you to select and de-select (by nominating and denominating) ranges which have good or bad data. For example, if you do gait analysis you may wish to include the two first gait cycles but not the third one because you suspect the data is noisy or whatever.

Furthermore, you can nominate a normalisation range either for kinetic and kinematic data or for kinematic data only. This allows you to use only the ranges where there is a good force plate strike for your kinetic data and still use all the other cycles to display kinematic data.

You can toggle whether a range is kinetic and kinematic nominated, kinematic only nominated or denominated by double-clicking the range (but not on top of an event icon!). You can also right-click the range and choose the nomination type from the range's submenu.

Note that Polygon can automatically determine whether a range is likely to be good for kinetic data. This is done by correlating the range to force plate activity. Polygon's algorithm searches for a period where the force plate continuously registers a force higher than the threshold value (see the Preferences) and determines if this has at least a 90% overlap with the range on the time bar. If this is the case, Polygon will allow the range to be nominated for kinetics, otherwise only kinematic nomination will be allowed.

You can choose in the Preferences whether to apply this automatic algorithm to the normalisation ranges or not.

4.7.3 Adding and Removing Events and Contexts

Polygon allows the user to add and remove both events and contexts. This is quite straightforward and the functionality is accessible through shortcut menus.

To add a new event, move the current time cursor to the spot where you'd like the event to appear. *It is important to note that this is where the event will appear, not where the mouse cursor is when you right-click.*

Once you've moved the cursor to the correct position, right-click anywhere on the context bar to which you'd like to add the event. From the shortcut menu, choose "Add Event" and then the type of event you'd like to add. Finally, name the event data object and confirm - the event will appear on the time bar.

Removing an event is done by simply right-clicking on the event cursor and selecting "Remove Event" from the shortcut menu.

To add a whole new context, you will have to right-click either the file node in the data bar or the "Events" node to which you'd like to add another context. Either way, a shortcut menu will appear which has the option "Add Context" - select this option and name the context, confirm, and it will appear under the "Events" node in the data tree.

To remove a context, simply double-left click on the context bar *outside* the normalisation ranges. If there's no space for you to double-click you will need to zoom out on the time bar. The double-click should produce a blue rectangle around the context to signify that it is picked. Now select "Remove Context" from the shortcut menu and it will be removed.

4.7.4 Synchronising

The most advanced aspect of contexts in Polygon is the ability to synchronise the events from two different contexts in time. This enables, for example, a pre-operation trial and a post-operation trial to be synchronised even though the C3D files aren't synchronised. It also does a contraction/expansion of time so that the events used to define the normalisation ranges in two synchronised contexts occur at the same time. This means that two trials where the subjects have different cadences can be compared directly.

As mentioned, synchronising works by synchronising the events in two different contexts. To achieve this, both the contexts need to be visualised on the time bar. One of the contexts, the one that the other is synchronised to, will remain unchanged. This one we'll call the synchronisor. The other, the one that will be changed, we'll call the synchronisee.

To select which context to use as the synchronisor, double click the context bar. A thin blue rectangle should appear around the context to indicate that it is selected. Now right-click the synchronisee (the other context) and select "Synchronise" from the shortcut menu. Observe that the synchronisee's normalisation range(s) move to match up with the synchronisor's and a different pattern is used to paint the range. If one of the contexts contain more ranges than the other, the "overflow" ranges will not be synchronised.

The workspace view is the most useful visualisation tool to use with synchronsied contexts. For example, two trials of the same patient could be loaded into Polygon, one pre-operation and one post-operation. Using tools in the workspace, they could be aligned side-by-side. Assign a context to each display set (for example the individual trials' left context for each display set) and synchronise them as described above. You will now be able to visualise the two trials side by side in space, and if the events have been properly defined, walking synchronised too.

Another possible use is to defined two different display sets for the same trial, one for the left bones and one for the right bones. Then, the trial's left context could be assigned to the left bones and the right context to the right bones. Now if you synchronise the left and right contexts, you will be able to see the left and right part of the body walking in sync.

5. Other Functionality

5.1 Move or Remove Views

You can re-arrange the current pane configuration of your report by either removing or moving a pane (only one at the time). This is done either by choosing the "Remove" or "Move" items from the "Pane" menu or by choosing the 12th or 13th icon from the left on the tool bar.

