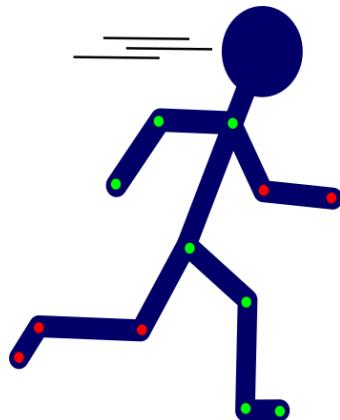


# MotionAnalyser

User manual

Jean-Luc Boulland



*July 2023*

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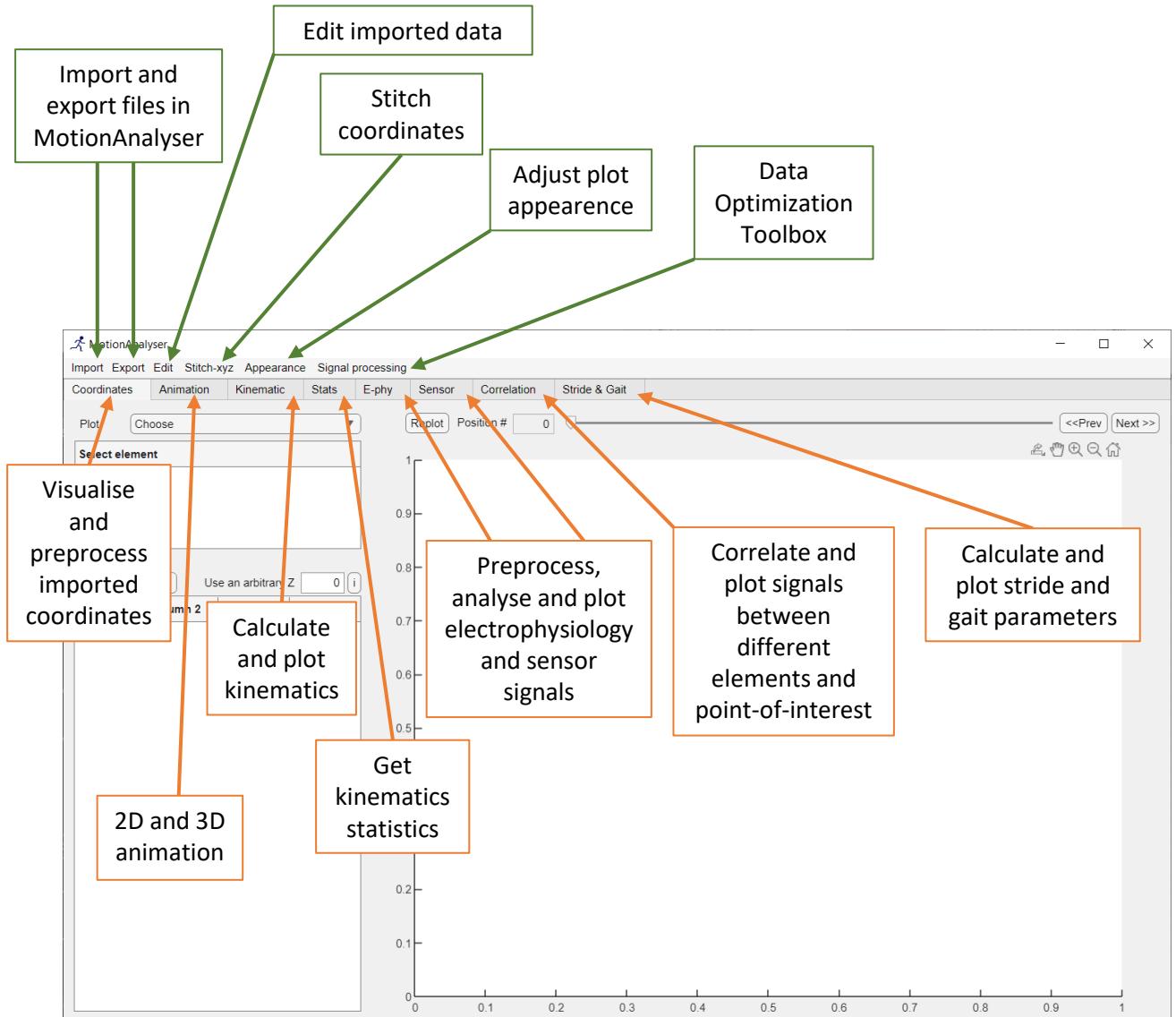
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# Software overview



MotionAnalyser is designed with **task-oriented tabs** that facilitate multimodal analysis of movement using video tracking or motion capture, electrophysiology traces, and signals from sensor systems like pressure sensors, goniometers, and accelerometers.

The menu provides users with the ability to perform different actions on the data displayed in the tabs. Each tab includes distinct buttons that execute functions specific to that particular tab.

# Coordinates tab

The purpose of this tab is to serve as a platform for preprocessing coordinates. It consists of a spacious plot area, options for selecting position, an editable data table, an editable element selection table, and a plot type selector.



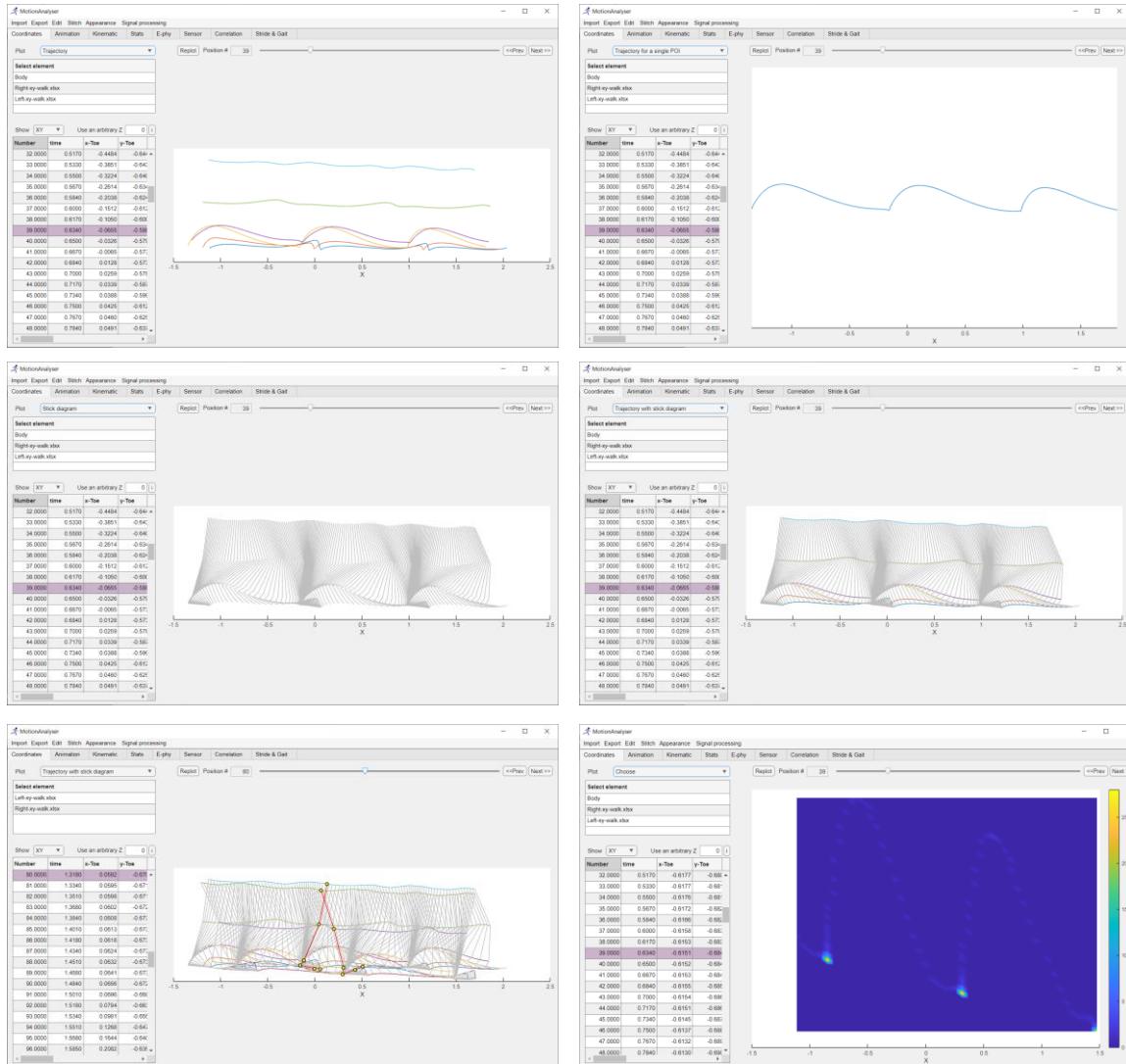
To edit a data value, simply click on the value of interest and type in the new value. To change the designation of elements, click on the element you wish to modify and enter a new name. To plot elements together, click and hold the shift key while selecting the elements of interest.

# Coordinates tab

The plot selector provides several options for visualizing the data, including:

- Plotting the trajectory for all points.
- Plotting the trajectory of a user-defined point.
- Displaying a stick diagram.
- Overlaying the stick diagram with the trajectory.
- Generating a heat map for a defined point of interest.

These options allow for different visual representations of the data based on the user's needs.

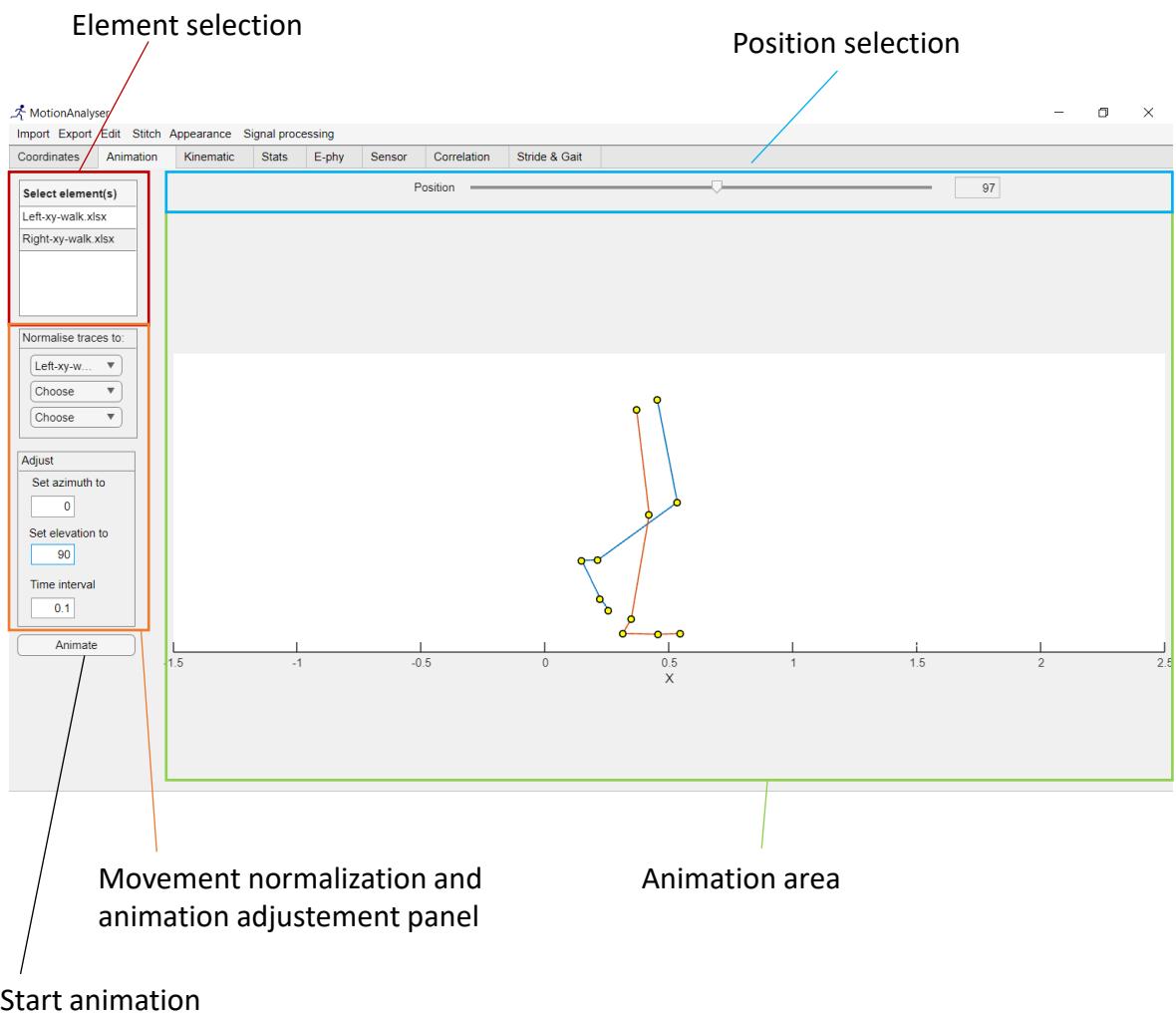


# Animation tab

This tab offers various options for modelling movement using an animated stick diagram. It is organized into several zones, including:

- A spacious area for the animated model.
- A position selection sliding bar.
- An element selection table.
- A panel to normalize the movement and adjust different animation parameters.

Additionally, the appearance of the animated model can be customized using the "Appearance" menu, which will be described later in this user manual.

