SMARTANALYZER HANDBOOK

February 20, 2009

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Chapter 1

Introduction

1.1 Before SmartAnalyzer

Motion capture is a technique of digitally recording movements for medical applications, entertainment and sports.

Data acquisition is performed by an infrared optoelectronic system and the analysis is based on the detection and three-dimensional reconstruction of passive markers positioned on anatomical landmarks.

The second step, after movement acquisition, is the markers labelling: in this way, the recorded three-dimensional coordinates, that are inside the registered file of movement, are recognized and linked to the corresponding real point on subject to permit the following steps.

For many years the elaboration of the trials in order to obtain a report, using motion analysis software, was allowed only for trials that were recorded using conventional markers displacement, like Davis protocol, Saflo protocol and so on.

The acquisition and the markers labelling of a self-made protocol was enabled, but the elaboration of the trial, in order to interpret data, was possible only exporting data from motion analysis software and using alternative application.

Until now.

In these years, a powerful biomechanical software was born. This accomplishment opened the door to great advances in motion analysis.

1.2 SmartAnalyzer: the working scheme

SmartAnalyzer is a powerful biomechanical software able to take as input a protocol and a variable number of acquired trials.

Even if it could potentially work on any acquisition system, it is mandatory to label the markers according to the model built iusing BTS SmartTracker or BTS Tracker in order to process the acquired trials.

Then the reconstructed and labeled files (Smart *.tdf, Elite *.raw, Vicon *c3d,...) can be easily processed (fig. 1.1).

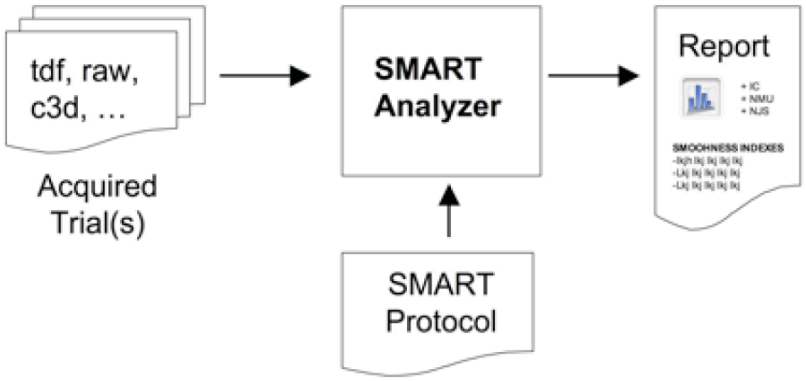


Figure 1.1: The overall view of SmartAnalyzer working scheme. SmartAnalyzer nload many file formats - with reconstructed and labeled data in them - and using specific Smart protocol is able to produce a specific clinical report.

SmartAnalyzer is a software program that evaluates the captured data quantitatively.

SmartAnalyzer allows customized protocols to automatically generate all the necessary data for a complete analysis of the motion.

The user has the capability of developing with ease and efficiency, customizable analysis protocols. The multimedia report are configurable depending on need and can be printed, exported or shared on the web.

It takes some time to fully understand how Analyzer works but in the next sections will take the user through the basic operations step by step.

Chapter 2

SmartAnalyzer: the user guide

2.1 SmartAnalyzer Main Window

SmartAnalyzer is a powerful tool which allows you to biomechanical data acquired by the SMART System as importing other system's files. With an easy to use graphical Drag and Drop interface you will learn how to analyze previously acquired file, how to elaborate the data setting up computational schemes called Protocols and finally how to present the result of interest into an exportable graphical form called Report.

SmartAnalyzer is quite a powerful analysis instrument which allows you to perform quickly complex operation and set computational scheme and reports which applies automatically to new files once you get familiar with it. We suggest you to give a look to this Getting Started section to have a feel of what the program is about, and then go trough the Tutorials, giving a look to the Reference Section when needed. All the basic operations like opening a file and watching data stored in it are described in the first tutorials.

When you open SmartAnalyzer you will see two distinct area of the main window: the Data Panel on the left and they gray area on the right called Client Area.

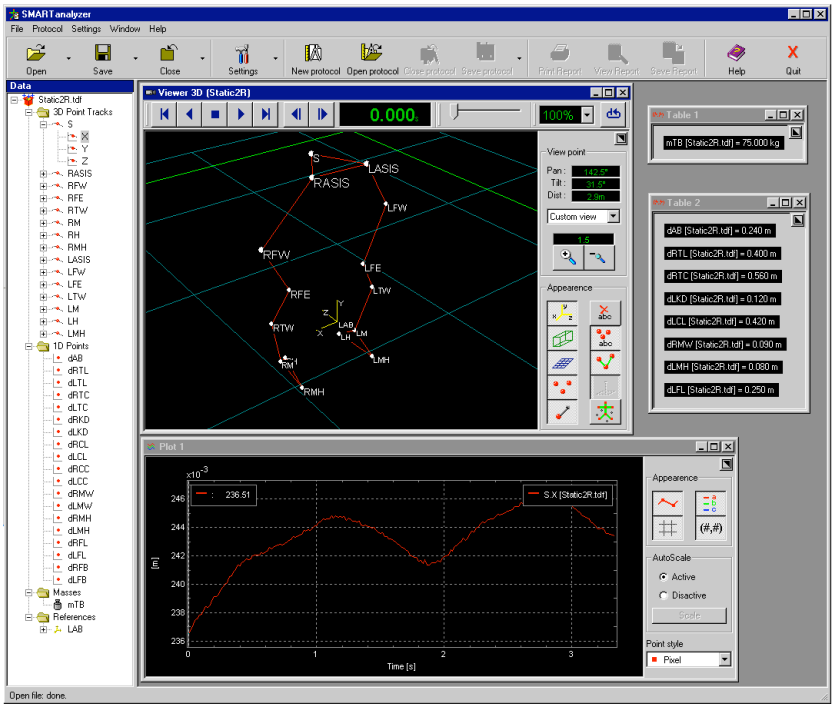


Figure 2.1:

Data Panel This panel contains all the data that are currently loaded in SMARTanalyzer, arranged in trials and folders. You can click on the nodes to expand or collapse them in order to show or hide the data they contain. Data stored are sorted by Data Types and can be dragged to be viewed in the Client Area, used as inputs for the operators which constitute a Protocol or for the graphical form of a Report.

Client Area It's the dark grey area which contains the Viewer 3D window, the plot and the tables on the figure above. Whatever data you drag with the mouse into the Client Area, a view of that data will appear. You can pick data from the Data Panel: data varying with time will be represented in plots, static data in

tables, while trials will be represented in a Viewer3D.

The purpose of the client area is to visualize the data which is stored in the client area. To do it you simply have to drag the corresponding nodes from the Data Panel and drop them in the client area. If the data dragged is a track, like a marker trajectory in a motion capture acquisition file, it will be shown as a plot; if it is an item it will be shown as a table. Also images and videos can be visualized in the Client Area.

2.2 Protocol window

A Protocol is the starting point for each computation you may want to perform on your data.

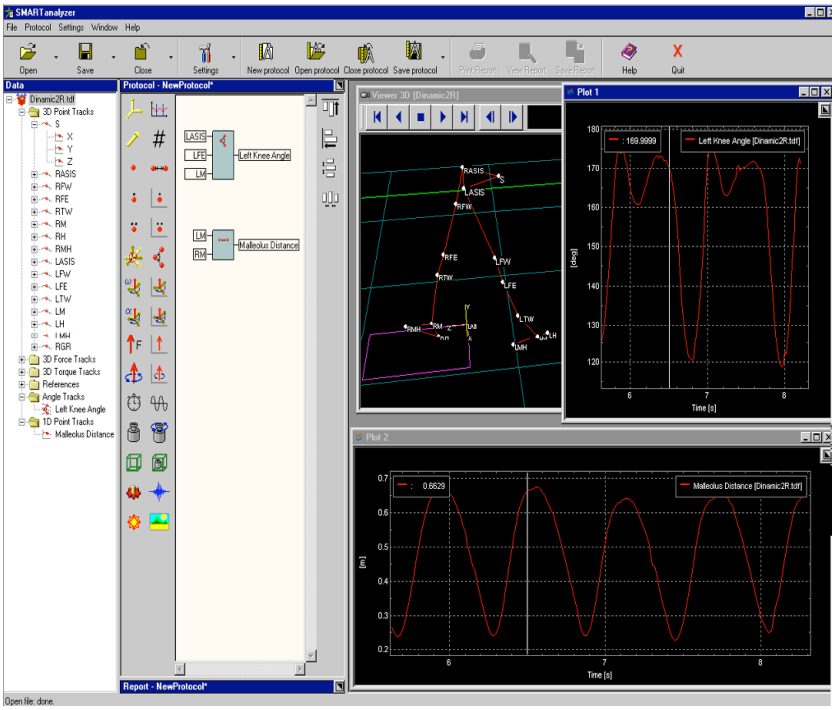


Figure 2.2:

It is a computation scheme which can be saved and then automatically applied to all file whose data are called with the same conventional names.

Protocol functions are graphically arranged into a form called Protocol Panel, which works with an intuitive drag and drop interface.

The Protocol Panel It's light yellow background which appears at the right of the Data Panel when you load a protocol or create a new one, and it provides all the tools to create your computation model. On the left side of the Protocol Panel there is the so-called Object Toolbar, while on the right side you can find the Edit Toolbar. On the Object Toolbar you can find a button for each type of objects you can compute with SMARTanalyzer; controls located on the Edit Toolbar let you adjust the layout of the Protocol on the Protocol Panel.

The Protocol Panel contains graphical devices called Operators, which represent the basic units of the computation model. Each operator performs a mathematical function, they take up to four data objects as inputs (they can be dragged from the Data Panel) and they produce a new output object which can also be a different data type: for example in the figure above you can see an Angle between three points operator which takes three 3D points tracks as input and produces an angle track as output. It can be seen that the new object is then included in the Data Panel.

Each button in the Object Toolbar indicates which kind of object will be the output of the listed operators. For example supposed we want to computed the angle between three points, first we press the button Angle and then from the list which appears we select the operator "Between three points".

2.3 Using SmartAnalyzer

First, open SmartAnalyzer.

SmartAnalyzer screen is divided in two zones at this point (fig. 2.3).

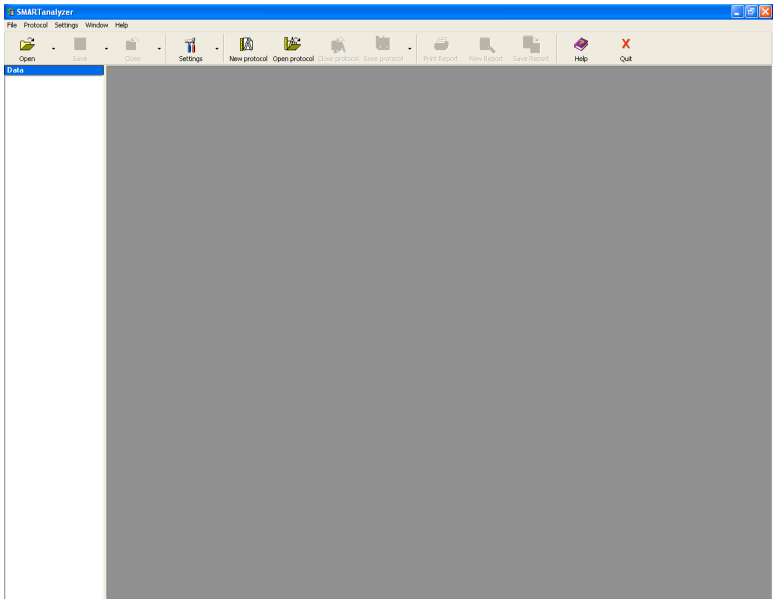


Figure 2.3:

2.3.1 The “File” command

The first step is open the file you want to analyze.

Click on “File”, SmartAnalyzer shows you a menu like the one reported in fig. 2.4.

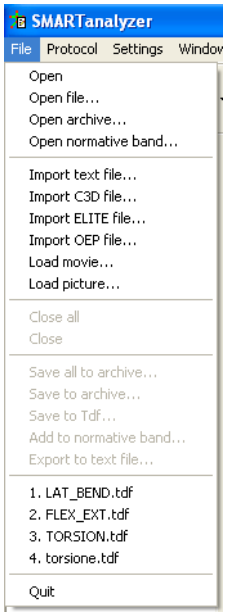


Figure 2.4:

SmartAnalyzer: File Types

SmartAnalyzer works with the TDF files, acquired by the SMART Motion Capture System, and has a series of files it uses to store protocols, archives and normative band files. Id addition it can read and write data in many other file formats, included the ELITE System data file and the C3D files. Data can be exported in text files readable by Excel and export reports in HTML.

Native Files

- SMART System Data Files (*.TDF). SmartAnalyzer reads TDF files acquired by the SMART Motion Capture System. They contain 3D tracks, force platform data, electromyographic analog signals and model links information. When you press the button Open a form opens which to select one or more TDF files to open.

- SMARTanalyzer Protocol Files (*.EPX). The protocols and corresponding reports are stored in the EPX file format. Before opening a protocol file you must open the file to which it will be applied.

- Archive Files (*.MDX). Archives are used to store all data contained in an acquisition: that is both data read from original file and data created by protocol operators. For example if I open a TDF file and use protocol operators to compute an angle and a distance, the angle and the distance will be located inside the acquisition data in the Data Panel; now it is possible to save all the data of the original TDF file together with the new angle and distance computed by right clicking on the acquisition node in the Data Panel and select Save to archive.

- Normative Bands Files (*.ENB). A Normative Bands file contains information about the normal range for a data. In clinical analysis normative bands files contain information about the normal range of biomechanical value (like joint angles rotation, body segment dimensions etc...) and they are often used to compare data of a particular subject with the the normal objects. In SMARTanalyzer a normative band file contains a collection of objects of a particular measure (they can be both items and cycle), and when opened it automatically gives the mean and the standard deviation on the instances of the object it contains. To insert an object in a normative band you just have to right click the object node in the Data Panel and choose Add to Normative Band. Once you open a normative band it appears as an acquisition in the Data Panel.

Import/Export Files

- C3D Files (*.C3D). The C3D is a public domain file format which is widely used in Biomechanics, Animation and Gait Analysis. You can find more information about it at the official C3D web site: www.c3d.org SMARTanalyzer can both read and write C3D data files.

- Text Files (*.EMT). SMARTanalyzer exports data in test file with the extension EMT. To do it just right click in the Data Panel on the object you want to export and choose Export to text file. Text files exported by SMARTanalyzer are readable by Excel. SMARTanalyzer can also read EMT files, in case the user wants to edit its own text data files.

- ELITE System Data Files (*.RIC, *.EMG, *.GRx, *.ACC, *.VEL, *.ANG, *.RAW, *.RIF, *.ANF, *.VAN, *.AAN) SMARTanalyzer can read data files produce by the ELITE System software suit. Here is a list of the file types and the kind of data they contains.

  - RIC: Reconstructed 3D coordinates.
  - EMG: Electromyographic analog signals.
  - GRx: Force Platform data; x stands for the number of the platform.
  - ACC: 3D accelerations.
  - VEL: 3D velocities.
  - ANG: Angles.
  - RAW: 3D marker coordinates after the tracking.
  - RIF: 3D filtered coordinates.
  - ANF: Filtered angles.
  - VAN: angular velocities.
  - AAN: Angular accelerations.
  - Vemgbis Plethysmography Data Files (*.DAT) Plethysmography DAT files processed by Vemgbis contains pulmonary volume data and spirometer flux data. They can be opened together with the corresponding TDF file (their data are thus added to the tdf acquisition data), or imported alone.

- HTML Files Reports can be exported in HTML file format. A main file will be created and all graphical objects will be placed in a directory with the same name. Graphical objects are exported as Adobe SVG objects.

2.3.2 The "Protocol" command

After opening the trial (or trials) the user want to analyze, clicking the protocol command the user can define a "New" protocol (fig. 2.5).

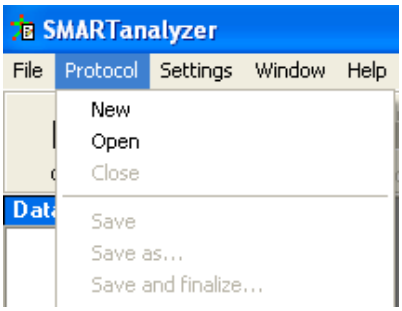


Figure 2.5:

2.3.3 The "Settings" command

Using the "Settigs" command, the user is able to modify the general settings of the software (fig. 2.6).

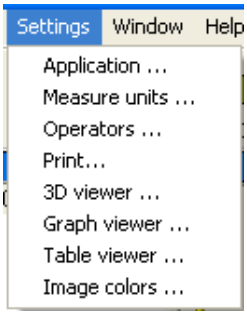


Figure 2.6:

"Application" (fig. 2.7)

The main general settings of SMARTanalyzer are set inside this form.

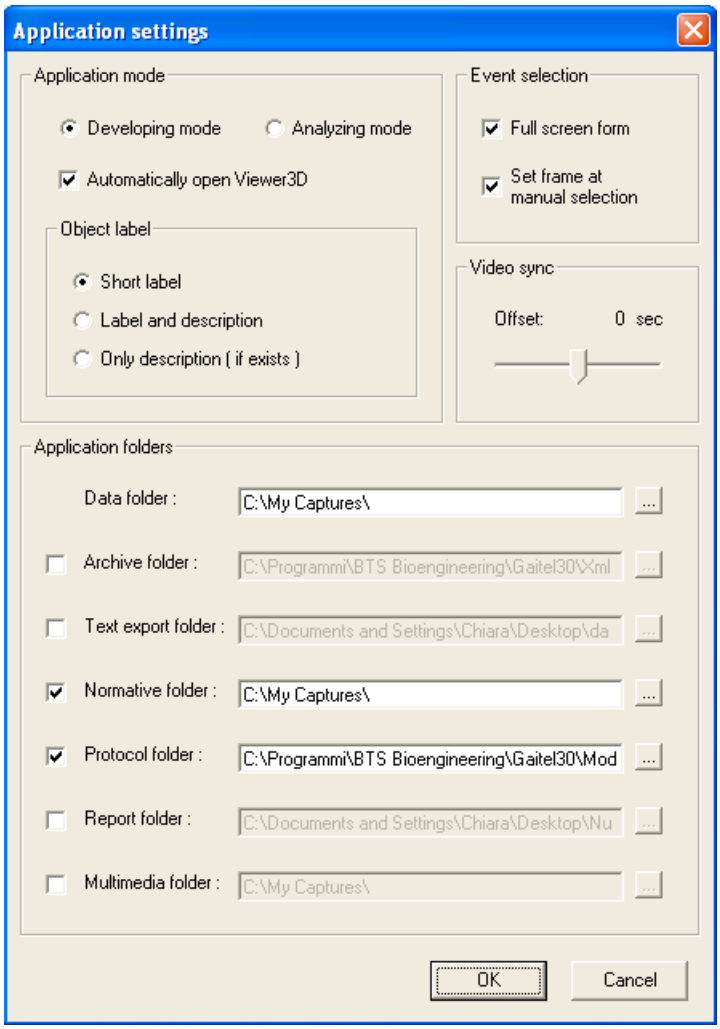


Figure 2.7:

Application Mode Set the mode under which SMARTanalyzer is running:

- Developing mode - allows the user to use all all functionalities of SMARTanalyzer, among which creating and modifying protocols.

- Analyzing mode - is the standard clinical mode; the user but cannot build nor change protocols, but it is possible to open protocols and edit reports.

Object Label

- Short label - legends in the client area shows object labels.
- Label and description - legends in the client area shows object labels and object descriptions.
- Only description (if exists) - legends in the client area shows only object descriptions if they exsist, otherwise shows object labels.

Event Selection

- Full screen mode - when selecting an event, the event selection window appears in full screen.
- Set frame at manual selection - each time you select an event in the event selection window (with a left click on the plot) the 3D Viewer goes at the corresponding frame.

Video Delay Delay between the beginning of the acquisition and the beginning of the video acquisition. Used to synchronize analog video acquisitions which have a little delay between the beginning of the motion capture acquisition and the beginning of the analog video acquisition.

Application folders Default folders for opening and saving various types of files; if boxes are unchecked last browsed folders are used as defaults. See File Types for an description of the different kind of files in SMARTanalyzer.

- Data folder - folder for the main data files: Tdf files, used when the Open button is pressed.

- Archive folder - folder for the archive files.
- Text export folder - folder for the text files.
- Normative folder - folder for the normative bands files.
- Protocol folder - folder for the protocol files.
- Report folder - folder for the Html exported report files.
- Multimedia folder - folder for the multimedia files: images and videos.

"Measure units" (fig. 2.8)

This form sets how the values of the different types of data are displayed in the Client Area and in the Reports.

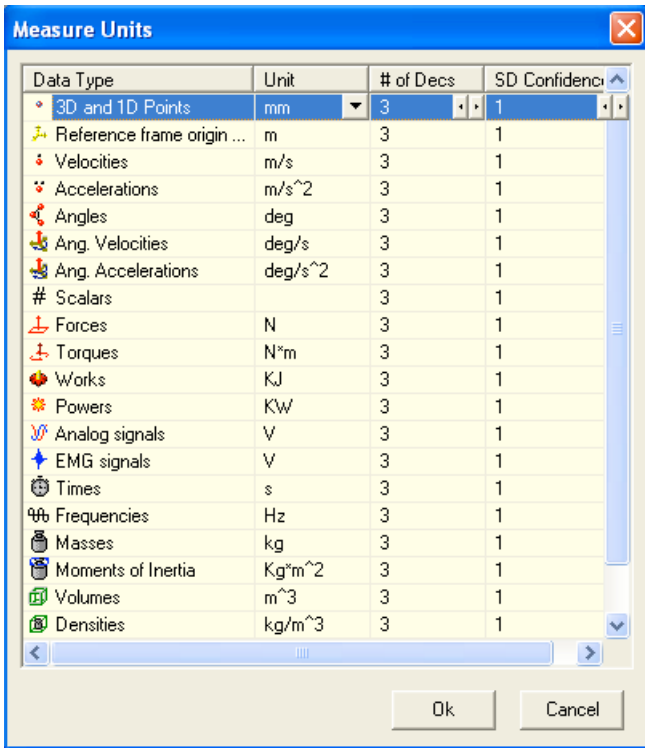


Figure 2.8:

Data Type Types of data used in SMARTanalyzer.

Unit Measure unit displayed.

# of Decs Number of decimal digits displayed.

SD Confidence Standard Deviation Confidence: this number multiplied by the standard deviation correspond to the confidence band displayed in the plots or in the cyclograms. The confidence band is an area filled with a color lighter than the signal one, around the mean signal. The default value is 1. This value is meaningful only for statistical signals.

"Operators" (fig. 2.9)

This form sets the parameters of the automatic event algorithms and of the filter operators.

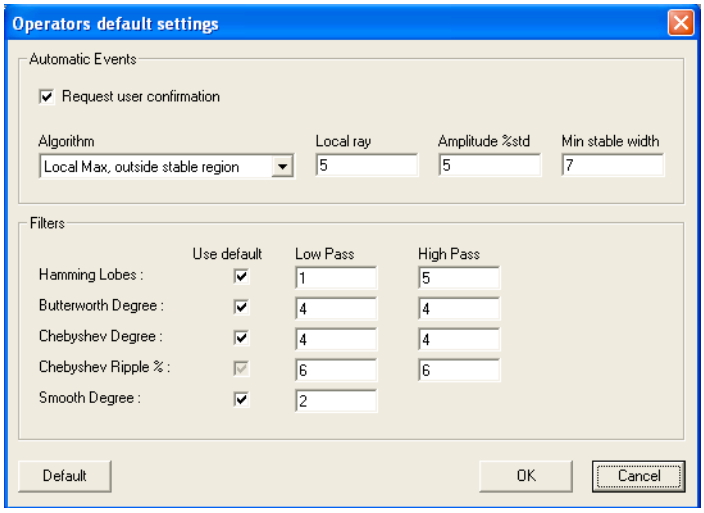


Figure 2.9:

Automatic Events Inside the event selection form it is possible to use a series of algorithms to automatically define events.

Algorithm Types

Local Max / Min, outside stable region - sets an event on every local maximum/minimum; to prevent noise peaks to be considered maximum / minimum points, a local maximum must also meet the following conditions: the candidate maximum/minimum must be global inside the number of frames set in Local ray before and after the event; also the event must not be inside a stable region, as defined below.

