**Tutorial 1 - Joint Model Personalization**

The Joint Model Personalization (JMP) tool optimizes joint parameters, body scaling, and marker placement to minimize IK marker distance errors. Reducing inverse kinematics marker distance errors reduces downstream errors in calculated inverse dynamic joint moments, muscle–tendon lengths and velocities, muscle moment arms, and ultimately muscle activations and forces. These quantities are used by subsequent Model Personalization tools.

The inputs to JMP are a scaled generic OpenSim model, kinematic marker data from one or more motion trials, and a JMP settings file. This tutorial will explore the creation of JMP settings file using both the NMSM Pipeline GUI in OpenSim, and by directly editing the settings file in a text editor.

Before running JMP:

The primary input to a JMP run is a scaled generic OpenSim model. JMP is designed for small adjustments to model parameters, so large scaling adjustments should still be done with OpenSim’s *Scale Model* Tool.

1. Open **RCNL2023.osim** in the OpenSim GUI.
2. Open the *Scale Model* Tool.
3. Load the settings file **ScaleSettings.xml.**
4. Run the scale tool
5. With the new model **UF\_Subject\_3\_v2** selected in the *Navigator* window, click on the *Coordinates* window.
6. Lock **knee\_adduction\_r** and **knee\_adduction\_l**
   1. The knee adduction angle models varus/valgus deformity and doesn’t change much during gait. The scale tool modifies this angle using static pose data, and then we don’t change it afterwards.
7. Save the scaled model as **UF\_Subject\_3\_scaled.osim.**

Setting up a JMP settings file:

1. Activate the NMSM GUI in OpenSim by navigating to *Tools>User Plugins*, and click **rcnlPlugin.dll**
2. Open **UF\_Subject\_3\_scaled.osim** in the OpenSim GUI
3. With **UF\_Subject\_3\_scaled.osim** selected in the OpenSim GUI, navigate to *Tools>Model Personalization>Joint Model Personalization*
   1. The following window should be opened:

A screenshot of a computer

AI-generated content may be incorrect.

1. Rename the output model file to **UF\_Subject\_3\_scaled\_JMPV1.osim**
2. Click *Add* to open a window to create a *JMP Task*.
   1. Name this task **Scale Hips**
   2. Select the *Markers File* to be **GaitTrial\_markers\_jmp.trc**
   3. Add a new body to this task:
      1. Body name: **Pelvis**
      2. Scale body: **Yes**
      3. Move markers: **Y-axis**
3. Create a new JMP Task:
   1. Name this task **Right Knee**
   2. Select the *Markers File* to be **GaitTrial\_markers\_jmp.trc**
   3. Add a new joint to this task.
      1. Joint name: **knee\_r**
      2. Parent frame translation: **None**
      3. Parent frame rotation: **X-, Y- axes**
      4. Child frame translation: **None**
      5. Child frame rotation: **X-, Y- axes**
4. Create a new JMP Task:
   1. Name this task Left Knee
   2. Select the *Markers File* to be GaitTrial\_markers\_jmp.trc
   3. Add a new joint to this task.
      1. Joint name: **knee\_l**
      2. Parent frame translation: **None**
      3. Parent frame rotation: **X-, Y- axes**
      4. Child frame translation: **None**
      5. Child frame rotation: **X-, Y- axes**
5. Save the settings file as **JMPSettingsV1.xml**
6. Open **JMPSettingsV1.xml** in a text editor of your choice, and explore the document

Running JMP:

1. Open MATLAB and open **runJMP.m** in your tutorial directory.
2. Open the project file (**Project.prj** inside your installation of nmsm-core.)
3. Ensure MATLAB is set up to use multi-processing, not multi-threading:
   1. In the bottom left, of matlab click the parallel processing icon, and click *parallel preferences*.
   2. In the drop down menu for *Default Profile*, select **Processes**.
4. Run the MATLAB section labelled **Run JMP V1**
   1. With the section selected, press shift+enter to run a section.
   2. This JMP run will take a few minutes to run.

Post JMP Analysis:

1. In the OpenSim GUI, open **UF\_Subject\_3\_scaled\_JMPV1.osim**.
2. Visually inspect this new model compared to **UF\_Subject\_3\_scaled.osim**. What changed?
3. Analyze the plots created by **runJMP.m**
   1. How do the post-JMP marker errors compare to the <max\_allowable\_error> specified in the settings file?

Experiment with different JMP formulations:

1. With **UF\_Subject\_3\_scaled\_JMPV1.osim** selected in the OpenSim GUI, open a new JMP GUI window.
   1. This allows us to use the previous JMP run as a starting point for a new JMP run.
2. Rename the output model file to **UF\_Subject\_3\_scaled\_JMPV2.osim**
3. Create a new JMP Task:
   1. Name this task **Right Femur Markers**
   2. Select the *Markers File* to be **GaitTrial\_markers\_jmp.trc**
   3. Add a new body to this task:
      1. Body name: **femur\_r**
      2. Scale body: **No**
      3. Move markers: **Y-, Z-axes**
   4. Add a new body to this task:
      1. Body name: **femur\_l**
      2. Scale body: **No**
      3. Move markers: **Y-, Z-axes**
4. Create a new JMP Task:
   1. Name this task **Left Femur Markers**
   2. Select the *Markers File* to be **GaitTrial\_markers\_jmp.trc**
   3. Add a new body to this task:
      1. Body name: **femur\_l**
      2. Scale body: **No**
      3. Move markers: **Y-, Z-axes**
5. Save this settings file as **JMPSettingsV2.xml**.
6. Run the MATLAB section labelled **Run JMP V2**
   1. With the section selected, press shift+enter to run a section.
7. Open **UF\_Subject\_3\_scaled\_JMPV2.osim** in the OpenSim GUI.
8. Visually inspect **UF\_Subject\_3\_scaled\_JMPV2.osim** compared to **UF\_Subject\_3\_scaled\_JMPV1.osim**

Change max allowable error:

1. Open **JMPSettingsV1.xml** in a text editor of your choice.
2. Change <output\_model\_file> to **UF\_Subject\_3\_scaled\_JMPV3.osim**
3. Change <max\_allowable\_error> term to be **0.02** instead of 0.01.
4. Save this settings file as **JMPSettingsV3.xml.**
5. Run the MATLAB section labelled **Run JMP V3**
6. With the section selected, press shift+enter to run a section.