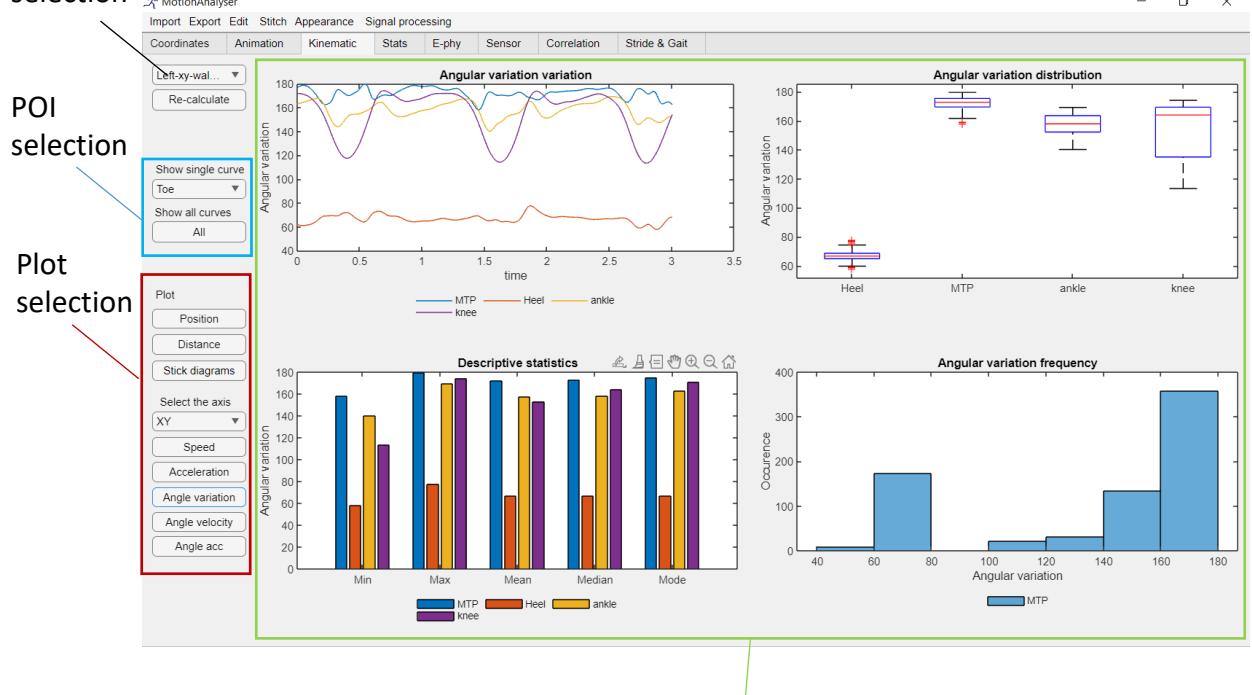


# Kinematic tab

This tab provides the option to calculate and plot kinematic parameters for each element independently. It consists of a graph area that can accommodate up to four plots. A point-of-interest selection panel allows users to plot only the data corresponding to a defined point of interest. By default, all points of interest are graphed. Furthermore, the tab includes an area where users can choose the desired parameter to be graphed and select the appropriate axis when relevant.

When clicking on a graph type or the "Recalculate" button for the first time in a session, a dialogue box appears, allowing the user to set the expression of the speed and acceleration as absolute values or relative values. Similarly, the expression of angles can be set as degrees or gradients.

## Element selection



Graph area

# Stats tab

This tab allows the user to query the data corresponding to any of the kinematic parameters. It consists of two tables and a selection area. The top table displays the values for the selected parameters. The second table, positioned underneath, displays descriptive statistics for the values displayed in the first table. The selection area, located on the left, enables users to identify the desired dataset.

The screenshot shows the MotionAnalyser software interface with the 'Stats' tab selected. The top navigation bar includes 'MotionAnalyser' icon, 'Import', 'Export', 'Edit', 'Stitch', 'Appearance', 'Signal processing', and tabs for 'Coordinates', 'Animation', 'Kinematic', 'Stats' (which is active), 'E-phy', 'Sensor', 'Correlation', and 'Stride & Gait'. On the left, there's a sidebar with 'Element' set to 'Left-xy-walk.xlsx', 'Parameter' set to 'Distance', and 'Point of Interest' set to 'MTP'. A 'Show table' button is also present. The main area contains two tables. The top table has columns for x, y, z, xy, xz, yz, and xyz, with data rows for various values. The bottom table provides descriptive statistics for these values: Min (8.9528e-07), Max (0.063541), Mean (0.017578), Median (0.0023613), and Sum (3.164).

	x	y	z	xy	xz	yz	xyz
0.0011	0.0011		NaN	0.0015	NaN	NaN	NaN
0.0009	0.0007		NaN	0.0011	NaN	NaN	NaN
0.0006	0.0002		NaN	0.0007	NaN	NaN	NaN
0.0006	0.0001		NaN	0.0006	NaN	NaN	NaN
0.0005	0.0002		NaN	0.0005	NaN	NaN	NaN
0.0003	0.0002		NaN	0.0004	NaN	NaN	NaN
0.0001	0.0002		NaN	0.0003	NaN	NaN	NaN
0.0001	0.0002		NaN	0.0002	NaN	NaN	NaN
0.0003	0.0000		NaN	0.0003	NaN	NaN	NaN
0.0008	0.0004		NaN	0.0009	NaN	NaN	NaN
0.0015	0.0013		NaN	0.0020	NaN	NaN	NaN
0.0021	0.0028		NaN	0.0035	NaN	NaN	NaN

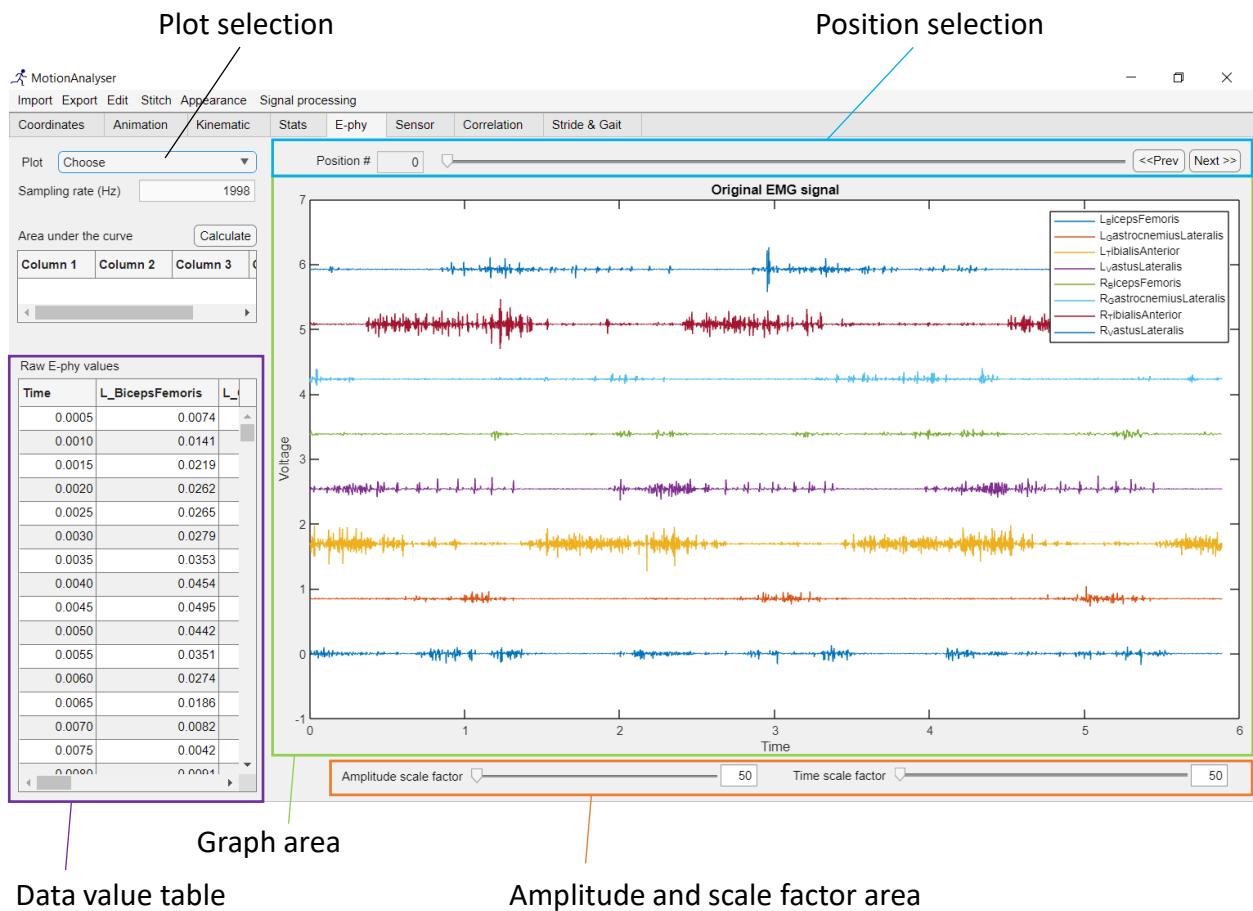
  

	x	y	z	xy	xz	yz	xyz
Min	8.9528e-07	1.1232e-06		3.3208e-05			
Max	0.063541	0.016679		0.06374			
Mean	0.017578	0.0034927		0.018533			
Median	0.0023613	0.0017634		0.0055596			
Sum	3.164	0.62869		3.336			

# E-phy and Sensor tabs

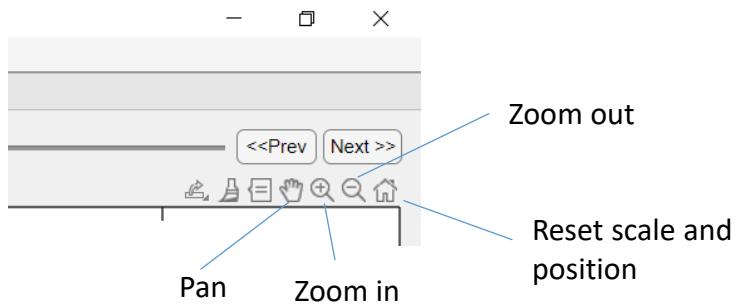
The E-phy and Sensor tabs are identical in functionality. While they could have been merged into a single tab with a selector, they were separated into two tabs to improve the readability of the data and user convenience. These tabs primarily interact with the "Signal processing" menu, but also the "Edit" and "Import" menus. Further details regarding these interactions will be provided later in the user manual.

Both tabs offer a large plot area where the curves for different recordings are stacked on the Y-axis. A horizontal sliding bar positioned at the top of the plot area enables time point selection. Additionally, two horizontal sliding bars at the bottom of the plot area allow for adjustment of the amplitude and time scales.



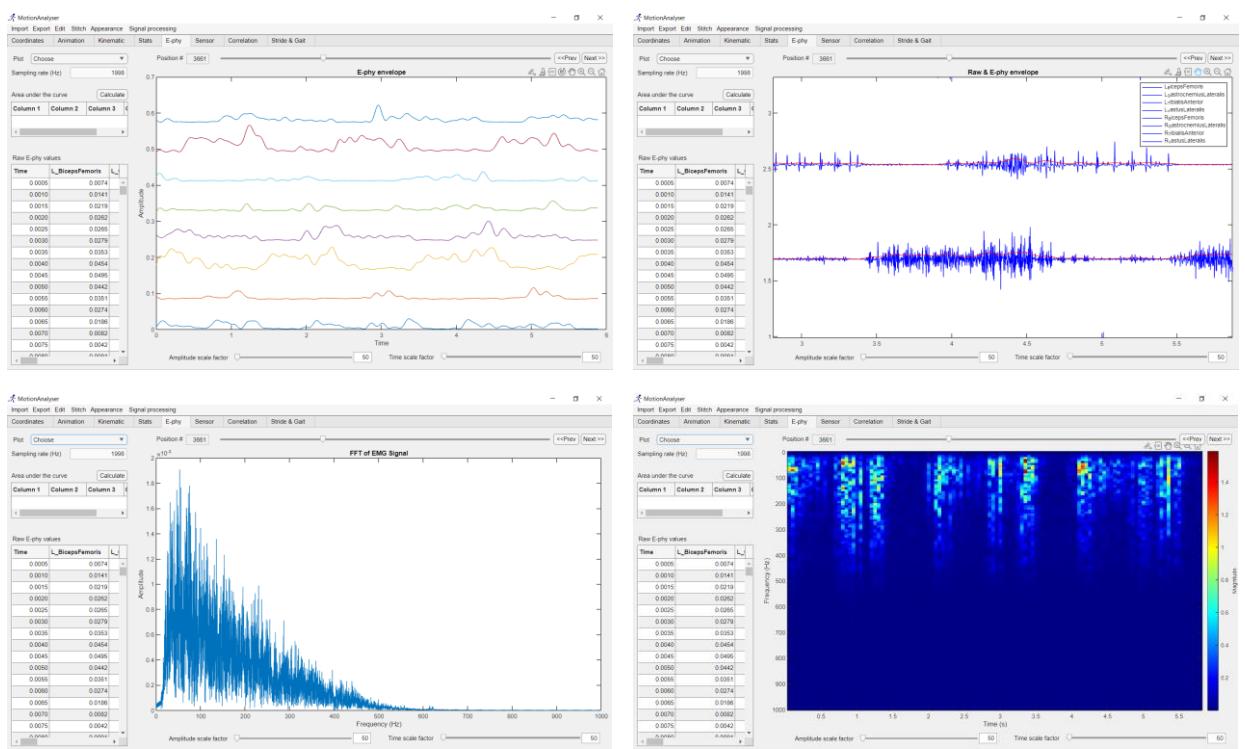
# E-phy and Sensor tabs

Note that at the top left corner of the plot area, other options for the display are available



The plot selector enables the user to choose what to plot:

- Raw trace
- Filtered trace
- Envelope
- Raw trace and envelope overlay
- FFT power spectrum
- FFT spectrogram

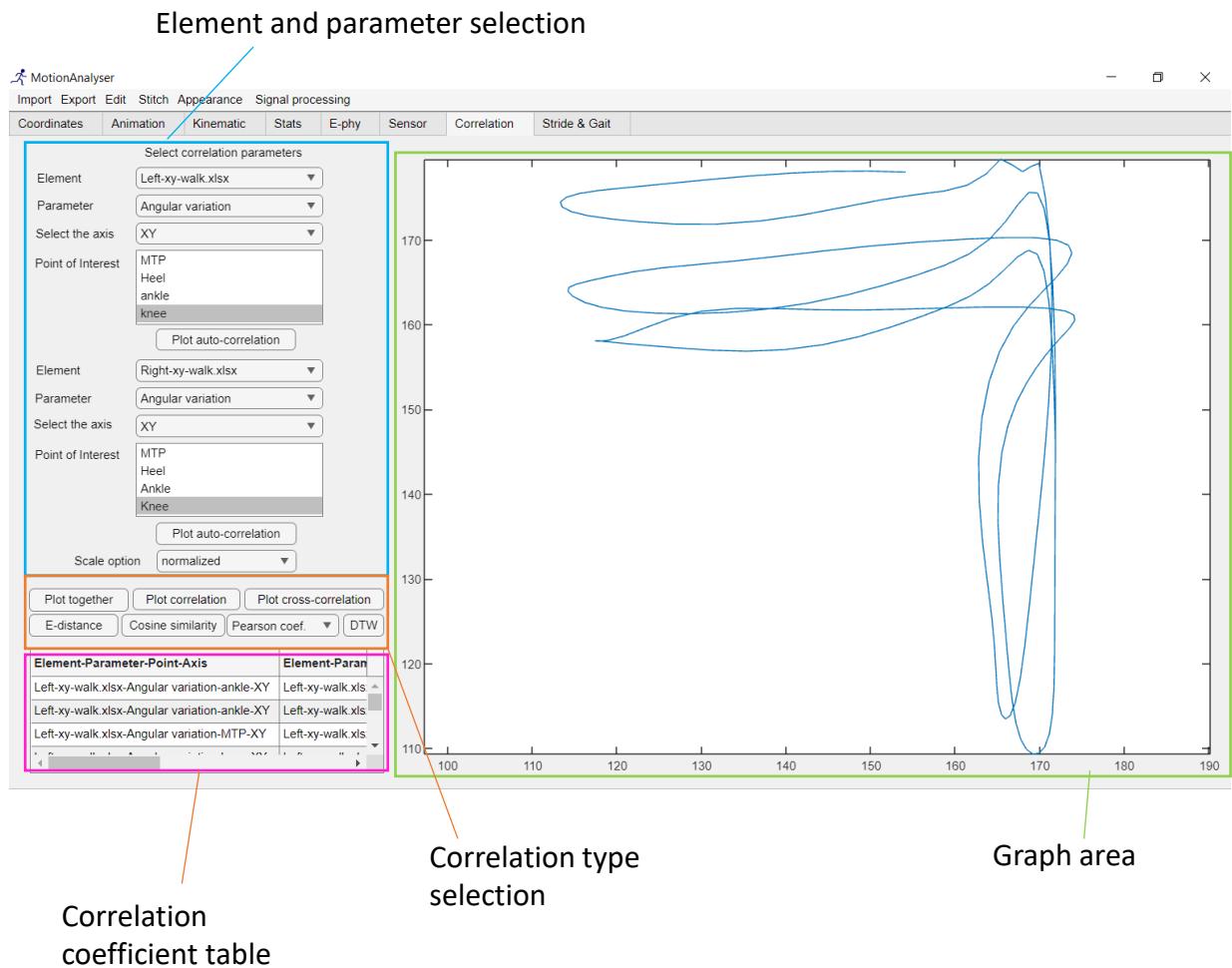


# Correlation tab

This tab is composed of several components, including:

