The techniques learned here will be consistent with all Visual3D models. However **the model described in this tutorial is only designed to illustrate the principles of model building and should not be considered the Default Visual3D lower-body model**. Once the User learns the basics of building models it is up to him or her to decide what model and marker set is most appropriate for their analyses.

This tutorial follows the YouTube 6DoF Model Building tutorial. The YouTube video can be found [http://www.youtube.com/watch?v=YMazpjExVdY here].

There are 6 basic steps to performing an analysis of motion capture data in Visual3D:

*Create a model of your subject using a standing trial and define the linked segments *Explore your movement trials, and associate them with your model *Perform any signal and event processing required *Define any biomechanical model-based calculations (joint angles, moments, powers, etc.) *Generate the desired reports *If desired, export data for statistical processing

In this tutorial we will: *Load a standing calibration trial *Define various segments to create a lower-body a gait model.

Key Concepts

A **calibration file** (often referred to as a **Standing Trial** or a **Static Trial**) is a short motion capture of the subject in a stationary pose. Marker positions are averaged automatically over all frames to compensate for noise in the data. **NOTE:** If the subject moved during the standing trial, you can specify a subset of frames using the [Modify Frame Range For Static Calibration] command from the **Model** Menu items. **Anatomical markers** or **Calibration markers** are placed at anatomically relevant locations (e.g. palpable bony landmarks near segment endpoints). **Tracking markers** are placed at convenient locations for tracking the segments. Suggested rules for marker placement on rigid clusters is described in the following article: Cappozzo A, Cappello A, Della Croce U, Pensalfini (1997) Surface-Marker Cluster Design Criteria for 3-D Bone Movement Reconstruction. **IEEE Transactions on Biomedical Engineering**, 44 (12), p 1165-1174.

Preparing for the Tutorial

1. Ensure that version 3.0 or later of Visual3D has been downloaded and installed.

2. Download the [sample data].

3. Save this file in the folder where you plan to save your motion capture files.

NOTE: The download contains the end result of this tutorial. It may be useful as a secondary resource for verifying your progress.

4. Launch the Visual3D program from the Start menu. The program will open to the main workspace.

Before completing this tutorial please review the [3D Viewer Animation Controls].

Create a Hybrid Model

1. From the **Model** menu, select Create → Hybrid Model from C3D file.

2. A dialog titled **Select the calibration file for the new model** will appear; Select *Sub01_StandingStaticCal01.c3d* Click Open.

3. Visual3D will switch to Model Building mode automatically. The 3D viewer will display the average value of the marker locations from the standing file. The dialog bar to the left of the screen will contain a list of segments, which by default will contain only a segment representing the Laboratory (e.g. Motion Capture Volume).

Note: You may need to modify the lab coordinate system in Visual3D to properly view the subject. Under **Settings** select *Modify Lab Coordinate System*, **change the A/P axis to -X and Axial to +Z**.

Note: Your screen may look slightly different.

3D View Options

Throughout this tutorial, play with some of the 3D view options to familiarize yourself with these options:

With your mouse, use the 3D Viewer Animation Controls to rotate/pan your view of the model.

1. Click the **View Target ID** toggle button on the toolbar until the target names appear.

2. Click the **View Segment** toggle button on the toolbar until the pelvis bone disappears (the same effect can be achieved by pressing F5 on your keyboard).

3. Click the **View Segment Geometry** toggle button on the toolbar until you toggle off geometric view the pelvis (the same effect can be achieved by pressing F7 on your keyboard).

4. Click the **View Segment Lines** toggle button on the toolbar until you toggle off the yellow lines which connect the segment end points.

Creating the Pelvis Segment

There are many possible markers for a pelvis segment that make sense anatomically, and have a history in the biomechanics community. Visual3D offers 3 default pelvis segments:

1) **Visual3D Pelvis** - The default pelvis segment in Visual3D is labeled a Visual3D Pelvis since the pelvis can be constructed as any other segment. Visual3D inherited this definition from MOVE3D (the precursor software to Visual3D) and has been used by the staff in the Physical Disabilities Branch at the NIH for more than 20 years.

2) **Coda Pelvis** - The CODA pelvis defines the location of the Hip Joint Centers using regression equations from the Bell and Brand articles.

3) **Helen Hayes (Davis) Pelvis** - The Helen Hayes (Davis) pelvis defines the location of the Hip Joint Centers using regression equations from the Davis article.

In this tutorial we are presenting the CODA pelvis: 1. On the segments tab:

1. From the Segment Name box, select Pelvis.

2. From the Segment Type box, select Coda.

3. Click Create.

4. Click **Build Model** to build the segment. You should now see a pelvis segment on your standing model. If you do not see the pelvis segment after clicking Build Model, double check the values you entered in the last step.