Enter / Exit stable region - set events at the beginning / end of stable regions with the direction set in Direction; a region to be stable must have values which varies less then the fraction (in percent) of the standard deviation of the signal as set in Amplitude %std, and must last as least Min stable width frames.

Zero Crossing - set an event for each time the signal crosses zero with the direction set in Direction; to be a valid crossing (thus preventing noise) the crossing must have a slope (in percent of the standard deviation per frame) as set in Amplitude %std.

Reference Crossing - set an event for each time the first input signal crosses the second input signal with the direction set in Direction; to be a valid crossing (thus preventing noise) the crossing must have a slope (in percent of the standard deviation per frame) as set in Amplitude %std.

Algorithm Parameters **Local ray -** how many frames before and after each instant define the local automatic algorithms.

Amplitude %std - percent fraction of the signal standard deviation, used in local automatic algorithms.

Min stable width - minimum width in frames of a local stable region to be considered by the automatic algorithm.

Direction - direction considered for the level crossing; it may have value Up, Down or All.

Filters

Use default - for the corresponding filter operators use the default setting values listed on the right textboxes; if unchecked the user must enter the corresponding values an additional scalar inputs.

Low Pass - number of nodes in the LP Hamming Filters; number of lobes in the LP Butterworth and Chebyshev filters; percent value of the maximum ripple in the LP Chebyshev filter; degree of the triangular and rectangular smoothing filters, which correspond to the number of frames consider before each frame and after each frame, for example if the degree is 2 then 5 frames are considered each time.

High Pass - number of nodes in the HP Hamming Filters; number of lobes in the HP Butterworth and Chebyshev filters; percent value of the maximum ripple in the HP Chebyshev filter

"3D viewer" (fig. 2.10)

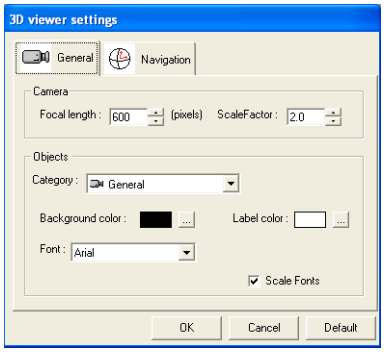


Figure 2.10:

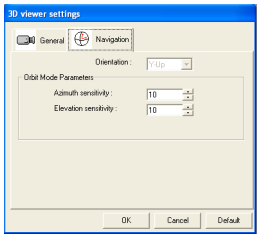


Figure 2.11:

"Graph viewer" (fig. 2.12)

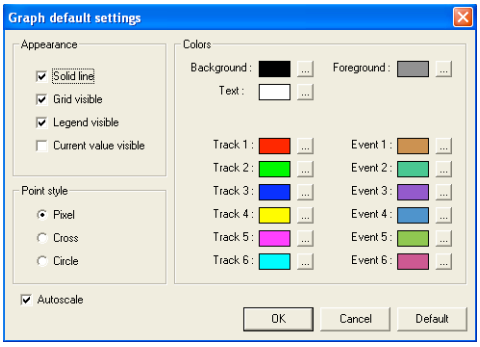


Figure 2.12:

"Table viewer" (fig. 2.13)

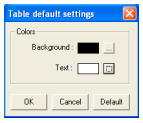


Figure 2.13:

"Image colors" (fig. 2.14)

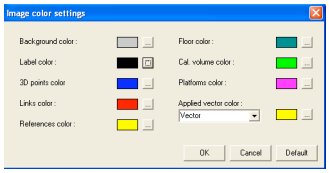


Figure 2.14:

2.4 Creating a protocol

Protocols are groups of operators that are used to analyze certain data. They are comprised of different tools that take the raw data and output a desired value.

There are many different protocols that can be created; each is created specifically for the desired output value.

This next section will take you through the basic steps of how to create a protocol; however what you choose to put in each protocol depends on what outputs you are interested in.

Click 'New Protocol'. A 'Protocol-NewProtocol' window will appear. In this window, there is a toolbox on the left. If you move the mouse over each tool a brief description will appear. If you click on a certain tool, numerous different operators will appear. Generally, the left column of the "toolbox" is for 3D data, the right column for 1D data. Each operator is unique, meaning there are specific inputs that it will accept; it may require one value or multiple values. Most operators have only one output.

Note: A 1D operator will not accept a 3D input, and viceversa.

Note: To view the 3D trial (if closed), click and drag the trial name from the 'Data' window to the gray space on the right. You can view all of the point tracks and force tracks this way also. To view recently created operators, click and drag the output from the 'Protocol' window to the gray space at the right.

Note: everytime the user defines a new variable, renames the operator using a confortable name.

In the following, the handbook shows you all the data types and the opera-

tors divided in tool: for many tools there are the same operators. In this case, the handbook has the paragraphs named “General operators”, “General math operators”, “”Event operators” and “Filter operators”.

The main thing that the user has to keep in mind is that all the tools of SmartAnalyzer answer to the question “What do you want to obtain?”.

2.4.1 Data types

As you can see in the Data Panel, all objects in SMARTanalyzer are divided into groups according to their physical dimensions (angles, velocities etc...), their Data Types and also the Temporal Domains to which they belong. Below is given a description of the possible data types and temporal domain, together with some example to how they can be obtained.

Data Types: 1D Objects, 3D Objects, References, Events, Images, Movies

Temporal Domains: Items, Tracks, Cycles, Item Sequences, Cycle Sequences

Data Types All possible kind of object handled by SMARTanalyzer are listed in the Protocol’s Object Toolbar. They all belong to one of the six data types listed below: 1D Objects, 3D Objects, References, Events, Images or Video. Some physical types can be associated to more than a data type. For example the physical type Velocity can be a 3D object (three-dimensional velocity) or 1D object (speed). When these two options are present, both objects are on the same row: the 3D object on the right and the correspondent 1D object on the right.

- 1D Objects: One dimensional objects can be single components of their 3D correspondents; for example the X component of a 3D acceleration is a 1D object, and it is possible to pick it up from the Data Panel.
- 3D Objects. Objects made of three 1D components; each component is a 1D object which can be separately selected and use as input for an operator, a report object or to be displayed in the Client Area.

- References: A reference represents a coordinates system. A reference system is made of one 3D point, which is the center of the reference system, and three 3D orthonormal vectors, which represent the three axis of the reference system. Every acquisition has its own reference system, but it is possible to create new reference systems and also to convert the coordinates of 3D cinematic objects (points, velocities and accelerations) for one reference system to another.

- Events: Events are temporal instants, determined by the user. A typical use is to select a value form an object track: the value that the object has in that particular instant. Events are also used to determine Cycles. They can be dragged on plots: vertical line will be shown in correspondence to the events time. It must be noted that an event belong to the acquisition from which it has been determined (check the Operators Reference to see how to build an event object), thus it is not possible to use events and other objects on the same operator if they belong to different acquisitions. For example you cannot use a temporal event from an acquisition to select an object track value that belong to another acquisition. An Event Sequences is a collection of events.

- Images: Images can be loaded in the Data Panel, where they are stored as the other objects. If you want to associate an image to an acquisition right click on the acquisition node and select Load picture otherwise you can select the menu File / Load Picture and the picture will be associated to the genera acquisition called Global Data. They can be added to the report pages using the report object Image. Image formats accepted are Bmb, Jpeg and Gif.

- Movies: Movies can be loaded in the Data Panel, where they are stored as the other objects. If you want to associate a Movies to an acquisition right click on the acquisition node and select Load movie otherwise you can select the menu File / Load movie and the picture will be associated

to the general acquisition called Global Data. They can be added to the report pages using the report object Movie. The movie format accepted is the Mpeg.

Temporal domains Data is usually stored in files as single values (the weight or the height of a subject etc...) or values changing over time (a point trajectorie, an electromyographic signal etc...). In SMARTanalyzer the single values object are called Items and the and the object whose values are changing over time are called Tracks.

Through SMARTanalyzer it is possible to create Cycles, which are normalized tracks, and Sequences of items and cycles.

- Items: An item is a data record constituted by a single value. Of course it can also be a 3D value or a Reference.
- Tracks: Tracks are objects whose values change over a period of time. Tracks have a starting time, a duration and a frequency (the frequency at which the data was acquired). It is not possible to have two tracks that belong to different acquisitions as inputs of the same operator (for example it is not possible to sum two tracks if they belong to different acquisitions). In the same way it is not possible to see in the same plot tracks from different acquisitions.
- Cycles: A cycle is a normalized track: it's temporal domain is normalized and goes from 0 to 100. Each cycle corresponds to the portion of track. Events are used to mark the instants on a track that will be the beginning and the end of the cycle (see the General Event Operators to see how a cycle is built). Cycles are useful to compare portions of tracks (taking they mean, their sum etc...), that otherwise a not compatible since they may have different temporal length.
- Item Sequences: An item sequence is a collection of items. For example an event sequence is obtained using the operator Multiple events on

one track; than you can use the event sequence to extract an item sequence from a track (each item is the value of the track at the time of the correspondent event). When an operation is done between two item sequences (for example a sum of two distance sequences) the output will be a sequence of objects; if n is the minimum number objects between the two inputs, the operation is done between the first n item of the first sequence and the first n items of the second sequence.

- Cycle Sequences: An cycle sequence is a collection of cycles. For example an cycle sequence can obtained using the operator Event sequence defined cycle. When an operation is done between two cycle sequences (for example a sum of two 3Dpoint cycle sequences) the output will be a sequence of cycles; if n is the minimum number objects between the two inputs, the operation is done between the first n item of the first sequence and the first n items of the second sequence.

2.4.2 Plotting an object

All the data type can be plotted on the client area in order to control the computation af an object.

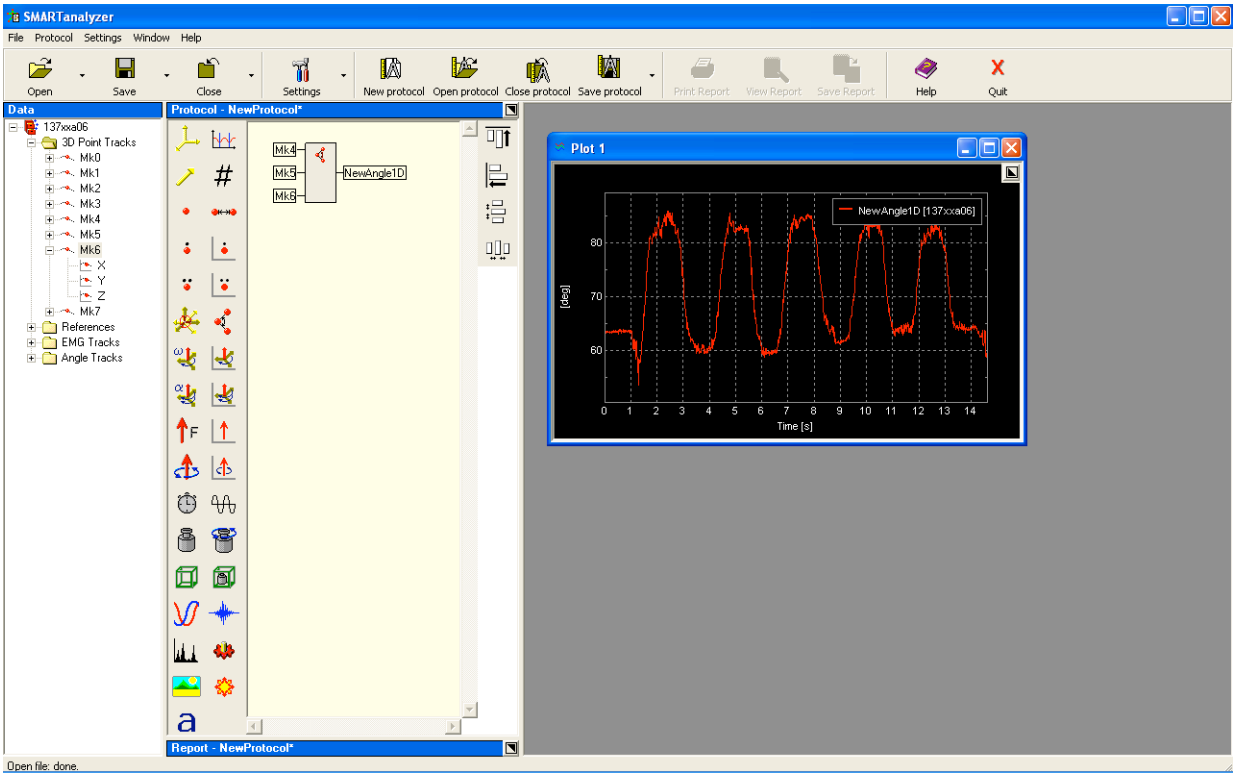


Figure 2.15:

Previous figure shows the track of a computed angle between Mk4-Mk5-Mk6 plotted on the client area.

Some operators returns objects that can be plotted also in the viewer of the trial.

In the next example, we computed a 3D vector between Mk4 and Mk5 and plotted it also in the trial window.

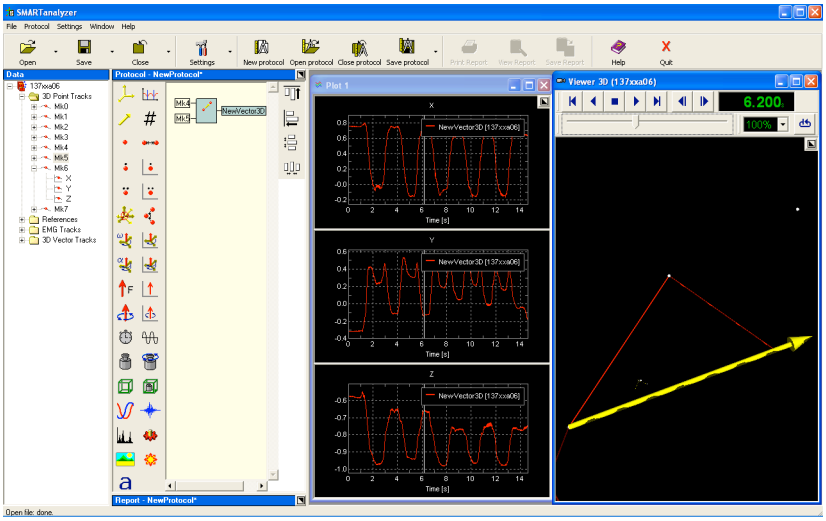


Figure 2.16:

2.4.3 Reference system

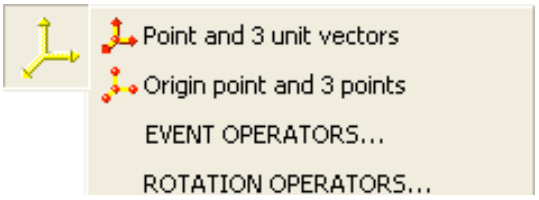


Figure 2.17:

Point and 3 unit vectors: this operators allows the user to define a new reference system.

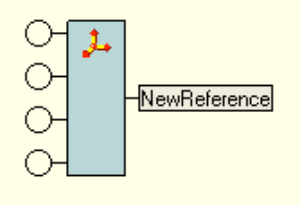


Figure 2.18:

The operator looks like Fig. 2.18 in the 'Protocol' window.

1. In the first round dot the user can insert a 3D points, that will be the origin of the new reference system.

2. In the second, third and fourth round dots the user can insert the vectors to define the three directions of the new reference system.

The general procedure of computation and the geometric rules that permits to define the reference system is that each one of the three inserted vectors define infinite planes. To determine the three planes that will be the axis of the reference, the system has to have some conditions: the first one is that the x axis is determined by the vector in the first round dot, the second condition is that the infinite planes getting through to vectors Mk4-Mk6 and Mk5-Mk6 have to be perpindicular each other, and the last condition that they have to be perpendicular also to the inserted "x axis".

Here an example (fig.):

Generally, the user wants to create a reference system starting from a plane (3 markers, that eliminate one of the condition that must be imposed): in this manner the definition of the reference is different: the user wants that the first inserted vector will be the x axis direction, the second the y axis, the last one the z axis.

If we consider the plane composed by Mk4-Mk5-Mk6 (fig. 2.19), for example, in order to define a new reference system, with origin in Mk4, with the normal (z axis) orthogonal to the plane defined by vectors Mk4-Mk6 and Mk4-Mk5, the user has to (fig. 2.20):

- define the two vectors between Mk4 and Mk5 and between Mk4 and Mk6;
- compute the normal product between these two vectors, in order to obtain the normal of the plane (normal to plane Mk4-Mk5-Mk6);
- compute the normal product between normal to plane Mk4-Mk5-Mk6 and the vector choosen as x axis, in order to define the third orthogonal vector;
- insert these vectors and the origin in the operator as said before;

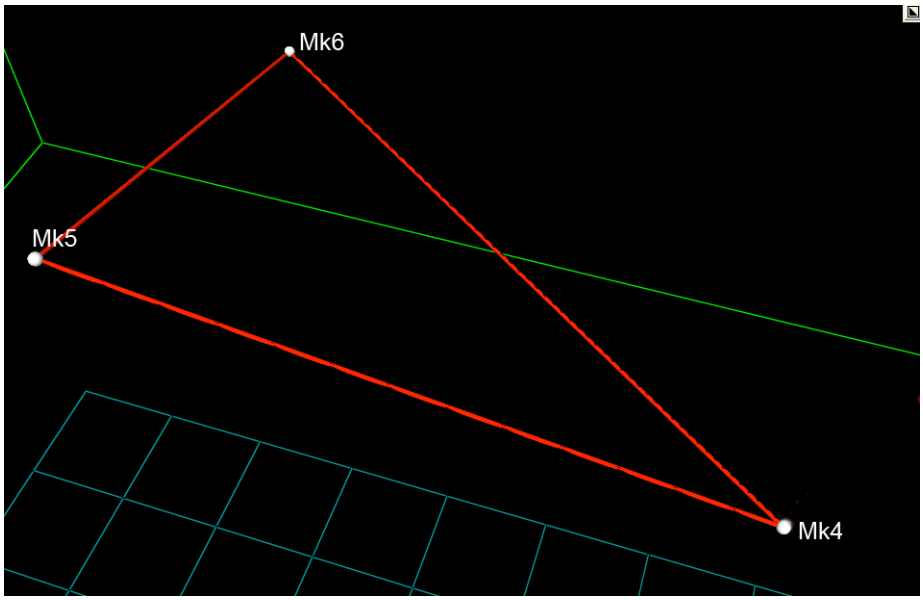
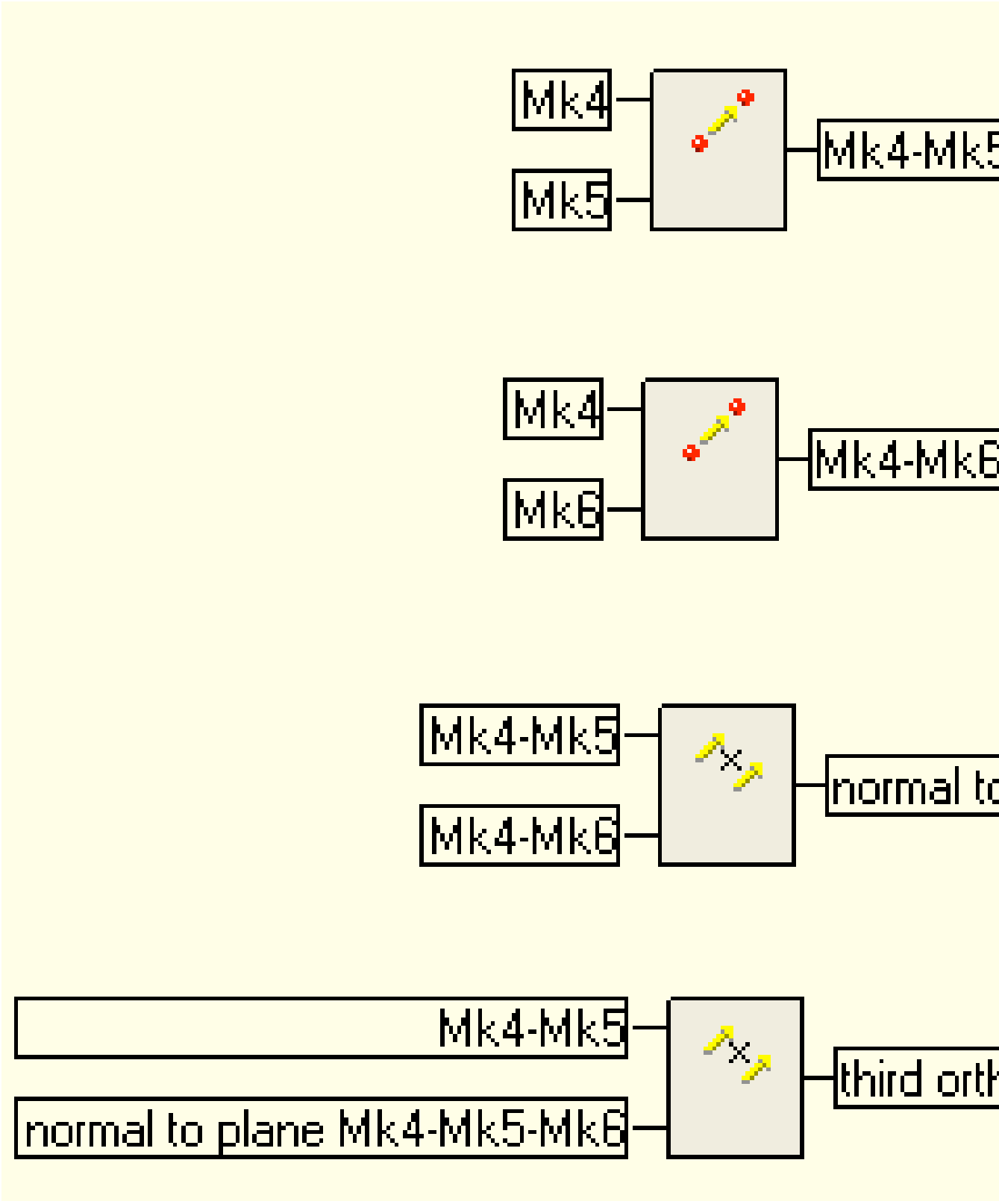


Figure 2.19:


Mk4
Mk5
Mk4-Mk5
Mk4
Mk6
Mk4-Mk6
Mk4-Mk5
Mk4-Mk6
normal to
Mk4-Mk5
normal to plane Mk4-Mk5-Mk6
third orth

The obtained result, using the figure 2.21 order, will be the reference reported in figure 2.22.

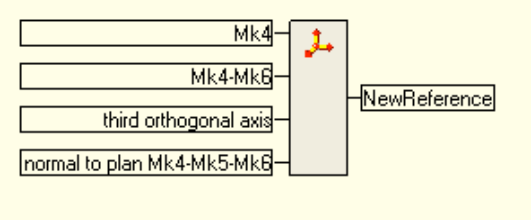


Figure 2.21:

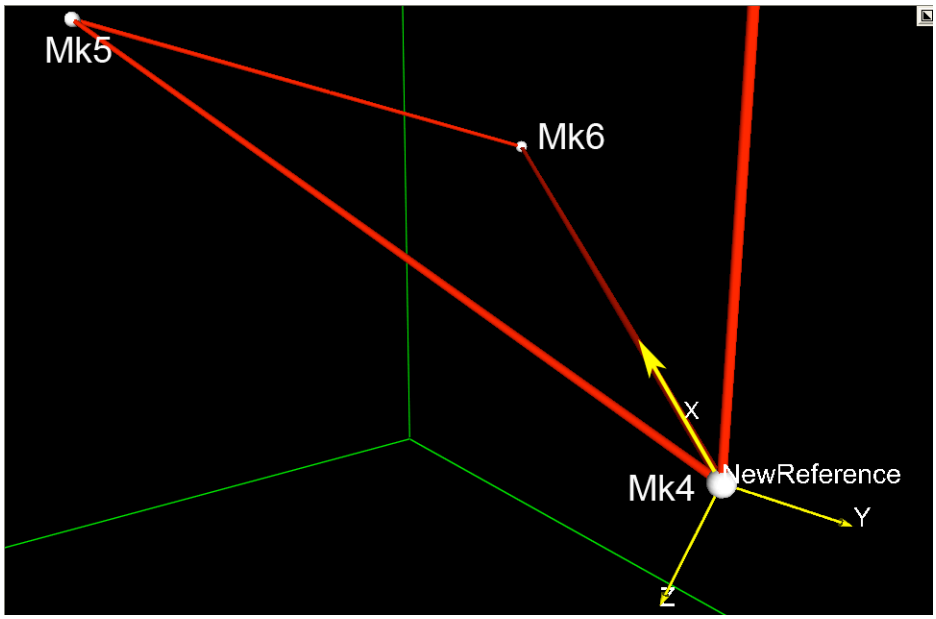


Figure 2.22:

If the user changes the order, for example changes the second and the third round dots (fig. 2.23), the result will be another reference (fig. 2.24) different from the previous one.