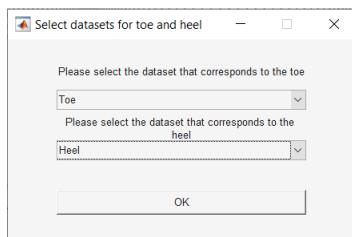
- A large plot area where the correlation plot is displayed.
- An area to select the first parameter to correlate.
- An identical area to select the second parameter to correlate.
- A correlation type selection area to choose the type of correlation.
- A correlation coefficient table that displays the computed correlation coefficients.

These components together facilitate the process of performing correlations between different parameters.

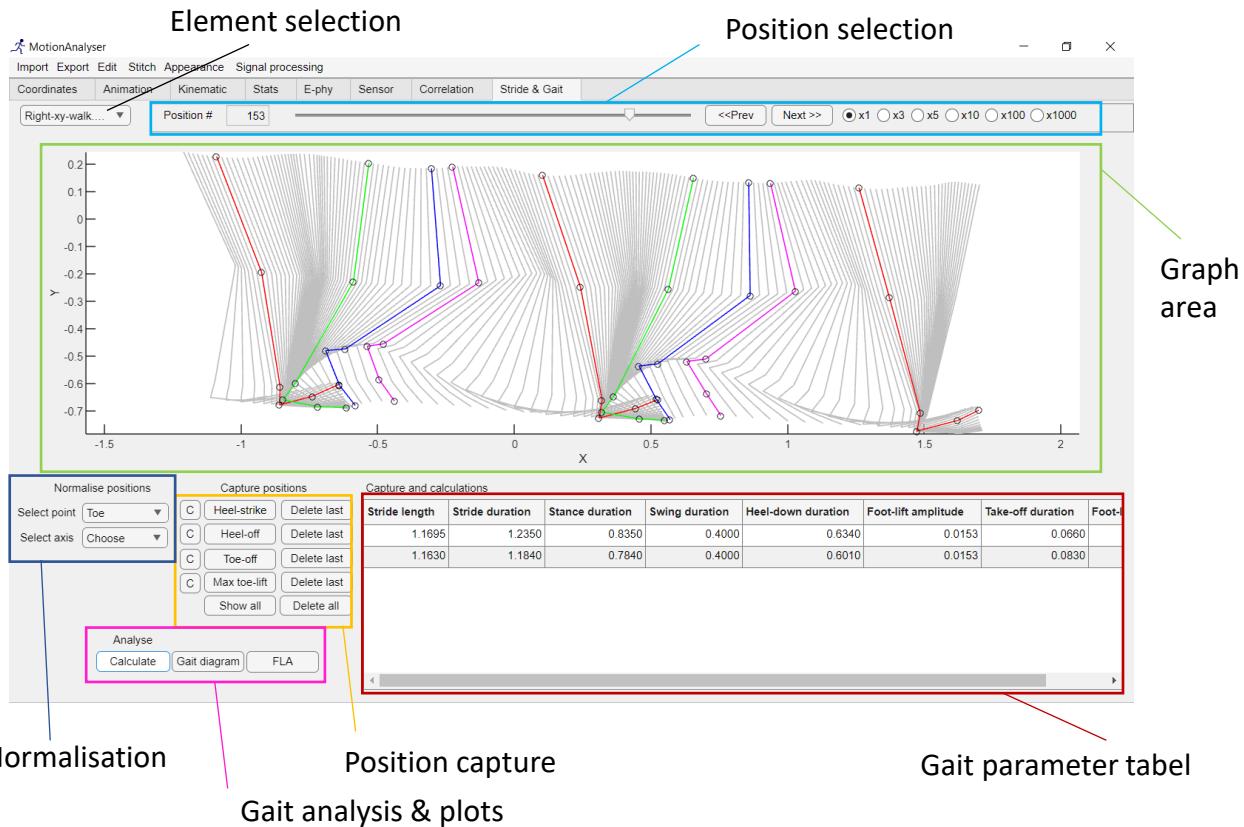


# Stride & Gait tab

This tab is specifically designed for gait analysis. Upon selection of the tab, a dialogue box prompts the user to define the dataset corresponding to the heel and toe. This information is crucial for accurate calculation of various gait parameters. However, as demonstrated in Annanvi and Boulland (2023), this tab can also be utilized for analyzing other movements that gait, including the leg pendulum and animal swimming.



The tab features a large horizontal plot area to display the movement positions. A position area with a horizontal sliding bar to navigate through the data. Additionally, a normalization area allows the user to apply x, y, or xy normalization of the movement based on a user-defined point of interest. Furthermore, there is an area dedicated to capturing positions that correspond to well-defined gait events. The program allows the identification of up to four typical positions: heel strike, heel-off, toe-off, and max toe-lift. At a minimum, a meaningful calculation requires the identification of two positions corresponding to a heel strike, which defines a stride.



# Import data

MotionAnalyser can import files in the following formats: xls, xlsx, csv, and txt. The source files must always have headers on the first row, with time as the first column.

Time (sec)	Toe	X	Y	Toe	X	Y	Heel	X	Y	ankle	X	Y	knee	X	Y	hip	X	Y
0	1,11884	-0,64772	1,19325	-0,64544	1,34668	-0,63138	1,30811	-0,57228	1,19239	-0,16883	1,1307	0,27841						
0,016	1,11884	-0,64772	1,19219	-0,64436	1,34633	-0,63046	1,30684	-0,5712	1,18396	-0,16967	1,11582	0,27597						
0,033	1,11884	-0,64847	1,19133	-0,64367	1,34581	-0,62922	1,30547	-0,56992	1,17515	-0,17055	1,10071	0,27349						
0,05	1,1189	-0,64923	1,19068	-0,64344	1,34507	-0,6275	1,30391	-0,56833	1,16557	-0,17146	1,0853	0,27093						
0,066	1,11881	-0,64997	1,19011	-0,64352	1,34419	-0,62522	1,30219	-0,5664	1,15498	-0,17238	1,06952	0,26835						
0,083	1,11853	-0,65066	1,1896	-0,64372	1,34324	-0,62229	1,30028	-0,56406	1,14322	-0,17332	1,0533	0,26582						
0,1	1,118	-0,65129	1,18926	-0,64394	1,34219	-0,61868	1,2981	-0,56119	1,1302	-0,17432	1,03659	0,26341						
0,116	1,11738	-0,65181	1,18912	-0,64418	1,34088	-0,61441	1,29547	-0,55763	1,11583	-0,17537	1,01937	0,26118						
0,133	1,11688	-0,65227	1,18905	-0,64438	1,33901	-0,60934	1,2921	-0,55327	1,10004	-0,17643	1,00167	0,25918						
0,15	1,11658	-0,65283	1,18877	-0,64442	1,33607	-0,60288	1,28764	-0,54802	1,08266	-0,17743	0,98355	0,25746						
0,166	1,11629	-0,65357	1,18799	-0,644	1,3314	-0,59413	1,28165	-0,54168	1,06329	-0,17841	0,96507	0,25605						
0,183	1,11584	-0,65441	1,18651	-0,64265	1,32442	-0,58236	1,27365	-0,53403	1,04147	-0,17943	0,9463	0,25495						
0,2	1,11529	-0,65524	1,18437	-0,63983	1,31495	-0,56746	1,26323	-0,52486	1,01691	-0,1805	0,92732	0,25411						
0,216	1,11448	-0,65584	1,18178	-0,63489	1,30317	-0,54997	1,25004	-0,514	0,98964	-0,18161	0,90821	0,25346						
0,233	1,11431	-0,65585	1,17872	-0,62756	1,28917	-0,53061	1,23387	-0,50138	0,95991	-0,18766	0,88908	0,25294						

Import xy-coordinates (see example above)

Import x and y coordinates from csv generated with DeepLabCut

Import coordinates from separated files (X and Y) as exported from Kinovea

Import xyz-coordinates

Import coordinates for stitching to already imported coordinates

Import electrophysiology traces

Import sensor signal traces } Source files must be organised like this:

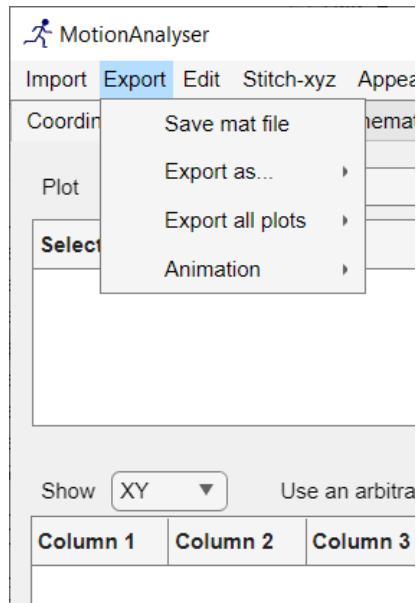
Import MATLAB files previously exported with MotionAnalyser

Reset (deletes all data)

Load mathematically defined data to test the software. Note that certain functions do not work correctly when used. This option will be removed in future software releases.

time	Deltoides brachii	Biceps brachii	Triceps brachii	Flexor digitorum
0	-0,07E-06	-2,41E-06	-1,75E-05	2,17E-05
0,0005	-3,80E-05	-2,58E-06	-1,72E-05	2,27E-05
0,001	-2,11E-05	-1,87E-06	-1,81E-05	2,33E-05
0,0015	-5,80E-06	-1,58E-06	-1,99E-05	2,38E-05
0,002	5,86E-07	-2,03E-06	-2,08E-05	2,36E-05
0,0025	-3,83E-06	-3,17E-06	-2,09E-05	2,19E-05
0,003	-1,31E-05	-4,97E-06	-2,13E-05	1,99E-05
0,0035	-2,21E-05	-6,29E-06	-2,11E-05	1,93E-05
0,004	-2,85E-05	-5,94E-06	-2,02E-05	2,02E-05
0,0045	-3,26E-05	-4,65E-06	-2,02E-05	2,18E-05
0,005	-3,31E-05	-3,79E-06	-2,03E-05	2,29E-05
0,0055	-2,39E-05	-3,08E-06	-1,86E-05	2,29E-05
0,006	-3,92E-06	-1,84E-06	-1,58E-05	2,25E-05
0,0065	1,63E-05	-6,49E-07	-1,36E-05	2,24E-05
0,007	2,20E-05	2,36E-07	-1,36E-05	2,18E-05
0,0075	7,80E-06	1,40E-06	-1,54E-05	2,04E-05
0,008	-1,68E-05	2,47E-06	-1,68E-05	1,90E-05
0,0085	-3,68E-05	2,78E-06	-1,68E-05	1,84E-05

# Export data



## Save mat file:

Save all imported and calculated data to a MAT file. You can then load it in the MATLAB workspace or reopen it in MotionAnalyser. This does not save figures.

## Export as:

Export all imported and calculated data to xls,xlsx, or csv files. Each dataset is exported as a separate file.

## Export all plots:

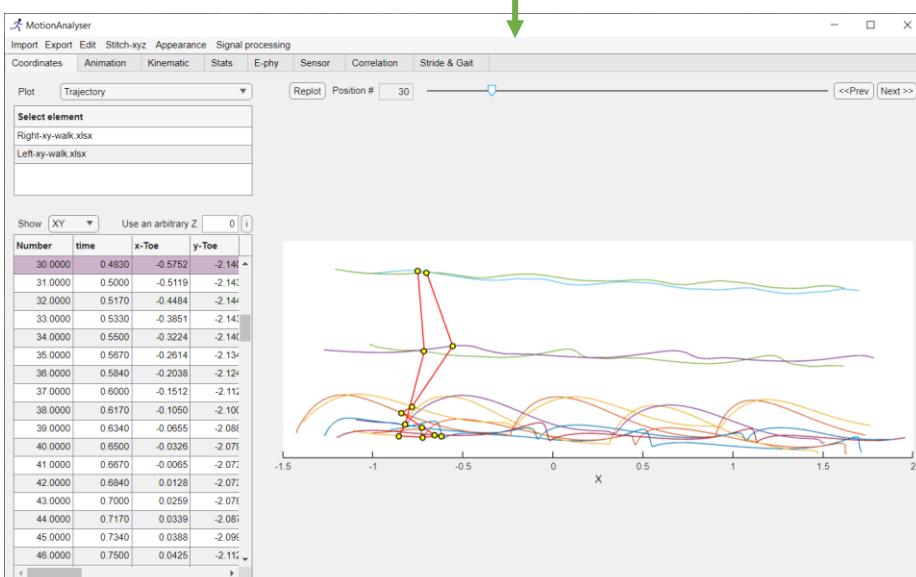
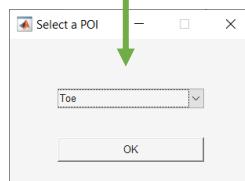
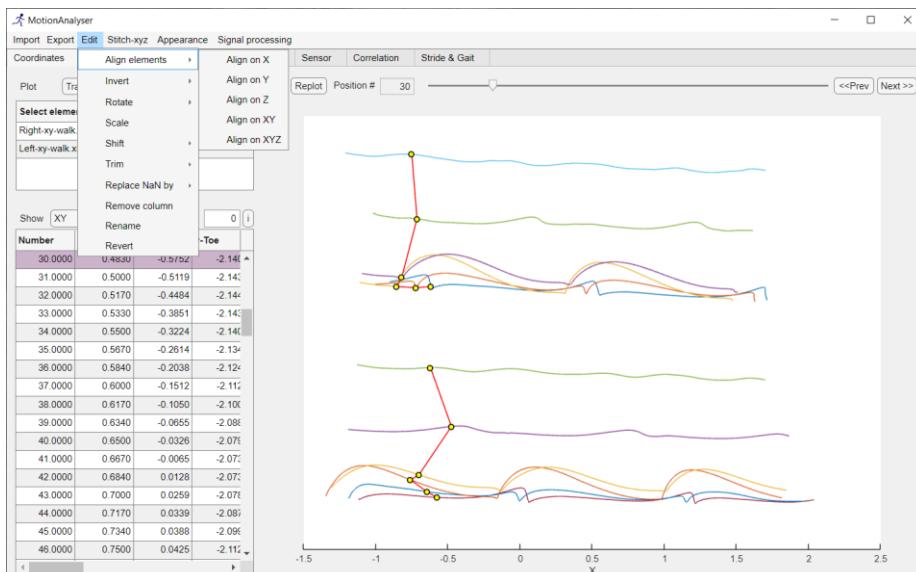
Export all currently displayed plots and figures as png files.

