The MotionMonitor xGen Hardware Guide: VICON Cameras- Nexus 2.0 Using Clusters

Overview

The MotionMonitor xGen can collect data from VICON Nexus 2.0, Nexus, Tracker and Workstation in realtime using ***The MotionMonitor xGen*** Rigid Body 6DOF Tracking. This process assumes that each segment is being tracked by at least 4 markers rigidly attached directly to the skin or to a rigid plate. ***The MotionMonitor xGen*** records the position and orientation of markers assigned to each rigid body or "virtual sensor", computes the centroid and coordinate system of these rigid bodies and then uses that data to perform ***The MotionMonitor xGen***'s standard analytical and visualization routines. The user has the option to use a fixed marker set to locate joint centers or, alternatively, can digitize landmarks using a stylus whose position and orientation are tracked using one of the 6DOF sensors. This document reviews the process of using the 6DOF method, as is commonly done with marker clusters, in Nexus 2.0.

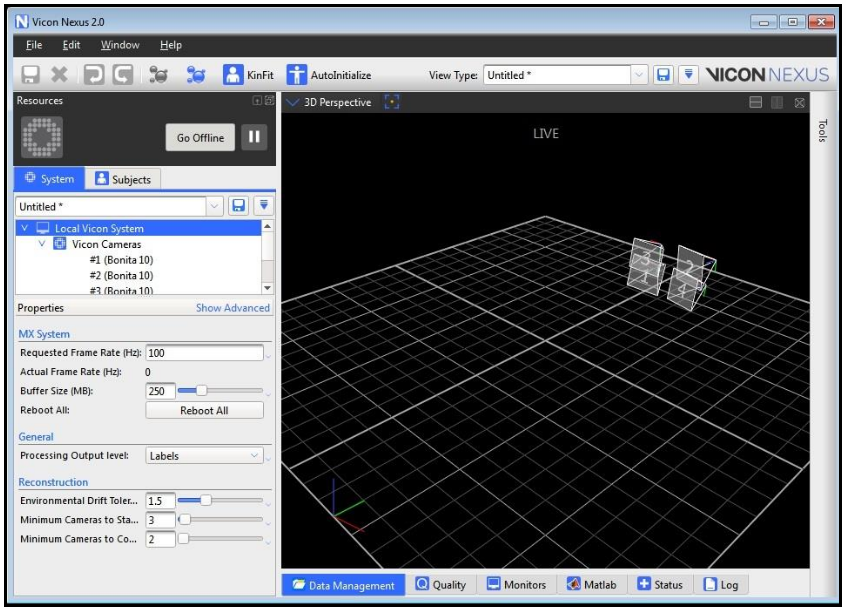
Rigid Body 6 DOF Tracking

Rigid Body 6 DOF tracking works on the following set of principles. The subject is instrumented with a minimum of 4 markers on each tracked body segment. The markers are relatively rigid (the more so the better) with respect to each other. Within Nexus 2.0, the markers are identified and combined into Segments. The purpose is to provide robust marker identification within Nexus 2.0 so that accurate, identified marker x, y, z positions can be streamed directly to ***The MotionMonitor xGen***.

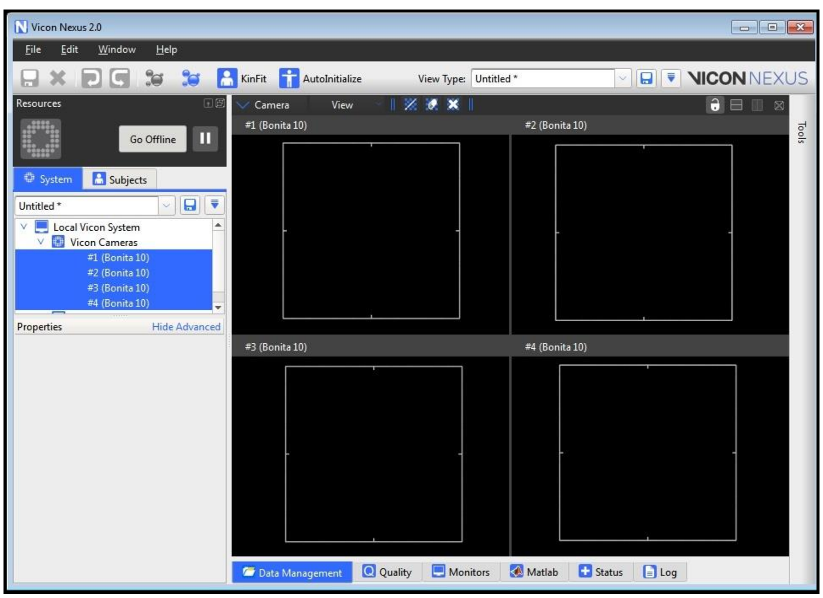
Within ***The MotionMonitor xGen*** "virtual sensors" or rigid bodies are computed from the marker's streamed (x,y,z) coordinates from Nexus 2.0. The computed position and orientation of these "virtual sensors" is used within ***The MotionMonitor xGen*** to track objects, define subject segment lengths, locate joint centers, digitize and track landmarks of interest, etc.