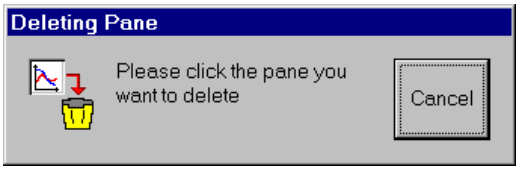


Figure 19 : Remove Pane Dialog

Removing a pane is very simple. Select the remove pane option as described above and observe that a little dialog will appear asking you to click the pane you want to remove. If you get cold feet you can also cancel the operation by clicking "cancel" in the dialog. However, most likely you will choose to boldly remove a pane and this is achieved by clicking the pane you want to get rid of. The other panes will then resize automatically to cover the available space. This operation is *not* undoable, so if you've spent half an hour setting up a view and not created a hyperlink to it, remove it and you've lost it forever.

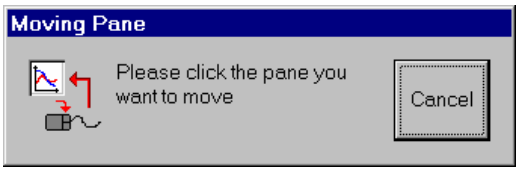


Figure 20 : Move Pane Dialog

Moving a pane is a little bit more tricky. Just as for removing a pane, a little dialog will appear (Figure 20) which asks you to pick the pane you want to move. The cursor will also change to indicate that a move operation is underway. Now you need to select the pane that you'd like to move. Once this is done, the dialog will change (Figure 21) and tell you to select the destination position for the pane, and this is where it gets slightly complicated. You now have to select another pane which will be cut in half to accommodate the pane you're moving. The position where you click the mouse in this pane decides in which way the pane will be cut. If you click towards the top of the pane, the pane will be cut horizontally and the pane you're moving will be inserted at the top. If you click towards the left of the pane, the pane will be cut vertically and the pane you're moving will be inserted at the left. Ditto for right and bottom.

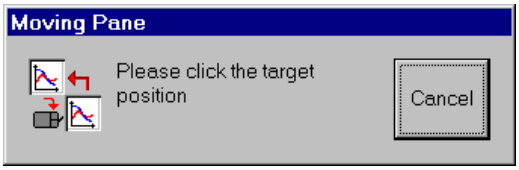


Figure 21 : Move Pane Second Dialog

An example: you have two panes and a vertical split. You want to swap them around. Choose the left pane and drop it at the left hand side of the right pane. This will split the right hand pane vertically and insert the other pane at the left side. However, since the pane was moved from the left side it opens up some space there and the former right pane is shifted across, achieving the desired result of swapping their places.

5.2 Saving Data in PXD Format

Polygon can save data in Polygon External Data (PXD) format. You can do this by selecting a data tree node which is the parent of the data you'd like to save. Then choose the "Save Data" option in the "File" menu and after you've typed a suitable name for the data file, it is saved. The file can then later be re-imported by Polygon through the normal import data mechanism described above.

5.3 Hide or show bars

Through the "View" menu you will be able to toggle the data bar, time bar, format bar, tool bar and status bar. These can also be toggles by pressing F7 (data bar), F8 (time bar), F9 (format bar), F10 (tool bar) or F11 (status bar).

Additionally, you can turn on or off the system menu by hitting F6 and the application's title bar by hitting F5.

5.4 Disconnecting the Time Bar

The "Panes" menu contains, apart from the "Move" and "Remove" pane options, a list of the views that are currently active in your report. You can disconnect these from the time bar by selecting any that are ticked, and reconnect by selecting any that are not ticked. This is useful if playing something is too sluggish because Polygon has too much work to do (or because your computer is too slow). Disconnecting the workspace, for example, will enable the movie to run smoother.

5.5 Changing Data, Keeping Layout

Sometimes it would be useful to be able to keep the layout that you see on the screen and just change the underlying data from one C3D file to another. For example, if you have imported 4 different trials of the same patient and created a nice layout of graphs, a skeleton and a movie for the first data file it would be useful if you could easily change to see the other data files.

Well, you can. The way to do this is to set up your layout (and save it using a global or local hyperlink) and then choose "Change Current" from the "Data" menu. If you do this you will be presented with a dialog containing the file names and the file reference number for all the files that are currently referenced in the visible panes.