## Animation:

Export animations as AVI or GIF files. Note that this process can be slow depending on the duration and sampling rate of the data.

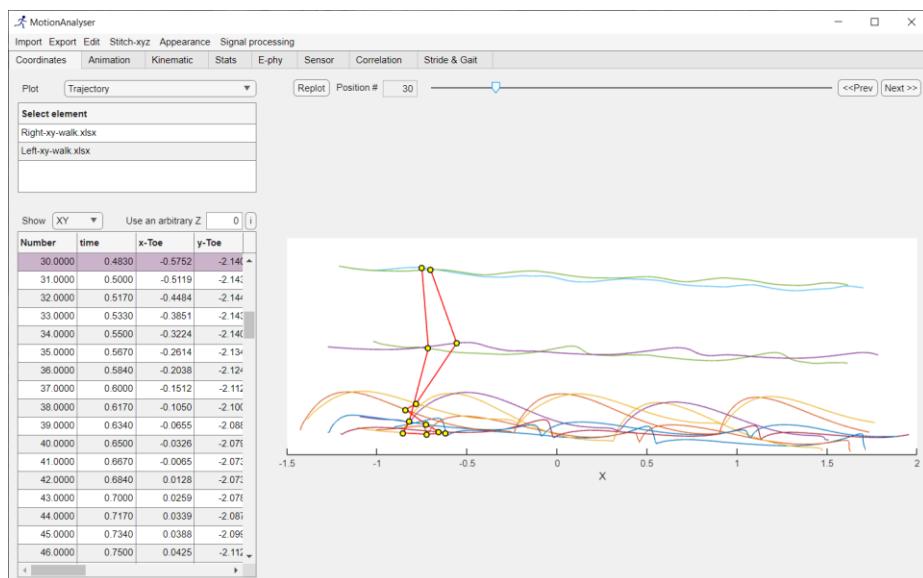
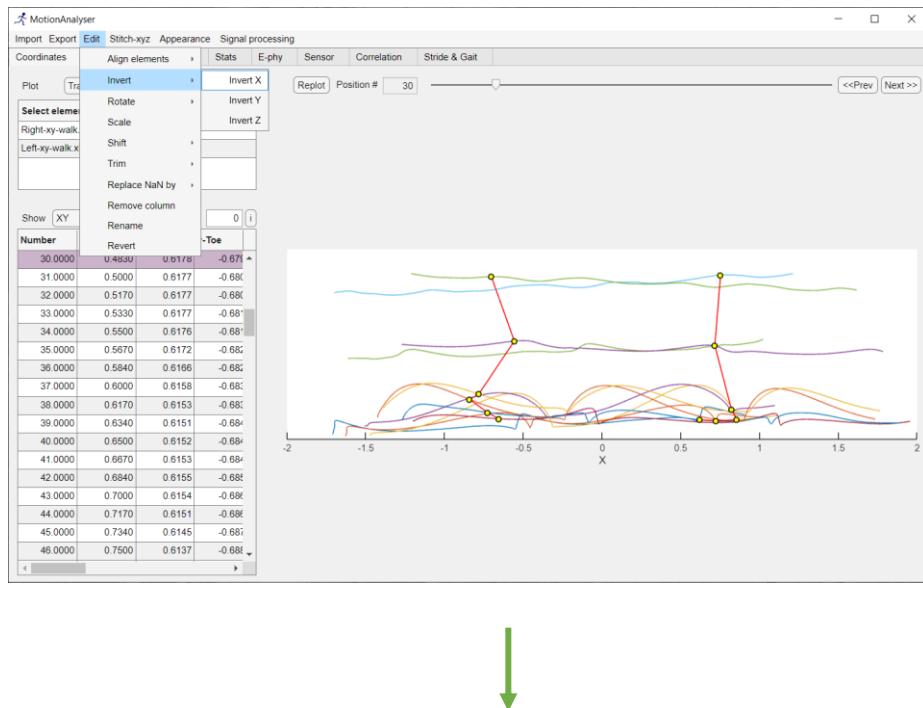
# Edit: Align elements

When working with two or more elements (e.g., two legs imported from different sets of coordinates), this option aligns them to a selected point of interest. The alignment can be performed in the x, y, z, xy, and xyz axes.



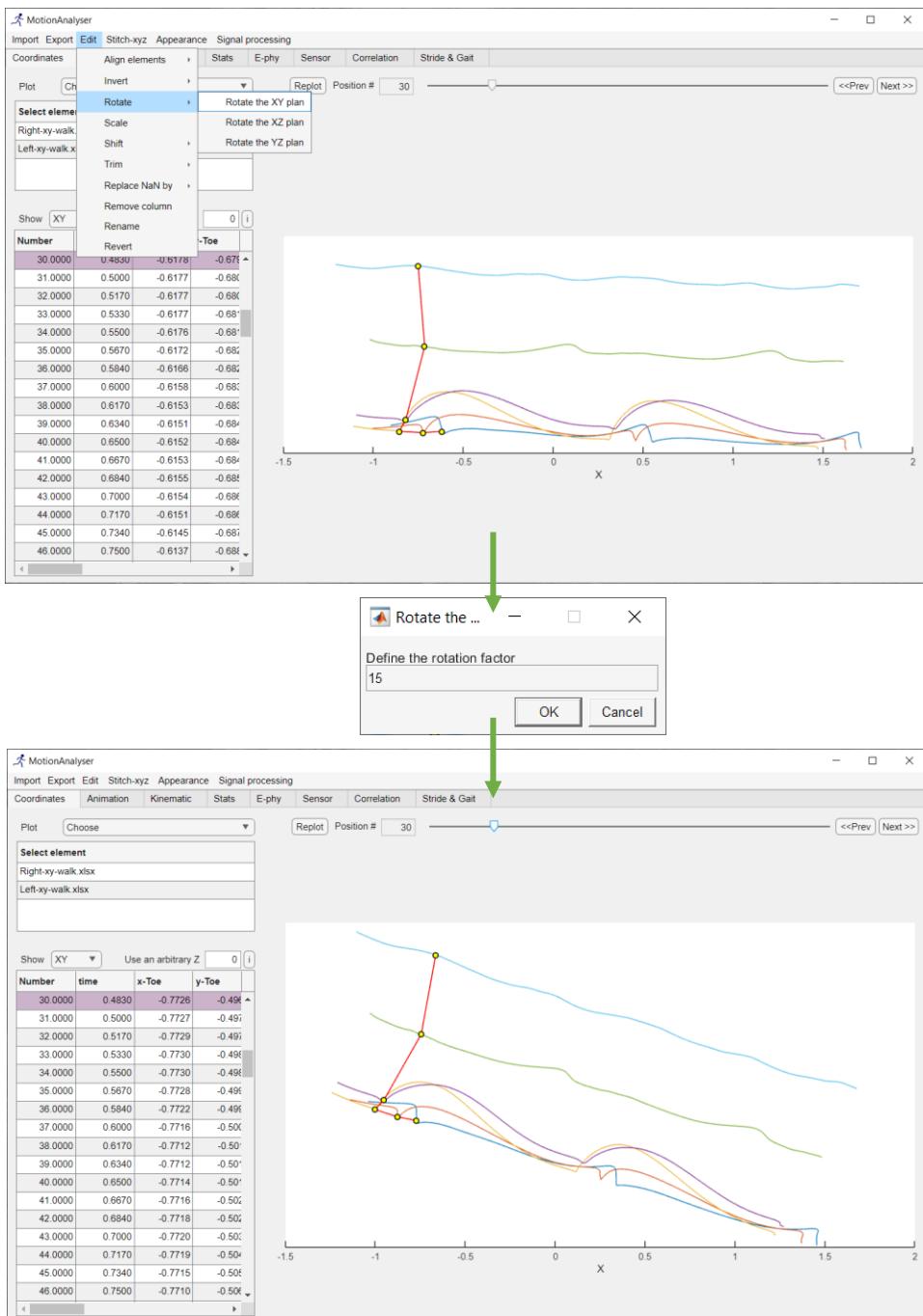
# Edit: Invert

This function allows for the inversion of the coordinates on the desired axis.



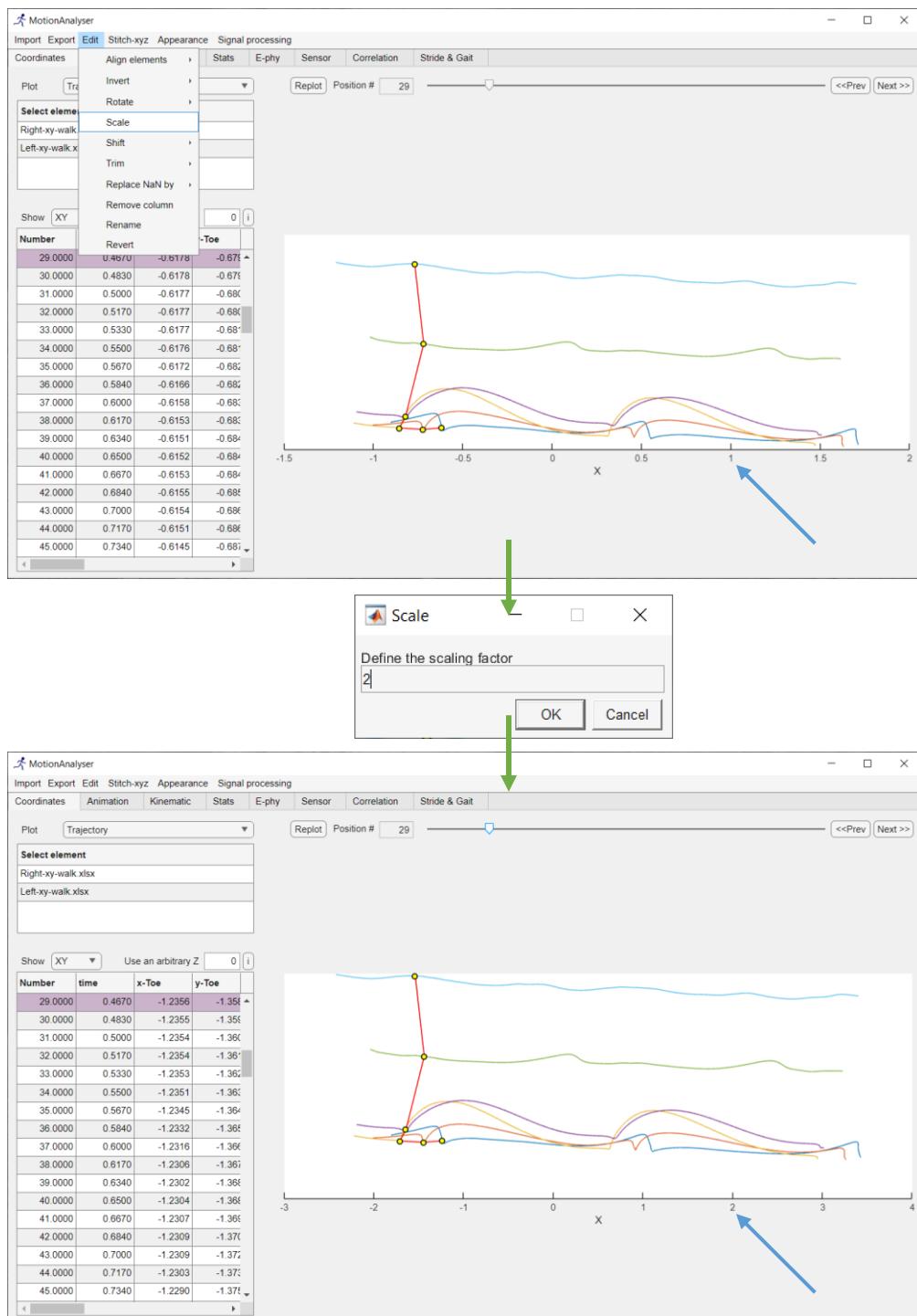
# Edit: Rotate

This function allow for the rotation of the coordinates along the desired axis.