A step by step guide to setup this method follows. This guide assumes that the camera hardware is connected and has been setup in the environment and that each camera is optimally zoomed and focused. It is also assumed that a Database has been created within Nexus 2.0.

1. After launching the Nexus 2.0 application, go to the System tab in the Resources pane and highlight "Local Vicon System" in the tree view. Under the Properties section enter the Requested Frame rate (Hz) and set the Processing Output level to "Labels".

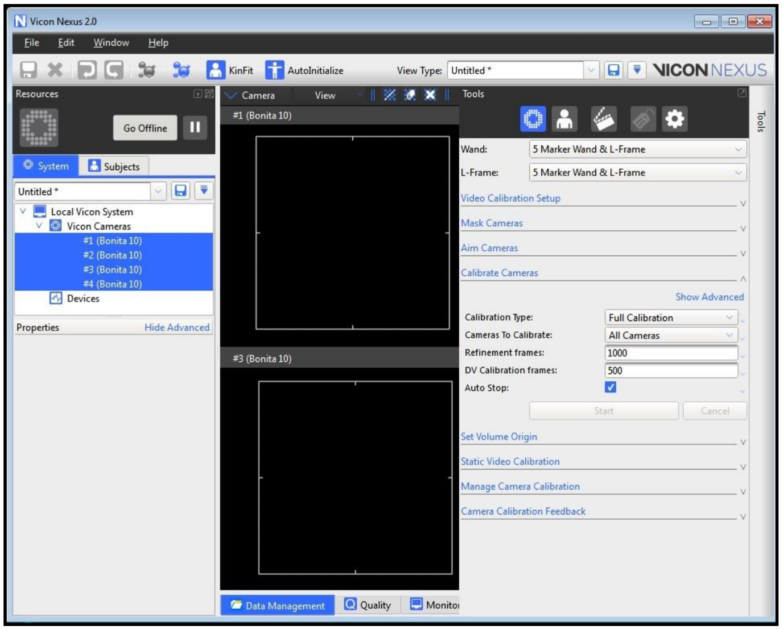


2. Next, highlight all the cameras within the System tab in the Resources pane, and select "Camera" view from the "Camera" dropdown in the Animation pane. At this time, all efforts should be made to eliminate unwanted reflections. If required, camera pixels can be masked automatically using the "Create Camera Masks" function in the Tools pane under System Preparation ( ) or manually using the masking icons in the Animation pane.

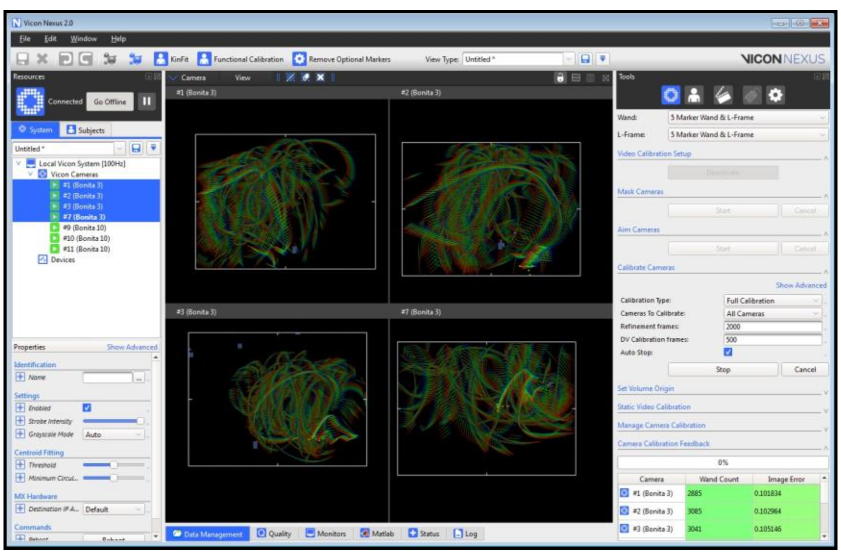


3. Now, begin the calibration process. From Tools, go to System Preparation ( ). Ensure the appropriate Wand and L-Frame are selected (i.e. "5 Marker Wand & L-Frame") and then

