The MotionMonitor xGen Hardware Guide: The MotionMonitor xGen Interface to Motion Analysis Cameras using Cortex

Overview

The MotionMonitor provides two different methods for interfacing and collecting data from Motion Analysis cameras. Each involves different levels of complexity and are appropriate for different research situations. These include:

- The MotionMonitor's C3D Model Builder
- Rigid-bodies 6 DOF Tracking

Motion Analysis cameras can be run with EVaRT or Cortex versions up to Cortex8, any version that supports the Motion Analysis SDK2. The steps are similar for each version of software, but the menu items and layouts look slightly different.

The MotionMonitor C3D Model Builder is a post-processing capability. It uses standard C3D files generated within Cortex as input to create rigid body 6 DOF sensors; locate joint centers; and define segment co-ordinate systems. If analog data was collected within Cortex, it can also be exported by way of the C3D file format.

The Rigid Body 6 DOF Tracking assumes that each segment is being tracked by at least 3 markers attached firmly to the skin or to a rigid plate. The MotionMonitor records the position and orientation of markers assigned to each "virtual sensor" (ie. Rigid Body), computes the centroid and coordinate system of these virtual sensors, and then uses that data to perform The MotionMonitor's standard analytical and visualization routines.

These methods ultimately generate the same information for the researcher. However, where and how certain functions are performed will vary significantly for the three methods.

The MotionMonitor's C3D Model Builder

See the MotionMonitor Knowledge Base article entitled "C3D Model Builder".

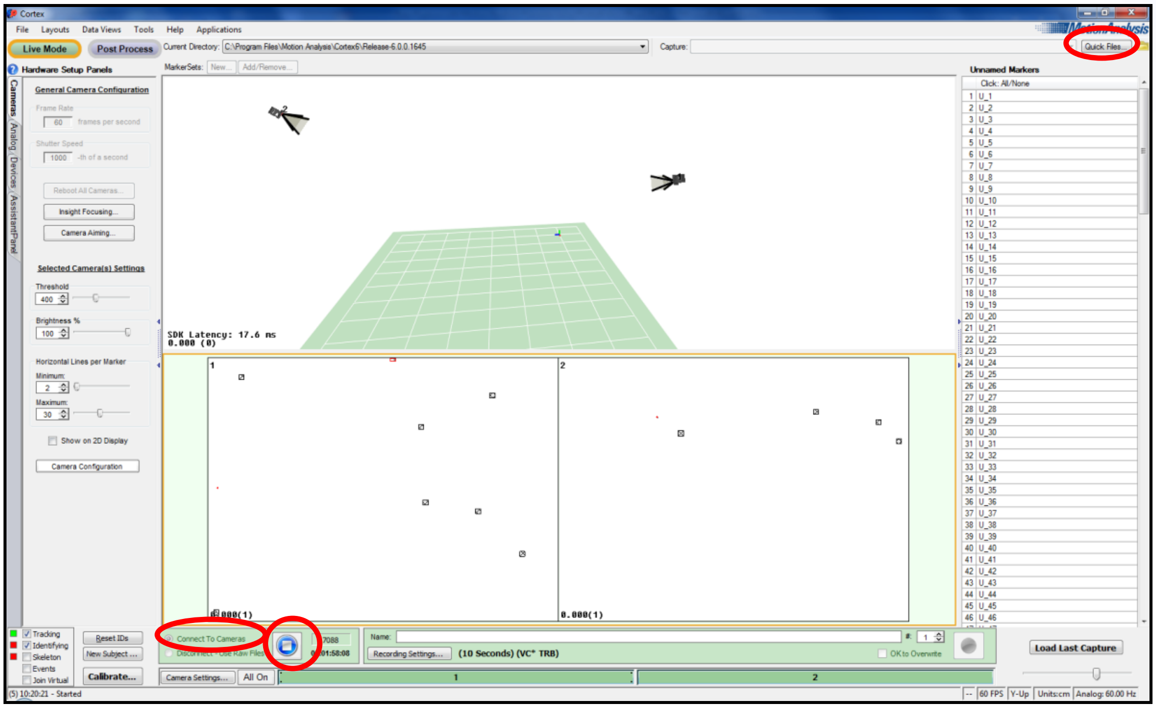
Rigid Body 6 DOF Tracking

This approach works on the following set of principles. The subject is instrumented with a minimum of 3 markers on each tracked body segment. The relative position between markers on a given segment should be relatively fixed (the more so the better). The purpose is to provide robust marker identification of markers within Cortex so accurate marker x,y,z's can be streamed directly to The MotionMonitor.

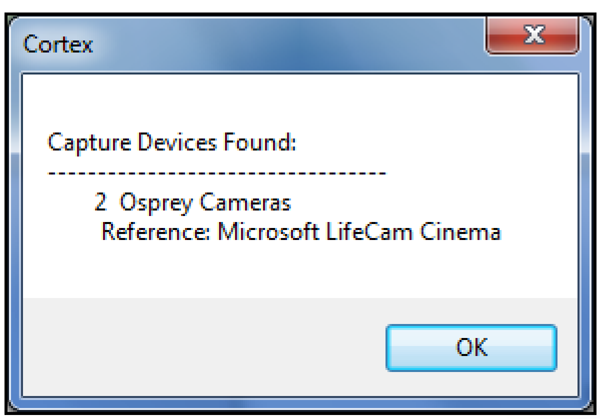
Within The MotionMonitor, "rigid bodies" are computed by assigning at least three of the markers streaming from Cortex to a rigid body. The centroid position and orientation of these rigid bodies are used within The MotionMonitor to track objects, define subject segment lengths, locate joint centers, digitize and track landmarks of interest, etc.