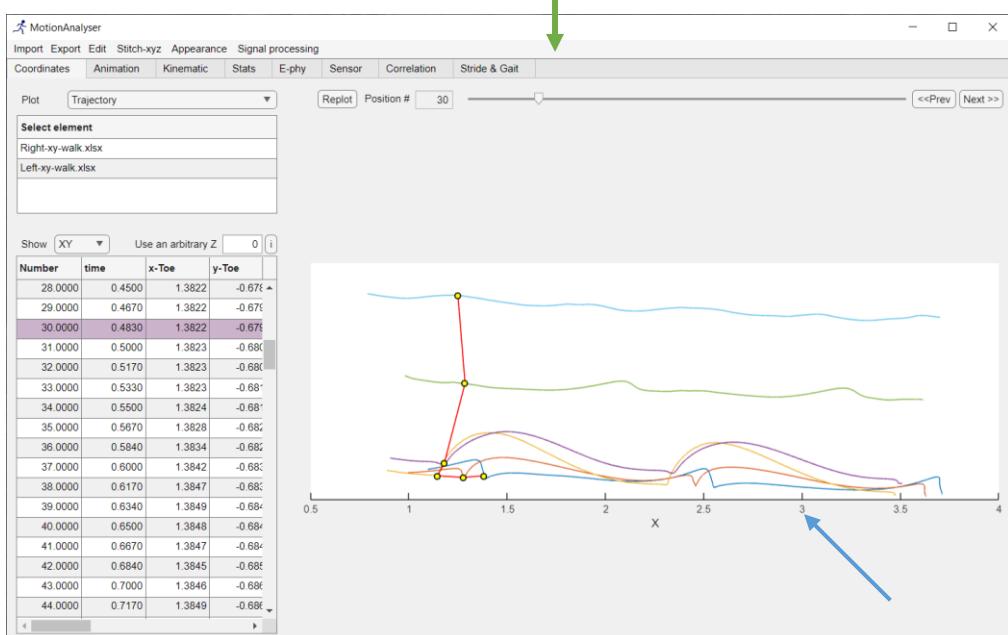
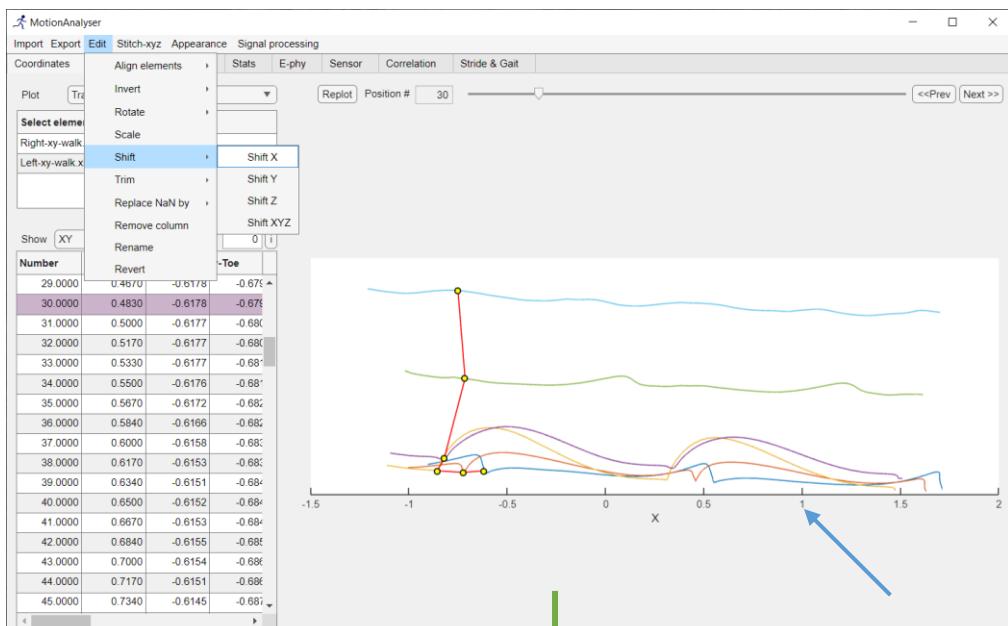
# Edit: Scale

This function enable the scaling of coordinates.



# Edit: Shift

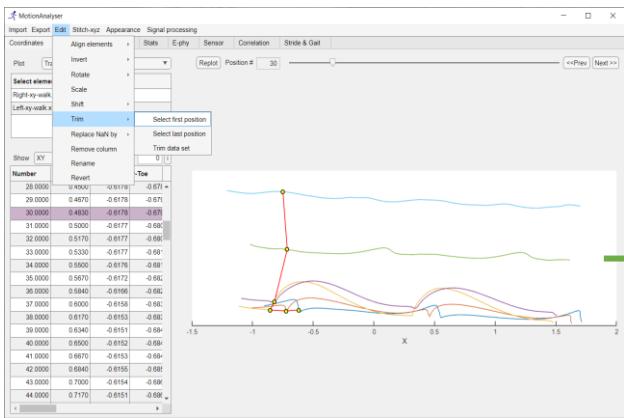
This function enables a translation of the coordinates along a desired axis by a desired amount.



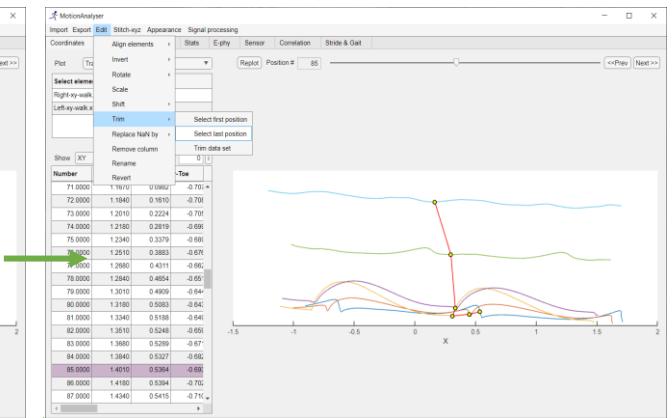
# Edit: Trim

This function enables trimming a dataset by selecting the desired first and last positions. It can be applied in the *Coordinates* tab and also in the *E-Phy* and the *Sensor* tabs.

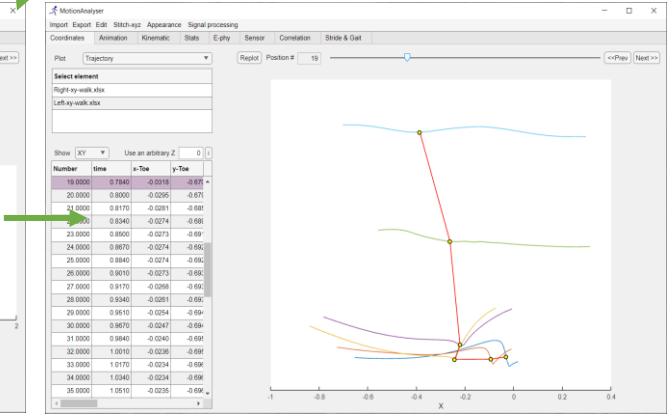
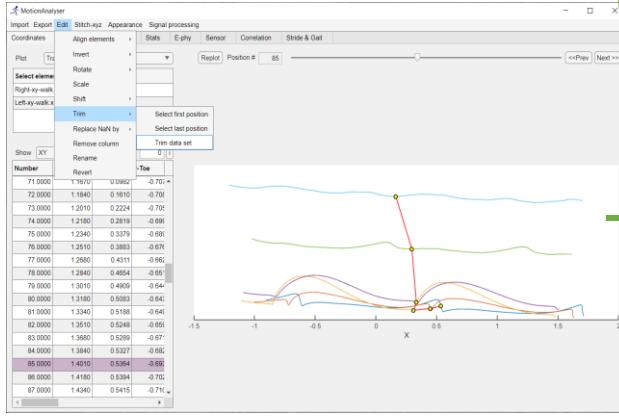
Select the first position



Select the last position

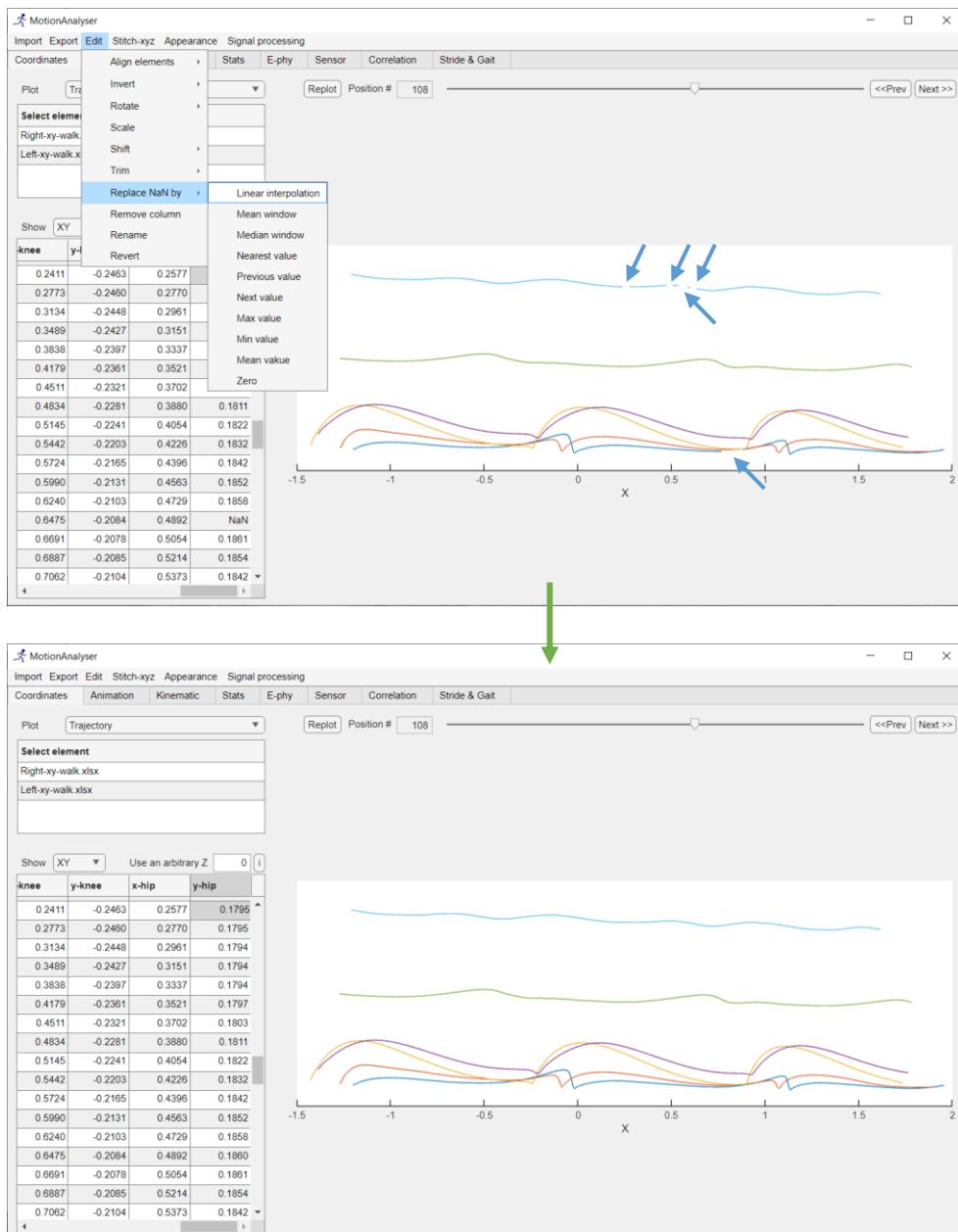


Trim the dataset



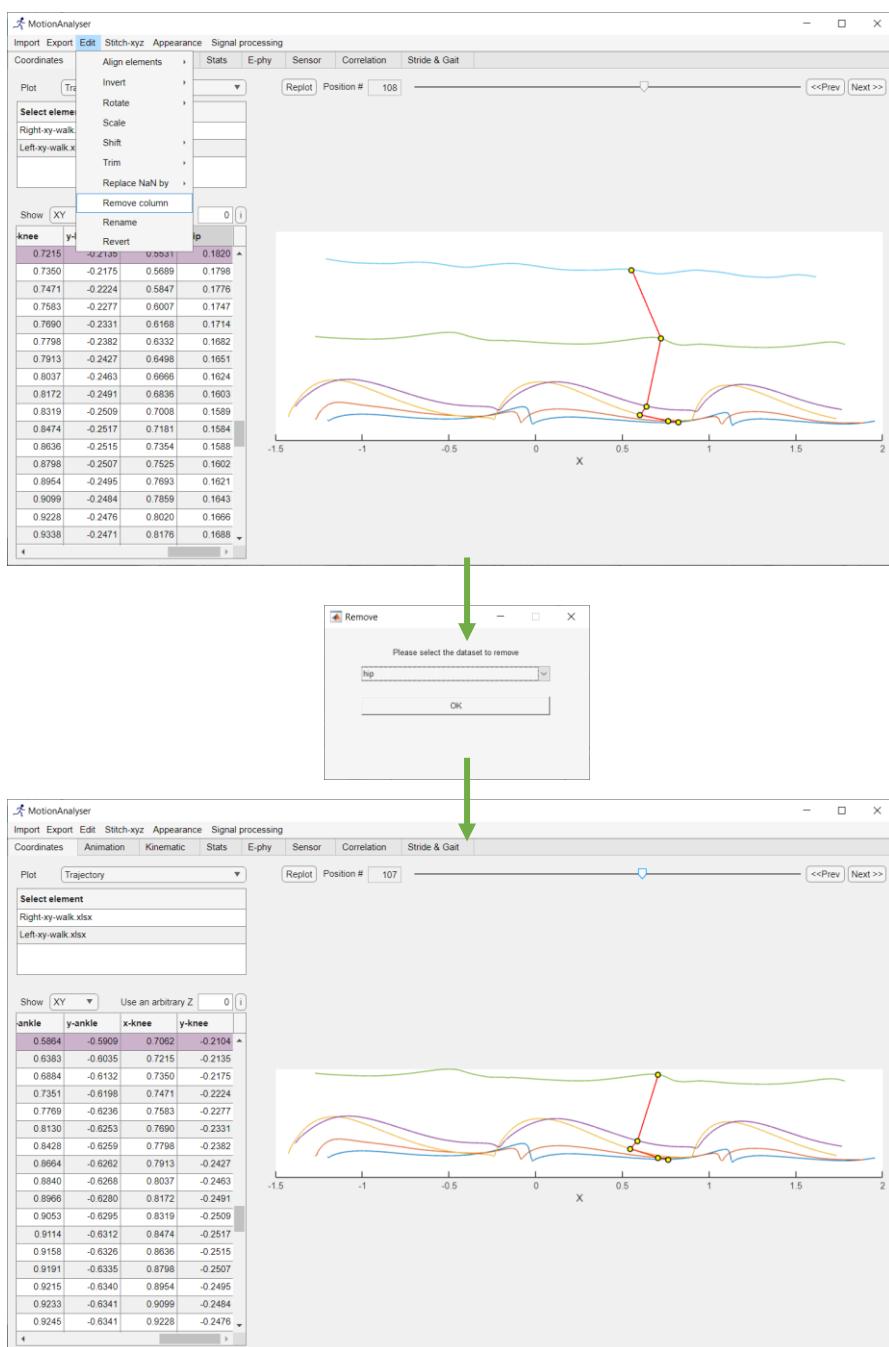
# Edit: Replace NaN by

This feature enables the replacement of NaN (Not-a-Number) values with a user-selected calculation method. The available methods include linear interpolation, mean window, median window, nearest value, previous value, next value, maximum value, minimum value, mean value, and zero. This functionality is currently only available in the *Coordinates* tab. However, in future releases, it will be implemented for the *E-phy* and the *Sensor* tabs as well.



# Edit: Remove column

The trimming function detailed previously enables the user to trim the data by rows. The Remove column function enables the user to remove a desired column of data, corresponding to a point of interest. In the example bellow, the hip joint is removed. This function also works in the *E-phy* and *Sensor* tabs.