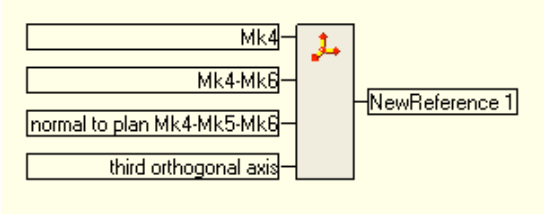


Figure 2.23:

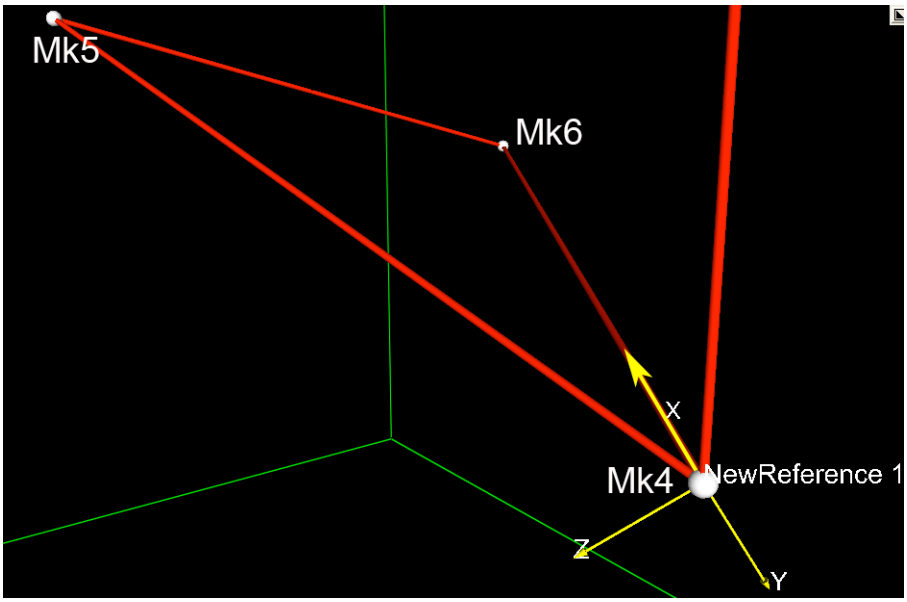


Figure 2.24:

Origin point and 3 points: this operators allows the user to define a new reference system, using different information respect to the previous one.

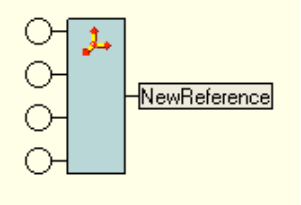


Figure 2.25:

The operator looks like Fig. 2.25 in the 'Protocol' window.

1. In the first round dot the user can insert a 3D points, that will be the origin of the new reference system.

2. In the second, third and fourth round dots the user can insert three 3D points to define the three directions of the new reference system.

Referring to the previous example of reference definition, in the following the definition of that reference using the "Origin point and 3 points" operator.

In this case, we may know that the first round dot will define the origin of the new reference, the second and the third round dots will contain the points that will define the first vector of the reference system (X axis), the fourth round dot will contain the last point that will define the plane in which the Y axis will be built, orthogonally to the X axis. The last vector that will define the Z axis will be built inside the computation as the normal product between the axis previously defined.

Let's see an example: considering Mk4, Mk5 and Mk6, we want to create the a new reference in Mk4 with X axis along the vector from Mk4 to Mk6, the Y axis on the plane defined by Mk4, Mk5 and Mk6.

The user has to put in the first and second round dots Mk4, in the third one Mk6 and in the last one Mk5: the result is shown in fig. 2.26.

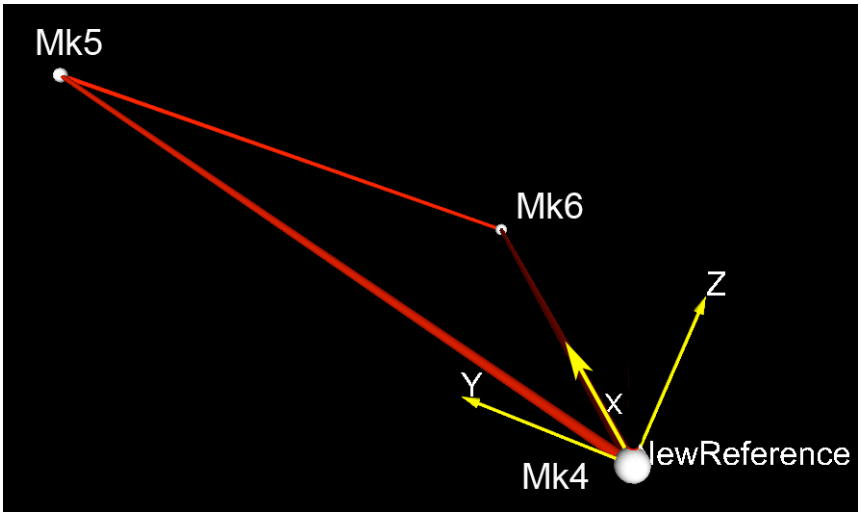


Figure 2.26:

Also in this case, changing the insertion order could generate something different from the expected results.

2.4.3.1 Rotation operators

"Rotate XXX DDD": this operator allows the user to rotate by XXX degrees the original reference around DDD ases.

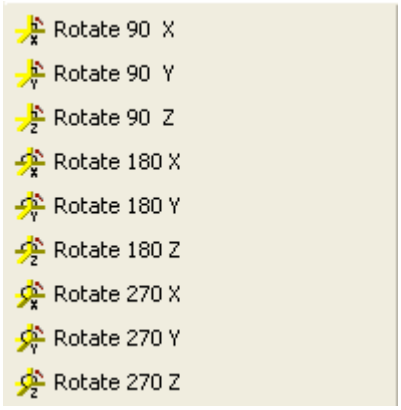


Figure 2.27:

1. In the round dot the user can insert the reference that wants to rotate. The operators tells the user the value of the rotation and that the rotation will be performed around a specific axis.

If the user wants to obtained a 90 degrees rotation, around X axis, of the reference, for example defined in the previous paragraph, he has to choose the first operator showed in fig. and put the defined reference in the round dot. Figure 2.28 shows the previous reference (a) and the new one (b) after the rotation.

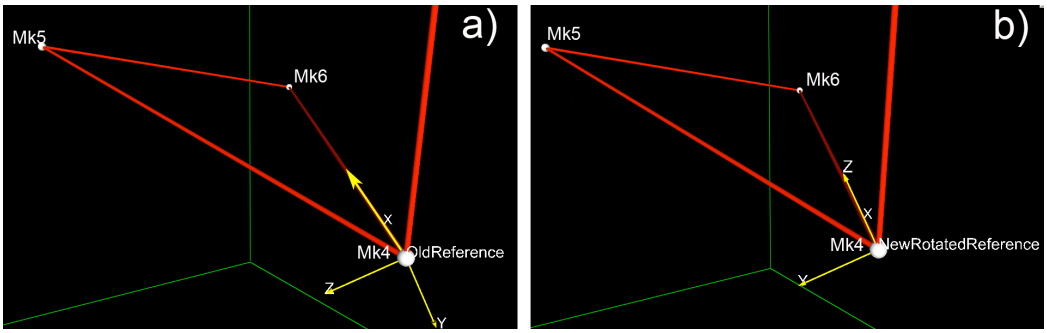


Figure 2.28:

"Reference and joint angle XYZ": definition of a new reference system rotated by a joint angle in XYZ order.

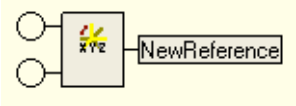


Figure 2.29:

1. In the first round dot the user can insert a reference system.

2. In the second round dot the user can insert a joint angle, a 3D angle, defined using the tool "3D angle", described in the following.

Using this operator, the new reference is built rotating the old one by the angle inserted in the second round dot. The rotation is performed rotating anticlockwisely around X axis first by the inserted component of angle “X”, then anticlockwisely around the new Y axis by the inserted component of angle “Y” and finally anticlockwisely around the new Z by the inserted component of angle “Z”.

In the following, the handbook shows you an example, considering a predefined 3D angle X=90 deg; Y= 90 deg; Z= 90 deg.

Going step by step, as said the first rotation is around X axis (2.30) by an inserted component of angle (X) whose value is set at 90 deg in this example.

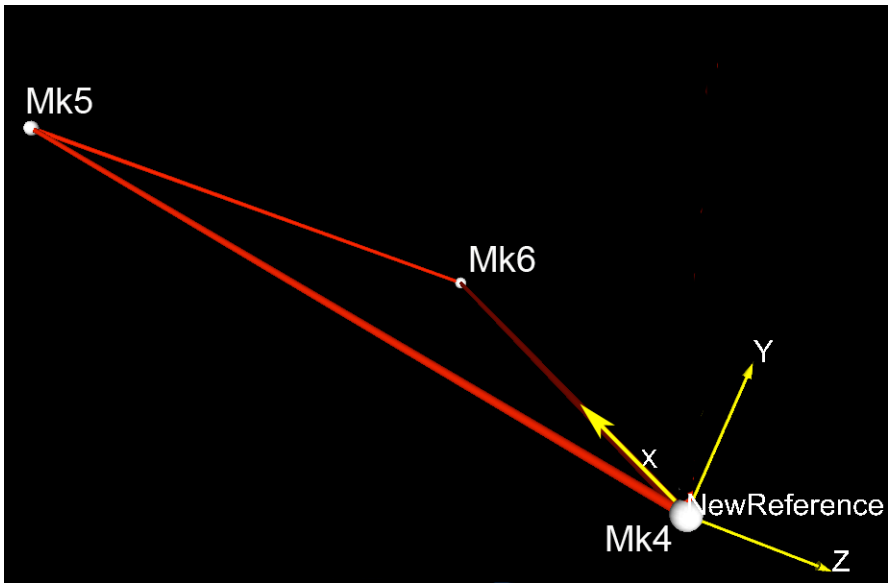


Figure 2.30:

The second rotation is around Y axis (2.31) by an inserted component of angle (Y), whose value is set at 90 deg in this example.

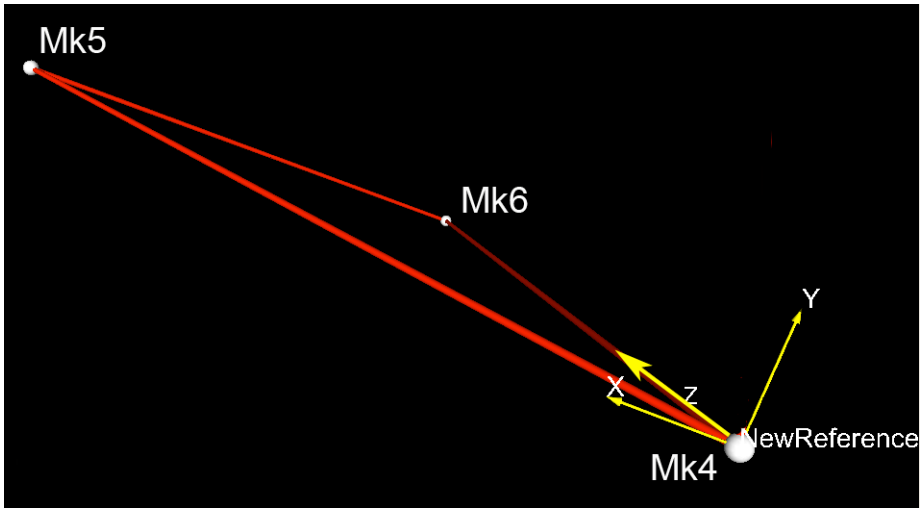


Figure 2.31:

The second rotation is around Z axis (2.32) by an inserted component of angle (Z), whose value is set at 90 deg in this example.

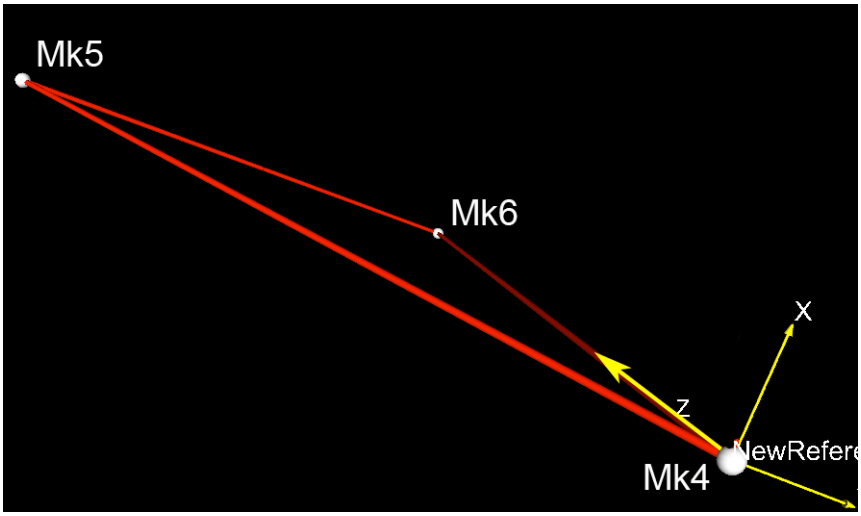


Figure 2.32:

"Reference and joint angle ZYX": definition of a new reference system rotated by a joint angle in ZYX order.

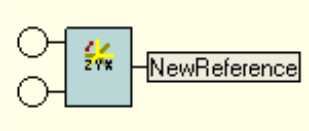


Figure 2.33:

1. In the first round dot the user can insert a reference system.

2. In the second round dot the user can insert a joint angle, a 3D angle, defined using the tool “3D angle”, described in the following.

Since the operator is order sensitive, “Reference and joint angle ZYX” returns a different reference system because of the first rotation is around Z axis by the component of the angle “Z”.

In the following an example of the two computation, in order to show the differences (Fig. 2.34).

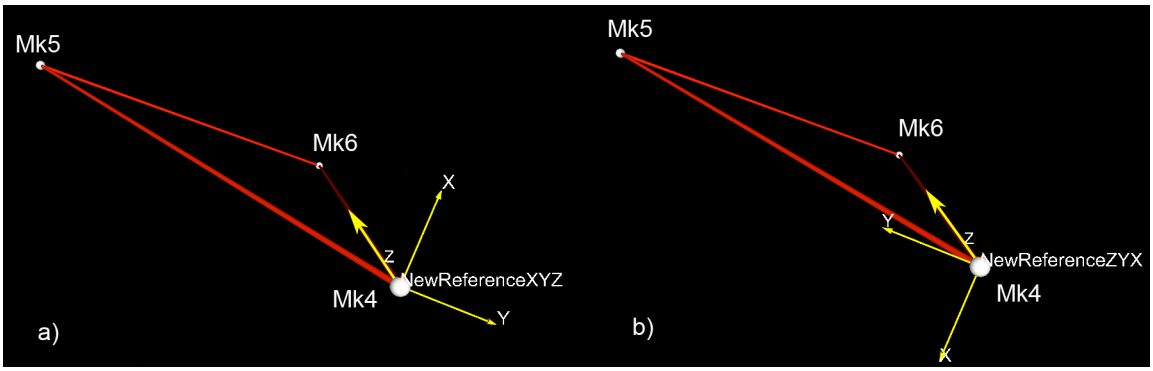


Figure 2.34:

“Reference and 1D angle”: The results of this operator is the definition of a new reference system rotated by 1D angle around an axes.

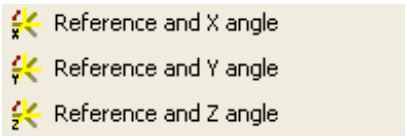


Figure 2.35:

1. In the first round dot the user can insert a reference system.

2. In the second round dot the user can insert a 1D angle, defined using the tool "1D angle", described in the following. The operators tells the user that the rotation will be performed around a specific axis.

2.4.4 Event

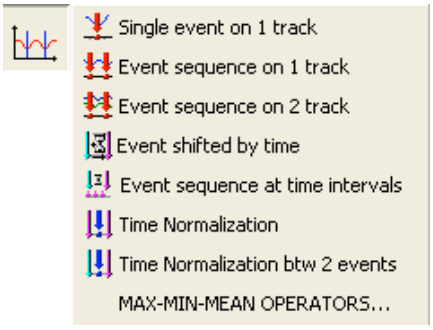


Figure 2.36: figure 35

The first three operators open a new window (Fig. **??**) that allows the user to define one or more specific events.

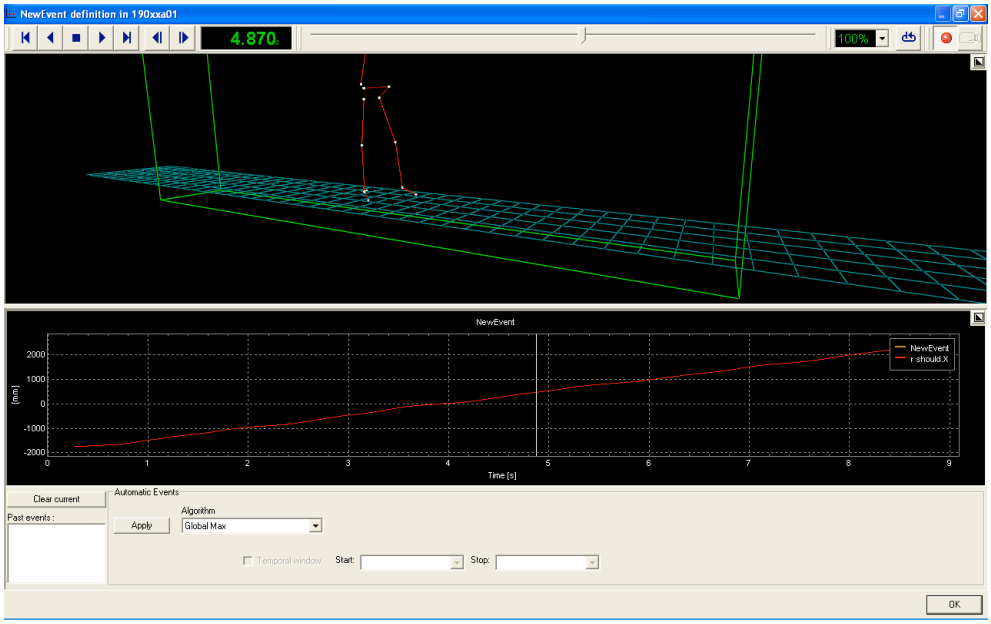


Figure 2.37:

In this window, the user can choose one or more events manually, or using the “Automatic Events”.

The “Automatic Events” is a useful option if the user wants to define one or more particular events, for example the “Global Max” (as reported in Fig. **??**).

In the “Settings command” paragraph, previously exposed, the reader can find the explanation of these commands.

“Single event on 1 track”: this operator allows the user to define a single event on a single track.

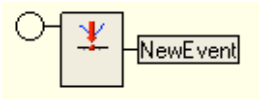


Figure 2.38:

1. In the round dot the user can insert a track and, after the opening of the help window, can define the single event.

“Event sequence on 1 track”: this operator allows the user to define more than a single event on a track.

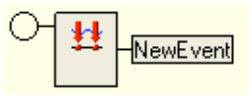


Figure 2.39:

1. In the round dot the user can insert a track and, after the opening of the help window, can define more than one event. In the help window the “Automatic Events” shows more than one possibility to define automatically the events the user wants to define.

“Event sequence on 2 track”: this operator allows the user to define more than a single event in 2 tracks.

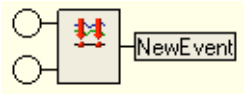


Figure 2.40:

1. In the first round dot the user can insert a track.

2. In the second round dot the user can insert another track.

The help window shows the two track the user put as inputs and can define more than one event. In the help window the “Automatic Events” shows more than one possibility to define automatically the events the user wants to define.

"Event shifted by time": this operator allows the user to create an event shifted by the input amount of time.

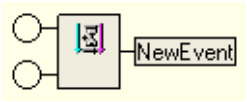


Figure 2.41:

1. In the first round dot the user can insert an event or an event sequence, previously defined.
2. In the second round dot the user can insert a time interval, defined using "Time" operator.

"Event sequence at time intervals": this operator allows the user to .

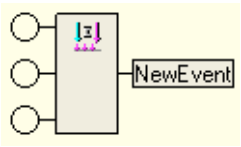


Figure 2.42:

1. .....
2. .....
3. .....

"Time Normalization": this operator allows the user to

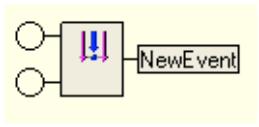


Figure 2.43:

1. .....
2. .....
3. -.....

“Time Normalization btw 2 events”: this operator allows the user to

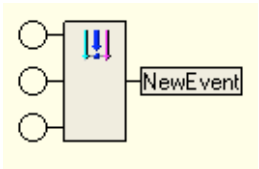


Figure 2.44:

1. .....
2. .....
3. .....

“MAX-MIN-MEAN operators”: these operators allow the user to compute some mathematical operation on the defined events.

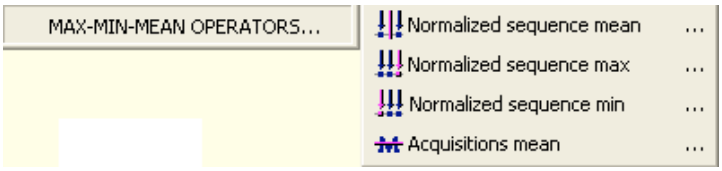


Figure 2.45:

.....

.....

.....

.....

2.4.5 3D Vector

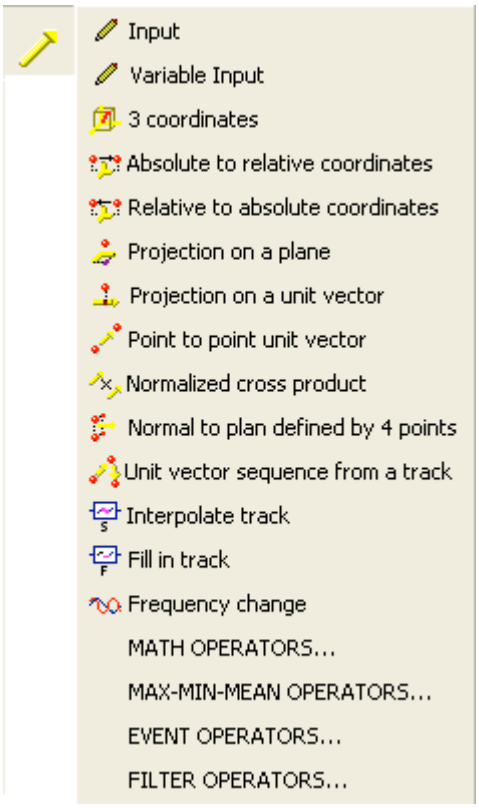


Figure 2.46:

"Point to point unit vector": this operator allows the user to define a 3D vector between two 3D points.

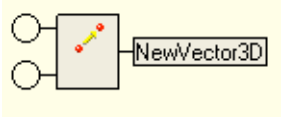


Figure 2.47:

1. In the first round dot the user can insert the starting 3D point.
2. In the second round dot the user can insert the ending 3D point.

The obtained result is a vector that starts from the first point to the second one.

“Normalized cross product”: this operator allows the user to compute the cross product between two vectors.

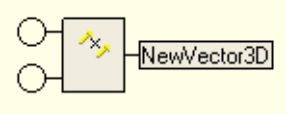


Figure 2.48:

1. In the first round dot the user can insert the first vector.
2. In the second round dot the user can insert the second vector.

Considering markers Mk4, Mk5 and Mk6, let’s start building vectors between Mk4-Mk5 and Mk4-Mk6, using the previous operator.

The cross product between these vectors creates a new vectur perpendicular respect to the plane on which the two builder vectors are (fig.).