Step by step procedures to set up the 6DOF method for Cortex and The MotionMonitor xGen are as follows:

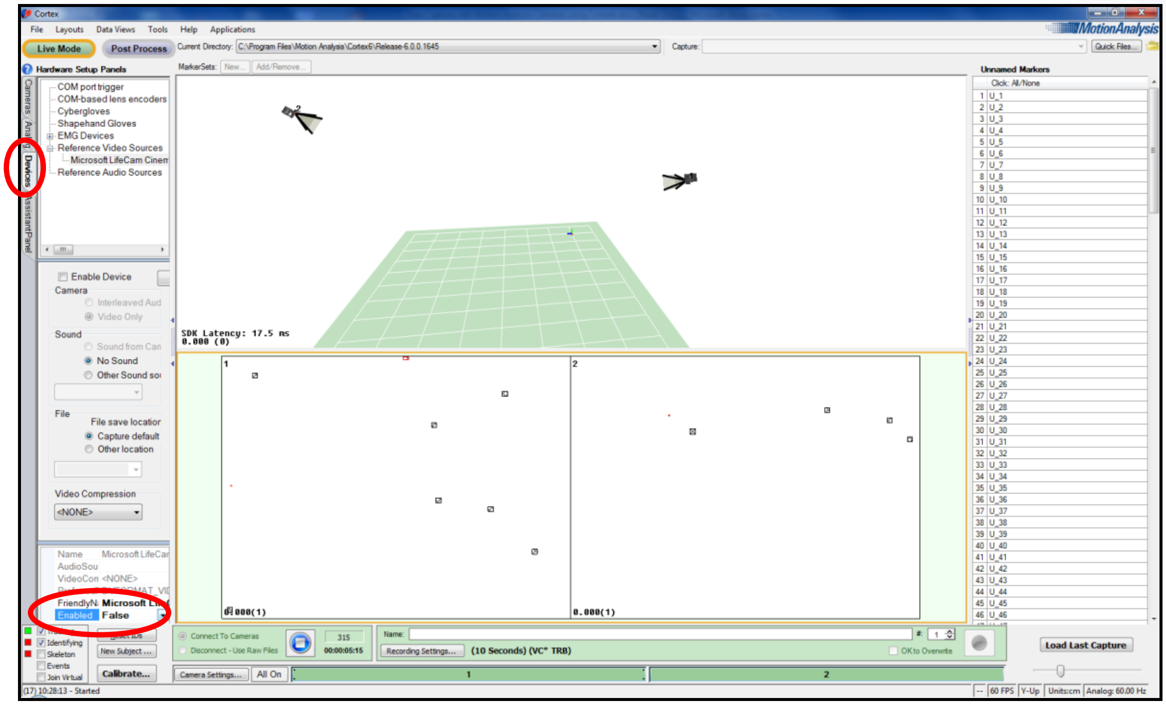
1. Beginning in Cortex, select a working folder by clicking on the Quick Files button in the upper right hand corner of Cortex. Use “Connect to Cameras” in the bottom left hand side of the Cortex window to connect, and use the “All On” button for the 2D camera view to turn on. To view in live mode, select the play button next to “Connect to Cameras.”



When connecting to cameras, Cortex will also search for any reference video hardware that is connected to the computer.

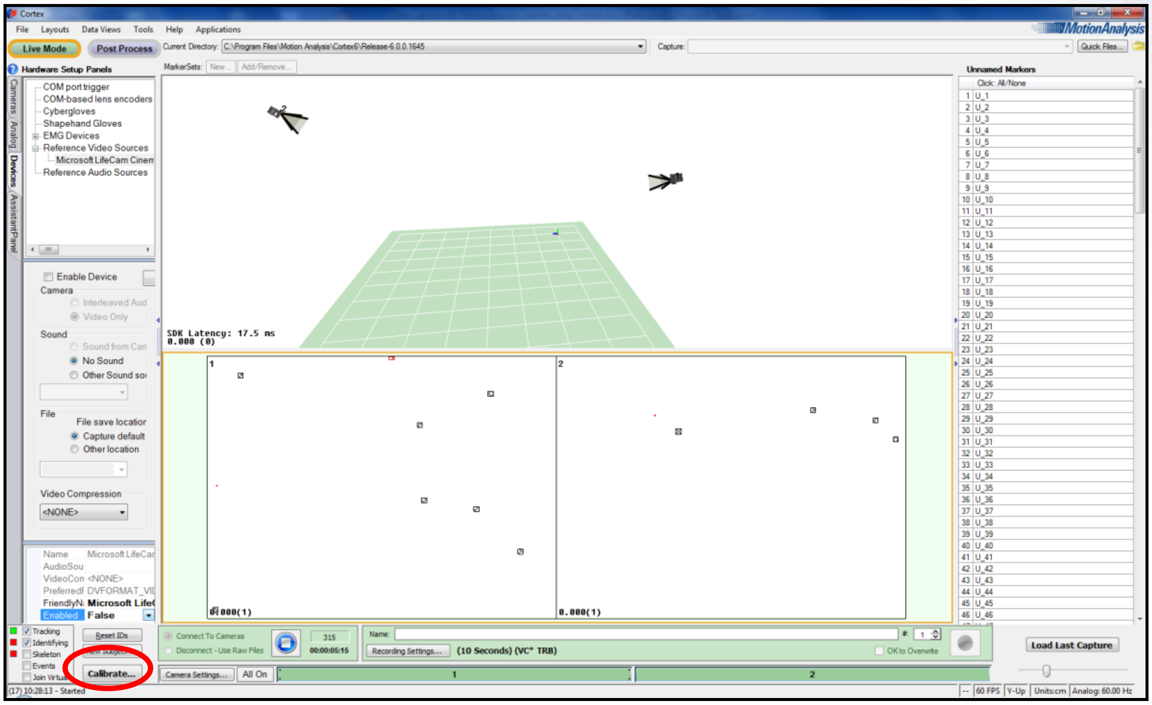


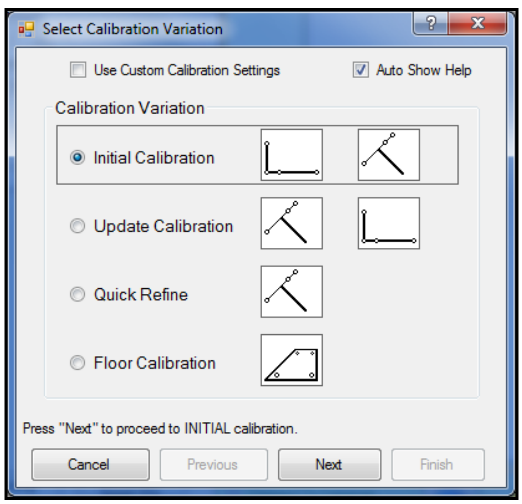
If Cortex is connected to this reference video, The MotionMonitor will not be able to access it. You will want to disconnect reference video in Cortex if digital video is going to be used in The MotionMonitor. To disconnect, toggle to the Devices tab and change the Enabled property to False.



2. Before calibrating, remove any extra markers from the field of view of the cameras. If needed, mask the cameras to hide any reflections that are being picked up as markers by the cameras. Do this by right-clicking in the 2D camera view and selection “Auto Mask Selected Cameras.”

