Tutorial 4 – Neural Control Personalization

The Neural Control Model Personalization tool finds muscle synergies that are as consistent as possible with ID joint moments and, when available, MTP-estimated muscle activations. The NCP tool fts muscle synergies at the level of muscle activations (i.e., after electromechanical delay and activation dynamics) for regions of the body where either all muscle activations are available from the MTP tool (e.g., the right lower extremity) or no muscle activations are available.

The inputs to the NCP tool are a post-JMP OpenSim model as well as data for IK motions, ID loads, muscle–tendon lengths and velocities, muscle moment arms, and, optionally, MTP-calculated muscle activations from one or more motion trials of interest.

1. **Before running NCP:**
2. Open the OpenSim model “UF\_Subject\_3\_reduced\_muscles.osim” in the OpenSim GUI.
3. Under the “Forces” tab on the model, explore the muscles available.
4. Take note of the extra groups added.
   1. These are added for organization so that MTP/NCP knows which model muscles to group together in the optimization.
   2. The four important groups are:
      1. Activation Muscle Groups – Muscles that we would expect to have similar activation profiles (ie lateral hamstrings; BFSH and BFLH will have similar activations to each other). \*These groups are used in MTP and NCP. \*
      2. Normalized Fiber Length Muscle Groups – Muscles that we would expect to have similar normalized fiber lengths. \*These groups are used in MTP and NCP. \*
      3. Collected EMG Muscle Groups – Muscle groups that we **do** **have** experimental EMG data for. These must have the same name as the respective EMG channel name your EMG data file (preprocessed\EMGData\gait\_1.sto). \*These groups are used in MTP. \*
      4. Missing EMG Muscle Groups – Muscle groups that we **do not** **have** experimental EMG data for. \*These groups are used in MTP. \*
   3. These groups need to be created manually in a text editor such as Notepad++, but we have example groups for lower limb models in the “NMSM Article” download on SimTK: <https://simtk.org/frs/?group_id=2397>
5. **Setting up an MTP settings file:**
6. Activate the NMSM GUI in OpenSim by navigating to “Tools>User Plugins”, and click “rcnlPlugin.dll”
7. With “UF\_Subject\_3\_reduced\_muscles.osim” selected in the OpenSim GUI, navigate to “Tools>Model Personalization>Neural Control Personalization”
   1. The following window should be opened:

A screenshot of a computer

AI-generated content may be incorrect.

1. Set the input Osimx file to be mtpResults\ UF\_Subject\_3\_reduced\_muscles\_mtp.osimx
2. Set the data directory to be preprocessed.
3. Set the results directory to be NCPResultsV1
4. For the coordinate list, select: [hip\_flexion\_r, knee\_angle\_r, ankle\_angle\_r].
5. For activation muscle groups, select [HipFlexorsActivationGroupR, GlutmaxActivationGroupR, HamslatActivationGroupR, VasActivationGroupR, GasActivationGroupR]
   1. Tip: The filter box at the top is very helpful to filter only activation groups
6. For normalized fiber length groups, select [GlutmaxNormalizedFiberLengthGroupR, HamsNormalizedFiberLengthGroupR, VasNormalizedFiberLengthGroupR, GasNormalizedFiberLengthGroupR]
7. Keep Muscle Tendon Length Initialization disabled.
8. Set the MTP results directory to be mtpResults
9. Include RightLeg in the synergy set with 3 synergies.
10. Save this settings file as “NCPSettingsV1.xml”
11. Open up NCPSettingsV1.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. Explore the optimization settings near the top of the settings file. These can be edited to change how fast the optimization will terminate.
12. **Running NCP:**
13. Open MATLAB and create a new script called runNCP.m in your MTP tutorial directory.
14. In the script, type: NeuralControlPersonalizationTool("NCPSettingsV1.xml")
15. To plot results, type: plotNcpResultsFromSettingsFile("NCPSettingsV1.xml")
16. Press Run
    1. Make sure the NMSM project file is open!
17. **Post NCP Analysis:**
18. Look through the plots created by the script. If everything was done correctly, there should be 3 plots.
    1. Plot 1 – Muscle Activations: Muscle activations produced by NCP synergies compared to the input MTP muscle activations.
    2. Plot 2 – Synergy Matching Quality: Variance accounted for (VAF) and root mean squared error (RMSE) for the synergy decomposition of muscle activations.
    3. Plot 3 – Joint Moment Matching: Joint moments generated by muscle forces compared to Inverse Dynamics joint moments
19. **Experiment with different numbers of synergies:**
20. Open NCPSettingsV1.xml in a text editor of your choice.
21. Change the results directory to NCPResultsV2
22. Change the number of synergies in RightLeg to 4.
23. Save this settings file as NCPSettingsV2.xml
24. Run this new settings file in MATLAB. Remember to change the settings file name in the plotting function too.
25. Questions:
    1. Does adding more synergies give better or worse muscle activation and joint moment tracking?
    2. What are the benefits and drawbacks of adding more synergies?
    3. How should we determine the correct number of synergies?
26. **Experiment with activation minimization:**
27. Open NCPSettingsV1.xml in a text editor of your choice.
28. Set the results directory to NCPResultsV3.
29. Set the is\_enabled field in the activation tracking cost term to false and set activation\_minimization to true.
30. Save this settings file as NCPSettingsV3.xml
31. Run this new settings file in MATLAB. Remember to change the settings file name in the plotting function too.
32. Questions:
    1. How does the moment tracking for this run compare to using activation tracking?
    2. What are the differences between activation minimization in NCP, and OpenSim’s Static Optimization Tool?