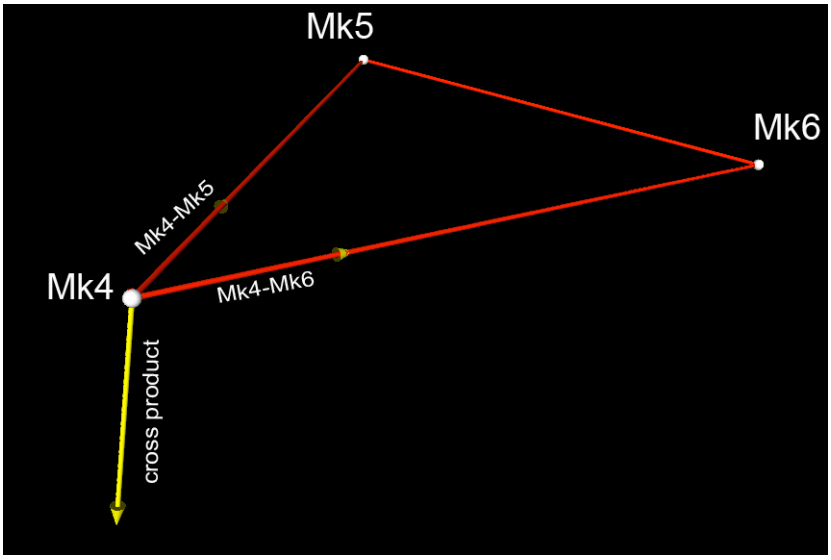


Figure 2.49:

Changing the insertion order, and so changing the order of the product, the vector will be create perpendicular to the others but the direction is the opposite of the one shown in figure.

??????????????????????????????????"Normal to plane defined by 4 points": this operator allows the user to compute the versor normal to a plane defined using 4 points.

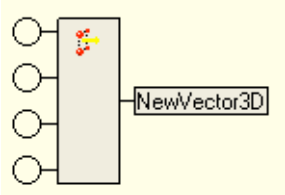


Figure 2.50:

1. In the first, second, third and fourth round dots the user can insert the four 3D points.

"Unit vector sequence from a track": this operator allows the user to create a sequence of unit vector from a 3D point sequence; each unit vector is the normalization of the vector between two successive 3D points of the input sequence.

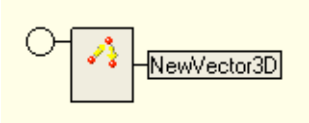


Figure 2.51:

1. In the first round dot the user can insert a 3D points sequence.

In order to create this, steps are listed below:

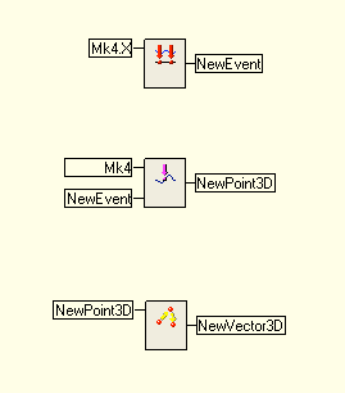


Figure 2.52:

The first step is creating an event sequence, using the "Event" operator.

The second one is to define a 3D point sequence, using "Point 3D" operator –> "event operators" –> "Event defined value", inserting a 3D point and the event sequence, previously defined. In this way, the user will obtain a sequence of 3D points.

Inserting this 3D points sequence in the “Unit vector sequence from a track”, the user will define a sequence of unit vectors that are the normalizaton of vectors between two successive points.

2.4.6 Scalar parameter

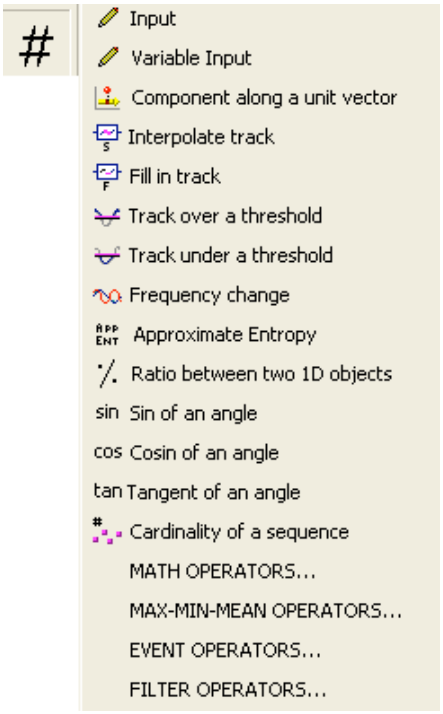


Figure 2.53:

“Component along a unit vector”: this operator allows the user to compute the scalar component of an object along a unit vector.

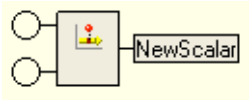


Figure 2.54:

1. In the first round dot the user can insert an object track, that will be projected.

2. In the second round dot the user can insert unit vector on which the object will be projected.

"Approximate entropy": this operator allows the user to compute the approximate entropy of an object track, depending on the user defined time width and reference value.

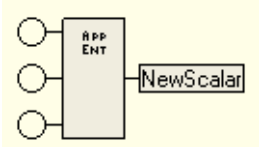


Figure 2.55:

1. .....

2. .....

"Ratio between two 1D objects": this operator allows the user to compute the ratio between two 1D objects.

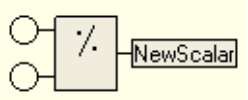


Figure 2.56:

1. In the first round dot the user can insert a 1D object.

2. In the second round dot the user can insert another 1D object.

This operator is really usefull because of for many objects there is not the opportunity to moltiplicate two objects. In order to succeed in, we have to transform one of these objects in a scalar, using the "ratio between two 1D objects" and dividing the object for a unit object, defined using "input" operator of that object.

In this way we can finally use the "product" operator that allows the user to compute a product between a scalar and an object.

"Sin of an angle": this operator allows the user to compute the sin of a 1D angle.

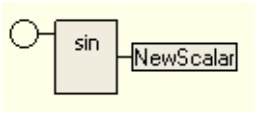


Figure 2.57:

1. In the first round dot the user can insert a 1D angle.

"Cosin of an angle": this operator allows the user to compute the cosin of a 1D angle.

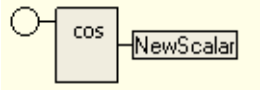


Figure 2.58:

1. In the first round dot the user can insert a 1D angle.

"Tangent of an angle": this operator allows the user to compute the tangent of a 1D angle.

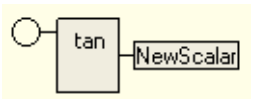


Figure 2.59:

1. In the first round dot the user can insert a 1D angle.

"Cardinality of a sequence": this operator allows the user to define the number of elements of a sequence.

Figure 2.60:

1. In the first round dot the user can insert a 1D point sequence.

2.4.6.1 Math Operators

"Square of a scalar": this operator allows the user to compute the square of a scalar.

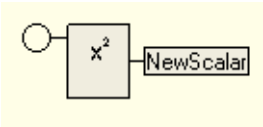


Figure 2.61:

1. In the round dot the user can insert a scalar.

"Square root of a scalar": this operator allows the user to compute the square root of a scalar.

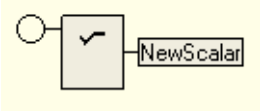


Figure 2.62:

1. In the round dot the user can insert a scalar.

"Scalar raised by a scalar": this operator allows the user to compute a scalar raised by a defined power.

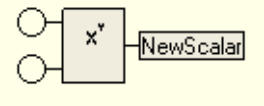


Figure 2.63:

1. In the first round dot the user can insert a scalar that will be raised.
2. In the second round dot the user can insert a scalar, that will be the power.

For the other math operators, the handbook sends the user to the "General math operators" paragraph.

2.4.7 Point 3D

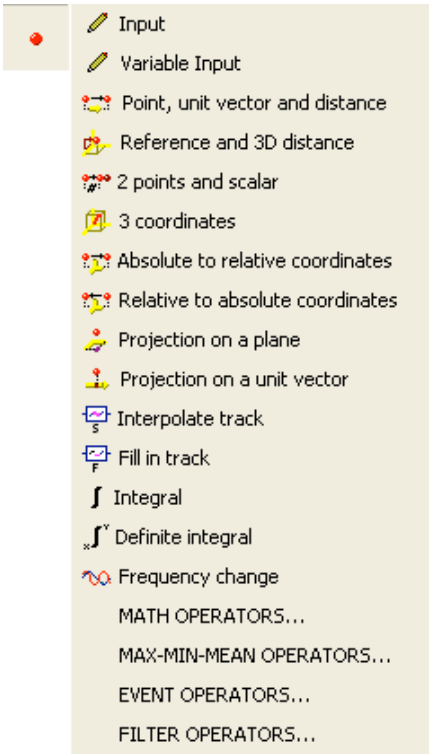


Figure 2.64:

"Point, unit vector and distance": this operator allows the user to define a new 3D point using a 3D point, a 3D vector and a 1D point or distance.

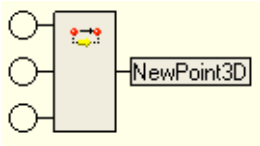


Figure 2.65:

1. In the first round dot the user can insert a 3D point.

2. In the second round dots the user can insert a unit vector.

3. In the third round dot the user can insert a 1D point or distance.

As example, we want to create a new 3D point, and so a so-called virtual marker, on the line between Mk4 and Mk5 and the distance between Mk5 and the new point is set to the distance between Mk5 and Mk6. The steps to obtain the new virtual marker is listed below (fig.):

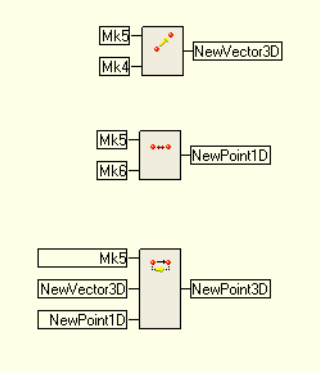


Figure 2.66:

The first step is creating a vector between Mk4 e Mk5 (fig.), in order to define the direction on which the new 3D point will be.

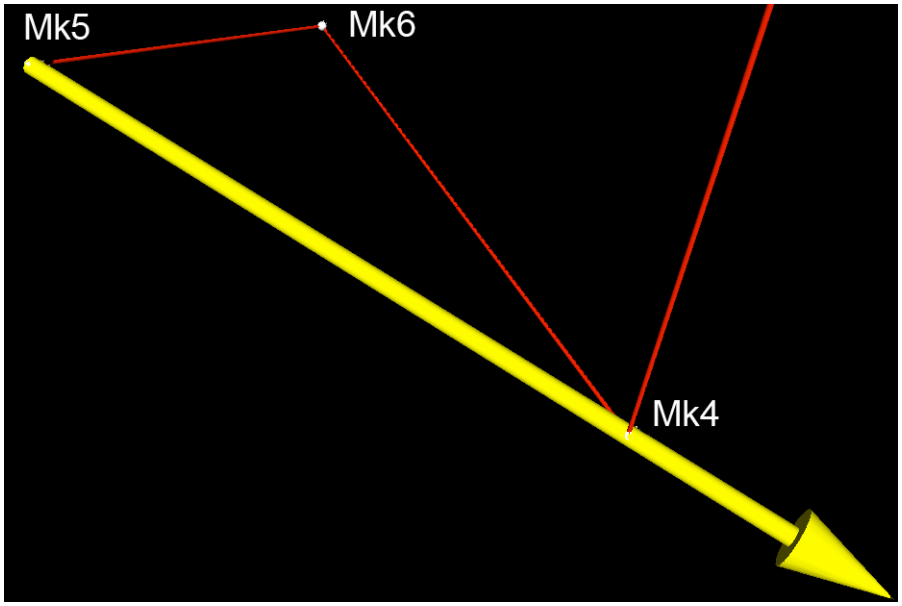


Figure 2.67:

The second step is computing the distance between Mk5 and Mk6, using “Point 1D” operator –> Point to point distance.

The last step defines the new virtual marker as described before (fig.):

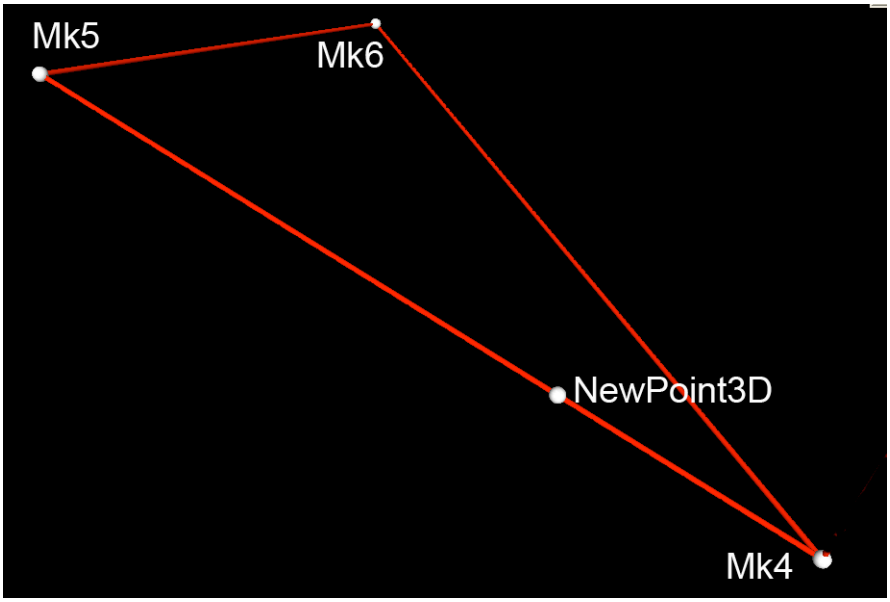


Figure 2.68:

"Reference and 3D distance": this operator allows the user to define a new 3D point using a reference system and three 1D point or distance.

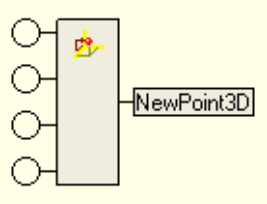


Figure 2.69:

1. In the first round dot the user can insert a reference system.
2. In the second round dot the user can insert a 1D point or distance.
3. In the third round dot the user can insert another 1D point or distance.

4. In the fourth round dot the user can insert another 1D point or distance.

Considering the lab reference system, we want to define a "virtual marker" which coordinates are the same of Mk5 in term of X and Y, instead the Z is the Z coordinate of Mk6.

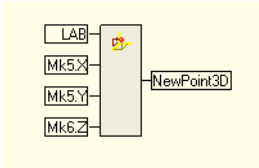


Figure 2.70:

The new 3D point will be displaced as shown in figure, as you can see the NewPoint3D has the same X and Y coordinates of Mk5, but the same Z coordinate of Mk6.

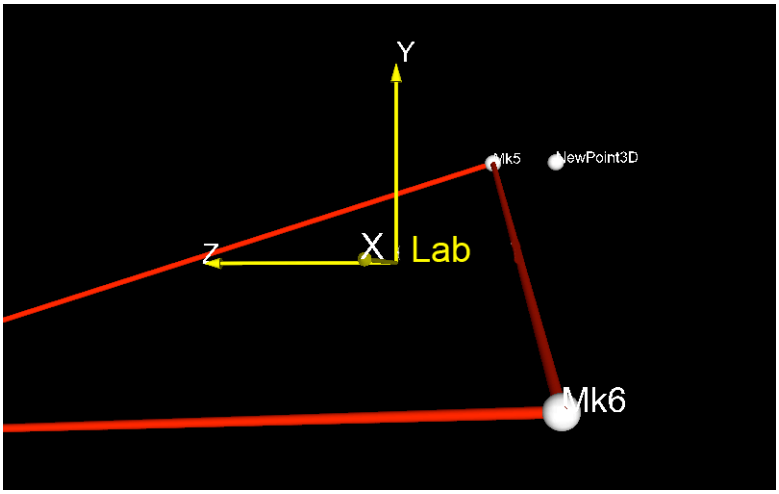


Figure 2.71:

"Reference and 3D distance": this operator allows the user to define a new 3D point using a two 3D points and a scalar.

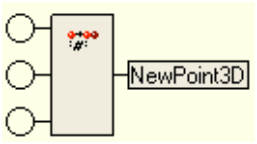


Figure 2.72:

1. In the first round dot the user can insert a 3D point.
2. In the second round dot the user can insert another 3D point.
3. In the third round dot the user can insert a scalar.

Here an example: we want to define a new 3D point on the line between Mk5 and Mk6 at 0.25 from Mk5.

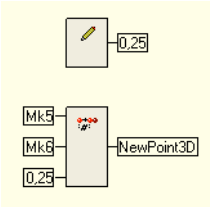


Figure 2.73:

The creating 3D point will be displaced in the way reported in figure.

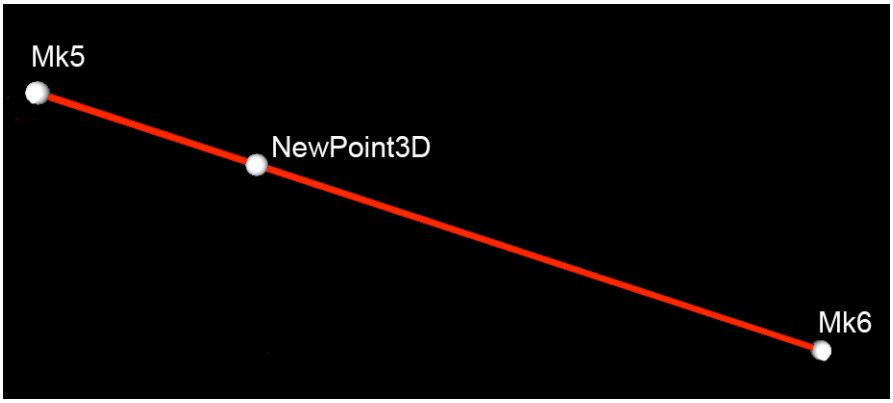


Figure 2.74:

2.4.8 Point 1D

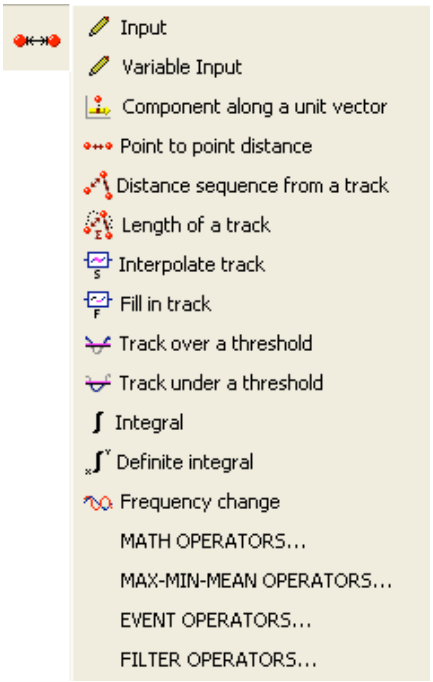


Figure 2.75:

"Point to point distance": this operator allows the user to compute a 1D distance between two 3D points.

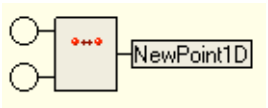


Figure 2.76:

1. In the first round dot the user can insert a 3D point.

2. In the second round dot the user can insert another 3D point.

"Distance sequence from a track": this operator allows the user to compute distance between two successive 3D points of a sequence.

Figure 2.77:

1. In the first round dot the user can insert a 3D point sequence.

As example, the user has to compute the spatial distance between the values assumed by Mk5 in two different event time. The steps to compute this distance are the following, shown in figure:

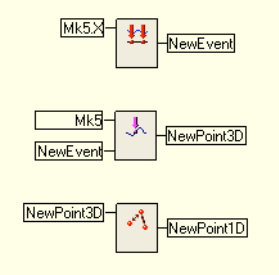


Figure 2.78:

"Length of a track": this operator allows the user to compute the total length of the trajectory of a 3D track.

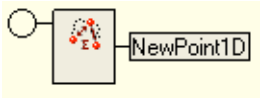


Figure 2.79:

1. In the first round dot the user can insert a 3D track.

2.4.9 3D velocity

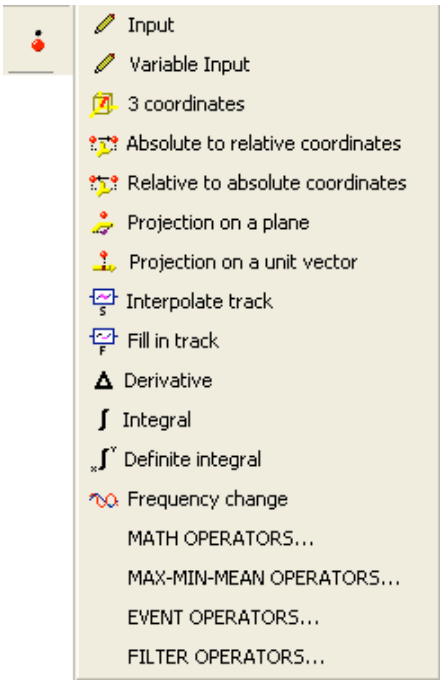


Figure 2.80:

Since some operators are common for some tools, the handbook send the user to the paragraph “General Operator Tool”.

2.4.10 1D velocity

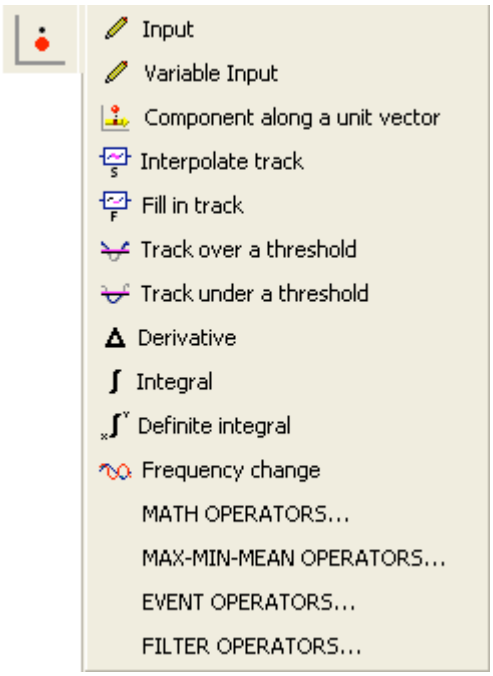


Figure 2.81:

Since some operators are common for some tools, the handbook send the user to the paragraph “General Operator Tool”.

2.4.11 3D acceleration

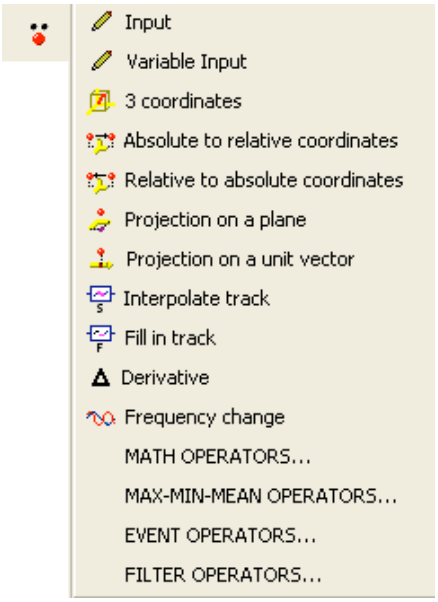


Figure 2.82:

Since some operators are common for some tools, the handbook send the user to the paragraph “General Operator Tool”.

2.4.12 1D acceleration

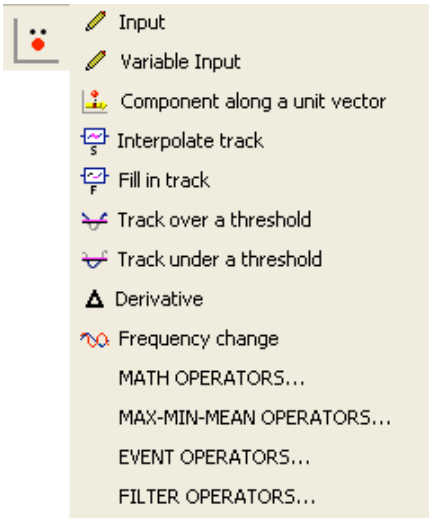


Figure 2.83:

Since some operators are common for some tools, the handbook send the user to the paragraph “General Operator Tool”.

2.4.13 3D angle

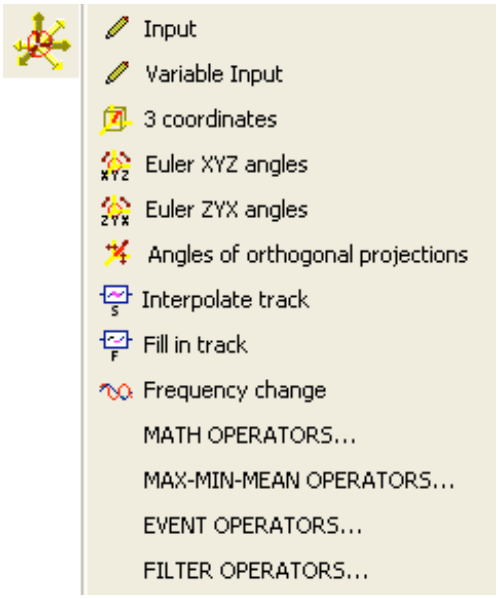


Figure 2.84:

"Euler XYZ angles": this operator allows the user to define Euler angles between 2 references in XYZ order.