To begin the calibration, select the Calibrate button, located in the bottom left corner. The next dialog will ask you to select a calibration variation. If you are performing the first calibration with the system make sure to first do the initial calibration with the L frame first and then with the wand calibration.





Follow the prompts that bring you through setting the L frame and wanding. Name and save the settings file with the menu item "File|Save System Setup". This settings file will be the base file loaded at the beginning of future sessions prior to each day's calibration.

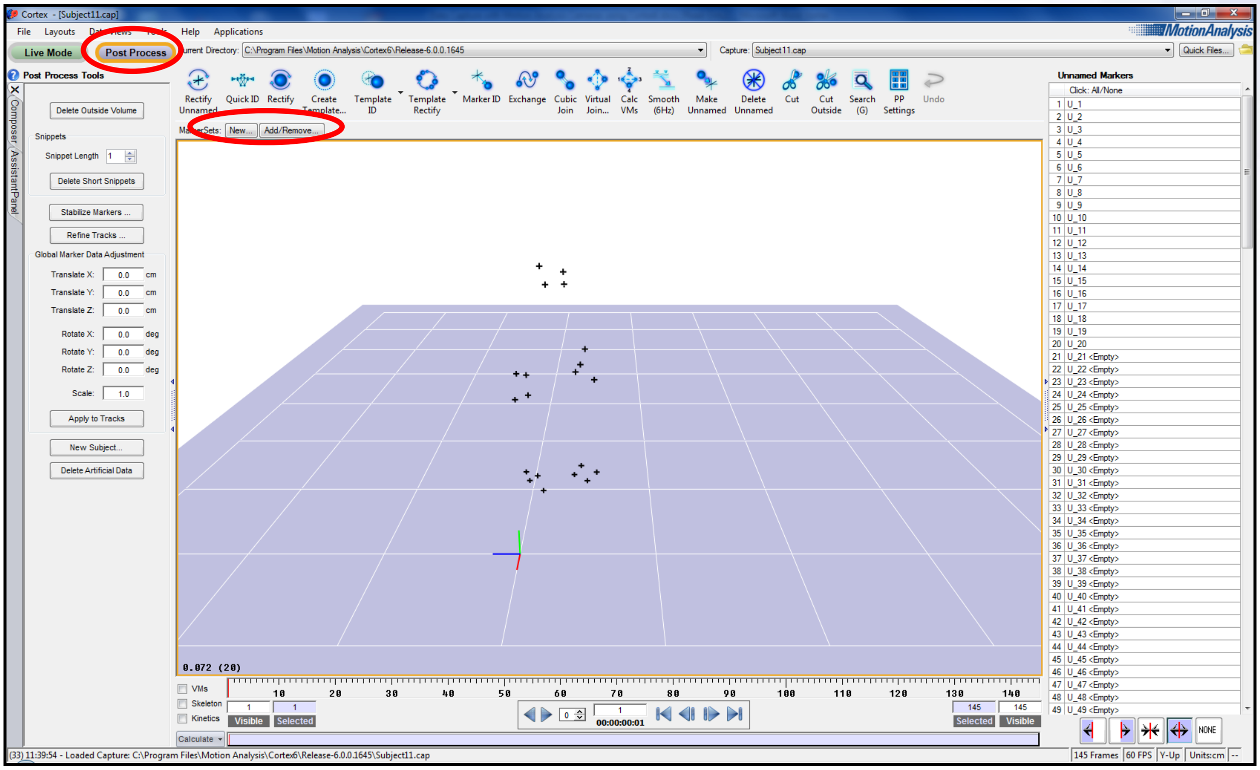
NOTES:

- Make sure only the markers on the L frame or wand are visible when in the capture volume.
- If the wand calibration calculation continues to diverge, a windows firewall may be interfering with Cortex. Go to Control Panel → Windows Firewall → Allow a program or feature through Windows Firewall, and allow Cortex to communicate through the firewalls for all networks. Another common reason for a divergent calibration is if there is an inaccurate initial focal length or Positioning specified in the Tools → Settings → Calibration → Lenses/Orientation dialog
- Other common calibration mistakes include improper L-Frame Measurements entered in the Tools → Settings → Calibration → Calibration Frame dialog. The units here must also be set to millimeters for use with The MotionMonitor.
- While calibrating in most cases, the “floor calibration” should be skipped (ie. click "Finish" after L-frame and wand calibration steps are completed and accurate). Additionally, the L frame should be placed in the same position and orientation during each camera calibration.

3. Attach markers and/or rigid body clusters to the subject.

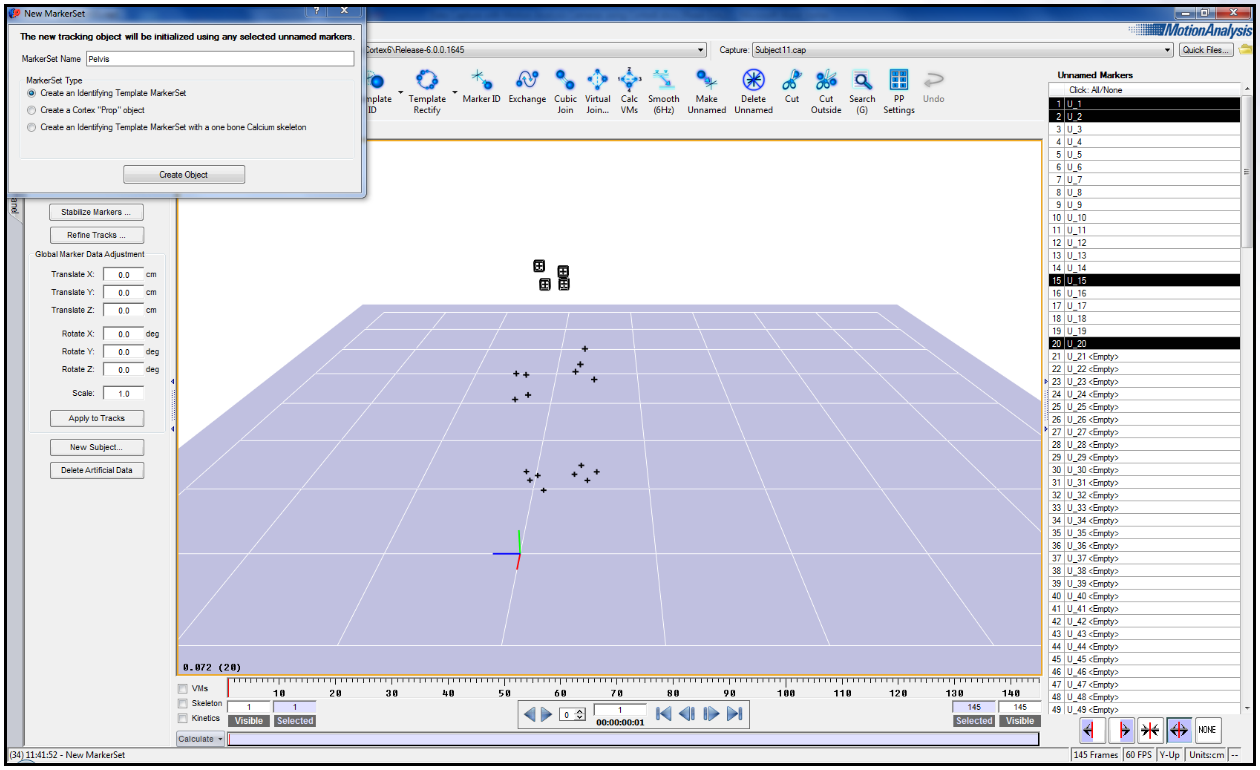
4. At the bottom-center of Cortex, make sure that “Recording Settings” are set correctly and specify a name for the recording. Have the subject take the neutral position at the start of the recording and then instruct them to perform movements similar to what will be collected during their dynamic trials. Having the subject assume the neutral position will make it easier to initially identify each of the markers and then having them move will help provide a robust model template for tracking. After the recording has completed, click the “Load Last Capture Button” which is located in the bottom right corner.