The dialog asks you to select the file from which you'd like to substitute the data. Once this is done, a similar dialog appears listing the files that you can substitute with. Selecting this will change the data that is visualised in your current pane layout.

This function can be especially useful if you want to create similar or identical hyperlinks, the only difference being the data file they reference. Simply set up the first one, create the link and then change the data using the procedure above and create a new hyperlink for each step.

Note that Polygon will allow you to change between two data files that are not of the same format. This could potentially lead to the movie, graphs or the workspace disappearing since Polygon could be unable to locate data at the same location as the previous data file in the new one.

5.6 Paste Special and Add Nodes

Polygon can also accept data from an external source by the "Paste Special" command, which has been implemented as an option available from the shortcut menu of the tree nodes in the data bar.

The Paste operation takes the data from the clipboard and it expects an Excel spreadsheet range which contains time series numbers organised in columns. Polygon will accept either a 1-column wide or a 3-column wide range from Excel.

To do the operation, select either one or three parallel columns in Excel that contain time series, the number of rows can be anything from two upwards. Highlight the destination tree node in

Polygon's data bar and select "Paste Special" from the shortcut menu. Type in the desired name for the data object in the dialog, the desired time base and the unit, hit OK and Polygon will create a brand new data object which will contain the copied data. The data object will be either a one-dimensional time series or a vector (3-dimensional) time series, depending on how many columns were copied from Excel.

If you would like to add a new tree node to accommodate the data, this is also possible. The "Data" menu on the main menu bar contains the option "Add Tree Node". If you choose this, a dialog will appear allowing you to select both the name and the type of the new tree node.

If you choose a new tree node of type "File", the node will always appear at the top level of the data tree hierarchy. However, any other type of tree node will appear as a child of the currently highlighted node.

5.7 Averaging data

You can average data with Polygon. The menu item for doing this is found under the "Data" menu, and is called "Average".

Selecting this option will bring up a dialog box:

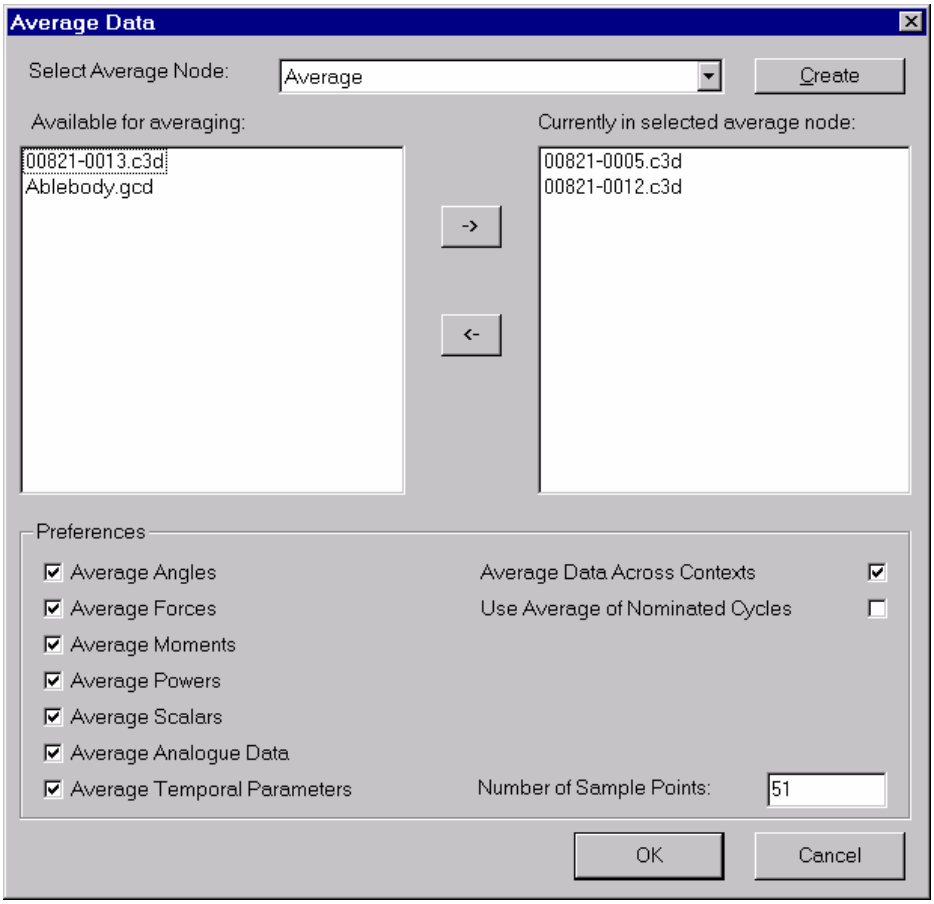


Figure 22 : Average Data Dialog

The dialog box has two main lists - the left list contains the files that are available for averaging and the right list contains the files that have been selected in the *currently selected* average node.

An average node is basically a node which has been generated by averaging several data files. If there are none in your data tree, you will have to create an empty one, which is done by pressing

the button in the top right hand corner labelled “Create” and entering a sensible name for the node.

Once you have selected or created an average node you are ready to add files to or remove files from the average node. This is done by highlighting the file and pressing the button with the arrow pointing in the direction you’d like to move the file. Alternatively, you can double-click the file and it will be moved from one list to another.

It is possible to remove individual data files from an existing average node - this may require you to import the data file in question though as it is necessary to have access to the original data to remove them from an average. It is also possible to combine different average nodes, and even add an average node to itself so that it’ll double the weight of the data files it contains.

When you have selected the files you’d like to average you should press “OK” to tell Polygon to do the averaging. A couple of seconds later (depending on how many files you have selected for averaging), the dialog will disappear and Polygon will have done the averaging - a new node will have appeared in the data bar containing the averaged data.

The data is averaged using the *first nominated normalising range* in or the *average of all the nominated ranged* for the contexts of each of the data files selected for averaging. If there is no context associated with a file, the data series are assumed to be pre-normalised and the whole series is used in the averaging.

The number of data points to use for each normalised averaged data series can be selected by typing the number into the box in the lower right hand corner. In general, these data points will not coincide with the sample points from the data files so Polygon will linearly interpolate between the sample points of the data files to obtain the points to use for the averaged file.

There are many options available in the dialog. You can choose whether to use the first nominated cycle or the average of all the nominated cycles as described above. You can also choose whether to *average across contexts*. Averaging across a context means that the same type of variable associated with different contexts will be combined. For example, two data objects named “LHipAngle” and “RHipAngle” will be combined to “HipAngle” in the average node. If averaging across contexts was not selected, the two variables would have been kept separate.

You can choose whether or not to include the following types of data series: angles, moments, powers, forces, scalars, analogue data and temporal data. If analogue EMG data is averaged, it is the *enveloped* EMG that gets averaged, not the raw. Also note that EMG data may not always be associated with the correct context if the name of the data objects (as seen in the data bar) don’t start with the correct letters (L and R in the case of Left and Right contexts). In this case, the data objects will be associated with the default context and you may have to manually assign the different contexts to the different data objects prior to averaging.

Polygon will only average the data that can be found in *all* the input files. In other words, if you have selected four different data files for averaging, and only three of these contain angles, the result will not contain any angles. It is recommended to check the data files for consistency before doing the averaging.

Note that you can save the averaged data using the “Save Data” function described above.

5.7.1 Averaging Data in a Template

Polygon allows you to set up an average node which will automatically be calculated in a template. If, for example, you base your template on 5 trials and you’d also like the average of these trials to be calculated, this is possible.

To create such a template, import the required number of data files to Polygon and then calculate the average as described above. Your data bar should now contain the data files and at least one average node. When you save this as a template, please *select the Average node as a Placeholder*.

When you use the template, Polygon will automatically re-calculate the average node every time you import a new data file into the data file placeholders. This means that you can set up a template based on any number of data files and the average node will always display the average of the placeholders that have been filled with data.

5.8 Scripts

Polygon has the ability to save hyperlinks as “scripts”, which are basically hyperlinks that are saved with the application rather than a report. The script hyperlinks can be assigned to tool bar buttons (and unassigned if you want to delete one), and pressing one of these tool bar buttons will execute the hyperlink.

There are two data files that are associated with this mechanism. One stores the appearance of the toolbar buttons, the other stores the actual scripts.

