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.

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.

1. **Before running GCP:**
2. Open the OpenSim model “BodyModel.osim” in the OpenSim GUI.
3. 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.
4. Run OpenSim inverse kinematics on BodyModel.osim with the static trial marker data.
5. Click on the “Coordinates” tab
6. Under “poses”, click “Set Default” and save the model. The default model pose is now the static trial pose.
7. **Setting up a GCP settings file:**
8. Activate the NMSM GUI in OpenSim by navigating to “Tools>User Plugins”, and click “rcnlPlugin.dll”
9. With “bodyModel.osim” selected in the OpenSim GUI, navigate to “Tools>Model Personalization>Ground Contact Personalization”
   1. The following window should be opened:

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1. Choose the input Osimx model to be the output Osimx model from NCP.
2. Choose the input directory to be “preprocessed”
3. Choose the motion file to be preprocessed\IKData\gait\_1.sto
4. Choose the ground reactions file to be preprocessed\GRFData\gait\_1.sto
5. Add a new contact surface named “Right Foot”
6. Set the time range to 0.5 – 1.6
7. Set the belt speed to 1.4
8. Set the force columns to [ground\_force\_2\_vx ground\_force\_2\_vy ground\_force\_2\_vz]
9. Set the moment columns to [ground\_moment\_2\_mx ground\_moment\_2\_my ground\_moment\_2\_mz]
10. Set the electrical center columns to [ground\_force\_2\_px ground\_force\_2\_py ground\_force\_2\_pz]
11. Set hindfoot body to calcn\_r
    1. Tip: You can type inside the drop down menu to get to the option you want faster.
12. Set toe marker to R\_Toe
13. Set Medial Marker to R\_Toe\_Medial
14. Set Heel Marker to R\_Heel
15. Set Lateral Marker to R\_Toe\_Lateral
16. Set Midfoot Superior Marker to R\_Midfoot\_Superior
17. Your full contact surface should look like:

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1. Save your settings file as “GCPSettingsV1.xml”
2. Open up GCPSettingsV1.xml in a text editor of your choice and explore the settings file.
   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 do each of the 3 automatically generated tasks focus on?
      1. Hint: Look at the max allowable errors of each cost term.
   4. Explore the optimization settings near the top of the settings file. These can be edited to change how fast the optimization will terminate.
3. With a text editor, scroll to the bottom of the settings file, and change max\_iterations to 20.
4. **Running GCP:**
5. Open MATLAB and create a new script called runGCP.m in your GCP tutorial directory.
6. In the script, type: GroundContactPersonalizationTool("GCPSettingsV1.xml")
7. To plot results, type: plotGcpResultsFromSettingsFile("GCPSettingsV1.xml")
8. Press Run
   1. Make sure the NMSM project file is open!
9. While running GCP:
   1. In the OpenSim GUI, open and inspect the model footModel\_1.osim
   2. To simplify the optimization, GCP only uses foot kinematics instead of full body kinematics.
   3. 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.
      1. Generally, using the subject’s static pose as the default pose in OpenSim works well.
10. **Post GCP analysis:**
11. Look through the plots created by the script. If everything was done correctly, there should be 3 plots.
    1. Plot 1 – Ground Reaction Matching: Ground reaction forces and moments produced by the contact model plotted against experimental ground reactions.
    2. Plot 2 – Kinematics: Adjusted foot kinematics produced by the optimization.
    3. Plot 3 – Stiffness Coefficients: A grid of stiffness coefficients for each foot.
12. Questions:
13. **Experiment with electrical center adjustment:**
14. Open GCPSettingsV1.xml in a text editor of your choice.
15. Change the results directory to GCPResultsV2
16. In task 3, change electricalCenterX and electricalCenterY to true.
17. Save this settings file as GCPSettingsV2.xml
18. Run this new settings file in MATLAB. Remember to change the settings file name in the plotting function too.
19. Questions:
    1. How does kinematic tracking quality with electrical center adjustment compare to without it?
    2. How does ground reaction tracking quality with electrical center adjustment compare to without it?
    3. Why might we want to adjust the force plate electrical center?
20. **Experiment with electrical center adjustment:**
21. Open GCPSettingsV1.xml in a text editor of your choice.
22. Change the results directory to GCPResultsV3
23. In all tasks, set dynamicFrictionCoefficient to false, and viscousFrictionCoefficient to true.
24. At the bottom of the settings file, set initial\_dynamic\_friction\_coefficient to 0, and initial\_viscous\_friction\_coefficient to 5.
25. Save this settings file as GCPSettingsV3.xml
26. Run this new settings file in MATLAB. Remember to change the settings file name in the plotting function too.
27. Questions:
    1. How does the tracking for X- and Z-moments compare between dynamic and viscous friction?