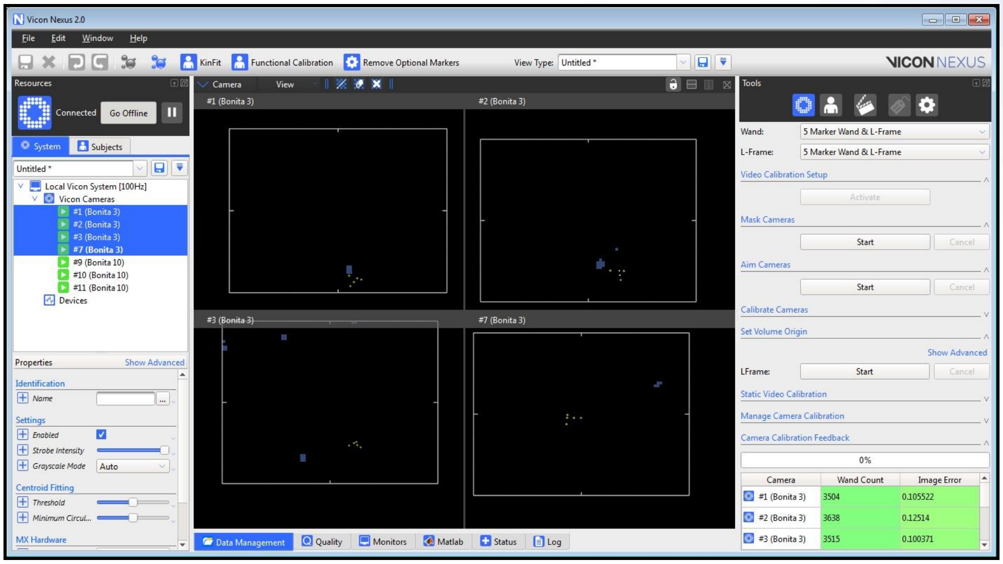
expand the "Calibrate Cameras" section. In the Refinement Frames field, enter the number of frames required to complete a calibration with good coverage over the entire collection volume and enable "Auto Stop". Click Start when you are ready to begin.



4. Move the wand throughout the measurement volume, being sure to move in all three axes. The camera view will display the area that has been covered with a rainbow, and the Wand Count will update as frames are collected. Once all of the cameras have recorded at least the required number of Refinement Frames, the calibration will be calculated. Note: It's important that the Refinement Frames for each camera update at a uniform rate, in order to ensure good calibration coverage.



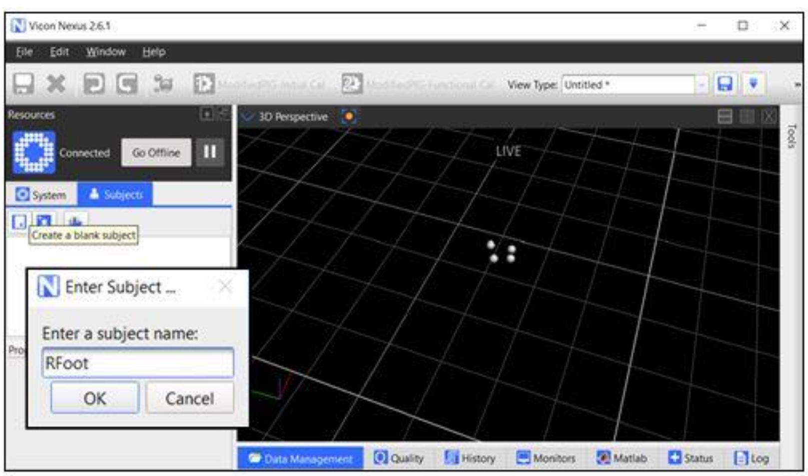
5. Now place the wand at the origin of the global coordinate system. Ensure that all 5 markers can be seen by each camera. Expand the "Set Volume Origin" dropdown. Click "Start" and then "Set Origin" when you are ready to take a reading.



