

## 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.

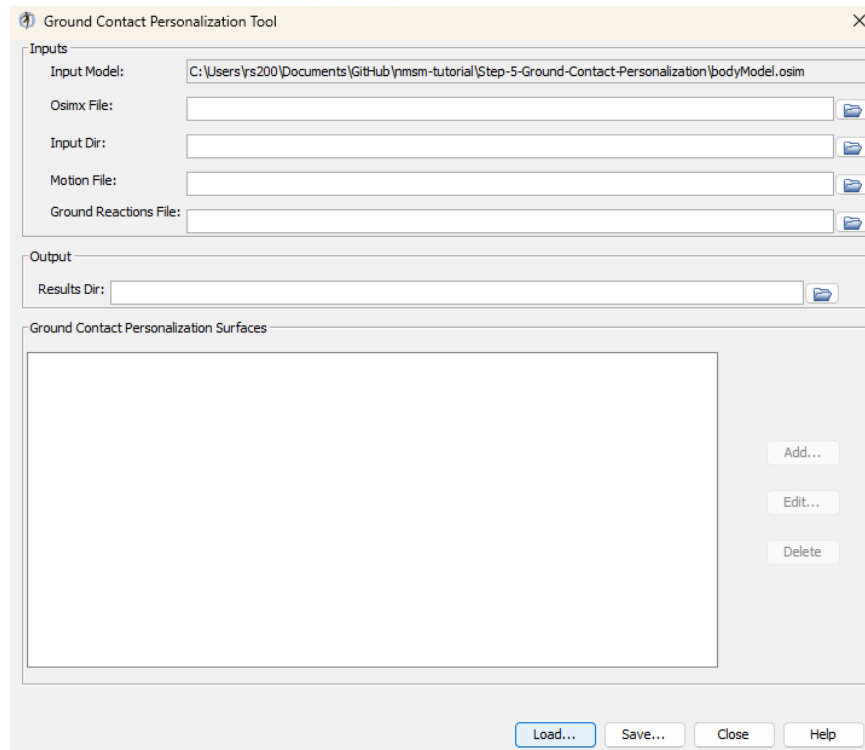
The inputs to the GCP tool are a post-JMP lower-body or full-body OpenSim model along with IK motion and associated ground reaction data for a walking trial, where the IK and ground reaction data must possess the same time increments.

### 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 its 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 **GCPResults**
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:

Create/Edit One GCPContactSurface

Surface Name:

☒ Enabled

☐ Left Foot

Time Range:  to:

Belt Speed:

Force Columns:

Moment Columns:

Electrical Center:

Hindfoot Body:

Toe Marker:

Medial Marker:  Lateral Marker:

Heel Marker:  Midfoot Superior Marker:

OK Cancel

21. Save your settings file as **GCPSettings.xml**
22. Open **GCPSettings.xml** in a text editor and explore the settings file.
23. With the 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. A full GCP run should allow more iterations (usually around 100).

## 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 file **runGCP.m**
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.

## Alternate GCP Formulations:

GCP supports adjusting force plate electrical centers. This can be useful for getting better moment matching in cases where the forceplate and motion capture coordinate systems have discrepancies between them. To adjust your electrical centers, enable the relevant design variables in the third task of your GCP where moments are primarily personalized. After the GCP run, how much did your electrical center get adjusted? How does adjusting the force plate electrical center improve your moment and force tracking quality?