5. “Load Last Capture” opens the Post Process display.

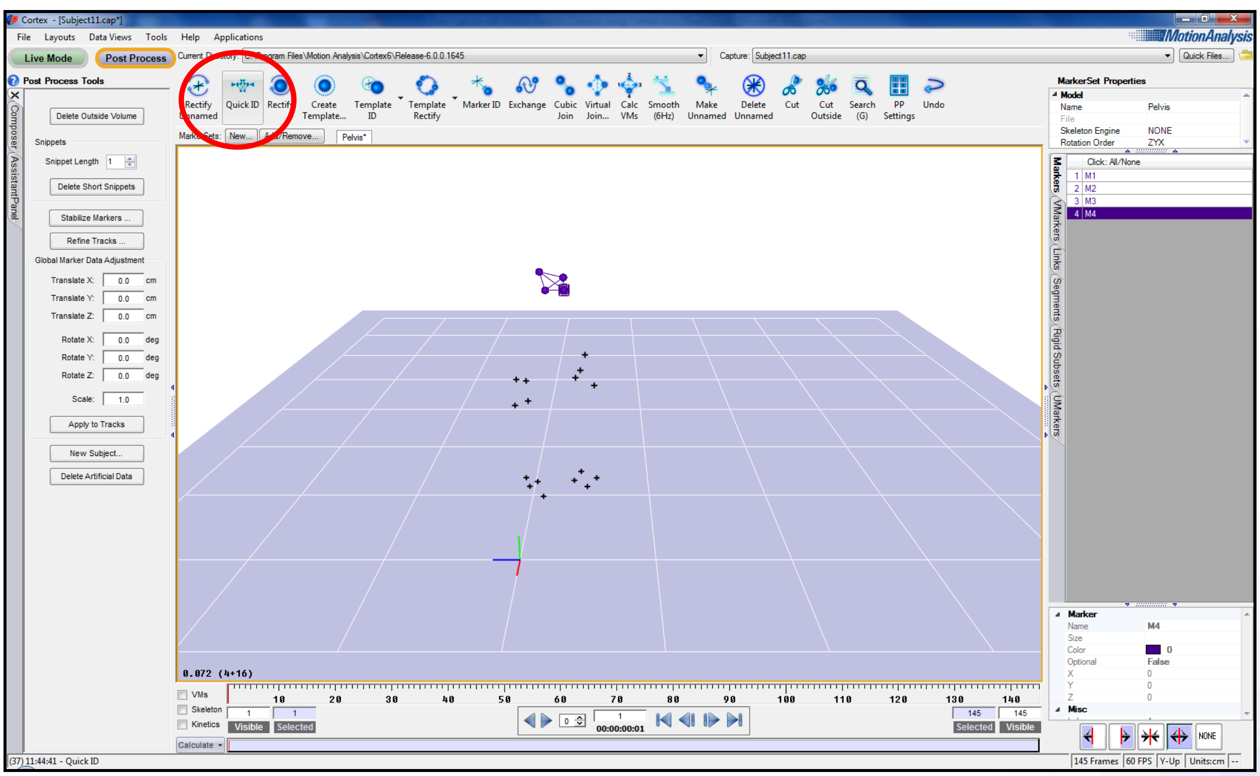


6. To add/load a marker set, click the appropriate button at the upper left corner of the 3D view window. The marker set names will appear in the right most panel. Note that the marker set may be empty or inaccurate the first time the setup is created. Go into “Live Mode” and stop the cameras. If the cameras are not stopped, then you will not be able to setup the markers. Go back to “Post Processing” and click on the marker set that was just created or the previous marker set that was loaded.