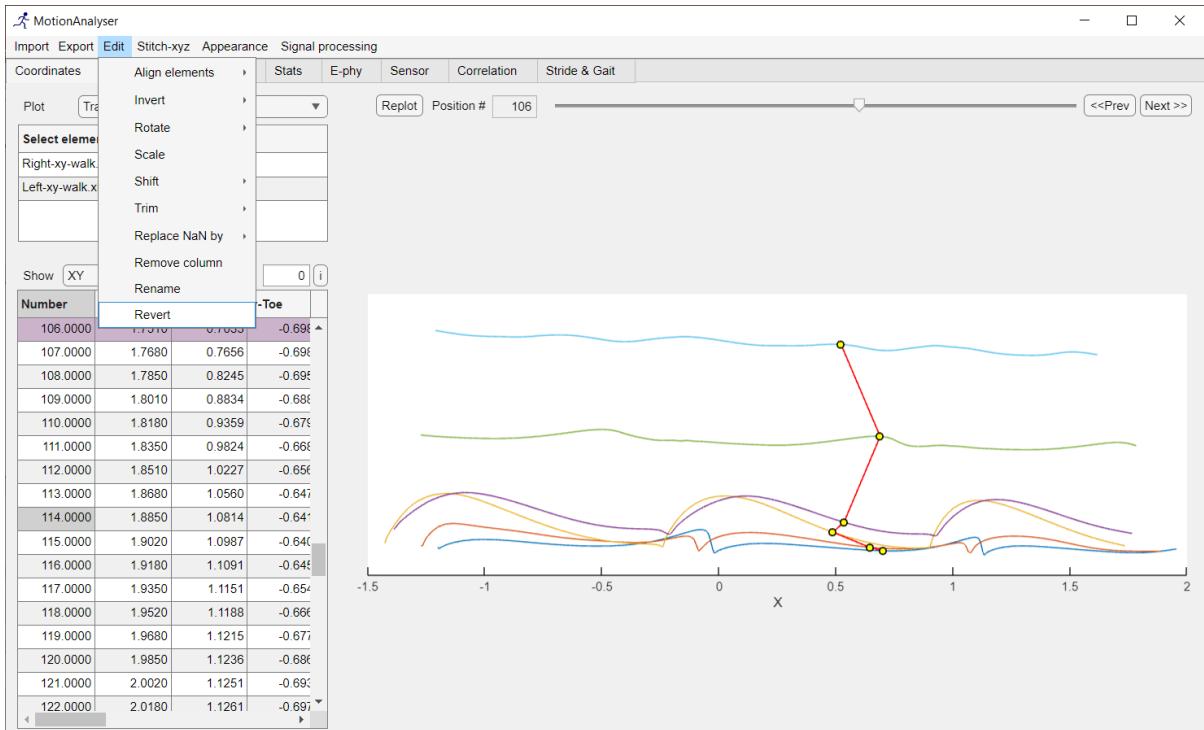


# Edit: Rename

This enables users to change the designation of a point-of-interest. In the example below, "Toe" is renamed as "tootsie-digits".

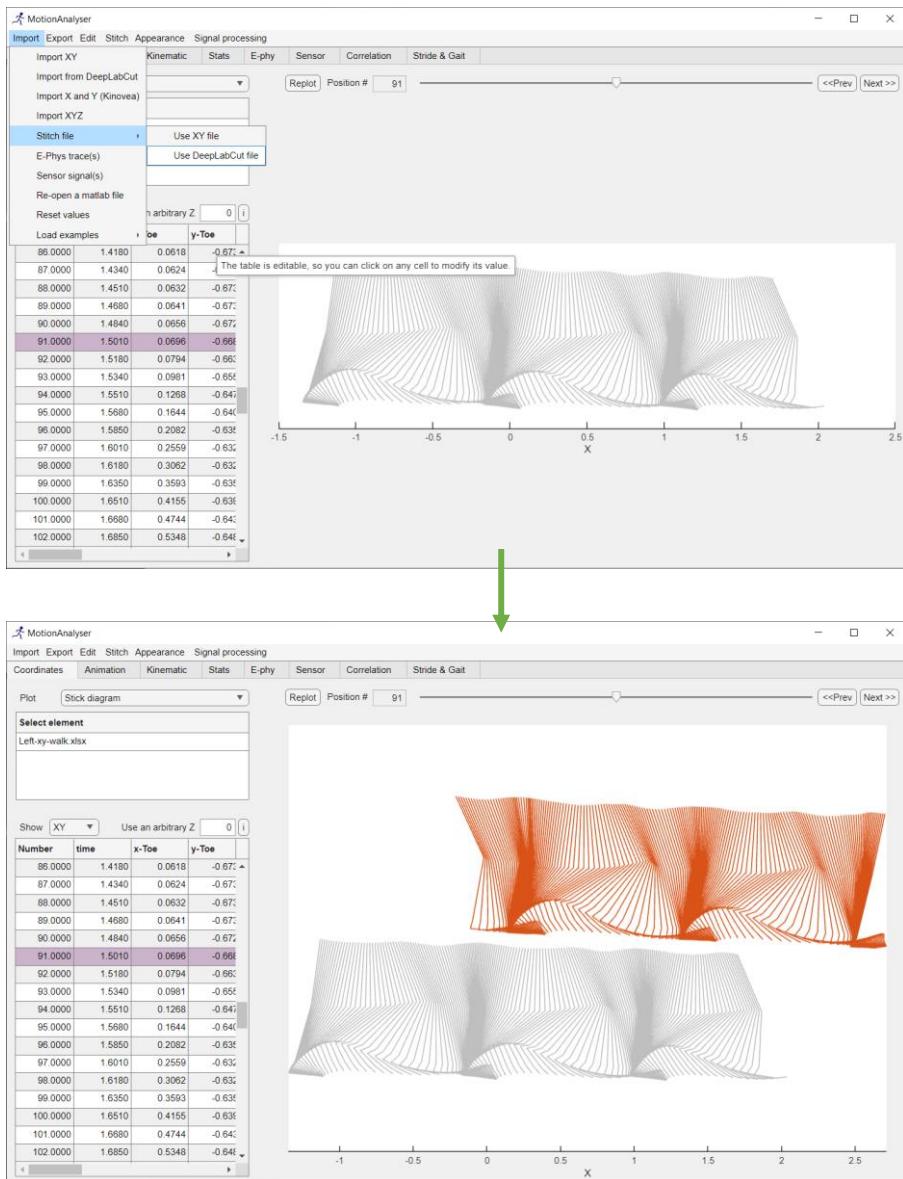
# Edit: Revert

Any of the functions in the "Edit" menu can be undone using the "Revert" function.



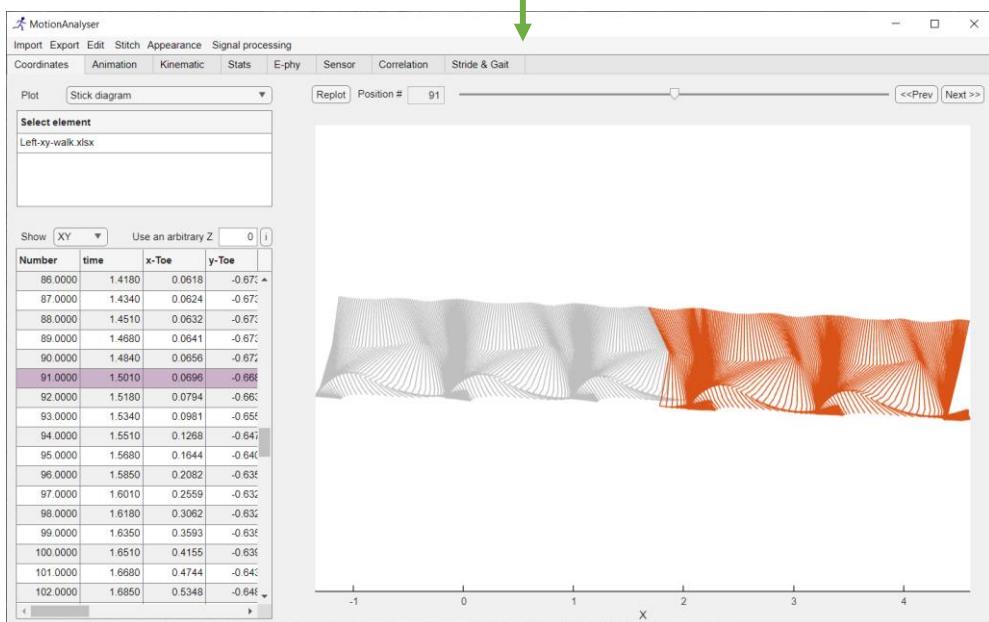
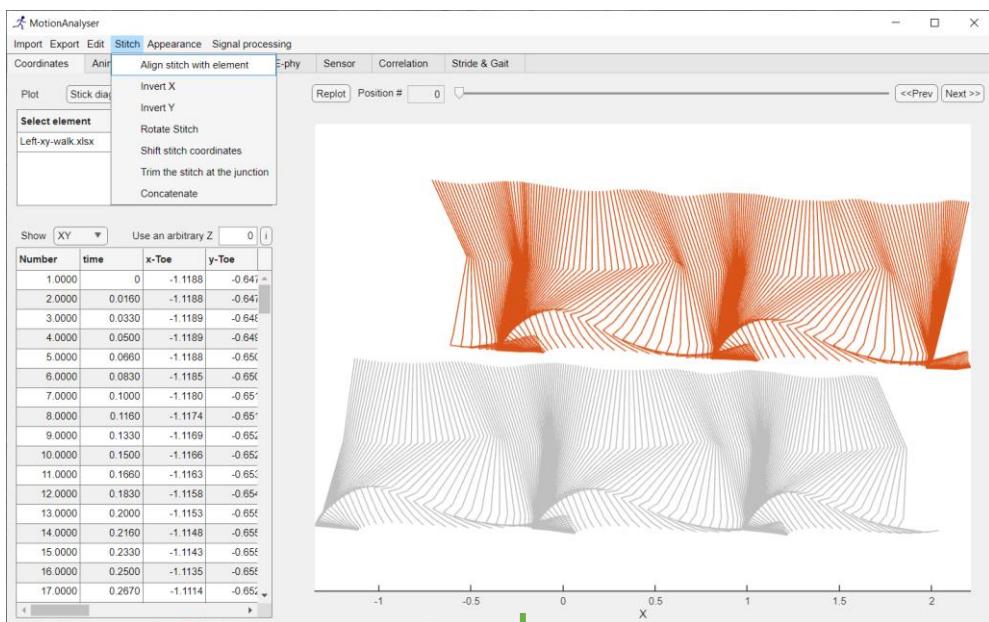
# Stitch: Load from Import menu

This menu is specifically designed to be used in the *Coordinates* tab and enables the concatenation of datasets obtained from different cameras. Stitch coordinates can be loaded from the import menu, as mentioned [earlier in this user manual](#). The imported stitch coordinates are automatically plotted in orange to avoid confusion with the main element, which is displayed in gray.

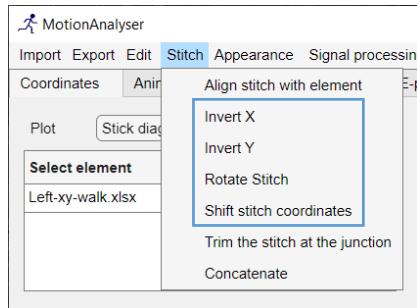


# Stitch: Align stitch with element

This function aligns the stitch sequence of coordinates with a user-defined point-of-interest.



# Stitch: Invert, Rotate, Shift, and Linear transform stitch

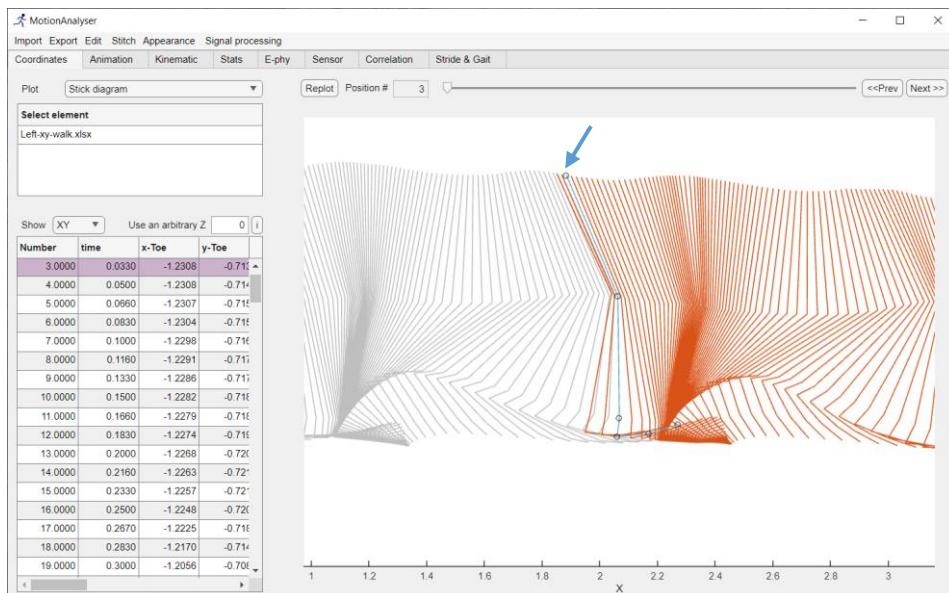


The *Stitch* menu includes some of the same functions found in the *Edit* menu, such as *Invert*, *Rotate*, and *Shift*. These functions have been placed in the *Stitch* menu to avoid confusion and because they specifically operate on stitch coordinates. They allow the user to manually invert the x and/or y coordinates, rotate the position of the stitch, or shift the stitch along the x or y axis.

These functions work in the same manner as previously described in this user manual, so there is no need to provide further description here. Altogether these functions enable the user to position and blend the stitch sequence at the appropriate position to ensure continuity in the movement.