6. From the "Camera" dropdown in the animation pane, select "3D Perspective". If Nexus 2.0 is in Offline mode, click "Go Live" to enter Live mode. The animation should replicate the real life position and layout of the camera system. Attach markers and/or rigid body clusters to the subject or objects to be tracked. Have the subjects/objects enter the capture space and confirm that the markers are displayed in real-time. **Note:** A minimum of **4** markers per rigid body are required to track body segments in Nexus 2.0, and markers *cannot* be shared between 2 rigid bodies. All markers must be assigned to a rigid body; unassigned markers cannot be streamed from Nexus 2.0 to ***The MotionMonitor xGen***.

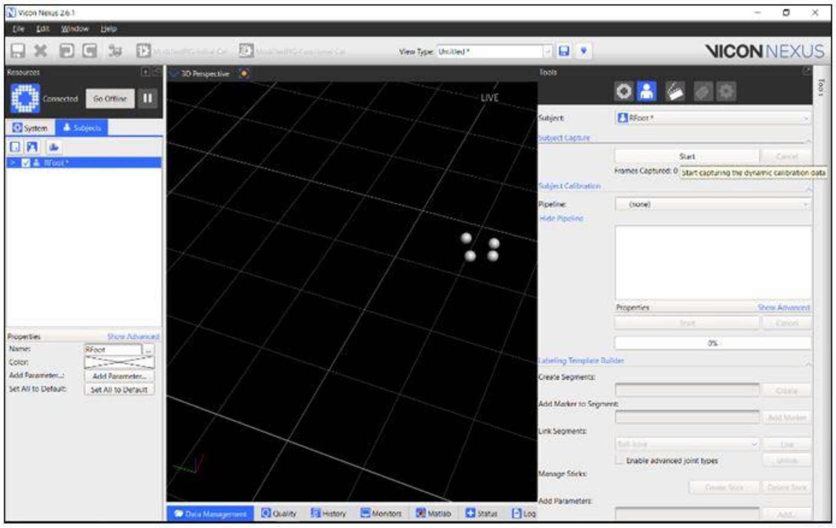
7. The next step is to generate a 'Subject Template' for each cluster, which will be used as a basis for tracking segments through digitization. Click on the "Subjects" tab in the Resources pane. Click the "Create a blank subject" button ( ) and name the subject according to the segment that cluster will be tracking.

   Note: Use a naming convention that does not require spaces.

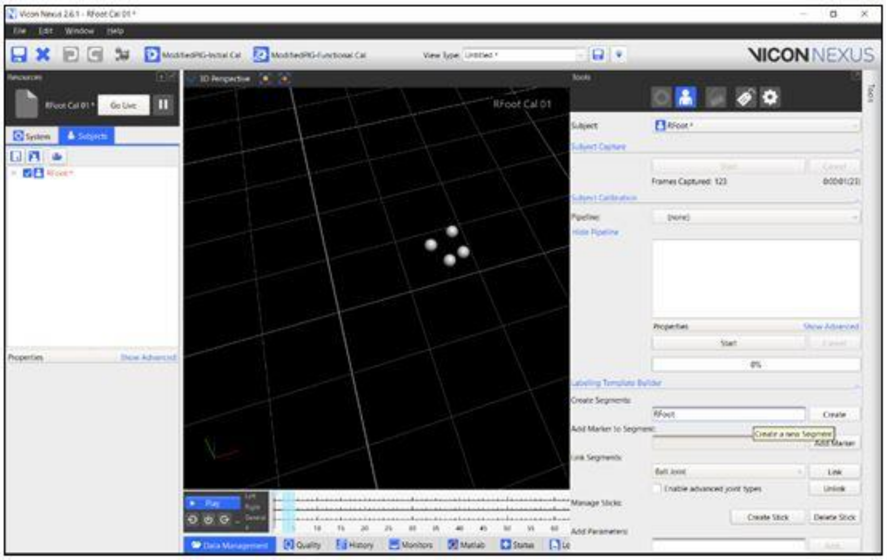


8. Click on the "Subject Preparation" icon ( ) in the Tools pane and select the name of the template you want to use from the "Subject" dropdown menu. Place the cluster in the space and select Start under the "Subject Capture" dialog to capture a trial. During the recording