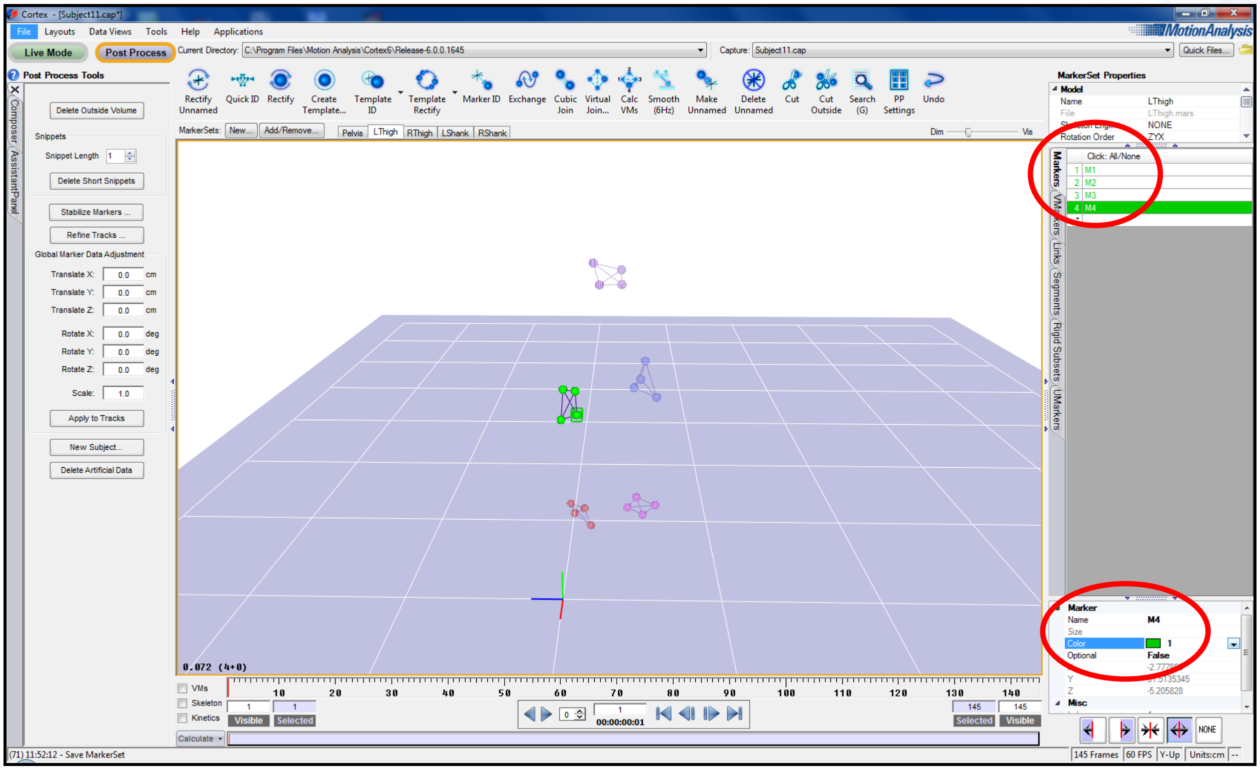
   If a new marker set needs to be created, select all markers that will be part of the marker set by holding Ctrl and clicking on each marker, and then click “MarkerSets: New…,” name it, and select “Create Object.” Do this for each rigid body cluster. If you did not click on all the markers and need to add another marker, right-click in the area with the list of markers and click “Insert” to add a new marker.



7. In the Post Process display, click the “Quick ID” button (toolbar above 3D view) to identify markers. In the 3-D View window click on each marker in-turn.



The name of the marker can be changed by clicking on the current name and then updating it. Once the marker has been created, click on it and a box will show up in the bottom right corner. If you would like to change the color of the marker this can be done by clicking on the area to the right of color and a drop down menu with different colors will show up. Continue to add, name and modify the markers until all of the markers are identified.

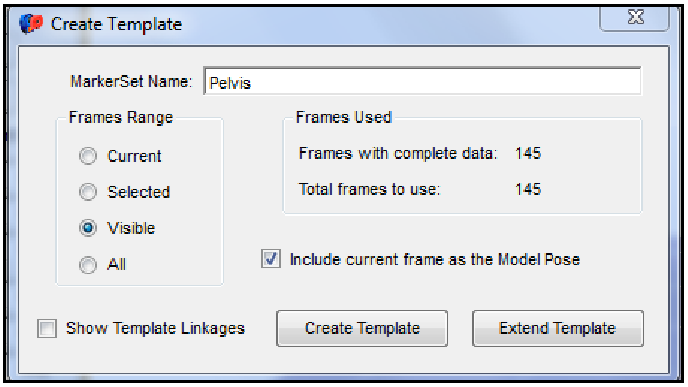


Care should be taken that the geometry of each rigid body is unique from other rigid bodies and that markers do not form equilateral objects (eg. Isosceles triangles, squares or rectangles).

If rigid body clusters will be used with the Digitization Method in The MotionMonitor, the Optional value for the markers should be left as “False”. If calibration only markers will be used with the Fixed Marker Method in The MotionMonitor, then any markers that will only be used for calibration should have the Optional value for the marker set to “True”, and all other markers should have the Optional value set to “False”. To get to the Optional value click on the marker and it will show up in the box in the bottom right corner. This will allow you to remove medial or calibration markers from your model after being setup in The MotionMonitor. Also, it’s important that if any calibration only markers are being used in your model, that they are added to the end or bottom of the marker list.

8. Click “Rectify” to ID all frames and Cubic Join (if needed). These functions will be applied to the trial according to the Active Frame selectors in the bottom right hand corner of Cortex. Review the data and playback the activity to make sure that the markers are identified throughout the activity and that no marker swapping occurs. It’s important that all markers are labeled correctly, because this will be the basis for which markers will be identified and streamed in real time.

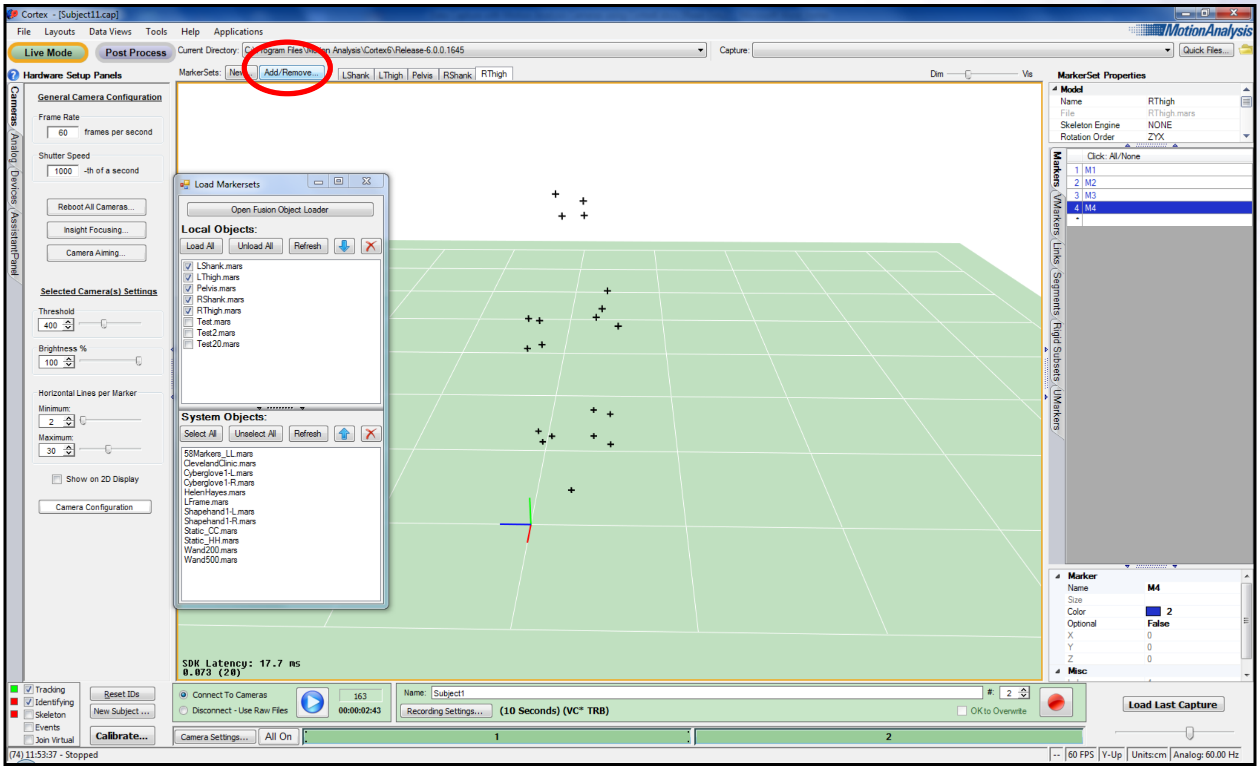
9. Then click "Create Template" to generate and save the template data. If successful, you will receive a message "Template has been created."