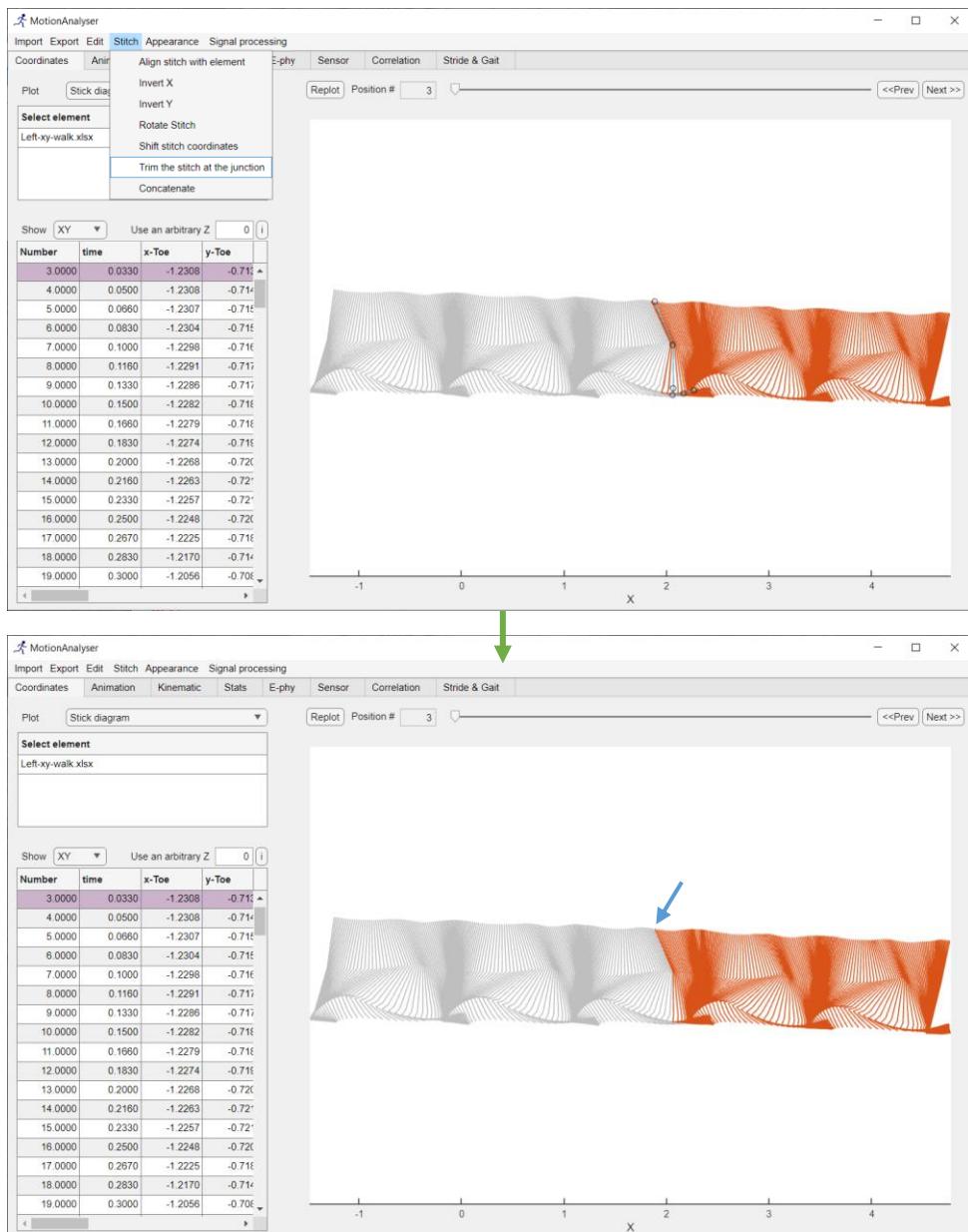
In future versions, the intention is to provide users with a range of options for compensating for potential optical mismatches between the main element and the stitch element.

Once the stitch sequence is appropriately positioned, the "Position" horizontal slider enables the selection of the transition position. This transition position determines where the stitch sequence will be trimmed and concatenated with the main sequence.



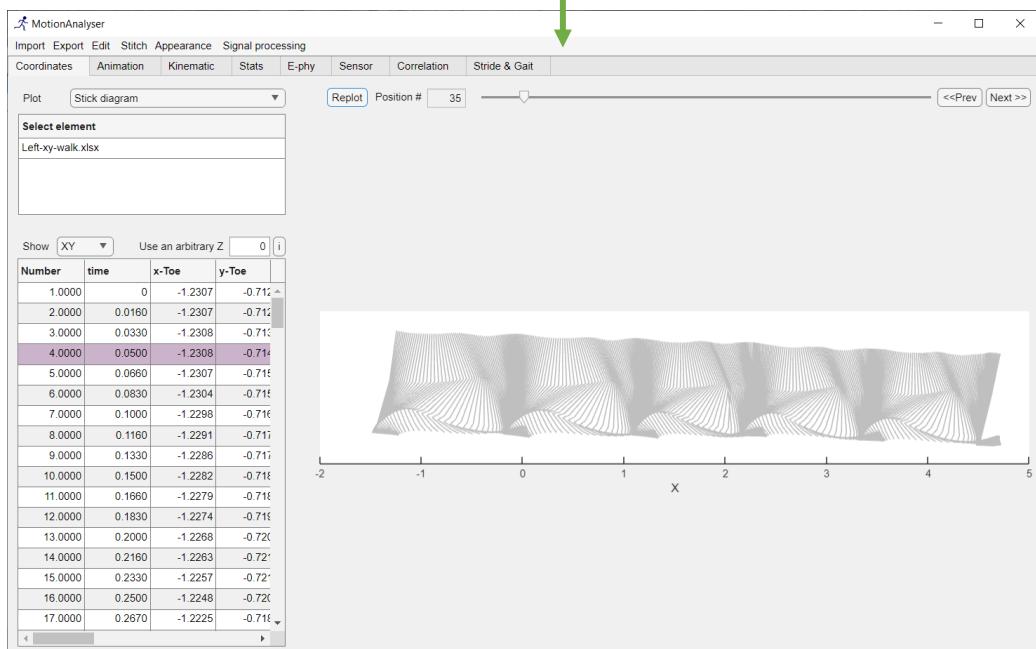
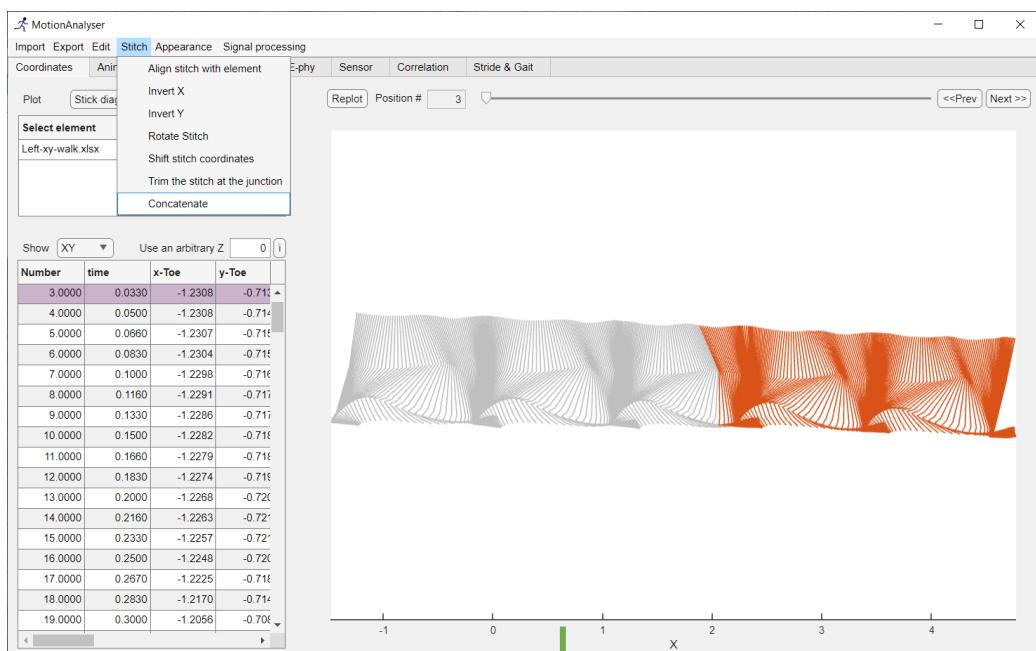
# Stitch: Trim the stitch at the junction

This function uses the position defined by the user as a reference to trim the stitch sequence. The specified position serves as a reference point for trimming and an later concatenating the stitch sequence with the main sequence.



# Stitch: Stitch onto specific point

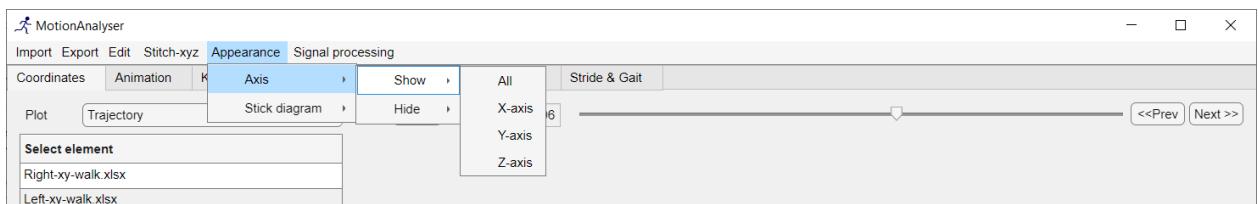
This function concatenates the stitch sequence with the main sequence.



# Appearance

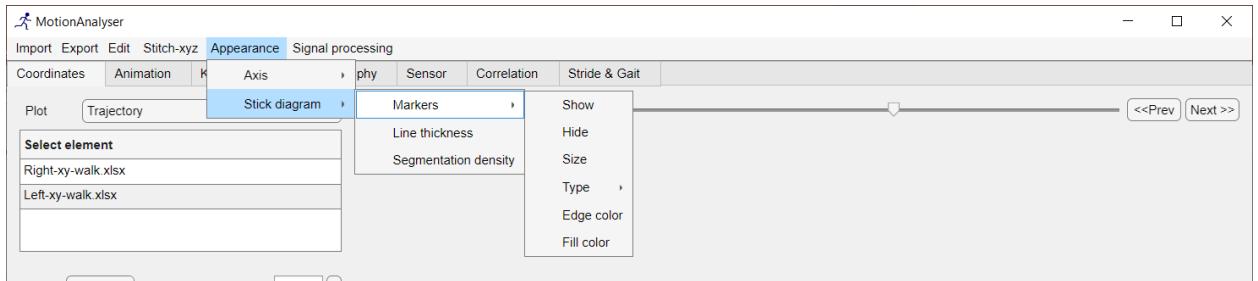
## Axis

This option enables the user to show / hide axis on the plots.

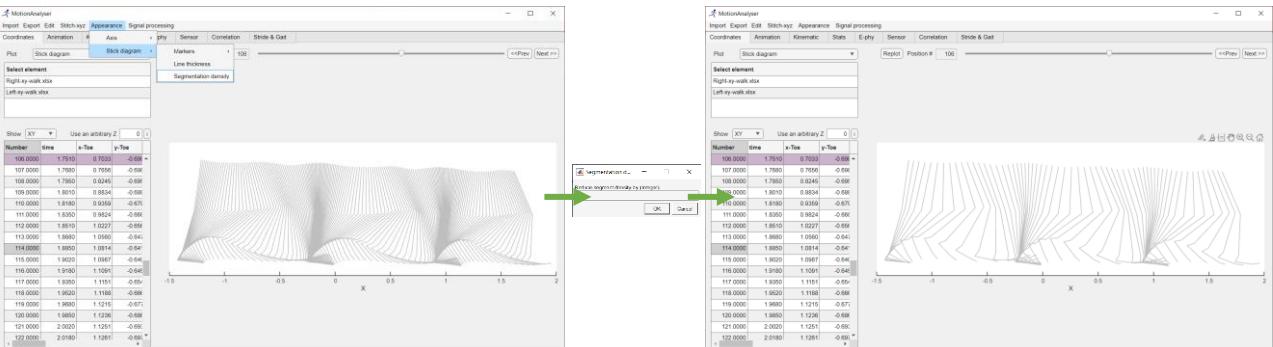


## Stick diagram

This option allows the user to modify the display of the stick diagram. It includes options for the appearance of the marker and line thickness.



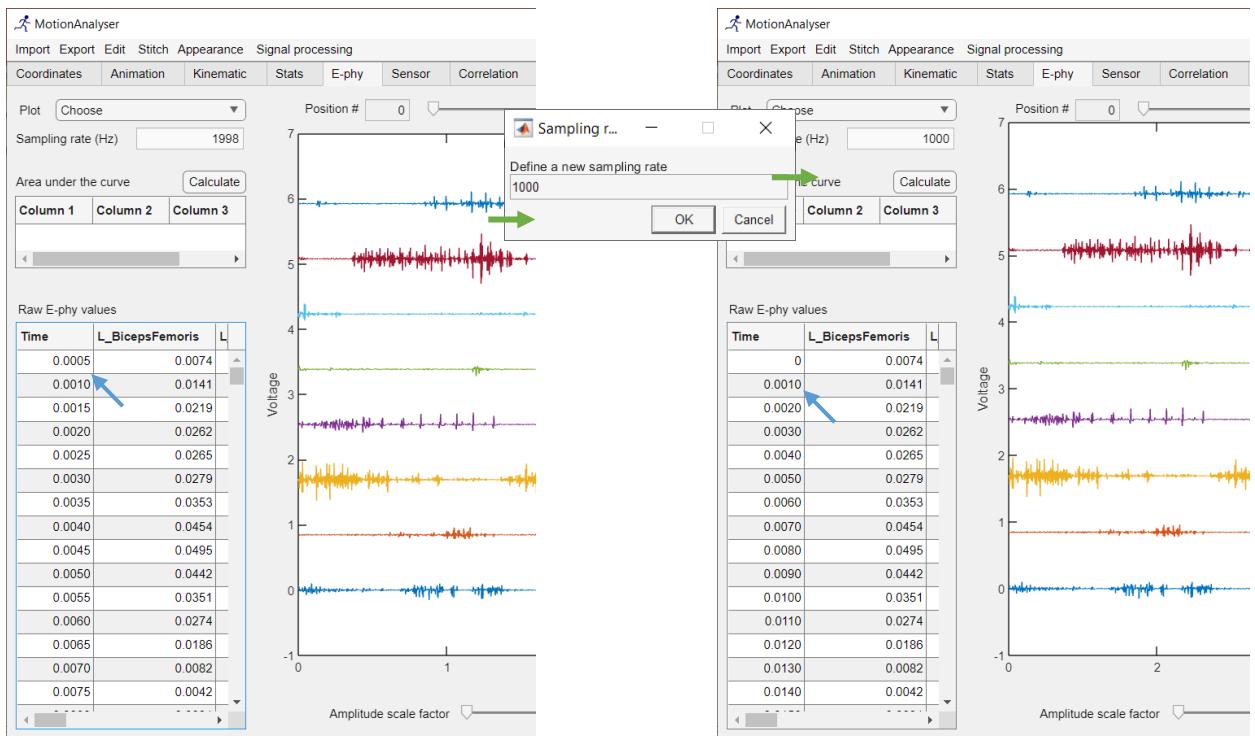
Another option also enables the reduction of segmentation density for displaying high-frequency data points.