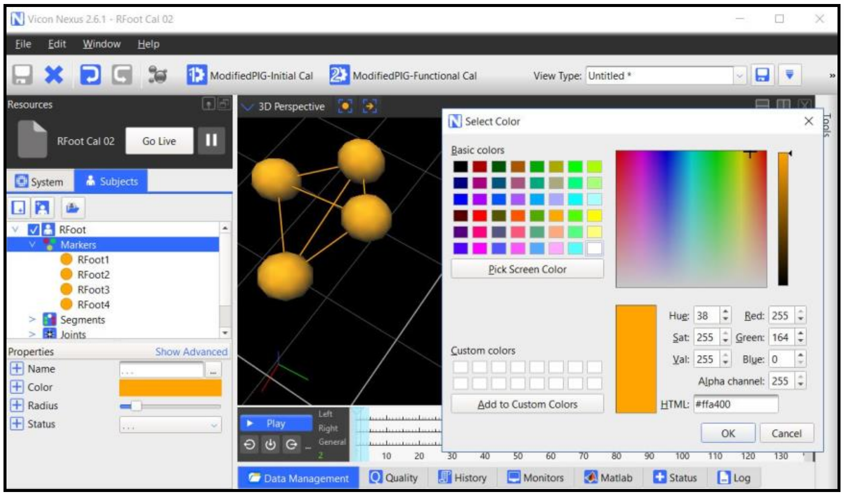
move the rigid body around in the space in a similar manner to how it will be moving for future data collections. A 10-15 second collection should suffice for a robust calibration. Click Stop to complete the data collection. If markers do not appear automatically, run a "Reconstruct" pipeline under the pipeline icon ( ) in the Tools pane. Alternatively you can use the shortcut button located near the top left-hand part of the screen ( ).



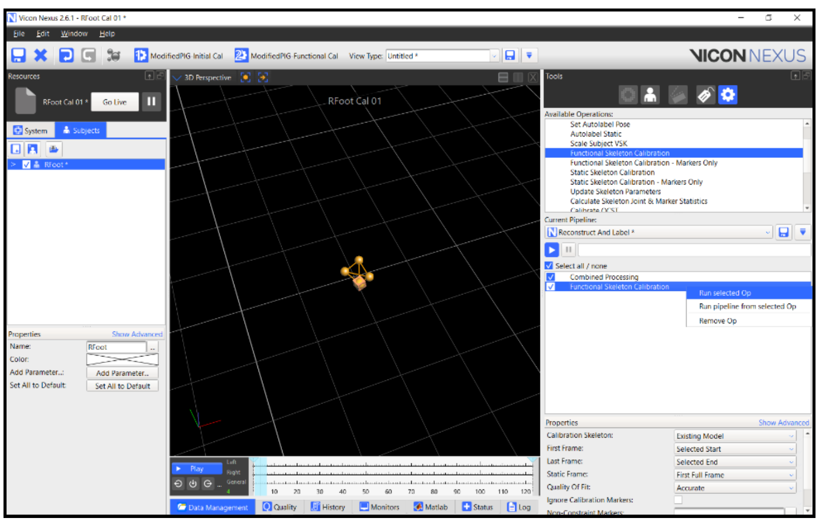
9. To label the cluster, select the Subject icon ( ) in the Tools pane and enter a name in the "Create Segments" field, then click "Create." Manually select the markers in the Animation pane that you want to assign to the rigid body and then click "Create" again. Make sure that the proper Subject is selected from the Subject drop-list in the Tools pane if multiple Subjects exist within the Resources Subjects tab.



10. After the segment is created, the markers can be assigned custom colors by selecting the Markers| Color option under the subject template. Note: Changing the color is not necessary but it helps differentiate the clusters from one another.