10. Save each marker set by right clicking on each marker set tab above the 3D display window and selecting "Save MarkerSet". Save the modified recording under "File|Save Capture".

11. To make the template more robust, do additional static and dynamic recordings. After each recording, load the previous capture and correct any markers that went missing or that were identified incorrectly. Then, select "Create Template" and choose to "Extend Template." It's extremely important at this point that the markers are identified correctly. Extending a template where the markers have been misidentified and saving the template can negate all of the previous work put into generating the template and makes the template useless for real time tracking. At this point, saving the marker set again will save the robust template that has been generated.

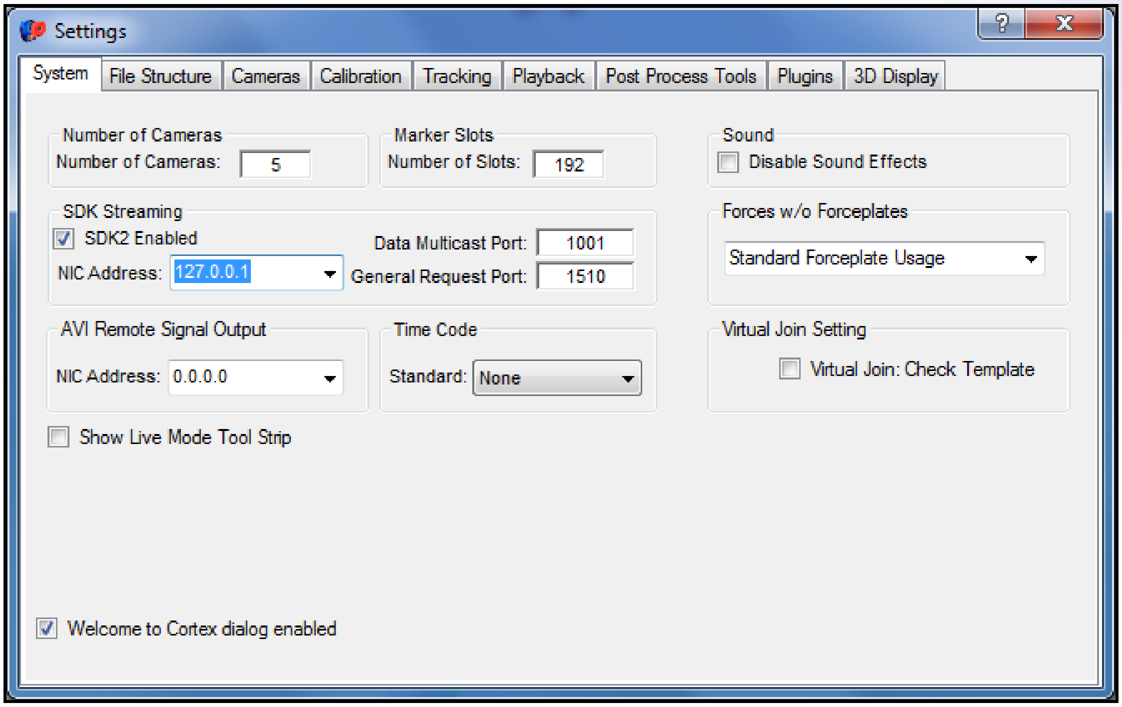
12. In order to use this template in real time go into Live Mode and then go to File|Add MarkerSet to ensure that the marker set is included in the local objects. Then, click on the "Add/Remove" marker set button above the top left corner of the 3D view. Check the marker sets that you want to be enabled. Then, ensure that you're connected to the cameras and click the Play button. The templates should now be recognized in real time. Make sure to load the marker set before clicking the play button. If tracking a stylus and subject at the same time, enable the stylus first in order to have it stream first in the marker list.



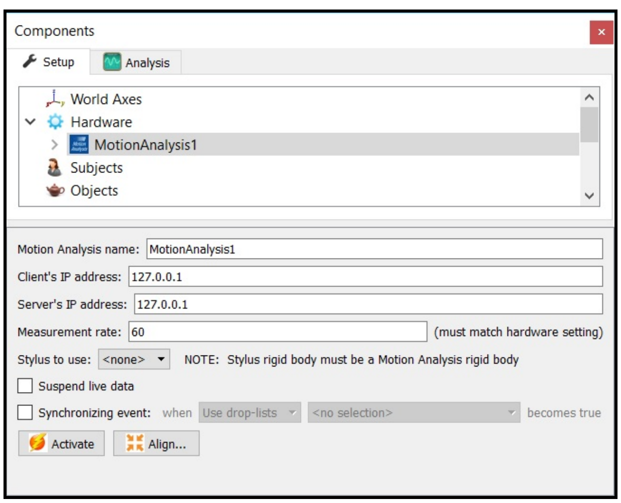
13. In future sessions (ie. after loading the project file, calibrating the space, and instrumenting the subject), one can go directly to the "Live Mode" display and, with the cameras running, click the "Add/Remove" button to add in each template for each rigid body. If needed, the template can be refit if not all markers are identified in Live Mode. If markers are misidentified, click the "Reset IDs" button. This will force the template to be re-identified.

