OpenSim Plugin to Extract Muscle Force Directions (MFD), Matlab Tool: Update Notes for OpenSim version 4.0

This document describes the updates and modifications made to the Matlab Tool version of MFD OpenSim plugin (https://simtk.org/projects/force_direction), for compatibility with OpenSim 4.0 platform while maintaining functionality of the original MFD plugin tool. The plugin tool was developed by Dr. Luca Modenese (l.modenese@imperial.ac.uk) and colleagues at Imperial College London, based on OpenSim 3.x platforms. Below is a list of key updates to the matlab functions:

1. OpenSim Matlab API function (method) language that changed from version 3.x to 4.0 are modified accordingly to be recognized by API v4.0.
2. Functionality added to reduce processed kinematics by only processing every N frames. 'N' is specified as input '**step_interval**' to 'getMuscleForceDirection.m' main function.
3. If input 'effective_attachm' = 'true', EFFECTIVE muscle attachments and MFD vectors are exported to file. Code is edited that when 'effective_attachm' = 'false', ANATOMICAL attachments and MFD vectors are exported (default). **Anatomical MFD** direct from anatomical bone attachment towards the next muscle path point (including conditional and wrap points, if active in current state). This is consistent with original MFD plugin functionality; see User Guide Pg. 2, Ch. 1.2.
4. Code is edited so all MFD outputs are converted and expressed in the specified body frame, '**bodyExpressResultsIn_name**'. (Default is 'bodyOfInterest_name') This includes anatomical/effective attachments, anatomical/effective MFD, and the 'transport moment' of effective MFD relative to anatomical bone attachment.
5. Created a simple function '**getBodyorGround.m**' to get PhysicalFrame by name. This is needed for OpenSim v4.x models, in which Ground is defined separately from other Bodies in the main BodySet.
6. In 'getCurrentMusclePathAsMat.m', method '**getCurrentPath(state)**' is used instead of 'getPathPointSet()' to recognize path points (e.g. wrap points) that may only exist at certain states.
7. When assigning coordinates at current state using 'realizeMatStructKinematics.m', functionality is added to compute **coordinates coupled** with an independent by a simple **linear function**. (More complex coupler functions or other motion types are not managed by current code, in which cases error would be displayed.)
8. 'realizeMatStructKinematics.m' now only receives one frame of kinematic data input, together with matching column headers. It should run faster than previous code version where full IK matrix was passed in every time step loop.
9. Created function '**transformVec.m**' to convert a 3D numerical vector from one coordinate frame to another. This reduces new Vec3() definitions and improves readability of the main code.

10. **Time** stamps are now retrieved from motion data matrix, then appended to the 1st column of each output matrix (which are subsequently written to files).
11. Created function '**printtoSTO.m**' to export MFD vectors and attachments results into an OpenSim-compatible .sto text file, similar to exports from the original plugin. Input includes result structure with a data matrix and matching column headers, plus the full storage file path. Top-row header and informational texts are optional inputs. This function can also be used to export non-MFD .sto files with a similar format.
12. **Column header formats** in output files are adjusted to clarify the subject of each data column. These headers are longer than previous versions.
    - **[*MuscleName*]_v[*x/y/z*]_from_[*bodyOfInterest*]_in_[*bodyExpressResultsIn*]**
      MFD vectors. 'From' indicates the direction is from attachment, pointing outwards.
    - **[*MuscleName*]_p[*x/y/z*]_on_[*bodyOfInterest*]_in_[*bodyExpressResultsIn*]**
      MFD attachments (either anatomical or effective).
    - Additionally, word ANATOMICAL or EFFECTIVE is printed in the top-row header of the .sto files to indicate the type of results exported.

MFD Matlab Tool v4.0 edited (and this document created) by:

Ke Song, MS

Graduate Research Assistant, Physical Therapy

Washington University in St. Louis

E-mail: ksong23@wustl.edu

September 18, 2019