The toolbar button appearance file is called “PolygonScriptImages.bmp”, and this file can be edited with any drawing program such as Microsoft Paint (which comes free with the Windows operating system). The bmp bitmap file should be 16 pixels high and 16 times however many toolbar buttons you would like wide. In other words, if you would like 10 toolbar buttons to which you can assign scripts, the bitmap needs to be 160 by 16 pixels, containing 10 16 by 16 images side by side. The default is a 10 button image and the images are the numbers 1 to 10.

You can save both global and local hyperlinks as scripts.

To assign a script to a toolbar button, select one of the unassigned buttons on the tool bar (they will be marked with a different background colour from the rest of them), and observe that the button stays pressed. Then set up a graph or a workspace pane just as you would do if creating a normal hyperlink. Choose “Create Hyperlink” from the shortcut menu, and observe that a dialog appears asking you whether you would like to assign the hyperlink to the toolbar button you pressed. Confirming this, you will see another dialog that asks you to type the script’s name - this is the name that will appear as the toolbar buttons tool tip, so make sure that you write something that will enable you to recognise what the hyperlink does.

Once you have done all this, the toolbar button will be assigned to the hyperlink script, and every time you press the button the hyperlink will be triggered (as long as you have an active report). The background colour of the toolbar button should also change to indicate that a script has been assigned to it.

Polygon will also allow you to let a script depend on the *active* node in the data bar (the active node being the one that is currently highlighted) rather than a node at a specific location. This is only possible if the script you are creating depends on *one data file only*. If this is the case, Polygon will automatically spot it and offer you the option of making the script dependent on the active node.

Possible uses:

- It takes a few seconds to visualise a skeleton with a mesh - you have to select the relevant data object in the data tree and double click, then pick a bone in the workspace and set the display set appearance. If you create a hyperlink after you’ve done this and assign it to a toolbar button, the job will be done with a single click in the future.
- If you often find that you want to display a particular set of graphs, for example left and right knee angles, a script would save all the searching for the relevant data objects.

It is also possible to unassign a script from a toolbar button (but the script will be lost!!) - click the toolbar button while holding the Ctrl-key down, a dialog warning you that you’re about to delete a script will appear.

Scripts are saved when Polygon exits, so if you exit Polygon by breaking its execution (via the Task Manager or if it should crash) the scripts you added during the session will not be saved.

Once you are satisfied with the scripts you’ve got you may want to draw your own little picture to go on the tool bar to make it more easily recognisable. As mentioned above, you can do this using a normal bitmap editor such as Paint, but please make sure that the size of the bitmap is 16 pixels high and a multiple of 16 pixels wide when you save it, otherwise Polygon may behave strangely.

5.9 Customising Polygon

It is possible to customise the appearance of Polygon if you'd like to add your "personal" touch to the application. There are three things you can do: add a logo at the right hand side of the time bar, change the title of the application and change the logo which is used in the top left corner and the about box.

These three can be changed by adding/changing three specific files in the same directory as the Polygon executable:

- "PolygonLogo.bmp" contains the bitmap found in the lower right corner. If Polygon cannot find such a bitmap, it will display nothing.
- "PolygonAppName.txt" is a one line text file which should contain the desired application name which appears in the main title bar and the about box. If no such file is specified, Polygon will use the default name.
- "PolygonIcon.ico" is an icon file containing the icon to use at the left hand side of the main title bar and in the about box. The default Polygon icon is used if no such file exists. Note that this doesn't change the icon used in "Windows Explorer" and other tools which shows the Polygon executable on the harddisk.

5.10 Using Excel to Create Report

Polygon has the ability to create a paper gait report by exporting the data from a trial C3D file to Microsoft Excel™. There are three stages in this procedure: first Polygon will launch Excel and open an Excel template file (which uses the .xlt file extension), then Polygon will write the data from the C3D file to the template and finally, Polygon will tell Excel to run a macro which is incorporated in the Excel template.

It is possible for expert users to write their own Excel templates or change the default template provided by Oxford Metrics. Details on how to do this can be found later in this chapter.

5.10.1 How it all works

From the user's point of view, the procedure is very straightforward:

1. Import a trial file
2. Right-click the trial file and select the "Send to Excel" option
3. Wait for Polygon to finish writing the data to Excel – the user will eventually gain control of Excel
4. Use Excel's functions to print or manipulate the data

More interesting is the stuff that goes on "under the bonnet". Polygon will when writing data to the spreadsheet follow some simple conventions.