    If, at this point, the markers are still not properly identified, you will need to perform a new recording, including a static pose and dynamic movements similar to the activities that will be performed. After each recording, load the previous capture and correct any markers that went missing or that were identified incorrectly. Then, select "Create Template" and choose to "Extend Template." It's extremely important at this point that the markers are identified correctly. If you include misidentified markers when extending the template, your model will not be able to track markers properly. Additionally, if the marker set is saved after incorporating improperly identified markers, the new marker set and template will not be able to track markers properly and you might have to begin the entire process over from scratch. So, care must be taken whenever extending a template or saving a marker set.

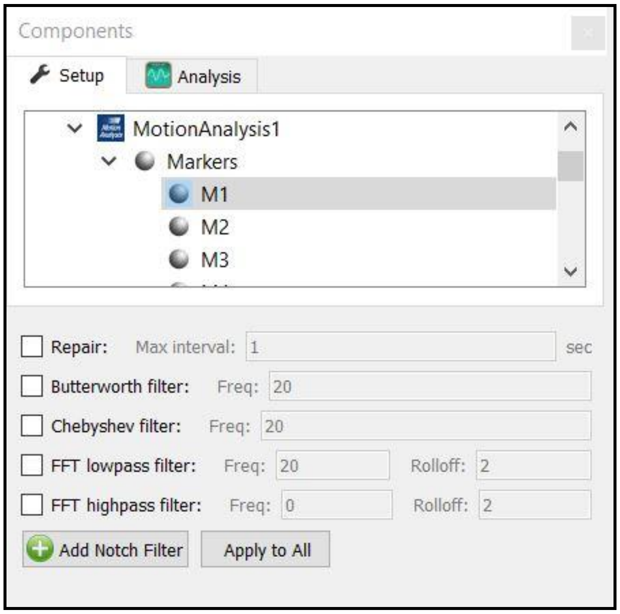
14. Cortex is now ready to begin streaming data. Adjust the streaming settings from Tools|Settings|System, Enable SDK2 and define the NIC address, as seen below. Cortex will stream data whenever running in "Live mode" with the Play button enabled. Save the system setup in order to retain all of these settings.



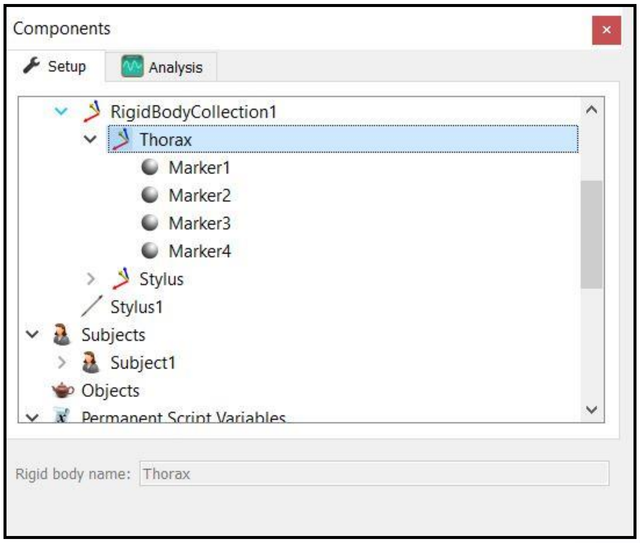
15. In **The MotionMonitor xGen**, go to the Setup tab in the Components Window and add or click on the Motion Analysis hardware component in order to configure the hardware. Confirm that the settings entered here match the settings of Cortex for the measurement rate and the IP address of the computer running Cortex. Click the Activate button to initialize communication with the Cortex.



16. After successfully activating the Motion Analysis device, the marker list and any 6DoF data, if using Props, form Cortex will be populated under the appropriate headers for the Motion Analysis component. Data repair and smoothing settings can be enabled or disabled here, pre or post data collection.



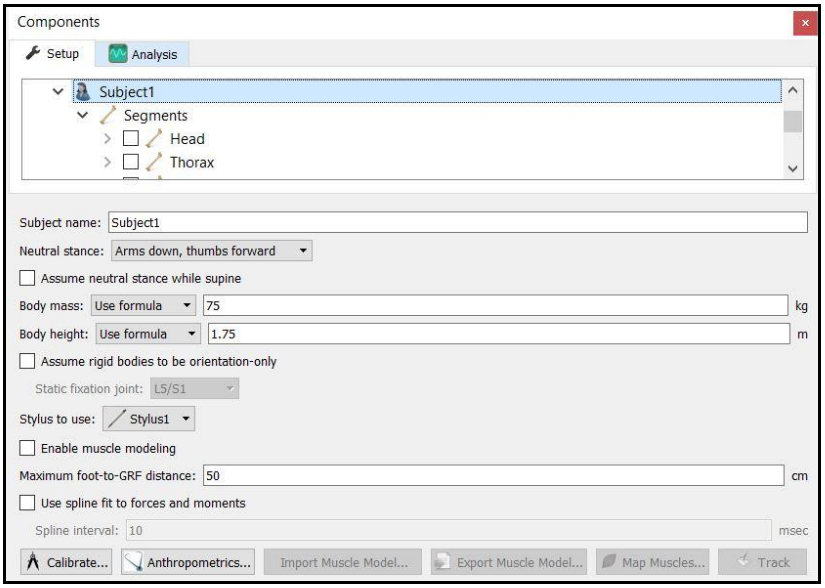
17. 6 DOF rigid bodies can be defined through **The MotionMonitor xGen** as seen in the dialog below. Rigid Body Collections can be added to the Setup Components dialog window as a Hardware device. Multiple Rigid Bodies can be added to a Rigid Body Collection, each of which can be defined using different combinations of marker assignments. Remember that 3 or more markers are required to create a Rigid Body. Markers can be selected for a rigid body either by selecting them through a drop down menu or defining them using a formula. Do not include markers in the rigid body definitions which will be removed for dynamic recordings. Markers can also be lassoed in the Animation window using the Shift key + Left Mouse button to create and add to an existing Rigid Body. Clicking on the Highlight button will highlight the selected Rigid Body markers in the Animation Window.



NOTE: The virtual markers "Calculated Left Hip Joint" and "Calculated Right Hip Joint" can be used as thigh markers. The Davis and Bell methods for locating the hip joint centers only require that you have 2 additional markers assigned to the thigh, whereas the Rotation method requires 3 markers during the static pose. During the dynamic trial, the hip joint and a minimum of 2 original thigh markers can be used to track the thigh when using the Rotation method. Any additional markers that are used for calibration only should not be included in the Rigid Body parameters.