Figure 2.85:

1. In the first round dot the user can insert a reference.
2. In the second round dot the user can insert another reference.

This computation returns a 3D angle which values are the Euler XYZ angles between two reference system, that is the needing angles to rotate one reference to obtain the other one.

"Euler ZYX angles": this operator allows the user to define Euler angles between 2 references in ZYX order.

Figure 2.86:

1. In the first round dot the user can insert a reference.
2. In the second round dot the user can insert another reference.

This computation returns a 3D angle which values are the Euler ZYX angles between two reference system, that is the needing angles to rotate one reference to obtain the other one.

"Angles of orthogonal projections": this operator allows the user to compute the three angles that a projected 3D vector produces on a reference system. The output will range from 0 to 360 degrees.

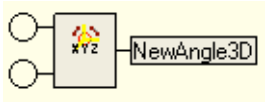


Figure 2.87:

1. In the first round dot the user can insert a 3D vector.
2. In the second round dot the user can insert a reference.

This computation returns a 3D angle which values are the values of the angles between the projections of the 3D vector on the reference and the unit vectors of the reference.

2.4.14 1D angle

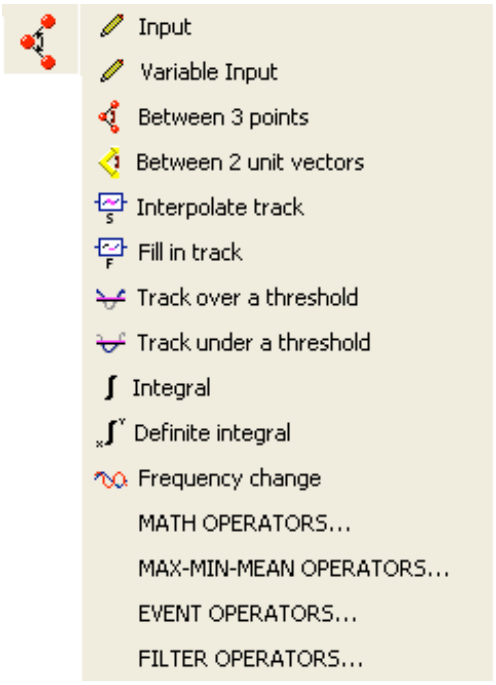


Figure 2.88:

"Between 3 points": this operator allows the user to define a 1D angle between three 3D points.

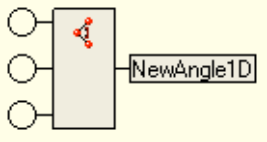


Figure 2.89:

1. In the first round dot the user can insert a 3D point.
2. In the second round dot the user can insert a 3D point, that will be the vertex of the angle

3. In the third round dot the user can insert another 3D point.

"Between 2 vectors": this operator allows the user to define a 1D angle between 2 vectors.

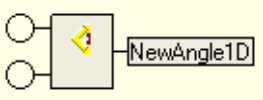


Figure 2.90:

1. In the first round dot the user can insert a 3D vector.
2. In the third round dot the user can insert another 3D vector.

2.4.15 3D Angular velocity

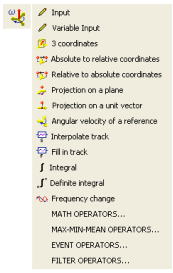


Figure 2.91:

"Angular velocity of a reference": this operator allows the user to define the 3D angular velocity of a reference.

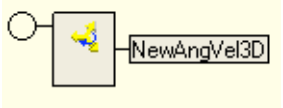


Figure 2.92:

1. In the first round dot the user can insert a reference.

2.4.16 Angular velocity

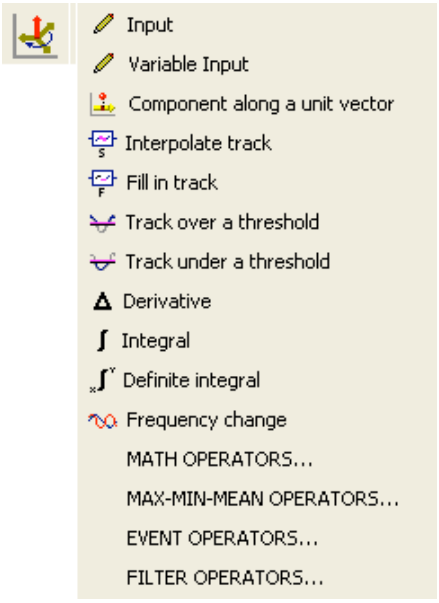


Figure 2.93:

Since some operators are common for some tools, the handbook sends the user to the paragraph “General Operator Tool”.

2.4.17 3D Angular acceleration

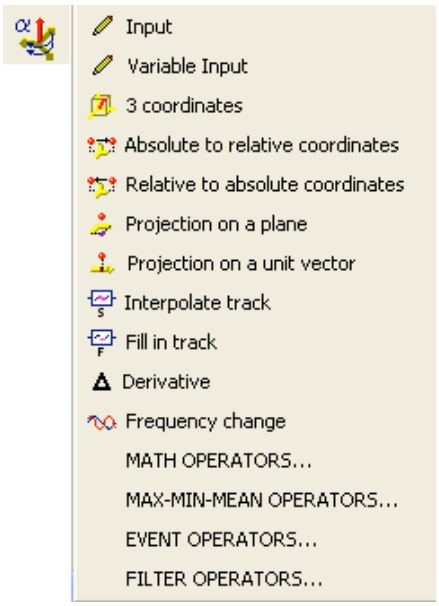


Figure 2.94:

Since some operators are common for some tools, the handbook send the user to the paragraph “General Operator Tool”.

2.4.18 Angular acceleration

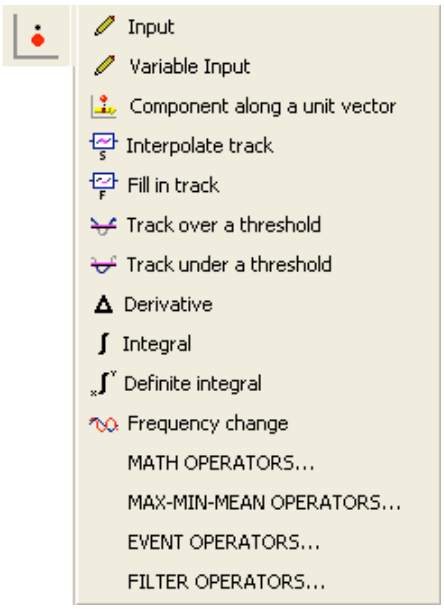


Figure 2.95:

Since some operators are common for some tools, the handbook send the user to the paragraph “General Operator Tool”.

For the “Math Operators”, the handbook has a special section named in that way.

2.4.19 3D force

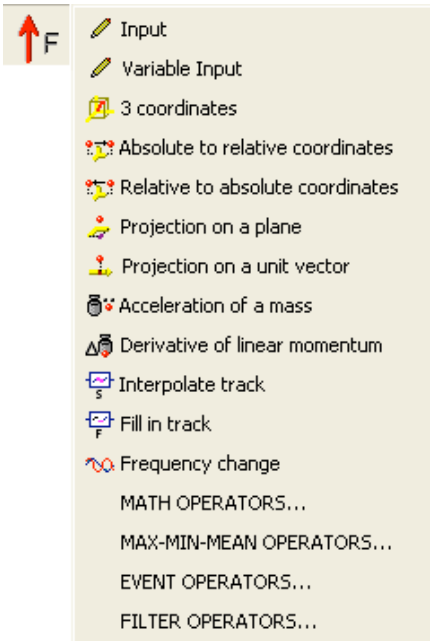


Figure 2.96:

"Acceleration of a mass": this operator allows the user to create a new 3D force from a 3D acceleration and a mass; the result is the force that if applied to the input mass produces the input acceleration.

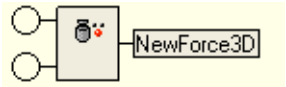


Figure 2.97:

1. In the first round dot the user can insert a 3D acceleration of the point to which the force is applied.

2. In the third round dot the user can insert the mass of the application point.

"Derivetive of linear momentum": this operator allows the user to create a new 3D force from a 3D point and a mass; the result is the force that if applied to the input mass produces the input point track.

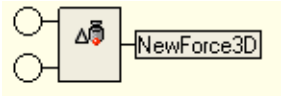


Figure 2.98:

1. In the first round dot the user can insert a 3D point to which the force is applied.
2. In the third round dot the user can insert the mass of the application point.

2.4.20 1D force

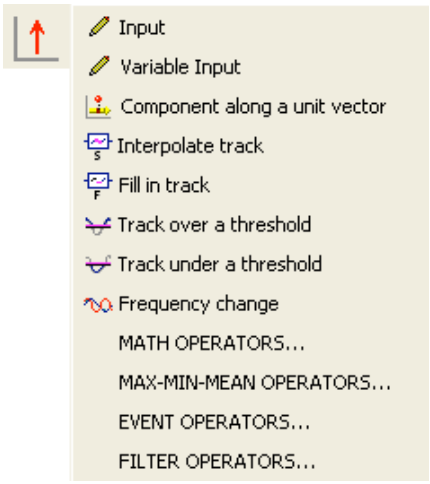


Figure 2.99:

Since some operators are common for some tools, the handbook send the user to the paragraph "General Operator Tool".

For the “Math Operators”, “Event Operators” and “Filter Operators”, the handbook has a special section named in that way.

2.4.21 3D torque

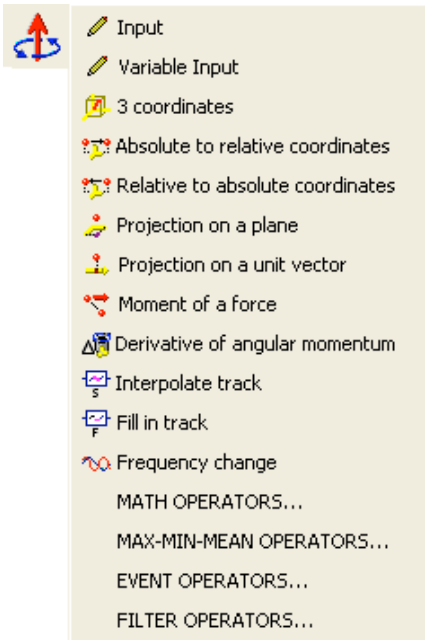


Figure 2.100:

“Moment of a force”: this operator allows the user to create a momentum of a force with respect to a point.

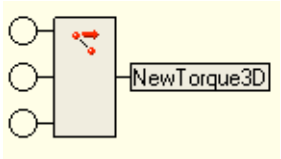


Figure 2.101:

1. In the first round dot the user can insert a 3D force.

2. In the second round dot the user can insert a 3D point that is the application point.

3. In the third round dot the user can insert a 3D point that makes the momentum arm together with the previous 3D point.

Derivative of angular momentum": this operator allows the user to create a new 3D torque from a 3D acceleration and a mass; the result is the torque that if applied to an object with the input moment of inertia produces the input reference system track.

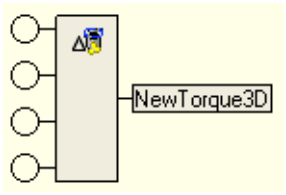


Figure 2.102:

1. In the first round dot the user can insert the reference system attached to the rotating mass.

2. In the second round dot the user can insert the X component of the moment of inertia to which the torque is applied third input.

3. In the third round dot the user can insert the Y component of the moment of inertia to which the torque is applied.

4. In the fourth round dot the user can insert the Z component of the moment of inertia to which the torque is applied.

2.4.22 1D torque

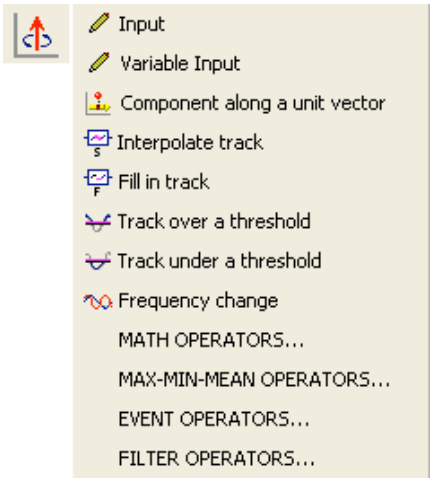


Figure 2.103:

Since some operators are common for some tools, the handbook send the user to the paragraph “General Operator Tool”.

For the “Math Operators”, “Event Operators” and “Filter Operators”, the handbook has a special section named in that way.

2.4.23 Time

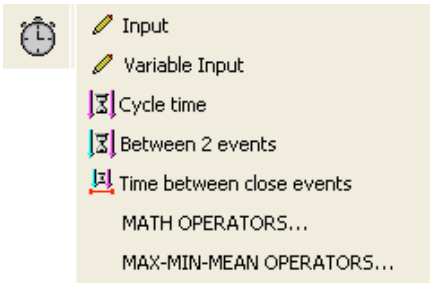


Figure 2.104:

"Cycle time": this operator allows the user to create a sequence of times from a sequence of events; each time being the time between two successive events of the input sequence.

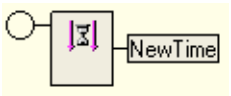


Figure 2.105:

1. In the first round dot the user can insert an event sequence that determines the sequence of times.

"Between 2 events": this operator allows the user to create a sequence of times from a sequence of events; each time being the time between an event of the first event sequence and an event of the second event sequence.

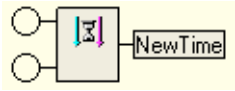


Figure 2.106:

1. In the first round dot the user can insert an event sequence that determines the starting points of the sequence of times.
2. In the second round dot the user can insert an event sequence that determines the ending points of the sequence of times.

"Time between close events": this operator allows the user to create a sequence of times between two sequences of events within a limited interval.

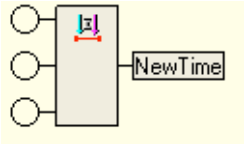


Figure 2.107:

1. In the first round dot the user can insert an event sequence that determines the starting points of the sequence of times.

2. In the second round dot the user can insert an event sequence that determines the ending points of the sequence of times.

3. In the third round dot the user can insert a sequence of time.

2.4.24 Frequency

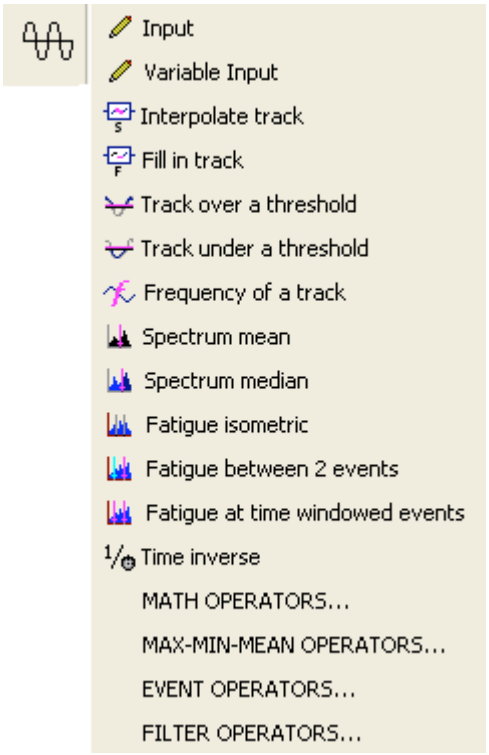


Figure 2.108:

"Frequency of a track": this operator allows the user to compute a frequency of an input track.

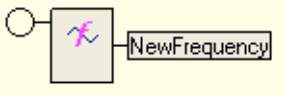


Figure 2.109:

1. In the round dot the user can insert the track whose frequency is extracted.

"Spectrum mean": this operator allows the user to create a sequence of times from a sequence of events; each time being the time between an event of the first event sequence and an event of the second event sequence.

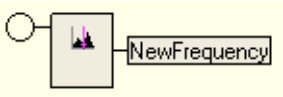


Figure 2.110:

1. In the first round dot the user can insert an event sequence that determines the starting points of the sequence of times.
2. In the second round dot the user can insert an event sequence that determines the ending points of the sequence of times.

"Spectrum median": this operator allows the user to create a sequence of times between two sequences of events within a limited interval.

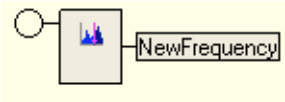


Figure 2.111:

1. In the first round dot the user can insert an event sequence that determines the starting points of the sequence of times.

2. In the second round dot the user can insert an event sequence that determines the ending points of the sequence of times.

3. In the third round dot the user can insert a sequence of time.

"Fatigue isometric": this operator allows the user to create a sequence of times between two sequences of events within a limited interval.

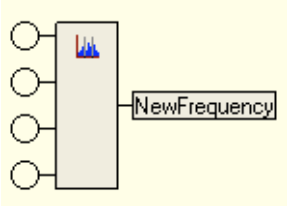


Figure 2.112:

1. In the first round dot the user can insert an event sequence that determines the starting points of the sequence of times.

2. In the second round dot the user can insert an event sequence that determines the ending points of the sequence of times.

3. In the third round dot the user can insert a sequence of time.

"Fatigue between 2 events": this operator allows the user to create a sequence of times between two sequences of events within a limited interval.

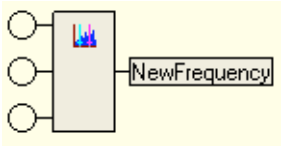


Figure 2.113:

1. In the first round dot the user can insert an event sequence that determines the starting points of the sequence of times.
2. In the second round dot the user can insert an event sequence that determines the ending points of the sequence of times.
3. In the third round dot the user can insert a sequence of time.

"Fatigue at time windowed events": this operator allows the user to create a sequence of times between two sequences of events within a limited interval.

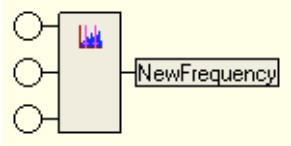


Figure 2.114:

1. In the first round dot the user can insert an event sequence that determines the starting points of the sequence of times.
2. In the second round dot the user can insert an event sequence that determines the ending points of the sequence of times.
3. In the third round dot the user can insert a sequence of time.

"Time inverse": this operator allows the user to compute a frequency as an input time inverse.

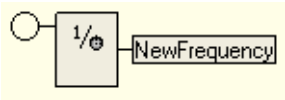


Figure 2.115:

1. In the round dot the user can insert a time that is the inverse of the frequency.

2.4.25 Mass

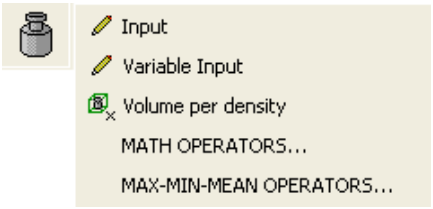


Figure 2.116:

"Volume per density": this operator allows the user to compute a mass as the product of the input volume and the input mass density.

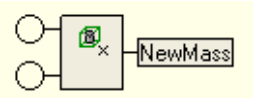


Figure 2.117:

1. In the first round dot the user can insert a volume.
2. In the second round dot the user can insert the mass density.

2.4.26 Moment of inertia

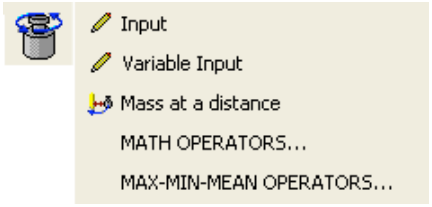


Figure 2.118:

"Mass at a distance": this operator allows the user to compute the momentum of inertia of a mass at a given distance from the rotation axes.

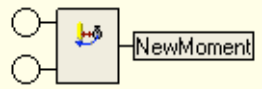


Figure 2.119:

1. In the first round dot the user can a mass, supposed concentrated in one point .

2. In the second round dot the user can insert a distance between the mass and the rotation axes.

2.4.27 Volume

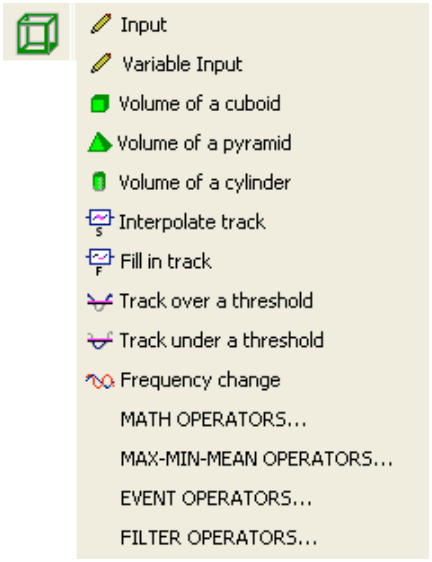


Figure 2.120:

“Volume of a cuboid”: this operator allows the user to compute the volume of a cuboid.

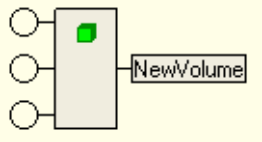


Figure 2.121:

1. In the first round dot the user can insert a distance, that is the height of the cuboid.
2. In the second round dot the user can insert a distance, that is the width of the cuboid.
3. In the third round dot the user can insert a a distance, that is the depth of the cuboid.

“Volume of a pyramid”: this operator allows the user to compute the volume of a pyramid.

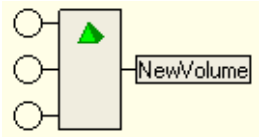


Figure 2.122:

1. In the first round dot the user can insert a distance, that is the height of the pyramid.
2. In the second round dot the user can insert a distance, that is the width of the pyramid.
3. In the third round dot the user can insert a a distance, that is the depth of the pyramid.

"Volume of a cylinder": this operator allows the user to compute the volume of a cylinder.

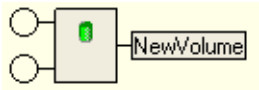


Figure 2.123:

1. In the first round dot the user can insert a distance, that is the height of the cylinder.
2. In the second round dot the user can insert a distance, that is the radius of the cylinder.

2.4.28 Density

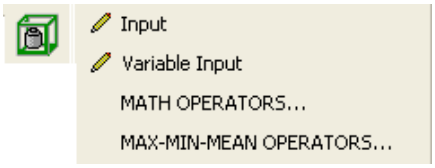


Figure 2.124:

Since some operators are common for some tools, the handbook send the user to the paragraph "General Operator Tool".

For the "Math Operators", "Event Operators" and "Filter Operators", the handbook has a special section named in that way.

2.4.29 Analog signal

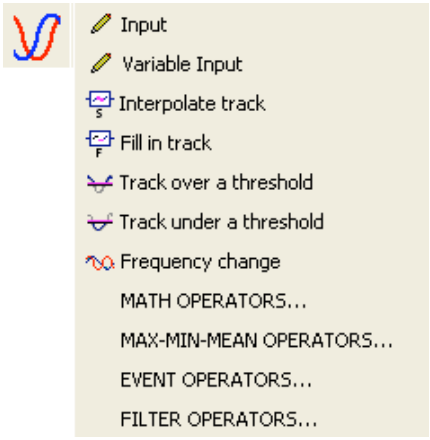


Figure 2.125:

Since some operators are common for some tools, the handbook send the user to the paragraph “General Operator Tool”.

For the “Math Operators”, “Event Operators” and “Filter Operators”, the handbook has a special section named in that way.

2.4.30 Electromyographic signal

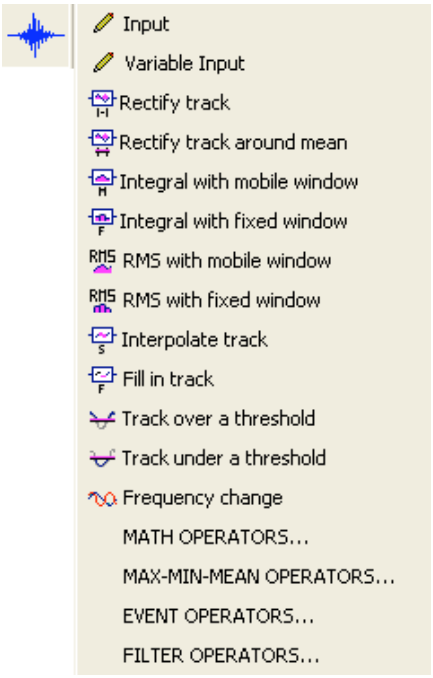


Figure 2.126:

"Rectify track": this operator allows the user to compute a new track in which each value of the output EMG signal is the absolute of the corresponding value in the input EMG signal.