View the Pelvis Segment Coordinate System

It is often helpful to isolate the segment's coordinate system in order to validate that it is setup correctly. This view can also help you visualize where the center of gravity for a segment is located. Follow the procedure below to isolate the segment's coordinate system by toggling off the other views. When you are done you will be left with the Coordinate System of the Pelvis as represented by a Red Line (x-axis), Green Line (y-axis) and a Blue Line (z-axis).

Note: Each of the view buttons is a toggle button and will either toggle on or off a particular view.

Click the Views Segment toggle button caption on the toolbar until the pelvis bone disappears (the same effect can be achieved by pressing F5 on your keyboard).

Click the Views Segment Geometry toggle button caption on the toolbar until you toggle off geometric view the pelvis (the same effect can be achieved by pressing F7 on your keyboard).

Click the Views Segment Lines toggle button caption on the toolbar until you toggle off the yellow lines which connect the segment end points.

Modify the pelvis Coordinate System

Double-click on the Pelvis segment and select . Select , and select the A/P axis to be +Y, and axial axis as +Z.

A little fun with the Graphics

You may skip to this section if you wish. It is possible to replace the ”bones” with another bone or object file. As a ridiculous example, you can change the pelvis model to display a skull rather than the pelvis bones. This example can be found here.

Save the Data

Save often to prevent loss of files due to power outages or Windows errors.

Save the Workspace to a .cmz file

Maintain a series of .cmz files as you work so that you can revert to a previous step.

From the **File** menu, click on **Save As**.

In the Save As dialog box label your file *MyTutorial1.cmz*, navigate to the location of your choice and click **Save**.

Save the Model Template

Save the segment definitions as a **model template (mdh)** file to allow you to re-create models using the same marker set. From the **Model** menu select **Save Model Template**.

In the Save As dialog box label your file *Tutorial_ModelTemplate.mdh*, navigate to the location of your choice and click **Save**.

Apply the Model Template

Now that the model template exists, you can use this template on other data sets.

From the **Model** menu select **Apply Model Template**.

In the dialog box select the appropriate .mdh file.

Define the Rest of the Segments

Define the Right Thigh Segment

Create Thigh Segment:

1. From the **Segments** tab, select **Right Thigh** in the **Segment Name** drop down list box

2. Click **Create**. A new tab labeled **Right Thigh** will open.

3. In the **Right Thigh** tab, enter these values:

Define Proximal Joint Radius		
Lateral: *None*	**Joint:** *RIGHT_HIP*	**Medial:** *None*
Radius: 0.5*DISTANCE(RIGHT_HIP,LEFT_HIP)		
Define Distal Joint Radius		
Lateral: *RFLE*	**Joint:** *None*	**Medial:** *RFME*
Select Tracking Targets:		

RTH1, RTH2, RTH3, RTH4	

4. Click **Build Model**. A 3D image of a thigh will appear.

Note: If you receive an error message about inertial properties and custom segments, you may have entered an incorrect number for the proximal radius.

5. Modify the Right Thigh coordinate system by clicking **Segment Properties** and **Modify Segment Coordinate System**. **Change the A/P axis to +Y and the Axial Axis to +Z**.

6. Click **Close Tab** before proceeding.

Note: Closing the tab will not affect the model in any way.

Define the Right Shank Segment

Create Virtual Knee Joint Center:

1. Click Landmarks button

2. Click Add New Landmark button

3. Create Landmark: RIGHT_KNEE

Landmark Name: *RIGHT_KNEE*
Define Orientation Using:
Starting Point: *RFLE*
Ending Point: *RFME*

4. Offset Using the Following **AXIAL** Offset: 0.5

5. **Check:** Offset by Percent (1.0 = 100%)

6. **Check:** Calibration Only Landmark

Create Right Shank Segment:

1. In the **Segments** tab, select **Right Shank** in the **Segment Name** box.

2. **Click** on the **Create Segment** button.

3. In the Right Shank tab, enter these values:

Define Proximal Joint Radius		
Lateral: *None*	**Joint:** *RIGHT_KNEE*	**Medial:** *None*
Radius: *RTH_DISTAL_RADIUS*		
Define Distal Joint Radius		
Lateral: *RFAL*	**Joint:** *None*	**Medial:** *RTAM*

Select Tracking Targets:	
RSHK1, RSHK2, RSHK3, RSHK4	

4. Click **Apply** and **Build Model**

5. Go to **Segment Properties** and Modify **Segment Coordinate System**. **Change the A/P axis to +Y and the Axial Axis to +Z**.