The template must have a worksheet called "Params". This particular worksheet contains all the information which enables Polygon to determine where to put the data. Have a look at the template supplied by Oxford Metrics for an example.

1. The first column and row contain system names which Polygon knows about. These are protected, and can only be changed by users who know the password that enables them to be unprotected – which basically means that no-one should change these. Since Polygon knows these names it is possible to search for a specific cell by looking for one name in the top row and one in the leftmost column.
2. The second column and row contain plain-language descriptions of the variable that the system names determine.
3. The other cells in the "Params" sheet contain the values of the variables that are determined by the cell's row and column description.

In addition to the "Params" sheet, the Excel template spreadsheet contains sheets for storing data and sheets for displaying graphs. The sheets for storing data are called "Data" and "Normal", which then holds the trial data and the normal data.

The data sheets must have *names of variables* in each column, at the row specified by the "DATA_NAME_ROW" system variable in the "Params" sheet. These names are the very same names that are found in the trial files, for example "LHipAngle". Furthermore, if the Polygon variable is a vector the name in the Excel spreadsheet needs to have the component number attached.

The C3D file may, for example, contain a variable called "LKneeAngle" which is a vector containing the three components of a Left Knee Angle, flexion/extension, valgus/varus and rotation. The Excel template doesn't know that the first component is called "Flexion/extension", so the variable name in the template *must* be LKneeAngle (1) where there is a whitespace between the variable name and the opening bracket.

If Polygon finds a match between the data sheet's variable names and the variable names in the trial file, Polygon will write either a complete gait cycle (if events are defined) or all the valid data in the variable to Excel. However, not all the samples from the C3D will be written – a specific number of points will be used (this can be specified in the "Params" sheet, but 51 is the default) and data will be linearly interpolated as necessary.

In addition to 51 (or whatever) data values, Polygon will also write the variable's normalising context (if applicable) and the vertical unit to the "data" worksheet.

Exactly the same applies to the normal sheet. The only criteria Polygon uses to determine whether to write to the data sheet or the normal sheet is to see if the data that the user has asked to be sent to Excel is averaged or not. If not, the data goes to the data sheet, if it has been averaged the data goes to the normal sheet.

Once all the data has been matched and Polygon has finished writing data to the worksheets, an Excel macro is started.

5.10.2 The Excel Macro

The macro is written using the Microsoft Visual Basic™ scripting functionality which is used to control Excel. The macro that is supplied with the Oxford Metrics Polygon software is baked into the excel template and has a specific name which Polygon must know about (it can be set in the preferences).

The macro goes through each and every chart (which is the same as graph) in the worksheets and whenever it finds one it adjusts the data range and colour of the traces. It also does some other minor work, but shouldn't take more than a few seconds. Once it has finished, the user gains control of Excel and is free to print and/or play around as desired.

The macro will do several things to each chart – it will make the charts look at the correct number of data cells in the "data" and "normal" sheets, it will change the colour of the traces according to the context colour and add the "toe off" cursors and it will add the unit to the vertical axis.

5.10.3 Changing the Macro and Template

The template supplied by Oxford Metrics has several charts in it which has been added to make the report look like a "proper" gait analysis report. The charts are organised in four separate worksheets called "Joint Rotation Angles", "Joint Moments", "Joint Powers" and "Joint Forces".

The user us free to change the template, but is advised to read the Excel documentation first so that changes are not made randomly. Generally, each chart in the spreadsheet has one or more data series (traces) which needs to "look at" numbers in the "data" sheet or "normal" sheet.

In the author's experience, making an Excel spreadsheet "look right" can be quite a tedious affair. Therefore, anyone who would like to change the template is well advised to use whatever is there already as a basis. For example, if you would like to add a new chart which displays some variable called "LElbowAngles" you would need to do the following:

1. Add the variable names to the "data" sheet (and don't forget the component number if the variable is a vector).
2. Add a new chart to one of the graph sheets.

3. Make the chart's source data point to the correct column(s) in the data sheet and/or normal sheet. Note that the supplied macro will automatically make the chart look at the entire range of the variable's data – the chart needs only to be pointed to the correct column so specifying one cell in that column as the source data will do.
4. Save the spreadsheet as a template.
5. Ensure that Polygon's preference is set to use the correct template.
6. Send the data to Excel as described above.

