**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.

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.

1. **Before running JMP:**
2. Open the OpenSim model “UF\_Subject\_3\_scaled.osim**”** in the OpenSim GUI.
3. Run the Inverse Kinematics (IK) tool on the model using the marker file “GaitTrial\_markers\_jmp.trc”
   1. Keep all weights equal to 1. When JMP runs IK, it also uses weights of 1.
4. Open “GaitTrial\_markers\_jmp.trc” in the OpenSim GUI with “File>Preview Experimental Data”
5. Sync the experimental marker motion with your generated IK Result and inspect the motion
   1. What is the average marker RMS error throughout the gait cycle?
   2. Which markers have the highest error. Why do you think this is?
6. **Setting up a JMP settings file:**
7. Activate the NMSM GUI in OpenSim by navigating to “Tools>User Plugins”, and click “rcnlPlugin.dll”
8. 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 “[working\_directory]\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 marker file to be “GaitTrial\_markers\_jmp.trc”
   3. Click “Add” under the “Bodies in this Task” window.
      1. Select the body name to be “pelvis”, check “Scale Body”, and allow markers to move in the Y-direction.
3. Create a new JMP Task:
   1. Name this task “Right Knee”
   2. Select the marker file to be “GaitTrial\_markers\_jmp.trc”
   3. Click “Add” under the “Joints in this Task” window.
      1. Select the joint name to be knee\_r.
      2. Under parent frame, check only rotation in the X- & Y-directions.
      3. Under child frame, check only rotation in the X- & Y- directions.
4. Create a new JMP Task:
   1. Name this task “Left Knee”
   2. Select the marker file to be “GaitTrial\_markers\_jmp.trc”
   3. Click “Add” under the “Joints in this Task” window.
      1. Select the joint name to be knee\_l.
      2. Under parent frame, check only rotation in the X- & Y-directions.
      3. Under child frame, check only rotation in the X- & Y- directions.
5. Save the settings file as “JMPSettingsV1.xml”
6. Open up the JMP settings file in a text editor of your choice, and explore the document
   1. What elements could you directly edit in the GUI?
   2. Were there any elements that show up in the file that you didn’t specify in the GUI?
   3. What is the default value given for max allowable error? What does this term represent in terms of the JMP optimization?
   4. Explore the optimization settings at the bottom of the settings file. These can be edited to change how fast the optimization will terminate.
7. **Running JMP:**
8. Open MATLAB and create a new script called runJMP.m in your JMP tutorial directory.
9. In the script, type: JointModelPersonalizationTool("JMPSettingsV1.xml")
10. 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.
11. Press Run
    1. This JMP run will take a few minutes to run.
12. **Post JMP Analysis:**
13. In the OpenSim GUI, open the new model created by JMP.
14. Re-run IK following the steps in Section 1 above.
15. Compare the marker errors of the post-JMP model to those of the pre-JMP model.
    1. How do the RMS errors compare? Is this an expected result?
    2. What is the maximum marker error for the post-JMP model? How does this number compare to the Max Allowable Error parameter for your JMP runs?
16. **Experiment with different JMP formulations:**
17. With the post-JMP model 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.
18. Rename the output model file to “[working\_directory]\UF\_Subject\_3\_scaled\_JMPV2.osim”
19. Create a new JMP Task:
    1. Name this task “Move Markers”
    2. Select the marker file to be “GaitTrial\_markers\_jmp.trc”
    3. Click “Add” under the “Bodies in this Task” window.
       1. Select the body name to be “femur\_r”, check “Scale Body”, and allow markers to move in the X- & Y-direction.
    4. Click “Add” under the “Bodies in this Task” window.
       1. Select the body name to be “tibia\_r”, check “Scale Body”, and allow markers to move in the X- & Y-direction.
20. Save this settings file as “JMPSettingsV2.xml” and run it in MATLAB.
21. Visually compare the new model created by this JMP run to the model created by JMPSettingsV1.
    1. What direction did the markers move? Does this make sense in the context of soft tissue movement during gait?
22. **Change max allowable error:**
23. Open JMPSettingsV1.xml in a text editor of your choice.
24. Rename the output model file to “[working\_directory]\UF\_Subject\_3\_scaled\_JMPV3.osim”
25. Change the max allowable error term to be 0.02 instead of 0.01.
26. Save this settings file as JMPSettingsV3.xml and run it in MATLAB
27. Run inverse kinematics on this new model.
    1. How do the marker errors compare to the JMP model with a smaller max allowable error?
    2. Is this an expected result?