Reverting to the original segmentation density, can be done by using a segmentation density of 1.

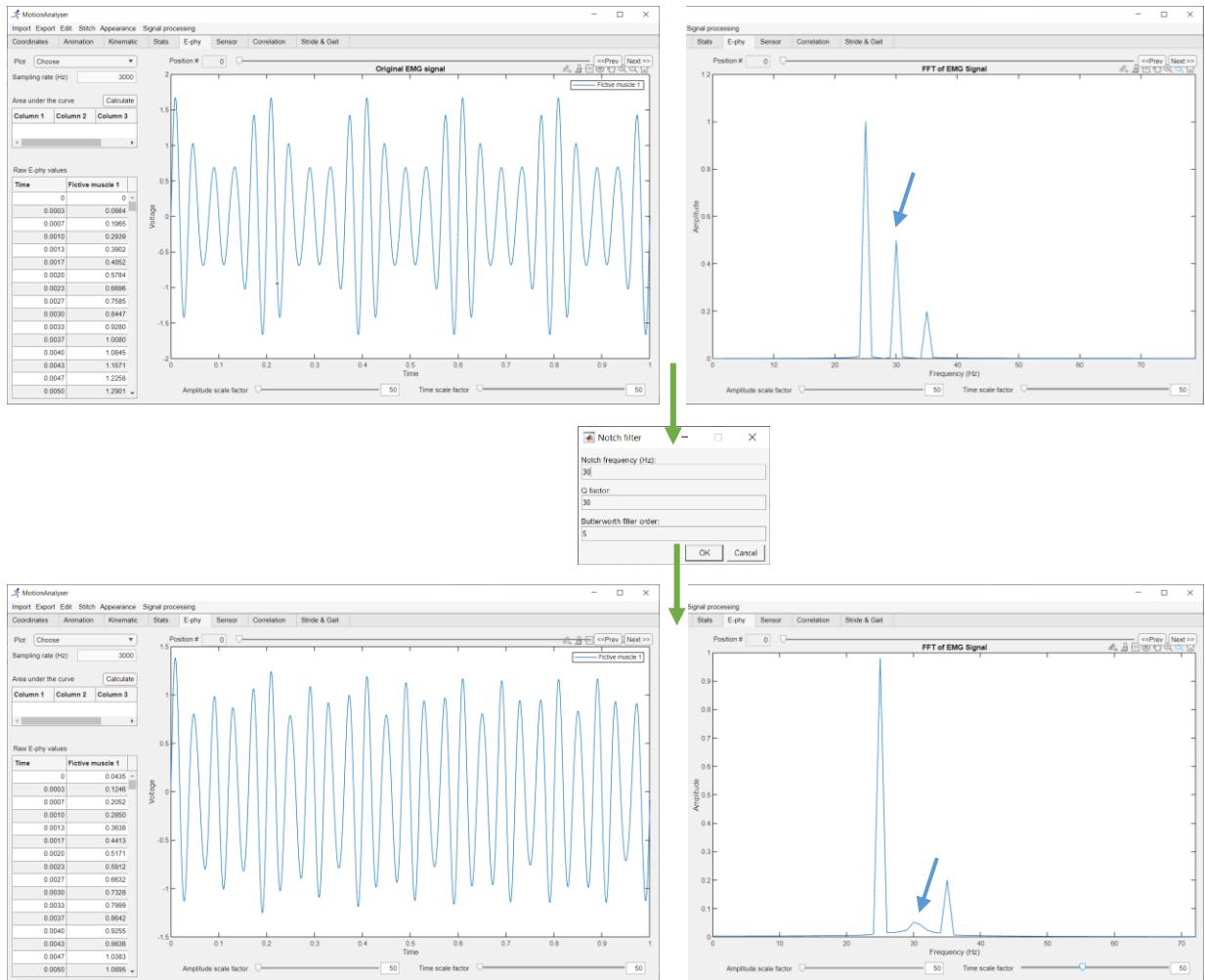
# Signal processing: Temporal resolution

This function enables the adjustment of the temporal resolution. It should not be confused with resampling or interpolation as it solely modifies the time array to a user-defined value. This function is available for the *Coordinates*, *E-phy* and *Sensor* tabs.



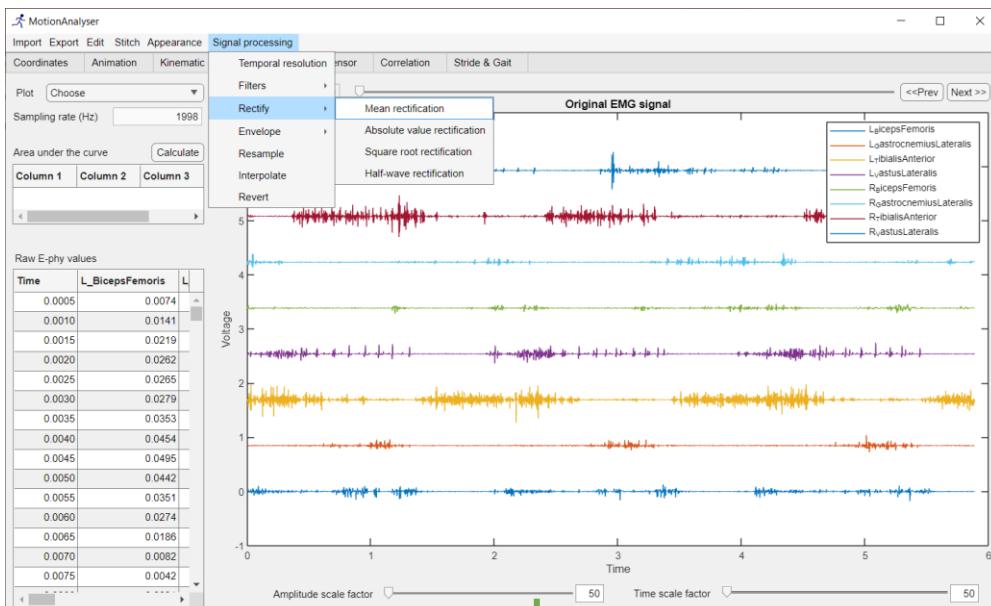
# Signal processing: Filters

This function allows for the filtering of raw signals from the *Coordinates*, *E-Phy*, and *Sensor* tabs. The available options include band-pass, low-pass, high-pass, and notch filters, which can be adjusted by the user. In the following example, a notch filter at 30 Hz is applied.



# Signal processing: Rectification

This function enables signal rectification in the *Coordinates*, *E-phy*, and *Sensor* tabs. The rectifying method used can be mean rectification, absolute value rectification, square root rectification, or half-wave rectification.



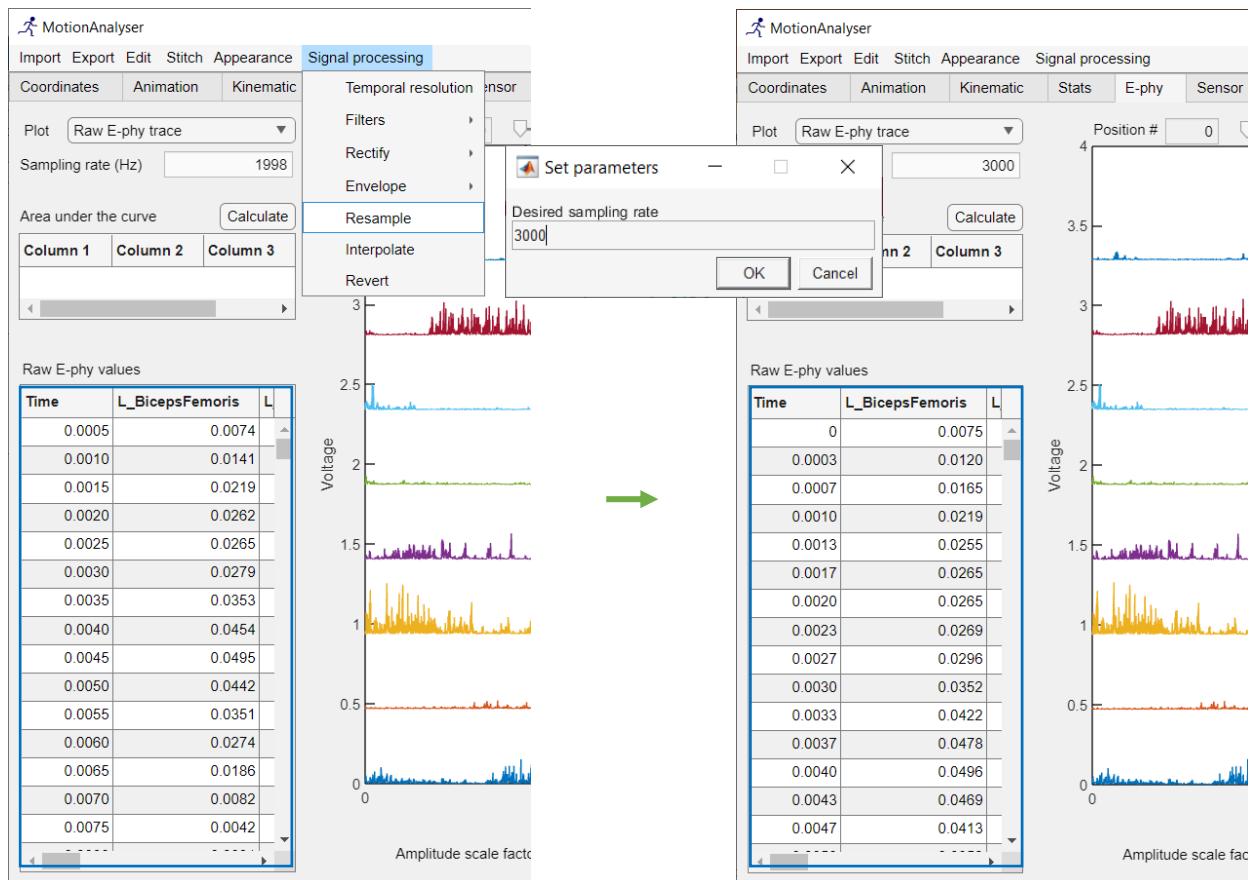
# Signal processing: Envelope

This function allows for the creation of a signal envelope in the *Coordinates*, *E-phy*, and *Sensor* tabs. Various mathematical models are available for this purpose, including low pass, moving average, low pass and moving average, root mean square, and Hilbert transform.



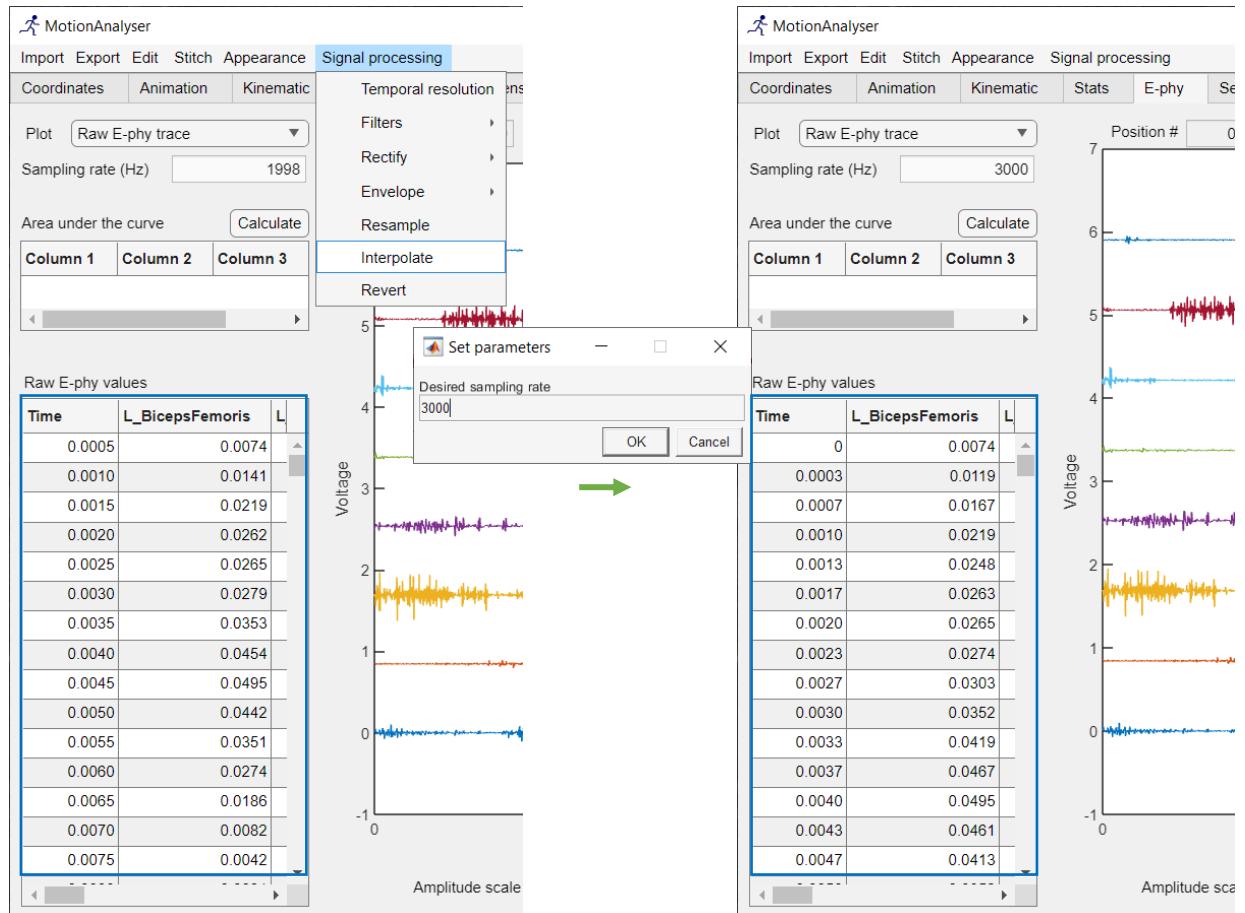
# Signal processing: Resample

This function enables the resampling of a signal from its original frequency to a user-defined frequency. This is particularly useful for correlating signals that have different starting sampling rates. The function can be applied in the *Coordinates*, *E-phy*, and *Sensor* tabs. In cases where resampling introduces artifacts, an alternative method is to use interpolation (refer to the next page for more information).



# Signal processing: Interpolate

This function serves as an alternative to the resampling function discussed on the previous page. It enables the user to modify the frequency of a signal. This function is applicable in the Coordinates, E-phy, and Sensor tabs.



# Signal processing: Revert

Any of the functions in the "Signal processing" menu can be reverted using the "Revert" function. This functionality is available for the *Coordinates*, *E-phy*, and *Sensor* tabs.