It can be quite tedious to make the charts look uniform and good. Patience and some knowledge of Excel is important – unfortunately, there's nothing Polygon can do to help you here!

If you are a real expert user you may want to customise the macro as well. This is not recommended for users who are unfamiliar with Visual Basic. Please refer to the relevant Excel/VB documentation on how to do this.

5.10.4 How to Export Normal Data

As you may have discovered already, Polygon can only export one data file to one Excel template. How is it possible to export both normal and patient data to the same spreadsheet?

The trick is to do it in two stages. First, import your normal data to Polygon and send the data to Excel using the "blank" template supplied by Oxford Metrics. Second, save the spreadsheet as a new template with a different name, for example "GaitReportWithNormals" or something equally descriptive. Then change the Polygon preferences to use this template instead – next time you send patient data to Excel, the normal data will be in the template already! If your gait lab uses different normals for different purposes, the above procedure can of course be repeated, the trick here is to remember to point Polygon to the correct template every time a new trial is sent to Excel.

6. Glossary

Context

A context describes a collection of information enabling Polygon to *normalise* data. The information consists of one or more *events*, but at least two events of the same type will be necessary for Polygon to be able to normalise. The context to which an event belongs is intended to describe the event. So, if a "Heel Contact" event belongs to the context "Left" it means that the event is actually "Left Heel Contact". In gait analysis, the contexts are usually "Left" or "Right", but there is nothing to stop the user from using other contexts if it is felt that that would be appropriate.

Events

An event is something that has happened at a specific point in a trial. An event is instantaneous and has a name and a time (relative to the start of the trial, e.g. 3.4 seconds after the trial started) associated with it. Typical events used in gait analysis are "Foot Contact" and "Toe Off", but other events could be interesting for other applications of the Polygon software. For example, golf swing analysis could use events such as "Start of back swing" or "Ball contact".

Hyperlinks (global & local)

Normalising Data

When Polygon displays kinematic and kinetic graphs the default is to use *events* and *contexts* to normalise the data. But what exactly does this mean and what is the difference between normalised and not normalised data?

Let's consider some *time dependent data*, such as the knee flexion/extension curves which are calculated by the Plug-in Gait model. The curve will correspond roughly to what an independent observer will see as the "bend in the knee". In other words, if the curve has a high value the knee is more bent than when the curve has low value, plotted against time. For example, if a trial is 7 seconds

long and the subject walks along completing five full strides with each leg you will expect to see the knee flexion/extension curves to have five similar looking sections, one after the other, as you plot the angle against time.

However, the curves for the left knee angle and the right knee angle will be time shifted with respect to each other because, unless the subject is jumping along, the knees will be flexed and extended at different times. This makes it difficult to compare the shape of the two curves.

Furthermore, there's the issue of comparing two different trials. For example, you may wish to compare the knee flexion/extension angles for an adult and a child. However, the curves if plotted against time will not only be time shifted with respect to each other (unless the two happen to walk perfectly in sync which is pretty unlikely), the child will most likely walk *faster* than the adult and thus fit in more strides in the same time. The child's angle graph will then look more squashed than the adult's when plotted on the same graph against time.

To overcome these problems, Polygon can normalise the graphs. Polygon will use *events* that are associated with the time dependent data to identify key points in time where something significant happened. When analysing strides, the standard practice is to use *foot contact* events. Returning to the example above, the person who completed five strides with each foot will have experienced six foot contacts for each foot during the trial. If these are correctly identified in Polygon, the kinematic and kinetic data can be normalised by only plotting the section of the data that are between two consecutive foot contact events. Furthermore, instead of plotting against time, we plot against the *percent of cycle* of which the two foot contact events define 0% and 100%.

In this way we can directly compare two graphs. It doesn't matter that the left and right knee flexion/extension angles are time shifted because the events that define the start and the end of the normalisation happen at different times for the left and the right foot. If the subject walks symmetrically and the events are correctly defined, the two curves should overlap very well. However, if there's asymmetry they may differ or if the events have been poorly defined the curves may appear time shifted or squashed when compared to each other.

Time Dependent Data