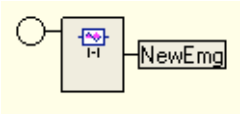


Figure 2.127:

1. In the first round dot the user can insert a EMG signal to be rectified.

"Rectify track around a mean": this operator allows the user to compute a new track in which each value of the output signal is the absolute of the corresponding value in the input signal minus the input signal mean.

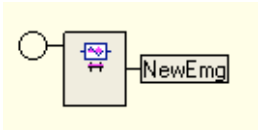


Figure 2.128:

1. In the first round dot the user can insert a EMG signal to be rectified around a mean

"Integral with mobile window": this operator allows the user to .....

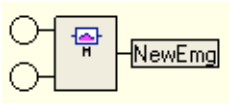


Figure 2.129:

1. .....
2. .....

"Integral with fixed window": this operator allows the user to .....

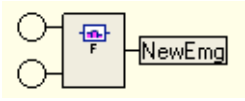


Figure 2.130:

1. .....

2. .....

“RMS with mobile window”: this operator allows the user to .....

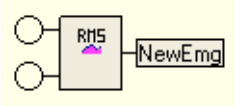


Figure 2.131:

1. .....

2. .....

“RMS with fixed window”: this operator allows the user to .....

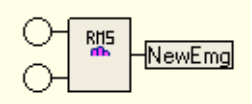


Figure 2.132:

1. .....

2. .....

2.4.31 Spectral signal

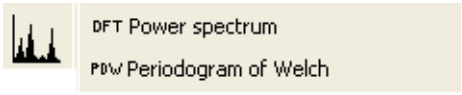


Figure 2.133:

“Power spectrum”: this operator allows the user to definethe DFT spectrum of an analog signal.....

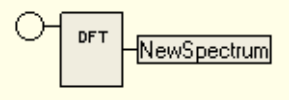


Figure 2.134:

1. In the first round dot the user can insert a value of the analog signal (for example EMG signal).

"Periodogram of Welch": this operator allows the user to .....

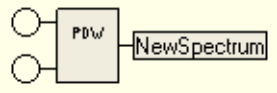


Figure 2.135:

1. In the first round dot the user can insert a value of the analog signal (for example EMG signal).
2. In the second round dot the user can insert a time.

2.4.32 Work

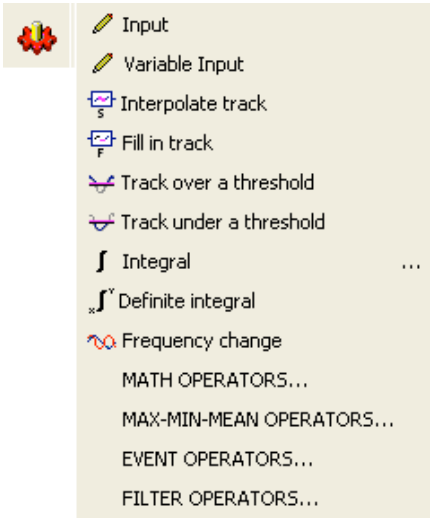


Figure 2.136:

Since some operators are common for some tools, the handbook send the user to the paragraph “General Operator Tool”.

For the “Math Operators”, “Event Operators” and “Filter Operators”, the handbook has a special section named in that way.

2.4.33 Picture

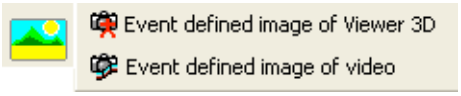


Figure 2.137:

“Event defined image of viewer 3D”: this operator allows the user to create a sequence of images taken from a viewer 3D (the user can adjust the viewpoint for each image). The instants correspond to the input event sequence. A single event produces a single image.

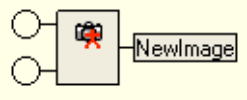


Figure 2.138:

1. In the first round dot the user can insert the images that are taken from it's Viewer 3D.
2. In the second round dot the user can insert an event sequence that is the instants of the image taken.

"Event defined image of viewer 3D": this operator allows the user to create a sequence of images taken from a Video. The instants correspond to the input event sequence. A single event produces a single image.

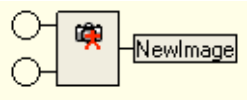


Figure 2.139:

1. In the first round dot the user can insert from which the images are taken.
2. In the second round dot the user can insert an event sequence that is the instants of the image taken.

2.4.34 Power

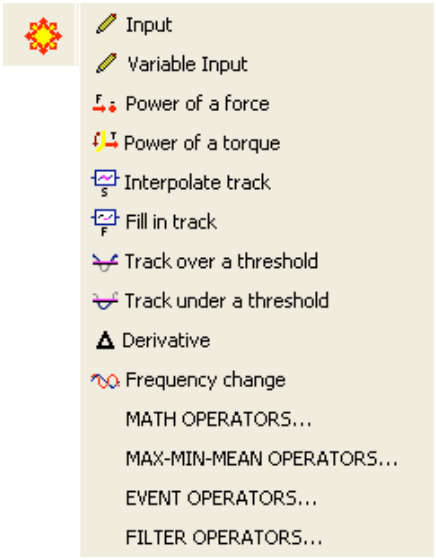


Figure 2.140:

"Power of a force": this operator allows the user to compute the power of a force.

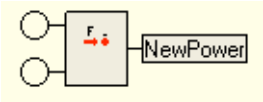


Figure 2.141:

1. In the first round dot the user can insert a force, whose power will be computed.
2. In the second round dot the user can insert a 3D velocity, the velocity of the point to which the force is applied

"Power of a torque": this operator allows the user to compute the power of a torque.

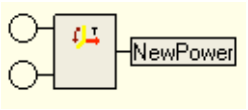


Figure 2.142:

1. In the first round dot the user can insert a torque, whose power will be computed.

2. In the second round dot the user can insert an angular velocity, the angular velocity of the reference system to which the torque is attached

2.4.35 Text

Figure 2.143:

Since some operators are common for some tools, the handbook send the user to the paragraph “General Operator Tool”.

For the “Math Operators”, “Event Operators” and “Filter Operators”, the handbook has a special section named in that way.

2.5 General operator tools

In the following, the handbbok presents the operators that are in common for some tools. The rule is the same showed before: the meaning of the operator is the same but the user has to keep in mind that the result answer to the question “What do I want to obtain?”.

2.5.1 Input

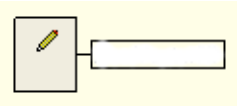


Figure 2.144:

With this operator the user can define values of an object like a vector, a scalar and so on and then this object is stored as a constant.

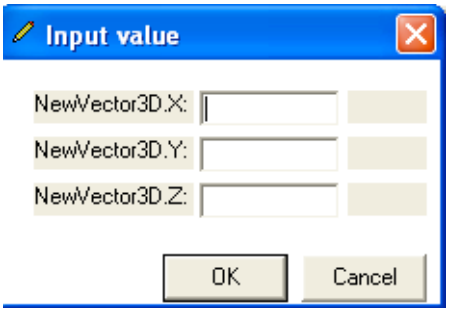


Figure 2.145:

Values defining the object are manually entered by the user at creation time (Fig.).

2.5.2 Variable input

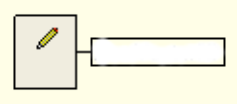


Figure 2.146:

With this operator the user can define values of an object like a vector, a scalar and so on and then, once the protocol was saved and reused, the software asks the user to insert the values.

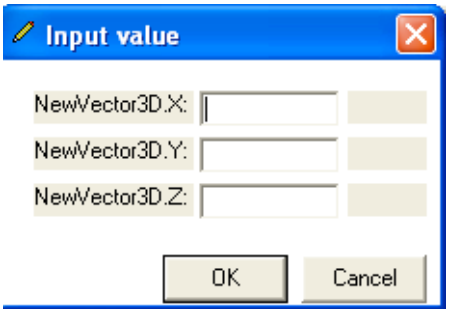


Figure 2.147:

Values defining the object are manually entered by the user every time the user applied the protocol (Fig.).

2.5.3 3 coordinates

This operator allows the user to define a 3D object using 3 coordinates respect to the absolute reference system.

Figure 2.148:

1. In the round dot the user can insert the X, Y and Z values of the new vector.

2.5.4 Absolute to relative coordinates

This operator allows the user to change the reference system, from relative to absolute coordinates, of a vector.

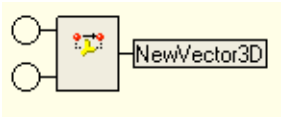


Figure 2.149:

1. In the first round dot the user can insert the 3D vector.

2. In the second round dot the user can insert the new reference system.

It is very important to know that once loading the trial the user wants to analyze all the objects are referred to the lab reference system.

This operator allows the user to refer a 3D objetc to another reference system, creating by the user inside the protocol.

This is particular useful in some situations: for example, if the user wants to study and analyze the movement of a plane respect to another plane (like in gait analysis, the movement of the thigh referred to the movement of the pelvis for example), he can create a new reference system according to the movement and then analyze all the objects referring them to this reference.

Thinking to the movement of the plane Mk4-Mk5-Mk6, we want to analyze this movement respect to plane Mk1-Mk2-Mk3, i.e. considering this plane as steady.

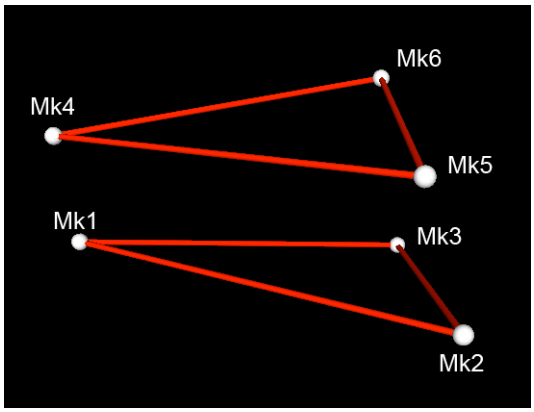


Figure 2.150:

As said before, once the user loads the trial in SmartAnalyzer, all the measures are referred to lab reference: we have to create a new reference system according to plane Mk1-Mk2-Mk3, obviously in this system the movement of these three markers is described by three constants.

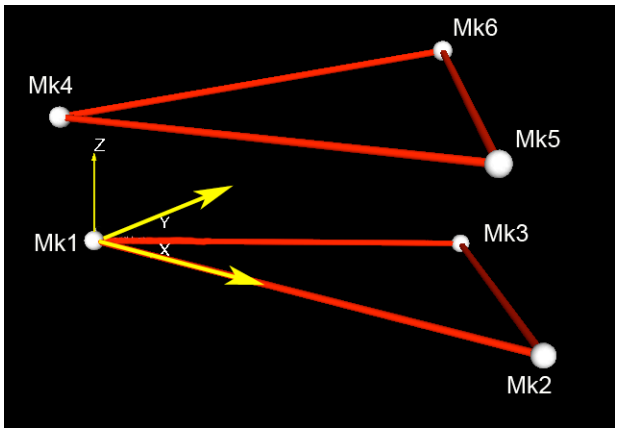


Figure 2.151:

At this point we have all the elements to use the changing operator. Putting this reference and for example Mk4 in the operator, we obtain the coordinates of this point referred to the just created reference system, as you can see in figure, plotting on the same graph Mk4 (in red) and the “transformed” Mk4 (in green).

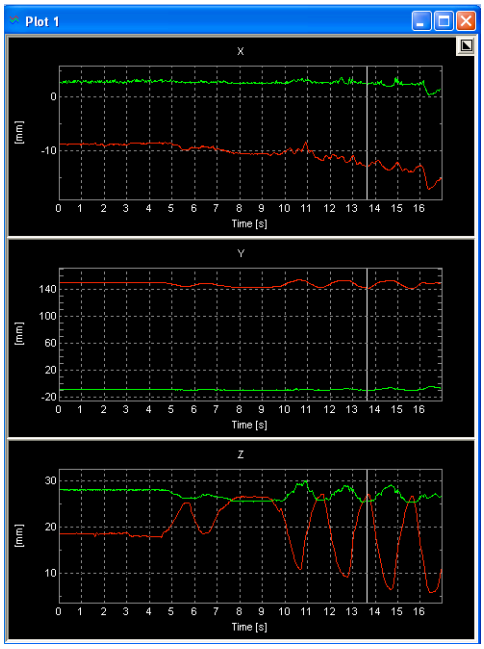


Figure 2.152:

The results of the analysis is not different using one reference or the other one, but in some situation it's easier referring all the computation to a relative reference system, avoiding errors. It is something like "changing the point of view".

2.5.5 Relative to absolute coordinates

This operator allows the user to change the reference system, from relative to absolute coordinates, of 3D object.

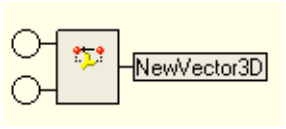


Figure 2.153:

1. In the first round dot the user can insert the 3D vector.

2. In the second round dot the user can insert the new reference system.

This operator allows the user to compute the inverse operation previously exposed. For example, after the analysis made using the relative reference system in order to simplfy the computation, the user could be asked to return a result in absolute coordinates.

2.5.6 Projection on a plane

This operator allows the user to project a 3D object on a plane.

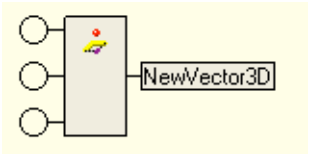


Figure 2.154:

1. In the first round dot the user can insert the 3D object.
2. In the second round dot the user can insert a versor of the plane.
3. In the third round dot the user can insert another versor of the plane.

Let's see an example. We want to project Mk5 on the plane defined by versors i and j of lab reference. The result is a new 3D point that moves on that plane. In this example, since i and j are lab reference versors and remembering that all the objects are referred to absolute (lab) reference, it means obtaining the same point (Mk5) without moving in z direction.

The following figure shows the coordinates of Mk5 (in green) and of its projection (in red) as said before:

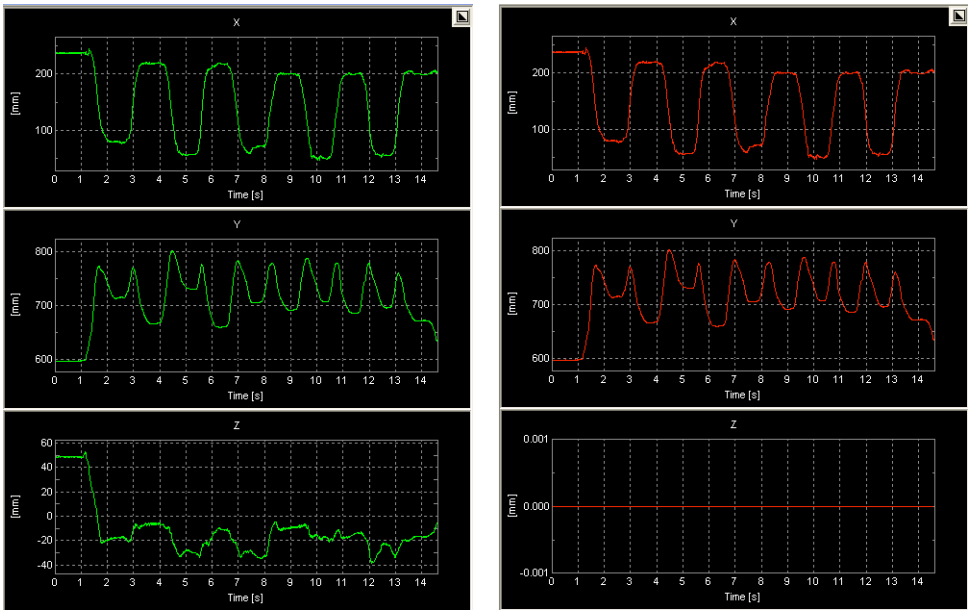


Figure 2.155:

2.5.7 Projection on a unit vector

This operator allows the user to project a 3D vector on a unit vector.

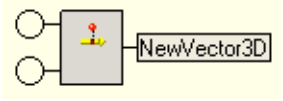


Figure 2.156:

1. In the first round dot the user can insert the 3D object.
2. In the second round dot the user can insert the vector on which the user wants to project the 3D vector.

Projecting for example Mk5 on i versor, i.e. on one of the versor that defines lab reference, in particular x direction, we obtained a new 3D point with y and z coordinates 0.

It means this operator returns the component of the 3D object on that versor.

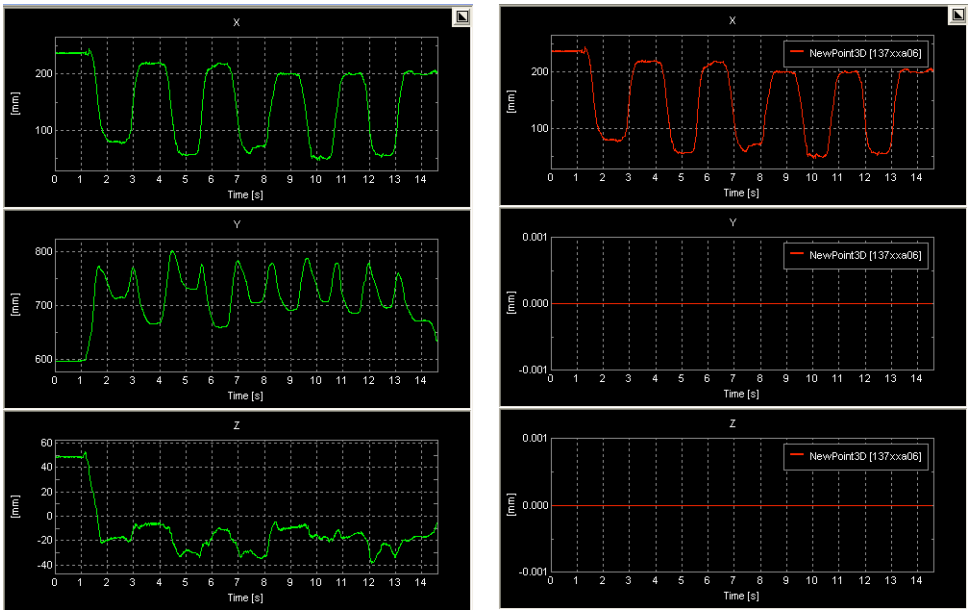


Figure 2.157:

2.5.8 Component along a unit vector

This operator allows the user to compute a component of an object along a unit vector.

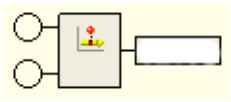


Figure 2.158:

1. In the first round dot the user can insert the 3D object.
2. In the second round dot the user can insert the vector on which the user wants to project the 3D object.

As the previous operator, this one returns the component along a versor for a 1D object.

2.5.9 Interpolate track

This operator allows the user to interpolate a signal using cubic spline curves; the signal is the input object track.

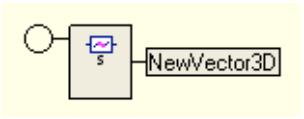


Figure 2.159:

1. In the first round dot the user can insert an object track, the signal to be interpolated.

this operator is particularly useful when the signal the user want to analyze, or to insert as a variable in the protocol, is not continuos. This operator uses a cubic spline curves in order to recreate the continuos original signal.

It is important to start a protocol using this operator (or the other interpolation operators) for all the signale we want to use, in order to avoid signal missing values that will not permit to conclude the analysis.

In the following an example of interpolation using this operator. Focusing our attention on x coordinate of a 3D point, we can observe (fig.) some signal missing values zooming on that zone (ctrl+left click).

??

'??

2.5.10 Fill in track

This operator allows the user to interpolate a signal filling it's missing values with an input value; the signal is the input object track.

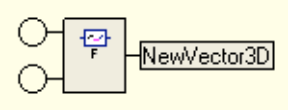


Figure 2.160:

1. In the first round dot the user can insert an object track, the signal to be interpolated.

2. .....

2.5.11 Frequency change

This operator allows the user to create a new object track which will be the input object track, with the frequency changed by the input entered frequency. The frequency translation is done via subsampling/oversampling, according to whether if the output track has a frequency lower/higher than the original track.

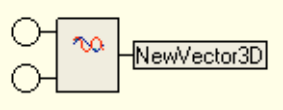


Figure 2.161:

1. In the first round dot the user can insert an object track, whose frequency will be changed.

2. In the second round dot the user can insert a frequency, defined using the tool “Frequency”, showed in the following.

Figure in the following shows the input track (in red) and the track changed using an input frequency (in green).

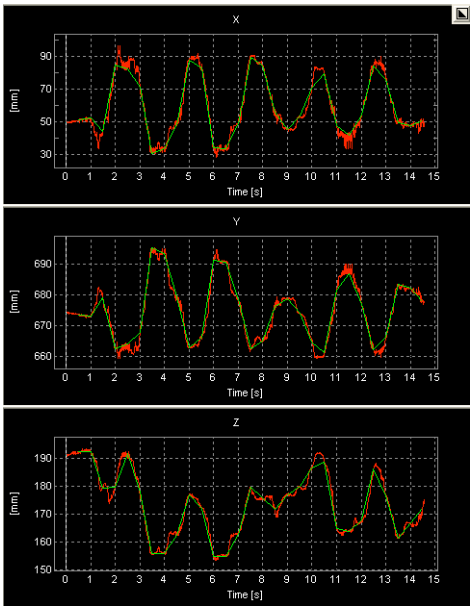


Figure 2.162:

2.5.12 Integral

This operator allows the user to create a new object as the integral with respect to time of the input object.

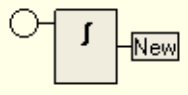


Figure 2.163:

1. In the round dot the user can insert the variable to be integrated.

2.5.13 Definite integral

This operator allows the user to create a new object as the definite integral with respect to time of the input object; the starting and ending points are the input events

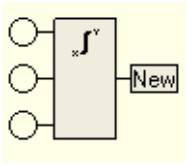


Figure 2.164:

1. In the first round dot the user can insert the variable to be differentiated
2. In the second round dot the user can insert an event or an event sequence, that is the beginning of the integration
3. In the third round dot the user can insert an event or an event sequence, that is the end of the integration .

2.5.14 Track over a threshold

This operator allows the user to define the portion of a track that is over a user defined threshold, using the “input” operator.

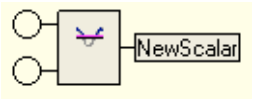


Figure 2.165:

1. In the first round dot the user can insert an object track.
2. In the second round dot the user can insert the value of the threshold.

For example, considering the “x” coordinate of a marker, the user wants to analyze the track of this 1D point over a defined threshold.

Next figure shows the original track in red and the obtained one, in green, using a threshold set at 150 mm.

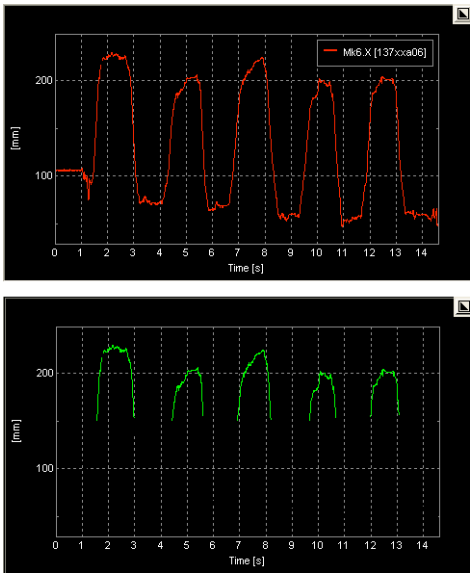


Figure 2.166:

2.5.15 Track under a threshold

This operator allows the user to define the portion of a track that is under a user defined threshold, using the “input” operator.

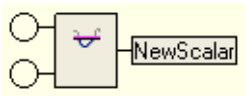


Figure 2.167:

1. In the first round dot the user can insert an object track.
2. In the second round dot the user can insert the value of the threshold.

2.6 General math operators

2.6.1 Sum of 2 objects

This operator allows the user to compute the sum of two objects.

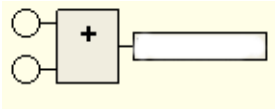


Figure 2.168:

1. In the first round dot the user can insert an object.
2. In the second round dot the user can insert another object.

2.6.2 Difference of 2 objects

This operator allows the user to compute the difference of two objects.

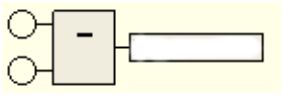


Figure 2.169:

1. In the first round dot the user can insert an object.
2. In the second round dot the user can insert another object.

2.6.3 Multiple of an object

This operator allows the user to compute the product between an object and a scalar.

