Tutorial 6 – Tracking Optimization

The Tracking Optimization (TO) tool uses a personalized model to produce a dynamically consistent movement simulation that closely reproduces all available experimental motion data, including joint motions, joint moments, ground reaction forces and moments, and muscle activations. To achieve a dynamically consistent motion, the tool spreads out matching errors between the different experimental quantities based on user-specified maximum allowable errors.

The tool accepts a post-JMP OpenSim model (.osim fle) and personalized NMSM Pipeline model (.osimx fle) along with experimental IK motions, ID loads, ground reactions, muscle–tendon lengths and velocities, muscle moment arms, and, if using synergy controls, NCP results for the trial of interest.

1. **Before running TO:**
2. Open the OpenSim model “RightLegAndPelvis.osim” in the OpenSim GUI.
3. **Setting up a Torque Driven TO settings file:**
4. Activate the NMSM GUI in OpenSim by navigating to “Tools>User Plugins”, and click “rcnlPlugin.dll”
5. With “RightLegAndPelvis.osim” selected in the OpenSim GUI, navigate to “Tools>Treatment Optimization>Tracking Optimization”
   1. The following window should be opened:

A screenshot of a computer

AI-generated content may be incorrect.

1. Set the input Osimx file as “RightLegAndPelvis.osimx”
2. Set the initial guess directory to be preprocessed
3. Set the tracked quantities directory to be preprocessed
4. Set the results directory to be TorqueTOResultsV1
5. Click the button to generate a default optimal control settings file, and then click browse to select the newly created file.
6. Set the states coordinate list to [hip\_flexion\_r knee\_angle\_r ankle\_angle\_r]
7. Under the RCNL controllers tab, add [hip\_flexion\_r knee\_angle\_r ankle\_angle\_r] to the RCNL Torque Controller coordinate list.
8. Cost terms:
   1. generalized\_coordinate\_tracking for [hip\_flexion\_r knee\_angle\_r ankle\_angle\_r], max allowable error = 0.1
9. Constraint terms:
   1. kinetic\_consistency for [hip\_flexion\_r\_moment knee\_angle\_r\_moment ankle\_angle\_r\_moment], max\_error = 0.1, min\_error = -0.1
10. Save the settings file as “TorqueTOSettingsV1.xml”
11. **Setting up a Synergy Driven TO settings file:**
12. Open the NMSM Tracking Optimization GUI in OpenSim and load the TorqueTOSettingsV1.xml settings file.
13. Change the initial guess directory to ncpResults
    1. This gives an initial guess for the synergy controls.
14. Clear all coordinates out of the RCNL Torque Controller coordinate list
15. Add [hip\_flexion\_r knee\_angle\_r ankle\_angle\_r] to the RCNL Synergy Controller coordinate list.
16. Set the surrogate model data directory to be surrogateData.
17. Add a new cost term:
    1. muscle\_activation\_tracking for [bflh\_r bfsh\_r gasmed\_r glmax2\_r iliacus\_r recfem\_r soleus\_r tibant\_r vasmed\_r], max allowable error = 0.05
18. Save this settings file as “TorqueTOSettingsV1.xml”
19. **Running TO:**
20. Open MATLAB and create a new script called runTO.m in your MTP tutorial directory.
21. To run the torque driven TO, type TrackingOptimizationTool("TorqueDrivenTrackingOptimizationSettings.xml");
22. To run the synergy driven TO, type TrackingOptimizationTool("SynergyDrivenTrackingOptimizationSettings.xml");
23. To plot results, type
24. **Post TO Analysis:**
25. Look through the plots created by the script. If everything was done correctly, there should be 6 plots.
26. The joint angles and joint loads should both track the experimental data very closely.
27. Questions:
    1. Which joint angles have errors between the experimental data and the TO output? Why do some joint angles have zero errors?
    2. For the joint angles that have zero error, do they still have error in the corresponding joint moments? Is this an expected result? Why or why not?