Tutorial 5 – Ground Contact Personalization

The Ground Contact Model Personalization tool finds physical properties for elastic foundation foot–ground contact models that closely reproduce experimental ground reaction forces and moments while allowing slight changes in foot kinematics. The elastic foundation is composed of a uniform grid of linear springs with nonlinear damping and friction placed across the bottom of the foot. A personalized foot-ground contact model is important for predicting new movements because ground reaction forces and moments will change with the new movements.

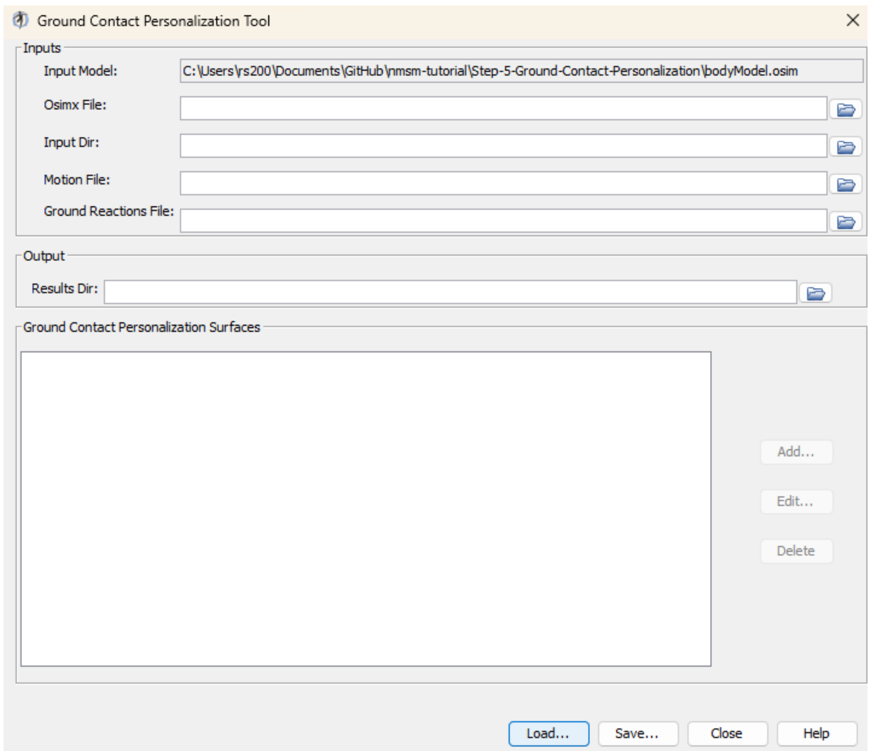
The inputs to the GCP tool are a post-JMP lower-body or full-body OpenSim model along with IK motion and associated ground reaction data for a walking trial, where the IK and ground reaction data must possess the same time increments.

Before running GCP:

1. Open the OpenSim model **BodyModel.osim** in the OpenSim GUI.
2. GCP uses the model's default pose to place springs on the foot. It is important that this model has the feet flat on the ground and at the correct height above the ground. With these criteria, the static pose is generally a good choice for the default pose.
3. Run OpenSim *Inverse Kinematics* on **BodyModel.osim** with the premade settings file **IKSettingsStaticPose.xml**.
4. Click on the *Coordinates* tab
5. Under *poses*, click **Set Default** and save the model. The default model pose is now the static trial pose.

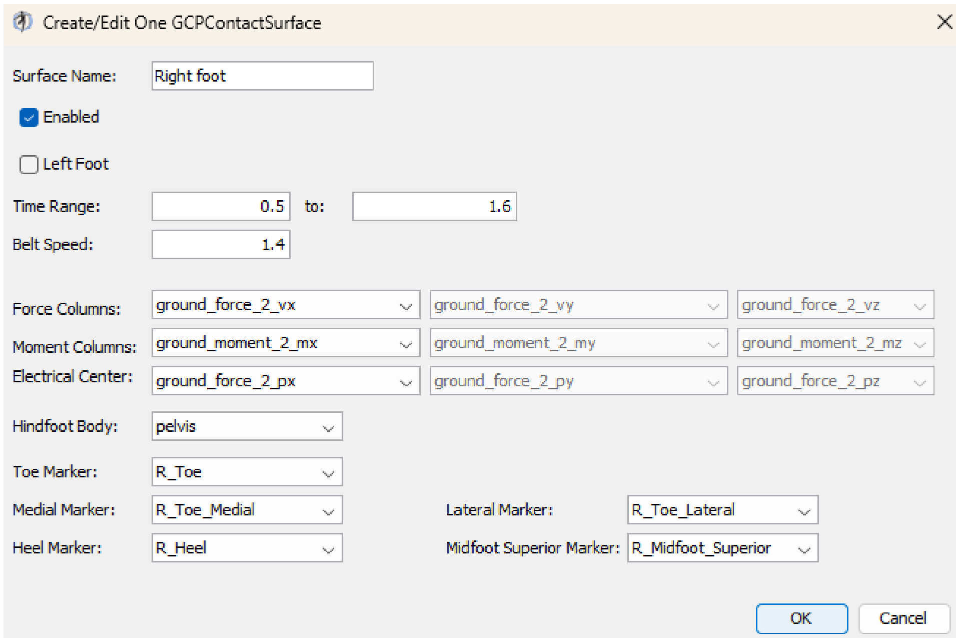
Setting up a GCP settings file:

1. Activate the NMSM GUI in OpenSim by navigating to *Tools>User Plugins*, and click **rcnlPlugin.dll.**
2. With **bodyModel.osim** selected in the OpenSim GUI, navigate to *Tools>Model Personalization>Ground Contact Personalization*
    a. The following window should be opened:



3. Leave the *Osimx file* field empty.
4. Choose the *input directory* to be **preprocessed**
5. Choose the *motion file* to be **preprocessed\IKData\gait_1.sto**
6. Choose the *ground reactions file* to be **preprocessed\GRFData\gait_1.sto**
7. Choose the *results directory* to be **GCPResultsV1**
8. Add a new contact surface named **Right Foot**
9. Set the *time range* to **0.5 – 1.6**
10. Set the *belt speed* to **1.4**
11. Set the *force columns* to (**ground_force_2_vx ground_force_2_vy ground_force_2_vz**)
12. Set the *moment columns* to (**ground_moment_2_mx ground_moment_2_my ground_moment_2_mz**)
13. Set the *electrical center columns* to (**ground_force_2_px ground_force_2_py ground_force_2_pz**)
14. Set *hindfoot body* to **calcn_r**
    a. Tip: You can type inside the drop down menu to get to the option you want faster.

15. Set *toe marker* to **R_Toe**
16. Set *Medial Marker* to **R_Toe_Medial**
17. Set *Heel Marker* to **R_Heel**
18. Set *Lateral Marker* to **R_Toe_Lateral**
19. Set *Midfoot Superior Marker* to **R_Midfoot_Superior**
20. Your full contact surface should look like:



21. Save your settings file as **GCPSettingsV1.xml**
22. Open up **GCPSettingsV1.xml** in a text editor of your choice and explore the settings file.
23. With a text editor, scroll to the bottom of the settings file, and change <max_iterations> to 20.
    a. This is to make the optimization terminate earlier to save time.

Running GCP:

1. Open MATLAB and open **runGCP.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:
    a. In the bottom left, of matlab click the parallel processing icon, and click *parallel preferences*.
    b. In the drop down menu for *Default Profile*, select **Processes**.
4. Run the MATLAB section labelled **Run GCP V1**
    a. With the section selected, press shift+enter to run a section.
5. While running GCP:
    a. In the OpenSim GUI, open and inspect the model **footModel_1.osim**

b. To simplify the optimization, GCP only uses foot kinematics instead of full body kinematics.
c. The location of the springs is determined by the "default" pose of the osim model. To place the springs well, it is important that the full body model's feet are flat on the ground and placed at an appropriate height.

Post GCP analysis:

1. Look through the plots created by the script. If everything was done correctly, there should be 3 plots.
    a. Plot 1 – Ground Reaction Matching: Ground reaction forces and moments produced by the contact model plotted against experimental ground reactions.
    b. Plot 2 – Kinematics: Adjusted foot kinematics produced by the optimization.
    c. Plot 3 – Stiffness Coefficients: A grid of stiffness coefficients for each foot.

Experiment with electrical center adjustment:

1. Create a copy of **GCPSettingsV1.xml** and name it **GCPSettingsV2.xml**
2. Open **GCPSettingsV2.xml** in a text editor of your choice.
3. Change the `<results_directory>` to **GCPResultsV2.**
4. In task 3 of your `<GCPTaskSet>`, change `<electricalCenterX>`and `<electricalCenterZ>` to true.
5. Save this settings file as **GCPSettingsV2.xml**
6. Run the MATLAB section labelled **Run GCP V2**
    a. With the section selected, press shift+enter to run a section.

Experiment with viscous friction:

1. Create a copy of **GCPSettingsV1.xml** and name it **GCPSettingsV3.xml**
2. Open **GCPSettingsV3.xml** in a text editor of your choice.
3. Change the `<results_directory>` to **GCPResultsV3.**
4. In all tasks, set `<dynamicFrictionCoefficient>` to **false**, and `<viscousFrictionCoefficient>` to **true**.
5. At the bottom of the settings file, set `<initial_dynamic_friction_coefficient>` to **0**, and `<initial_viscous_friction_coefficient>` to **5**.
6. Save this settings file as **GCPSettingsV3.xml**
7. Run the MATLAB section labelled **Run GCP V3**
    a. With the section selected, press shift+enter to run a section.