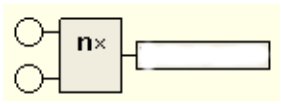


Figure 2.170:

1. In the first round dot the user can insert an object.
2. In the second round dot the user can insert a scalar.

2.6.4 Object multiplicated by a 3D vector

This operator allows the user to compute the product between an objects and a 3D vector.

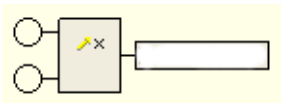


Figure 2.171:

1. In the first round dot the user can insert an object track.
2. In the second round dot the user can insert a 3D vector.

2.6.5 Object divided by a scalar

This operator allows the user to compute the ratio between an object and a scalar.

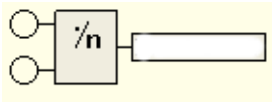


Figure 2.172:

1. In the first round dot the user can insert an object track.
2. In the second round dot the user can insert a scalar.

2.6.6 Object divided by a 3D vector

This operator allows the user to compute the ratio between an object and a 3D vector.

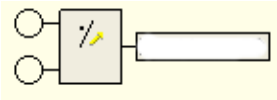


Figure 2.173:

1. In the first round dot the user can insert an object track.
2. In the second round dot the user can insert a 3D vector.

2.7 Max-Min-Mean operators

2.7.1 Temporal mean

This operator allows the user to compute compute the average value of an object track.

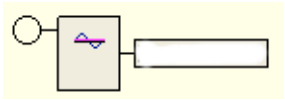


Figure 2.174:

1. In the first round dot the user can insert an object track, whose arithmetic mean is calculated

2.7.2 Temporal max

This operator allows the user to compute the max value of an object track.

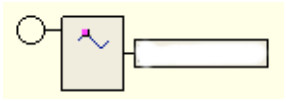


Figure 2.175:

1. In the first round dot the user can insert an object track, whose max is calculated

2.7.3 Temporal min

This operator allows the user to compute the min value of an object track.

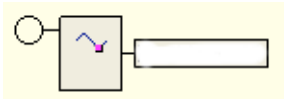


Figure 2.176:

1. In the first round dot the user can insert an object track, whose min is calculated

2.7.4 Cycle mean

This operator allows the user to compute a sequence of mean: the mean values of each cycle in a cycle sequence; the cycle sequence is created from an object track and an event sequence

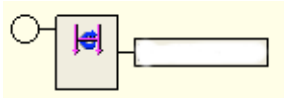


Figure 2.177:

1. In the first round dot the user can insert an object track, from which the cycles are created and then mean extracted.

2. In the second round dot the user can insert a event eequence: determine on the object track the starting points of each cycle.

2.7.5 Cycle max

This operator allows the user to compute a sequence of max: the max values of each cycle in a cycle sequence; the cycle sequence is created from an object track and an event sequence.

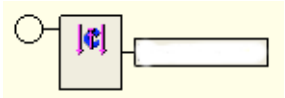


Figure 2.178:

1. In the first round dot the user can insert an object track, from which the cycles are created and then max extracted.

2. In the second round dot the user can insert a event sequence: determine on the object track the starting points of each cycle.

2.7.6 Cycle min

This operator allows the user to compute a sequence of min: the min values of each cycle in a cycle sequence; the cycle sequence is created from an object track and an event sequence.

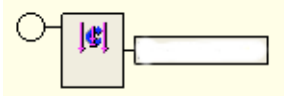


Figure 2.179:

1. In the first round dot the user can insert an object track, from which the cycles are created and then min extracted.

2. In the second round dot the user can insert a event sequence: determine on the object track the starting points of each cycle.

2.7.7 Sequence mean

This operator allows the user to compute the mean of the values of a sequence.

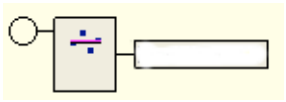


Figure 2.180:

1. In the first round dot the user can insert a sequence, from whose values of the mean is calculated .

2.7.8 Sequence max

This operator allows the user to compute the max of the values of a sequence.

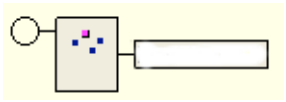


Figure 2.181:

1. In the first round dot the user can insert a sequence, from whose values of the max is calculated.

2.7.9 Sequence min

This operator allows the user to compute the min of the values of a sequence.

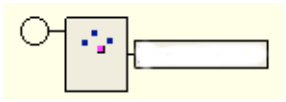


Figure 2.182:

1. In the first round dot the user can insert a sequence, from whose values of the min is calculated.

2.7.10 Cycle sequence mean

This operator allows the user to compute the mean cycle from a cycle sequence; the value of the output cycle at a given frame is the mean of the cycle sequence values for that frame.

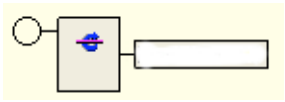


Figure 2.183:

1. In the first round dot the user can insert a cycle sequence, from whose values the mean cycle is calculated

2.7.11 Cycle sequence max

This operator allows the user to compute the max cycle from a cycle sequence; the value of the output cycle at a given frame is the max of the cycle sequence values for that frame.

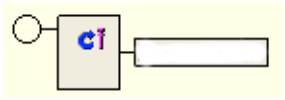


Figure 2.184:

1. In the first round dots the user can insert a cycle sequence, from whose values the max cycle is calculated.

2.7.12 Cycle sequence min

This operator allows the user to compute the min cycle from a cycle sequence; the value of the output cycle at a given frame is the min of the cycle sequence values for that frame.

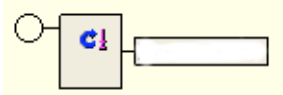


Figure 2.185:

1. In the first round dot the user can insert a cycle sequence, from whose values the max cycle is calculated.

2.7.13 Mean between 2 events

This operator allows the user to compute a sequence of mean: the mean values of each cycle in a cycle sequence; the cycle sequence is created from an object track and two event sequences.

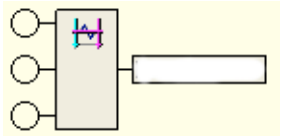


Figure 2.186:

1. In the first round dot the user can insert an object track, from which the cycles are created and then mean extracted
2. In the second round dot the user can insert an event sequence: determine on the object track the starting points of each cycle.
3. In the third round dot the user can insert another event sequence: determine on the object track the ending points of each cycle.

2.7.14 Max between 2 events

This operator allows the user to compute a sequence of max: the max values of each cycle in a cycle sequence; the cycle sequence is created from an object track and two event sequences.

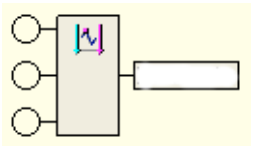


Figure 2.187:

1. In the first round dot the user can insert an object track, from which the cycles are created and then max extracted
2. In the second round dot the user can insert an event sequence: determine on the object track the starting points of each cycle.
3. In the third round dot the user can insert another event sequence: determine on the object track the ending points of each cycle.

2.7.15 Min between 2 events

This operator allows the user to compute a sequence of min: the min values of each cycle in a cycle sequence; the cycle sequence is created from an object track and two event sequences.

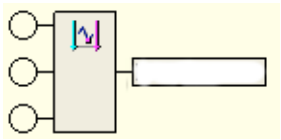


Figure 2.188:

1. In the first round dot the user can insert an object track, from which the cycles are created and then min extracted

2. In the second round dot the user can insert an event sequence: determine on the object track the starting points of each cycle.

3. In the third round dot the user can insert another event sequence: determine on the object track the ending points of each cycle.

2.7.16 Mean in event sequence

This operator allows the user to compute the mean of a track defined on a multiple event.

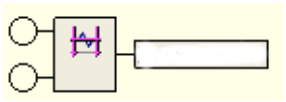


Figure 2.189:

1. In the first round dot the user can insert an object track.

2. In the second round dot the user can insert a event sequence.

2.7.17 Max in event sequence

This operator allows the user to compute the max of a track defined on a multiple event.

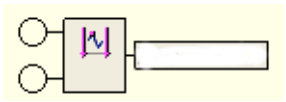


Figure 2.190:

1. In the first round dot the user can insert an object track.

2. In the second round dot the user can insert a event sequence.

2.7.18 Min in event sequence

This operator allows the user to compute the min of a track defined on a multiple event.

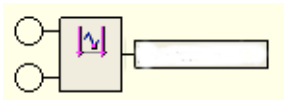


Figure 2.191:

1. In the first round dot the user can insert an object track.
2. In the second round dot the user can insert a event sequence.

2.7.19 Acquisitions mean

This operator allows the user to compute an event which is the mean among the events of a multiple acquisition.

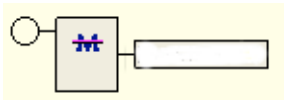


Figure 2.192:

1. In the first round dot the user can insert an event sequences of a multiple acquisition, of which the average is calculate.

2.8 Event operators

2.8.1 Event defined value

This operator allows the user to select an item (or item sequence) from the input object track; the item is determined by an input event.

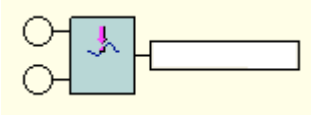


Figure 2.193:

1. In the first round dot the user can insert an object track: from which the output item is taken
2. In the second round dot the user can insert an event or event sequence, in correspondence of which the item is selected

2.8.2 Event defined cycle

This operator allows the user to create a sequence of cycles from an object track and an event sequence; a cycle is a normalized track: it's temporal range is normalized from 0 to 100; each output cycle correspond to the portion of track going from an event till the next one of the event sequence.

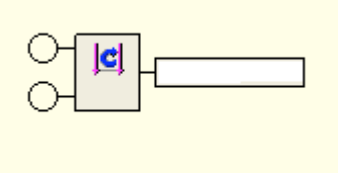


Figure 2.194:

1. In the first round dot the user can insert an object track, from which the cycles are created
2. In the second round dot the user can insert an event sequence, determine the portion of track corresponding to each cycle.

2.8.3 Event defined track

This operator allows the user to create an object track from another object track and an event sequence.

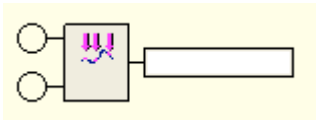


Figure 2.195:

1. In the first round dot the user can insert an object track, from which the new track is created.
2. In the second round dot the user can insert an event sequence.

2.8.4 Items sequence defined track

This operator allows the user to create .....

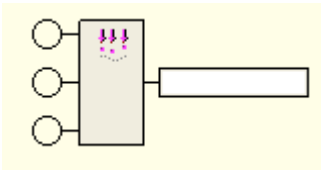


Figure 2.196:

1. In .....
2. In.....
3. I..,.....

2.8.5 Cycle between 2 events

This operator allows the user to create a sequence of cycles form an object track and two event sequences; a cycle is a normalized track: it's temporal range is

normalized from 0 to 100; each output cycle correspond to the portion of track going from an event of the first event sequence till an event of the second event sequence.

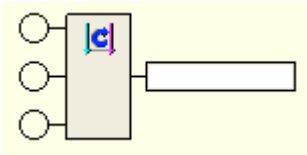


Figure 2.197:

1. In the first round dot the user can insert an object track, from which the output item is taken
2. In the second round dot the user can insert an event sequence, determine on the object track the starting points of each cycle
3. In the third round dot the user can insert an event sequence, determine on the object track the ending points of each cycle

2.8.6 Track between 2 events

This operator allows the user to create a track whose temporal domain goes from the first to the second input event; inside this time range it has the same values as the input track

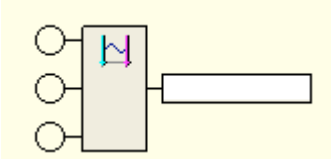


Figure 2.198:

1. In the first round dot the user can insert an object track, which will be "cut" between the two input events.

2. In the second round dot the user can insert an event or event sequence, determine determine the beginning of the output track.

3. In the third round dot the user can insert an an event or event sequence, determine determine the end of the output track.

2.9 Filter operators

2.9.1 Smooth track

This operator allows the user to Smooth a signal using a triangular window filter, of input order (the length of the window is 2*order+1); the signal is the input object track.

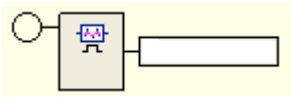


Figure 2.199:

1. In the first round dot the user can insert an object track, the signal to be filtered.

2. In the second round dot the user can insert a scalar, the order of the rectangular window filter.

2.9.2 Smooth track triangular

This operator allows the user to Smooth a signal using a rectangular window filter, of input order (the length of the window is 2*order+1); the signal is the input object track.

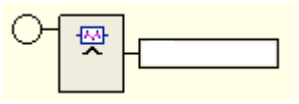


Figure 2.200:

1. In the first round dot the user can insert an object track, the signal to be filtered.
2. In the second round dot the user can insert a scalar, the order of the rectangular window filter.

2.9.3 Hamming LP filter

This operator allows the user to filter a signal using a Hamming low pass filter, at the input cut frequency; the signal is the input object track.

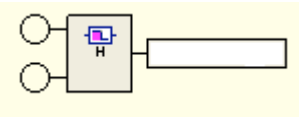


Figure 2.201:

1. In the first round dot the user can insert an object track, the signal to be filtered.
2. In the second round dot the user can insert a frequency, that will be the "cut" frequency.
3. In the third round dot the user can insert a scalar, the number of lobes of the filter.

2.9.4 Hamming HP filter

This operator allows the user to filter a signal using a Hamming high pass filter, at the input cut frequency; the signal is the input object track.

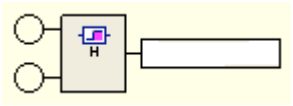


Figure 2.202:

1. In the first round dot the user can insert an object track, the signal to be filtered.
2. In the second round dot the user can insert a frequency, that will be the “cut” frequency.
3. In the third round dot the user can insert a scalar, the number of lobes of the filter.

2.9.5 Butterworth LP filter

This operator allows the user to filter a signal using a Butterworth low pass filter, at the input cut frequency; the signal is the input object track.

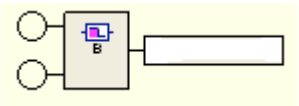


Figure 2.203:

1. In the first round dot the user can insert an object track, the signal to be filtered.
2. In the second round dot the user can insert a frequency, that will be the “cut” frequency.
3. In the third round dot the user can insert a scalar, the degree of the filter (must be even).

2.9.6 Butterworth HP filter

This operator allows the user to filter a signal using a Butterworth high pass filter, at the input cut frequency; the signal is the input object track.

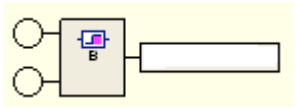


Figure 2.204:

1. In the first round dot the user can insert an object track, the signal to be filtered.
2. In the second round dot the user can insert a frequency, that will be the "cut" frequency.
3. In the third round dot the user can insert a scalar, the degree of the filter (must be even).

2.9.7 Chebyshev LP filter

This operator allows the user to filter a signal using a Chebyshev low pass filter, at the input cut frequency; the signal is the input object track.

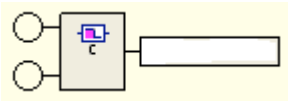


Figure 2.205:

1. In the first round dot the user can insert an object track, the signal to be filtered.
2. In the second round dot the user can insert a frequency, that will be the "cut" frequency.

3. In the third round dot the user can insert a scalar, the degree of the filter (must be even).

4. In the fourth round dot the user can insert a scalar, the ripple of the filter (percent).

2.9.8 Chebyshev HP filter

This operator allows the user to filter a signal using a Chebyshev high pass filter, at the input cut frequency; the signal is the input object track.

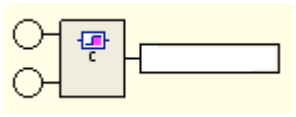


Figure 2.206:

1. In the first round dot the user can insert an object track, the signal to be filtered.

2. In the second round dot the user can insert a frequency, that will be the "cut" frequency.

3. In the third round dot the user can insert a scalar, the degree of the filter (must be even).

4. In the fourth round dot the user can insert a scalar, the ripple of the filter (percent).

2.10 The report

A Report is the mean to produce a graphical presentation of both the original data and the data elaborated with a Protocol, The graphical elements to be displayed are organized into the Report Panel, and a Report can consist of several pages.

Also a Report can be saved, thus creating a presentation scheme which can be applied over other files. It can be exported into an HTML file, a format suitable to have it shared or stored.

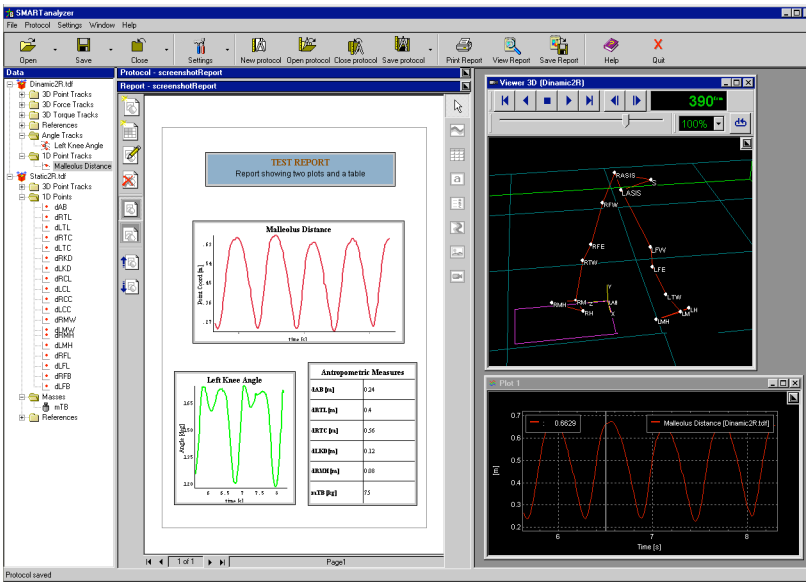


Figure 2.207:

Report Panel The Report Panel is the workspace into which to build a presentation report. The toolbar on the left contains the page editing tool, used to create or delete pages, change their order or edit their captions. The toolbar on the right contains the graphical objects used to display data: plots, tables, text boxes, legend boxes, cyclograms, images and video. They can be filled with data with the usual drag and drop interface.

All the objects can be moved and resized. They can also be edited to change parts of their aspect, like fonts type and size, lines thickness, colors, borders style etc...

2.10.1 Create a report

With SMARTanalyzer you can create HTML reports containing plots, tables and text boxes. You can design a report template and include it in a protocol in order to create reports automatically in the same way as the computations. The report panel is below the protocol panel: click on the little button on the upper right corner of the panel to hide it and show the other panel.

A report is organized in pages: to create a new page, click on the upper left button, and select in the box the number of elements you want to place on the page. If you want to create a blank page and choose the position of the report elements later, click on the bottom bar of the box.

At the right side of the report panel there is a toolbar: to create a report element, click on the appropriate button and design it on the page. Then you can drag the data from the left panel into a plot, or a table cell.

- To edit an element style, double-click on it.
- To delete an element, select it and press <Canc>.
- To move an element, drag it with the mouse.
- To save the report in HTML format, click on "Save Report"; you can preview the result by clicking on "View Report".
- To save the report template, simply click on "Save Protocol": the report template will be saved, too.

2.11 Apply a saved protocol

The steps to apply an existing protocol are the following:

- Open the files which contain the data you want to analyze.

- Open the protocol (click on "Open Protocol") and then associate each sequence name to one of the trials you have opened.

All data can be saved in data archives which can be re-opened later, or exported to Excel-compatible text files (select a trial and then select the action you want to perform from either the "File" menu, or the "Save" button submenu, or the context menu).

Chapter 3

An example

3.1 Basic computation

In this section, the user will learn to:

- open a data file
- compute the angle between three markers
- compute the distance between two markers
- view the quantities you have computed
- save your computation model in a protocol
- apply your computation model to another data file

3.1.1 Open a data file

To open a data file, click the Open button: a window named Data Manager will appear in which the data files are arranged in subjects; the user should first select the subject from the drop-down list at the upper left corner of the

window, choose the data file from the main list and then confirm by clicking Open.

Open the data file DamianiAs1r.tdf which belongs to the subject Samples.

Once the user has opened a file, a new window named Viewer 3D will appear with the 3D representation of the data contained in the file.

The user can change the point of view by placing the mouse pointer on the window and holding down the left mouse button while dragging; the user will see the scene rotate around a point named Camera Target.

To move the scene sideways, the user need to change the Camera Target position: hold down the left button together with the CTRL key and move the mouse.

the user may find useful to place the Camera Target at about the center of the markers cloud: this way, when the user rotates the scene the user won't have to move the scene sideways to re-center it.

To make the scene get closer or further, you need to change the Camera Target distance: to do this, hold down the left button together with the SHIFT key, and move the mouse up/down.

At the top of the Viewer 3D window there are some playback controls that you can use to play the sequence:

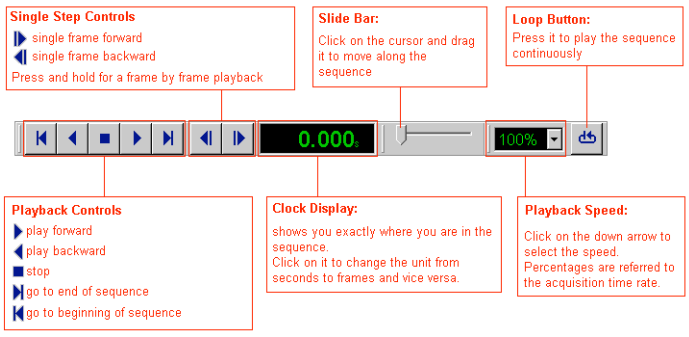


Figure 3.1:

Change the point of view of the Viewer 3D in order to achieve a better view

of the scene, then try the buttons at the top of the Viewer 3D window to see how they act.

Now look at the left side of the main window: there's a white panel named Data. This panel contains all the data that are currently loaded in SMARTanalyzer, arranged in trials and folders. You can click on the nodes to expand or collapse them in order to show or hide the data they contain.

The dark grey area which contains the Viewer 3D window is named Client Area. Whatever data you drag with the mouse into the Client Area, a view of that data will appear. You can pick data from the Data Panel: data varying with time will be represented in plots, static data in tables, while trials will be represented in a Viewer3D. So, if you close the Viewer 3D window, you can show it again by dragging the trial node into the Client Area.

Expand the trial node named DamianiAs1r.tdf, then expand the folders. Take the node named Mk13 and drag it into the Client Area with the mouse. Do the same with the LAB node. Expand the node named Marker 12 and drag one of its coordinates into the client area. Now close all the windows (also the Viewer3D) by clicking on the button at the upper right corner of each window. Then drag the trial node into the Client Area to view the Viewer 3D again.

3.1.2 Create a Protocol

A Protocol is the starting point for each computation you may want to perform on your data.

To create a new protocol, you just have to click the New Protocol button. A new panel with a light yellow background will appear at the right of the Data Panel: it is the Protocol Panel, and provides all the tools to create your computation model. On the left side of the Protocol Panel there is the so-called Object Toolbar, while on the right side you can find the Edit Toolbar.

On the Object Toolbar you can find a button for each type of objects you

can compute with SMARTanalyzer; controls located on the Edit Toolbar let you adjust the layout of the Protocol on the Protocol Panel.

You can drag with the mouse the right border of the Protocol Panel in order to enlarge or shrink its area.

3.1.3 Compute an angle

Whatever quantity you may want to compute, the operations you have to perform are very simple:

1. Click on the button on the Object Toolbar which represent the quantity;
2. Choose from the graphical menu which appears the "algorithm" by which you want the new data to be computed. At your click, a block appears in the Protocol Panel. You should then enter the name of the new object.
3. Drag the data (one at a time) from the Data Panel and drop them into the appropriate input circle of the computation block. Once that each input circle has been filled with input data, a node which represents the new data appears in the Data Panel.

You can find an exhaustive list of the available quantity types and algorithms here.

So, say you want to compute an angle between three markers: click the Angle button on the Object Toolbar, select as the algorithm, enter the name and then drag the input data from the Data Panel and drop them into the three circles. That's all!

When you drag data into an input circle, if the circle becomes red it means that the type of the input is correct; if it becomes dark gray it means that the type of the input is wrong, and you will not be allowed to drop the data into

that circle.

Compute the angle between the markers named Marker 8, Marker 9 and Marker10 (in this order), and name it LKneeAngle.

Once that the new data has been computed, you can pick it from the Data Panel and drag it into the Client Area in order to view its values, as you've seen above, in ths lesson.

Data can also be picked from the Protocol Panel: you simply have to place the mouse on a data label (it works both for input and output data labels) and then drag from that position.