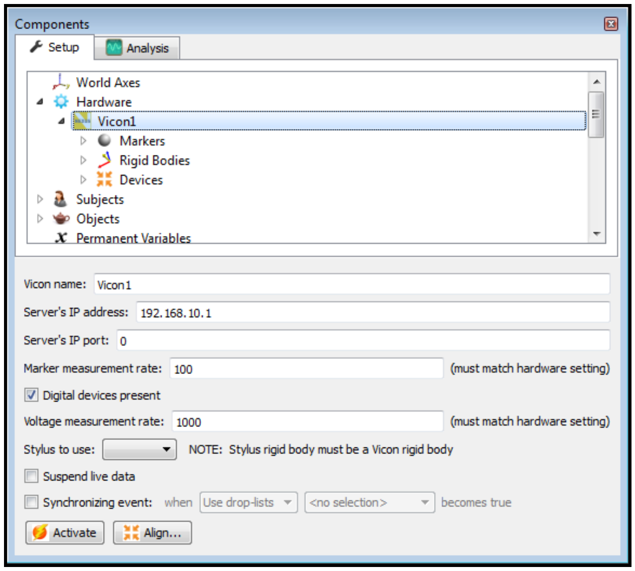
11. The final step is to apply a dynamic calibration to the rigid body. Under the Tools| Pipelines| Available Operators select 'Functional Skeleton Calibration' and run it by right clicking on the option. Once the functional calibration is complete, save the calibrated trial through the save icon in the toolbar and right click on the Subject in the Resources Subject tab and select Save Subject and Save Labeling Skeleton As Template to save the existing subject (VSK file) and labeling skeleton (VST file), respectively.



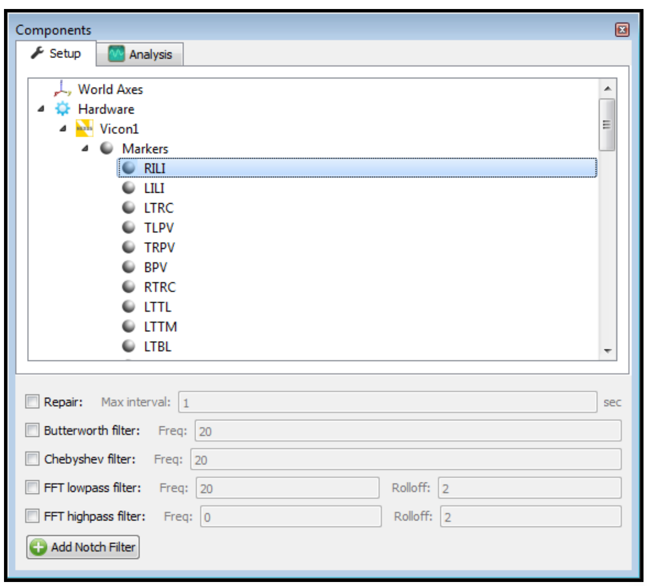
12. Repeat this process (steps 7-11) for all rigid bodies as needed. In the case where rigid marker cluster plates are used, the VST and VSK files will be one in the same and can be used without modification whenever a new subject enters the capture volume. If the marker positions within a rigid marker cluster ever changes, these procedures (steps 7-11) will need to be reperformed for that rigid body. However, instead of selecting "Create a blank subject" in step 7, you could select the "Create a new subject from a Labeling Skeleton" to load the VST file and prevent the need to completely start from scratch.

NOTE: If marker swapping occurs within Nexus 2.0 pressing "Ctrl + R" on the keyboard will reboot the camera's processors and re-label markers according to the subject's template.

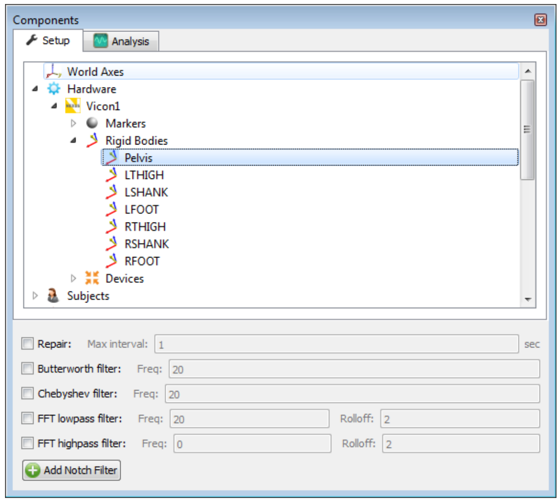
13. In **The MotionMonitor xGen**, go to the Setup tab in the Components Window and add or click on the Vicon hardware component in order to configure the hardware. Confirm that the settings entered here match the settings of Nexus for the measurement rate, number of markers and the IP address of the computer running Nexus. If analog data will be streaming from Nexus, enable the Digital Devices Present checkbox and set the measurement rate to match the settings of Vicon for analog data. Click the Activate button to initialize communication with the Vicon Nexus software. Please refer to the Vicon A/D Knowledge Base Article for more information on streaming analog data from Vicon into **The MotionMonitor xGen**