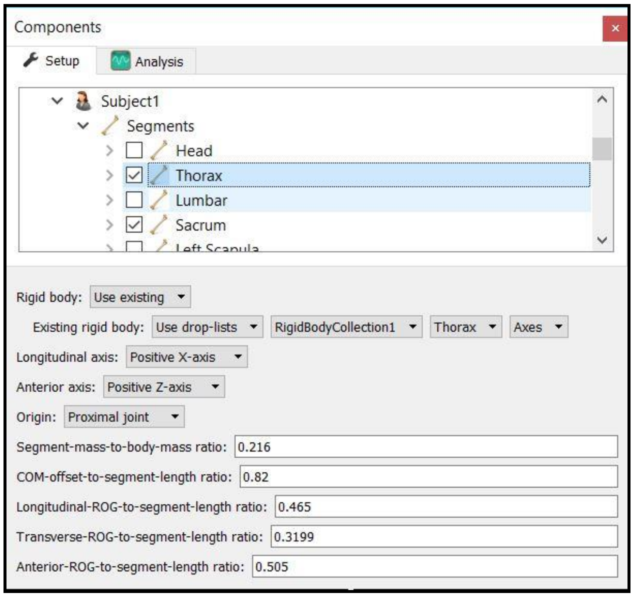
The Calibrate Rigid Bodies button takes a reading of the markers, computes centroids, creates sensor axes, establishes the relationship between markers and generally prepares the system to track the cluster of markers as 6 DOF data. Rigid Bodies can be calibrated one by one or all at the same time by going to the top level of the Rigid Bodies Collection and clicking the Calibrate All button. After this step, markers and their "sensor" axes can be viewed in Animation window or graphed and recorded as position and orientation data.

18. The next step is to define your biomechanical model within **The MotionMonitor xGen**, which entails selecting which body segments you'll be tracking, assigning rigid bodies to track each body segment, defining segment endpoints or joint centers and generating customized segment axes, if desirable. To begin this process, right click on the Subjects header within the Components Setup tab and add a new subject.

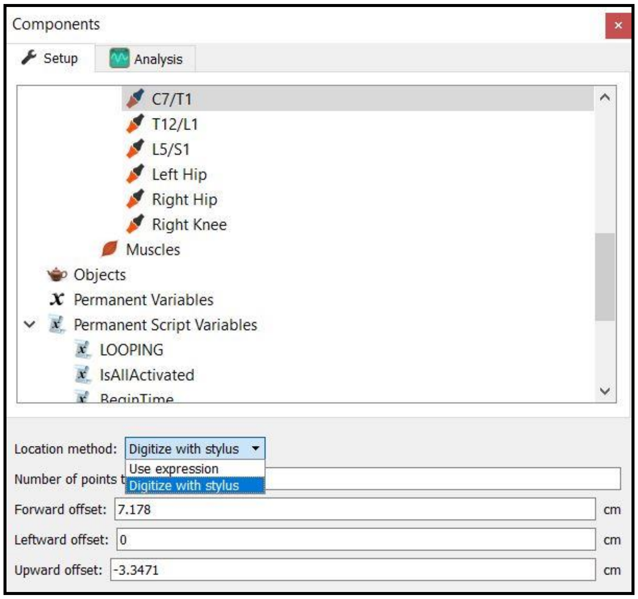


As seen above, a name can be assigned to the subject and basic anthropometric data can be entered. Confirmation for the orientation of the subject during the static reading and selection of a stylus to be used for digitizing, if required, are also selected here. The Calibrate button can be clicked after all of the required setup information has been entered.

19. The Segments header located under the Subject is where the desired segments to be tracked can be enabled as well as where the assignment for which rigid body will be used to track the segment is defined. Additional basic anthropometric information can be defined here for each segment as well.



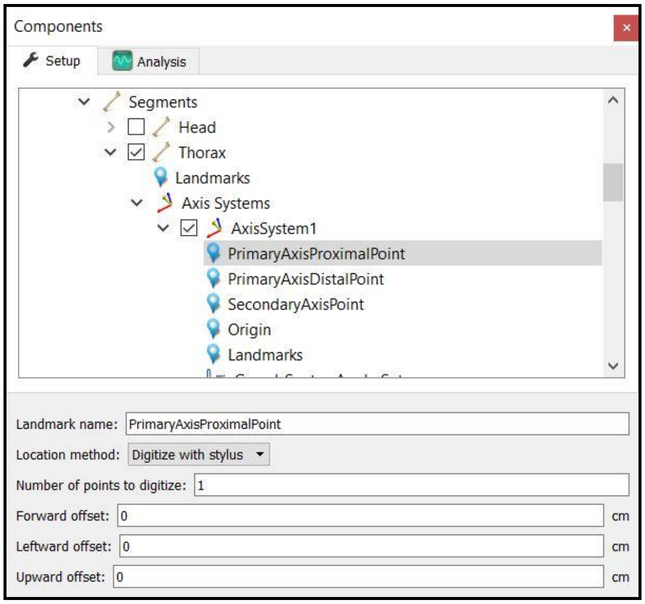
20. Each body segment which is enabled will require the definition of a proximal and distal endpoint or joint centers. The required joint centers will be automatically populated based on the selection of segments.



21. As seen above, each joint center can be defined using a digitizing method or expression based on marker positions. Alternatively, the hip and shoulder joints can be defined using linear regression algorithms or functional (rotational) methods.

22. Once these definitions are completed, the Subject Calibrate button can be clicked. A warning message will be displayed for any definitions that have not been appropriately defined.

23. Additionally, if alternative or anatomically based local coordinate systems are desired, they can be defined by right clicking on a segment and selecting Add Axis System. First, the Rigid Body axes tracking the segment and general axes layout are selected. Then, points can be defined for the proximal and distal endpoints of the primary axis, a point along the secondary axis and a point for the Origin. The default local coordinate axes generated by **The MotionMonitor xGen** are defined as having a long axes through the joint centers and A/P and M/L axes being orthogonal to the long axes and parallel to the world when the subject was standing in the neutral position.



24. At this point, the **The MotionMonitor xGen** subject is fully defined and can be used for **biomechanical models, recording activities, performing computations and reducing data**.

25. By saving a Workspace file, File|Save Workspace As, in **The MotionMonitor xGen**, all of the setup selections will be retained as a template and can easily be re-loaded using File|Load Workspace.