Prosthetics Overview

Prosthetics are a common and essential piece of assistive technology. Their geometry and motion differs from that of conventional segments, thus requiring separate analysis. This can be done accomplished in Visual3D. This page contains all relevant information for modelling and analyzing prosthetic data.

Modelling

Prosthetic segments can be created in any standard model by modifying the segments shown. This process is shown below in the **Modifying Segments** section and is the standard process for creating prosthetics segments. However, prosthetic models can be created as individual model files for re-use in separate data collections. These separate files can be appended to an existing model using the Append Model Template command.

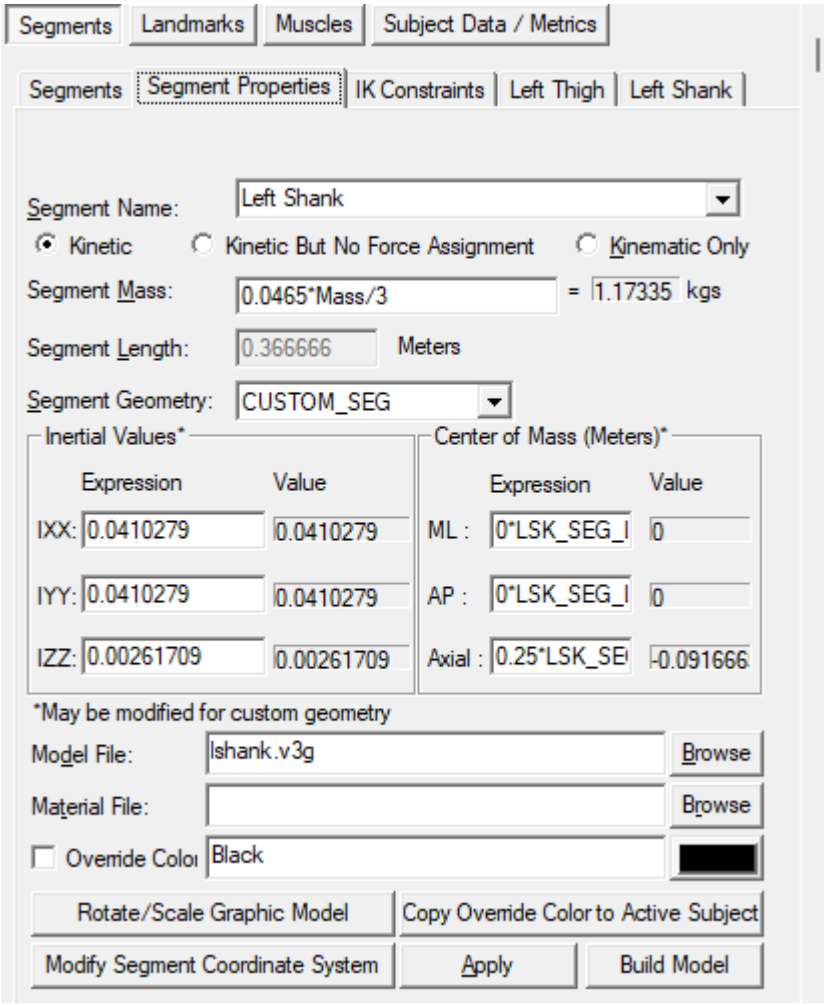
**Marker Placement **
There is no standard marker set for prosthetic limbs. Marker placement depends on the design of the prosthesis, available mounting locations, and the goals of the analysis. In general, markers should be attached to rigid portions of the prosthesis and positioned to minimize soft tissue or component movement relative to the segment they represent.

Modifying Segments

Visual3D allows to you modify many components of a segment when building a model. This allows customiziation of the segment to fit the model geometry, and is done in the **Model** tab under **Segment** > **Segment Properties**. The components of the segment that can be modified are:

- **Segment Mass:** The mass of any segment can be updated as desired. This value entered should be in Kilograms and can be entered as an expression. For example 0.142*MASS with MASS in this case being the overall mass of the model.
- **Segment Geometry:** The Geometry of the segment can be changed to a variety of default shapes that best fit the prosthetic. The following wiki page outlines each of these geometries, how they are calculated and marker requirements.
- **Segment Inertia:** The inertial properties and COM for any segment can be updated as desired. To customize the inertial properties ensure that you have selected **CUSTOM_SEG** from the Segment Geometry dropdown. Similar inertial properties can be inputed as expressions.
- **Material and Model Files:** The material of a segment can be customized by loading a material file. Many Visual3D compatible .obj prosthetic model files can be found here: 3D Prosthetic Models
- **Segment Color:** Segment Color is set by either the default value or the imported material file but can be overridden by checking the **Override Color** Box. From there select the desired color from the pallette on the right.

The following screenshot shows a sample dialog for a custom Shank segment that was modelled as a prosthetic.



Additionally, the Set_Segment_Properties command can be used to modify any aspect of the segment above through the pipeline.

Forces And Analysis

** Forces**
Ground reaction forces are assigned to prosthetic segments in the same manner as biological limbs. The force overview page outlines all necessary steps to create a force for prosthetic and biological limbs.

Analysis
Kinematic and kinetic analyses can be performed using standard Visual3D Model Based Computations such as joint and segment angles, moments and powers. However, interpretation of results should consider the mechanical design of the prosthesis vs biological movement.

Additional Information and Considerations

The following section lists some additional information and consideration that may be helpful and relevant when creating a prosthetic model.

- **UD Power:** The Link Model Based UD power command can be used to compute unified deformable power at the distal end of the foot and is very useful for users with below knee prosthetics.
- **Segment Mass Note:** The subject mass is used in the segment definitions based on a regression model that assumes an in-tact body. The subject mass should be the weight of the individual without the prosthetic on. You can then modify the mass and inertial properties of the prosthetic segments. Unfortunately we don't have a built-in function to add up the overall mass.
- **Lower Limb Joints:** A lower limb prosthetic should only be separated into two segments if there is an ankle joint, otherwise the limb can be represented by one rigid shank segment.
- **Pistoning Prosthetics:** If the prosthetic is NOT pistoning then it can be simply modelled as a rigid segment like any other segment in the body, this is the easiest case. If the prosthetic IS pistoning, then this is the more challenging scenario. You can model the prosthetic but not all analyses will be possible. For example, inverse dynamics calculations are not possible in this case. That said, if you're only interested in kinematics then this might not be a problem for you.

Tutorial

The following tutorial uses a open biomechanics data set collected by Grace Hunt from the University of Utah where nine participants with lower-limb prosthetics preform stand-up sit-down movements.

The K-Means prosthetic tutorial uses a premade model and pipelines to analyze kinetic behavior between participants wearing a variety of prosthetics.