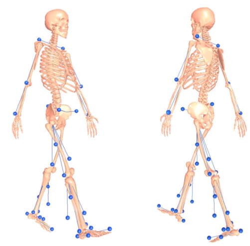
BIOMENG771 : OpenSim Lab 1: Kinematic Modelling of the Musculoskeletal System



Aim: In this lab you will gain experience in kinematic modelling of the musculoskeletal system using OpenSim, including functional joint centre calculation, model scaling, and inverse kinematics.

This lab is due September 16 at 12:00pm and is worth 10% of your final grade.

Problem: You want to investigate the use of walking poles to alter the kinematics and kinetics of walking gait. First, you would like to understand the influence of different hip joint centre predictions on the resulting hip joint kinematics. To solve this problem, we will use data from the 4th Grand Knee Challenge dataset (https://simtk.org/home/kneeloads), which you can download from Lab 1 in Canvas.

Task 1: Calculate hip joint centre using a functional method. Use the optimal hip centre location algorithm of Gamage and Lasenby (2002) (from tutorial 1) to calculate a functional hip joint centre for the left and right hip joint using the C3D trials provided (*jw_hip_lstar1.c3d* and *jw_hip_rstar1.c3d*). Filter your marker data first using a low-pass Butterworth filter with a reasonable cut-off frequency. Determine the x, y, z locations of the left and right hip joint centre in the pelvis coordinate system.

Task 2: Scale the generic OpenSim gait model to match the experimental markers. Open the *gait2354_simbody.osim* model file and attach the markers from the Grand Knee Challenge marker set (*GrandKneeMarkerSet.xml*) (ignore the upper limb markers). Use the experimental markers from the static trial (*jw_staticfor.c3d*) to scale the pelvis, thigh, shank, and foot segments of the OpenSim model. Go into the scaled.osim model file and record the x, y, z location of the left and right hip joint centres (with respect to the pelvis coordinate system).

Task 3: Perform inverse kinematics. Perform IK on the normal over ground walking trial (*jw_ngait_og1.c3d*) using the scaled model from Task 2. You will need to ensure that the y-axis is vertical, so after you export the .trc file from Mokka, use the matlab script provided to rotate the marker data appropriately. You can use equal weighting for all markers when you generate the IK solution.

Task 4: Compare normal overground walking to overground walking with walking poles. Using the same scaled model as Task 2, perform IK on the walking pole gait data (*jw_wpgait_ln4.c3d*). Again, use equal weighting on all markers.

Prepare a report that answers the following questions. For each question write a short paragraph that introduces the problem and then refers to the figure or table, where appropriate. Include tables or figures with appropriate axes and labelling to highlight your findings (note: you will lose marks for figures and tables that do not have labels, units, or captions!).

1. Create a table showing the left and right hip joint centre locations (i.e. xyz coordinates in pelvis CS) using the functional method (Task 1) and the scaled OpenSim model (Task 2). Include a column to show the absolute difference between the functional method compared to the OpenSim hip centre location (in mm). Add a caption to the table that succinctly describes the data and highlights the main differences that you observe. **(5 marks)**

2. Create a new table to show the xyz *scale factors* for the pelvis after scaling the model to match the experimental markers (Task 2)? Add a caption to this table explaining what these numbers represent. Justify your rationale for using (or not using) isotropic scaling when you scaled the pelvis segment. **(3 marks)**

3. The scaling method used in task 2 will result in a different location of the hip joint centre, compared to the functional method in task 1. Discuss the advantages and disadvantages of each method in the context of accurately estimating the pelvis bone AND hip joint centres. How might you validate these methods to determine their accuracy? **(5 marks)**

4. What was the cut off frequency you chose to filter the marker data prior to calculating the functional hip joint centres and justify why you selected this frequency. Discuss the limitation(s) of the functional method. **(3 marks)**

5. Create a single figure illustrating the hip, knee, and ankle flexion-extension for the right limb during the gait cycle of the normal walking trial (i.e. from the generalised coordinates from Task 3). Time normalize your data to 100 points so your time axis represents % stride. Indicate heel strike and toe-off events and periods of stance phase and swing phase. Add a caption to your figure to adequately describe the figure. **(6 marks)**

6. Which marker had the greatest RMS error between your experimental and model markers for the IK simulation from task 3? Discuss why you think this marker had the greatest error and what you might do to reduce this error. Why would you select different weights for different markers when performing inverse kinematics? **(3 marks)**

7. Create another figure comparing the hip, knee and ankle joint coordinates (angles) for the right limb between normal walking gait and the walking pole gait (ie. Plot the results from Task 3 AND Task 4). Plot data for the stance phase only (i.e. time-normalise your data to 100 points to enable a direct comparison across trials as a % stance). Add a caption to explain the figure, highlighting the main findings. **(5 marks)**

Upload your report to Canvas before 12:00PM on September 16.

Total is 30 marks