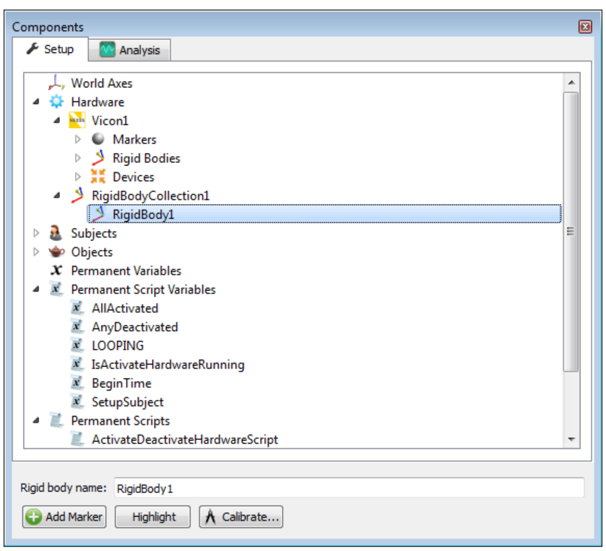
14. After successfully activating the Vicon device, the marker list, rigid bodies list and any analog data configured within Vicon will be populated under the appropriate headers for the Vicon component. Data repair and smoothing settings can be enabled or disabled here, pre or post data collection.

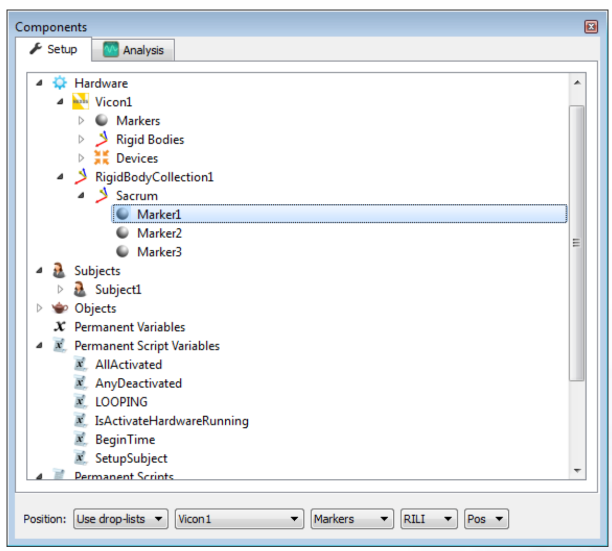


15. The Rigid Bodies header will be populated with any rigid bodies that were configured within Vicon Nexus. **Note:** In order for the rigid body data to actually be streamed, the Processing level within the System Resources tab in Vicon Nexus will need to be set to Kinematic fit and not Labeling.



16. 6 DOF rigid bodies could also 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. Clicking on the Highlight button will highlight the selected Rigid Body markers in the Animation Window.

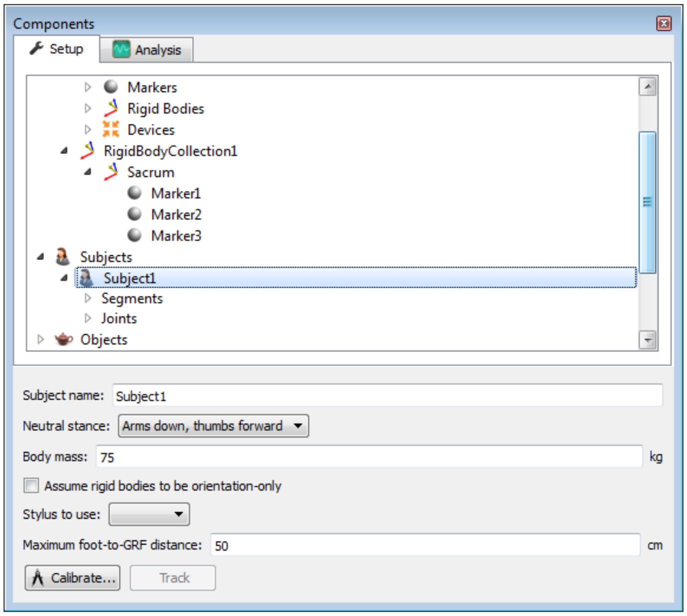




NOTE: The virtual markers “Calculated Left Hip Joint” and “Calculated Right Hip Joint” can be used as thigh markers. The Davis and Bell methods for locating the hip joint centers only require that you have 2 additional markers assigned to the thigh, whereas the Rotation method requires 3 markers during 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.