View the plot of LKneeAngle by dragging it into the Client Area. Try to drag it both from the Data Panel and the Protocol Panel

3.1.4 Compute a distance

Say you want to compute the distance between two markers: click the Point 1D button on the Object Toolbar, select as the algorithm, enter the name, then drag the input data from the Data Panel and drop them into the two input circles.

Compute the distance between the markers named Marker 5 and Marker 11, and name it FeetDistance.

View the plot of FeetDistance by dragging it into the Client Area. Try to drag it both from the Data Panel and the Protocol Panel

3.1.5 Save the computation model

To save your computation model click the Save Protocol button. The first time you save a new protocol, you will be asked to enter the name. Once you've chosen the protocol name, clicking the Save Protocol button will overwrite the protocol. To save the protocol with a new name click the arrow near Save Protocol and choose Save Protocol as.

Once you've chosen the protocol name, you will be asked to enter a sequence name for each trial that is visible in the Data Panel. The sequence name for a trial is a label that will be used as a placeholder to identify that trial the next time you apply the protocol. (The protocol needs to know the trial to which input data belong, but the file to which you apply the protocol the next time may have a different name, so the protocol will use the placeholder to locate the data, and the next time you apply the protocol you will be asked to associate the placeholders to the trials you have loaded).

To close the protocol you have to click the Close Protocol button, while to close the data file you need to click the Close button.

To close the program press the button Quit.

Save your computation model in a protocol named Tutorial1.epx (enter Jump trial as sequence name), then close the protocol and the data file.

3.2 Your first report

Up to now, you've learned how to open a data file and process the data in it by creating a protocol. This way you've obtained the data you've interested in. Now you can present them in a report.

In this section, you will learn to:

- create a report with plots, tables and text boxes
- check the results in the print preview
- print the report
- save the report in HTML format

3.2.1 Create a page

The report panel is below the protocol panel: click on the little button on the upper right corner of the panel to hide it and show the other panel.

Each report you create with SMARTanalyzer is organized in pages. So, the first step to create a new report is to create a blank page:

1. click the button New blank page .
2. the page has been created, you can check it on the page counter on the bottom.

On the right side of the report panel you can see the different kind of objects which you can insert into the report:

- Plots
- Tables
- Text boxes
- Legend boxes
- Cyclograms
- Images
- Video boxes

You will learn about legend boxes, cyclograms, images and video boxes in the next section.

Open the data file DamianiAs1r.tdf and apply to it the protocol Tutorial1.epx. On the left of the main window you can see the Data Panel, which shows the list of the trials and the data which they contain.

3.2.2 Add a plot

To insert an object you have to:

1. select the kind of object you want to insert by clicking the corresponding button with the mouse
2. draw the object on the page by tracing a rectangle while pressing the left mouse button

Draw a plot on the page.

Now you are ready to fill the plot with data.
To insert a data track in the plot

1. in the data panel, place the mouse on the track you want to draw
2. press and keep pressed the left mouse button
3. drag the track on the plot
4. release the mouse

Expand the trial DamianiAs1r.tdf on the Data panel by clicking on the cross symbol at the left of the acquisition name, then expand the folder Angle Tracks. Inside it you find the angle track LKneeAngle, drag it and drop it on the plot you've just created: the graph of the left knee angle will appear.

Add a table

To insert a table, you have to click on the corresponding button and draw the rectangle on the page, the same way as when you added the plot.

When you insert a table, a yellow label shows up which indicates the number of rows and columns of the table.

If you already know the number of rows and columns of the table it's faster

to create a table this way and then resize it.

Draw a table of 9 rows and 2 columns.

When you create a new table, the first column always contains header cells. You will learn in the next lessons how to change the headers position in a table.

To insert data in the table:

1. place the mouse on the label of the the data you want to insert
2. press and keep pressed the left mouse button
3. drag the data on the table
4. release the mouse

Data can only be inserted in data cells, not in header and title cells.

If the data is inserted in a cell of the second column and the first column is a header, the data label is automatically inserted in the first column.

On the Data panel expand Reference and then LAB: there you find the coordinates of the three axes of the laboratory reference system. Pick up the I vector (which represents the X axis) and drop it on the first three rows of the second column. The labels of the I vector will appear on the first column. Insert below the vectors J and K.

Add a text box

Draw a text box on the page.

To insert text in a text box:

1. double click the text box on the report viewer, an editing form will appear
2. double click the upper part of the bigger white box, there you can insert the title of the text box

3. double clicking the lower part of the bigger white box you can insert the main text

4. press Ok to apply changes and close the editing form

On the text box you've just created, insert "test Report" as title and "Left Knee Angle graph and Laboratory Reference orientation" as text. The title will appear centered and in bold style above the text

If you want a text box without a title just press the Show/Hide Title button at the upper left corner of the editing form.

When you save the protocol only the title of the text box will be saved, the main text is left for the user to enter it each time.

Preview and print

The preview allows you to see the final aspect of the report when printed and to verify changes you make to objects.

Press the button Preview , a window with the print preview will appear. You'd better get used to click often this button.

If it seems like the text in the report has not a correct dimension or the colors don't correspond to the one you chose, before making changes check it with the preview. The report will be printed and saved in HTML exactly as you see it in the preview.

To print the report press the button Print , a window will appear which allows you to print and chose the printer settings.

Check the preview of your report and then print it.

When you save a protocol, together with the computation model you save also the report model. This way, you don't have to design your report again the next time you apply the protocol.

Save the computation and report models in a new protocol file, called "Tutorial2.epx" (click the arrow near the Save Protocol button and select Save as...).

Save reports

Reports can be saved in HTML format, thus they can be easily shared with other users.

To save a report:

- click the button Save
- choose the path in which you want to save the file
- specify the file name
- press Save

To be able to view the report Internet Explorer version 6.0 or later and the SVGviewer are required. SVGviewer is a plugin for Internet Explorer made by Adobe.

Save the report on your desktop, quit SMARTanalyzer and open the report in Internet Explorer.

More pages, moving and resizing objects

In the previous section you've learned how to create a report with plots, tables and text boxes and how to print and save it.

In this section, you will learn to:

- create reports with more pages
- move and resize the report objects

Add pages

Open the data file DamianiAs1r.tdf and apply to it the protocol Tutorial2.epx (the one you've saved in Lesson 2). Hide the protocol panel and show the report

panel.

To add blank pages, just click the New blank page button

A new page is always created as last page.

You can also add a page and fill it automatically with objects placed in standard positions. To do so:

1. click the button New auto filled page
2. a little window divided into rectangles will open, select the number of areas into which you want to divide the page
3. press the left mouse button
4. for each area, choose if it has to contain a plot , a table , a text box , or if it has to be deleted.

To close the window without inserting a new page: right-click with the mouse, or place the mouse pointer on the lower gray bar and click with the left button.

Add a blank page and an auto-filled page with objects arranged in 3 rows and 2 columns. Delete the second object of the first row. Create a text box on the first row, two plots on the second row and two tables on the third row.

Navigate through the pages

A report is usually composed of several pages: if you want to go to another page use the navigation buttons at the bottom of the report panel.

Go directly to the first page, then move to the second and then back to the third.

When you activate the preview, you always see the first page of the report, regardless of which page is currently shown in the report panel. To view the other pages, use the navigation buttons at the top of the Preview window.

Activate the preview and check the aspect of all the pages.

Delete a page

To delete a page:

1. go to the page to delete and press the button Delete Page
2. a confirmation is required, click on Yes

Go to the second page (the blank one), then delete it.

Change the order of the pages

Buttons Move Page Up and Move Page Down allow you to change the order of the pages. Clicking Move Page Up moves the current page one position backward.
Clicking Move Page Down moves the current page one position forward.

Swap the two pages by moving the second page up.

Move and resize the objects

It is possible to move the objects inside the report pages and change their dimensions.

To move an object inside a report:

1. place the mouse on the object to move
2. press and keep pressed left mouse button
3. drag the object on the desired position

To resize an object:

1. place the mouse on the border of the object until the bidirectional arrow appears

2. press and keep pressed left mouse button

3. drag the border until you obtain the desired dimension

Go to the first page and resize the upper text box in order to fit the width of the page.

Change the page name

To edit the properties of the pages click the button Edit Page: a window will open which allows you to specify the name of the page.

You can change the name of the page also by clicking on the textbox at the right of the navigation buttons and entering the new name right there.

Go to the first page and name it "Auto filled"; go to the second and name it section 2.

Save the computation and report models in a new protocol file, named "Tutorial3.epx".

Editing Report Objects

In the previous section you've learned how to add more pages into your reports and how to move and resize the report objects.

In this section, you will learn to:

1. edit text boxes, tables and plots

2. create and edit legend boxes

3. copy, paste and delete objects

Edit text boxes

Open the data file DamianiAs1r.tdf and apply to it the protocol Tutorial3.epx (the one you've saved in the previous lesson).

Double click on the text box, an editing window for the text will appear. Now it is possible to define the properties of the text box.

Text boxes are divided into two areas, the first is reserved to the title (which can be visible or hidden), the second to the proper text. Each area is handled separately and the active area is light blue colored. To switch from one area to the other just click on the area of interest.

The button Show/Hide title allows you to show or hide the title.

To insert the title:

1. check that the button Show/Hide title be selected, otherwise click it
2. the upper area is the area of the title, click this area. On the bar you can read
3. insert the title of the textbox
4. press Apply to apply immediately your changes

To insert the text:

1. click on the area reserved for the text, on the bar you can read
2. insert the text and click Apply

The button Show/Hide border allows you to insert or hide the border of the text box. Click it to see the difference.

The other buttons allow you to format the text and choose the colors. It is possible to change the colors of the text in the two areas, the color of the

background and the color of the borders.

The borders are visible only in the print preview.

Edit the textbox in the second page of the report by changing the title color to red. In the text area write "Left knee angle, trial number 1". Select the title area, click the button Font Color and choose red, then press Apply. Click on View Report to see a preview of the changes.

Edit tables

Double click on a table: an editing window will open, which allows you to define the properties of the table.

To chose the style of the table:

1. click the arrow near the yellow and red grid
2. choose the kind of table by clicking the desired stile . Yellow cells represent data area, red cells represent the headers

Tables can have a title, which appears above the other cells.

To insert a title:

1. check that the button Show/Hide title be selected, otherwise click it
2. the upper cell is the area of the title, double click it. On the bar you can read and the title area is colored in light blue.
3. insert the title and click Apply

A table is so divided into three areas: data area in yellow, headers in pink and the title in light blue. For each one of these areas you can decide text format and color; but you have to select the area first.

Figure 3.2:

Click on the title area to select the title: the area becomes light blue colored.

Click the top-left gray square (1) to select data area: the data cells become yellow.

Click the first row under the title (2) or the first column (3) to select the headers: the headers cells become pink.

The dimension of rows and columns can be changed.

To change the dimension of rows and columns:

1. place the mouse over the gray area which surrounds the table
2. go over the border of the column or of the row which you want to resize until bidirectional arrows appear
3. press left mouse button and keeping it pressed drag the border to the desired position

To distribute evenly rows and columns:

1. click the button Distribute rows evenly for the rows
2. click the button Distribute columns evenly for the columns

Edit the table on the second page entering the title "Main Reference System" and setting the the character dimension to 10. Distribute the rows evenly.

The distribution takes effect only for rows and columns which contain data

To chose the style of the border:

1. press the arrow near the button Border style
2. choose the border style you prefer: you can draw all borders, only external borders, only the internal or no border . Click the desired style, your choices will be visible on the preview

While you can choose different font colors (click on the Font Color button) for the different areas of the table, border color (click on) and background color (click on) will be the same for the entire table. If you change the background color, your choice will be visible on the preview only.

Look at the preview of the table you just edited (View Report) and look at how the borders are. Edit the table and choose All Borders as border style. Look again at the preview to see how this affect the final appearance of the table.

Edit plots

Double click on a plot. You can decide whether if showing or not the element of a plot by clicking the buttons on the editing bar

Figure 3.3:

- Click 1 on to show/hide the title of the plot
- Click 2 on to show/hide the title of the x axis
- Click 3 on to show/hide the title of the y axis
- Click 4 on to show/hide the values of the x axis
- Click 5 on to show/hide the values of the y axis
- Click 6 on to show/hide the horizontal lines of the grid
- Click 7 on to show/hide the vertical lines of the grid
- Click 8 on to show/hide the plot labels
- Click 9 on to show/hide the automatic legend
- Click 10 on to show/hide the borders of the plot

To select the various elements of a plot you can click directly on the specific objects, the selected area will be highlighted in a light blue. Otherwise you can choose a specific element in the toolbar: click the vertical arrow near the first button of the horizontal toolbar (Click to select an object) and then chose the object by clicking it with the mouse.

For the titles and the labels you can choose the font and the text color . For the whole plot, you can choose the color of the borders and of the background.

Edit the LKneeAngle plot in the second page, show both the legend and the horizontal grid. Resize the plot enlarging it horizontally if needed to restore the dimension of the graphic part of the plot.

To chose the range, scale and step of the axis:

1. select an axis with the appropriate button, for example the x axis
2. specify the value of the first label position, you can enter it or use the side arrows to reach the desired value
3. set the step between the labels, not all values can be accepted
4. verify the allowed values by clicking the side arrows
5. to specify the range of the axes click Manual Scale
6. set the lower value
7. set the higher value

In the same plot set the Step of the X labels to 1, so that you see a label every second. Set the Y step to 10 and the Y first tick position to 100, apply and look at the results in the preview.

Copy and paste

To copy and paste an object:

1. click on the object with the right mouse button
2. from the menu chose Copy
3. go to the page in which you want to paste the object and place the mouse on an empty zone
4. click with the right mouse button
5. choose Paste

When paste and object, it doesn't contain all the information of the original. The following elements are not copied:

- tracks and titles on a plot
- data on the tables
- main text on the text boxes

If you copy and paste an object on the same page, the object is created over the original one.

Delete objects

To delete an object:

1. Right click on the object
2. from the menu choose Delete

otherwise:

1. click the object to delete
2. press the key Canc of the keyboard

In both cases the object is immediately deleted, you will not be asked a confirmation

Delete the upper empty plot of the first page. Go to the second page and copy the textbox, return to the first page and paste it: the main title and the color will remain as the original one. Save the protocol as "Tutorial4.epx".

More Report Objects

You have seen in the previous sections how to populate the report with objects and how to edit plots, tables and text boxes.

In this section, you will learn more about legend boxes, images and video boxes.

Legend boxes

Open the data file DamianiAs1r.tdf and apply to it the protocol Tutorial4.epx, saved in the previous lesson.

To insert a legend box you have to:

1. click the Design Legend button
2. draw the legend box on the page by tracing a rectangle while pressing the left mouse button

Editing a legend box legend has many things in common with editing text boxes.

To edit a legend box, just double-click on it.

A legend box has two areas, the Title Area and the Legend Area. The Title

Area can be shown/hidden by checking/unchecking the Show title option.

To insert a title double click the Title Area (make sure that the Show title option is checked).

You can insert text in the Legend Area one row at a time:

1. select the Legend Area
2. click the button Add line
3. insert the text in the highlighted row

Each row of the Legend Area is composed by a label and a symbol, and is identified by a color.

To modify the label of a row in the Legend Area:

1. double click the row to modify
2. enter the new text

To change the color of a row:

1. select with a click the row you wish to modify
2. click the Line Color button to choose the new color

To change the rows order:

1. select with a click the row to move
2. click on the buttons to move it

To delete a row in the Legend Area:

1. click the row to be deleted: you will see the selected row highlighted in white

2. click the button Delete current line

The text format can be set separately for the Title and Legend areas. First you have to select the area, then you can modify font size, name and style for that area.

Go to the first page of the report; the two objects in the middle of the page are two plots; drag the FeetDistance track on the left plot (you may find it on the 1D Point Tracks group in the Data panel), delete the plot on the right side and draw a legend in its place. Select the title and write "Feet to Feet distance", then add a line and write "dist. between two hells" and select Show lines. Look at the preview to see the results.

To change the color of the title, you just have to select the Title Area and click the Text color button.

For the color of the labels you have 2 possibilities:

1. You can assign to each label the same color as the symbol of that line by checking the Labels auto color option.

2. You can set a unique color for all the labels by unchecking the Labels auto color option and then clicking the Text color button; make sure that the Legend Area is selected.

The style of the symbols can be chosen by clicking the Marker style button; if you prefer, you can hide the symbols (by unchecking the Show lines option): in this case the Labels auto color option is automatically checked.

The button Show border allows to show or hide the border of the legend box.

The button Border color lets you choose the color of the border.

The button Back color lets you choose the color of the background.

Click on the line you just created and on Line color select the same color as

the track of the plot on the left. Select Show border and be sure that the Border Color is black.

To check the changes made to the legend, look at the print preview.

Using legend boxes as trial legends

Legend boxes can be used to display the name of a trial:

1. place the mouse pointer over the label (in the data panel) which represents the trial
2. click with the left mouse button and keep pressed
3. drag the trial into an empty legend
4. release the mouse button

Create an empty trial legend in the second page above the graph plot and drag the DamianiAs1r.tdf label on it. Edit the plot and hide the lines, so that only the trial name is visible. It should be of the same color than the track on the graph.

If the symbols are not visible enlarge the legend.

Images

Images are places where you can load pictures that were previously saved as bitmaps, GIFs, JPEGs. This way you can import external picture files into your report.

To insert an image you have to:

1. click the Design Image button
2. draw the image box on the page by tracing a rectangle while pressing the left mouse button

When you open a data file, if in the same folder there is a picture file with the same name as the data file then the picture file is loaded, too.

Otherwise, you can import a picture file in one of the following ways:

- Select from the main menu File >> Load picture, and choose the picture file you want to import. This way the picture is loaded into the trial Global data in the Data Panel
- Place the mouse on a trial node in the Data Panel, right click and select Load picture. The picture is loaded as an element of that trial

You can view the picture by dragging it from the Data Panel into the Client Area.

To make the picture appear in the report:

1. place the mouse on the picture node in the Data Panel
2. click with the left mouse button and keep pressed
3. drag the picture into the empty image box you've created
4. release the mouse

Like many other objects you can drag pictures also from the Client Area.

Right click on the data panel and load a picture. Delete the table on the lower right corner of the first page of the report, draw a smaller image and drag on it the image you have just loaded.

If you save a protocol which contains a report with an image taken from global data, you must load the image in the global data before loading the protocol, other the corresponding image box will be empty.

Video boxes

Video boxes are places where you can load movies that were previously saved as MPEGs, or any other format that your PC can read. This way you can import external movie files into your report.

To insert a video box you have to:

1. click the Design Video button
2. draw the video box on the page by tracing a rectangle while pressing the left mouse button

When you open a data file, if in the same folder there is a movie file with the same name as the data file then the movie file is loaded, too.

Otherwise, you can import a movie in one of the following ways:

- Select from the main menu File >> Load movie, and choose the movie file you want to import. This way the movie is loaded into Global data in the Data Panel
- Place the mouse on a trial node in the Data Panel, right click and select Load movie. The movie is loaded as an element of that trial

You can view the movie by dragging it from the Data Panel into the Client Area.

To make the movie appear in the report:

1. place the mouse on the movie node in the Data Panel
2. click with the left mouse button and keep pressed
3. drag the movie into the empty video box you've created
4. release the mouse

Like many other objects you can drag movies also from the Client Area.

Load a movie in the Data panel, draw a new blank page, draw a video box on the newly created page and and drag on the the movie. Click View report, go to the movie page and click on the movie box to make it play. Delete the page you just created and save the protocol as Tutorial4.epx.

Advanced Editing

Advanced editing: plots

Open the data file DamianiAs1r.tdf and apply to it the protocol Tutorial5.epx, created in the previous lesson.Go to the protocol window, compute the angle between the markers named Marker 2, Marker 3 and Marker4 (in this order), and name it RKneeAngle (as seen on lesson 1). Go to the second page of the report and drag on the plot the RKneeAngle track.

Open the editing window of the plot by double clicking the plot.

If you click the central area of the plot you alternatively select the tracks area or the grid. When the grid is selected a blue border which surrounds the tracks appears, when you select the tracks a rectangular blue area appears.

To select a track:

1. select the tracks area
2. click on the arrow near the name of the track
3. a list of all the tracks of the plot will appear, click on the desired one

To delete a track:

1. select the track to be deleted (clicking the arrow near the list of the tracks names)

2. press the button to delete the track

To edit the style, thickness and color of the tracks:

1. select the tracks area
2. select the track to be deleted (clicking the arrow near the track name, the tracks list appears)
3. select the track you want to edit
4. click the button to choose the style
5. click the button to choose the thickness
6. click the button to choose the color

To edit the aspect of the grid:

1. select the grid area, which is highlighted by a blue border
2. click the button to choose the style
3. click the button to choose the thickness
4. click the button to choose the color

To close the color window without changing the colors click the button

Open the plot in the second page, set a medium thickness for both the tracks (LKneeAngle and RKneeAngle). Set the color of RKneeAngle track to red. Change the title to "Knee Angles". Press View Report to see the results.

Advanced editing: tables

Open the editing window of the table by double clicking the table.

To select a row or a column:

1. place the mouse over the gray border which surrounds the table
2. click the row or the column which you want to select
3. cells are highlighted in pink if they belong to the header, in yellow if they are data cells and in light blue if it's the title cell

To delete a row or a column:

1. select the row or the column to be deleted (it must contain data cells)
2. press the button to delete a row, or the button to delete a column

To add a row or a column:

1. select a row or a column adjacent to the row you want to add (it must contain data cells)
2. press the button to insert a row, it will be inserted above the selected cell; if you click the arrow you can choose whether to insert the row above or below;
3. press the button to insert a column, it will be be inserted on the left of the selected column; if you click the arrow you can choose whether to insert the column on the left or on the right.

Edit the table on the second page, select the first data column (the one with "Lab Ix") and insert a new row above it, then insert one new row below the row "Lab Iz" and one below the row "Lab Jz". Write "X axes" on the first row created, "Y axes" and "Z axes" on the two other rows. After that press Distribute rows evenly. Save the protocol as Tutorial6.epx.

Your Report outside SMARTanalyzer

To obtain a report in HTML format is quite straightforward: you just have to press the button Save.

To visualize an HTML report you need Internet Explorer 6.0 or above and Adobe SVGviewer.

Report object names

Open the data file DamianiAs1r.tdf and apply to it the protocol Tutorial5.epx, created in the previous section.

When a report is saved, in addition to the HTML file a folder is created which has the same name as the file. This folder contains some files with extension .svg, one file for each object in the report. The name of the file is equal to the name of the report object.

To change a report object name:

1. click the object in the report with the right mouse button
2. from the menu which appears choose Name and enter the new name. The next time you save the report, the object will be saved in a file with the name you have entered

Rename the graph of the second page as "KneeAngPlot" and save the report as Tutorial7.

Copy objects from an HTML file and paste it into Office applications

To use a report object inside an Office application:

1. open with Internet Explorer a report which you previously saved

2. click with the right mouse button on an object and choose Copy SVG
3. paste the object into whatever program of the Office suite (Word, PowerPoint, etc...) using Paste Special and choosing the option bitmap

Open Tutorial7.htm and copy the graph "Knee Angles". then open the Paint from the accessories and paste the graph.

Zoom and pan report objects

Keeping the report opened inside Internet Explorer, you can zoom and pan the single objects, by moving the mouse on them.

To zoom an object:

- hold down the Ctrl key, the pointer changes shape. By clicking with the left mouse button you zoom forward
- hold down the Ctrl and Shift keys together: by clicking with the left mouse button you zoom backward
- hold down the Ctrl key and draw a rectangle with the mouse: you zoom in the selected area

To pan an object:

- hold down the Alt key and drag keeping pressed the left mouse button, also when the object is enlarged

To return to the original view you can click with the right mouse button and choose Original View.

If there are Videos, to play them you have to click on them with the mouse; to stop playing, just click again.

Go into the subdirectory Tutorial7_files and open the file KneeAngPlot.svg with Internet Explorer, then try to zoom and pan into the graph.

Export to text file and import in Excel

Let's return to the report in SMARTanalyzer.

To export data in text format:

1. click with the right mouse button on a folder of the Data panel, on the left
2. choose Export to text file
3. this way you export in a text format the content of the folder; you are given the possibility to select only a part of it

Back to SMARTanalyzer, with the data file DamianiAs1r.tdf open and the protocol Tutorial5.epx applied, in the Data panel expand the node "DamianiAs1r.tdf " and the node "Angle Tracks", then export the track "RKneeAngle" to the file AngleTrack.emt. Open the file with the Notepad to see how it is structured.

You can open the file you exported with Excel and automatically import data.