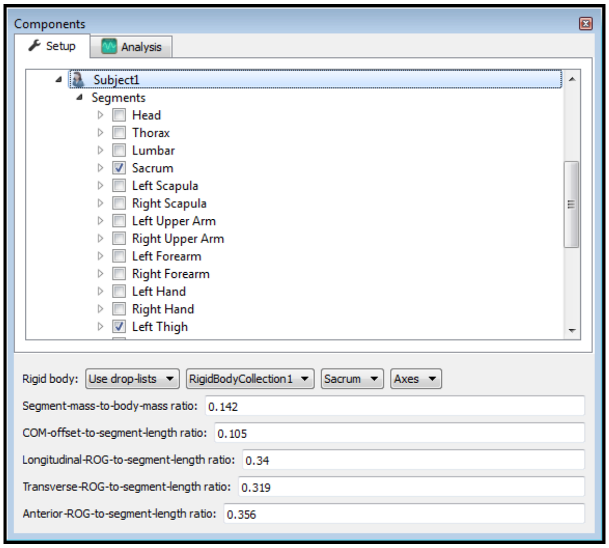
The Calibrate Rigid Bodies button takes a reading of the markers, computes centroids, creates sensor axes, establishes the relationship between markers and generally prepares the system to track the cluster of markers as 6 DOF data. Rigid Bodies can be calibrated one by one or all at the same time by 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.

17. 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.

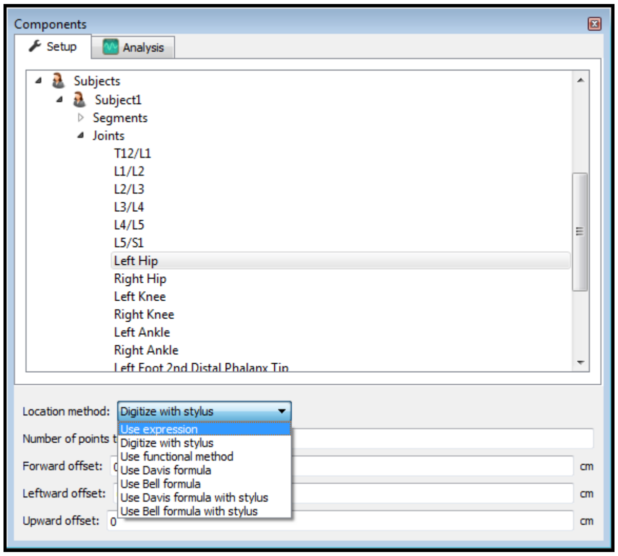


As seen above, a name can be assigned to the subject and basic anthropometric data can be entered. Confirmation for the orientation of the subject during the static reading and selection of a stylus to be used for digitizing, if required, are also selected here. The Calibrate button can be clicked after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

18. 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.



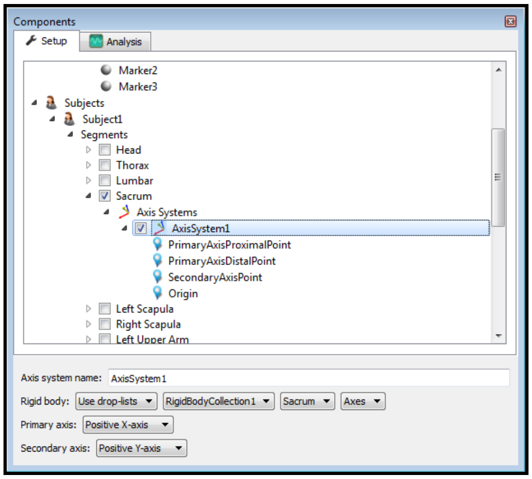
19. Each body segment which is enabled will require the definition of a proximal and distal endpoint or joint centers. The required joint centers will be automatically populated based on the selection of segments.



20. 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.

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

22. 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.



23. 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**.

24. 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.