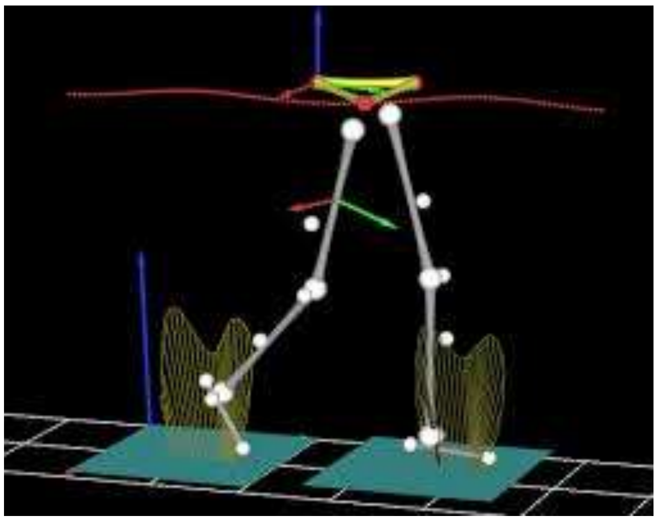
IBEHS 3P04 Winter 2020

Assignment 3

Gait Analysis Application



Date Assigned: Friday, March 23, 2020

Assignment Due: Friday, April 17, 2020, 12:00 pm (noon); Please feel free to submit sooner than this.

Assignment Type: Individual

Submission Details: Please upload your solution to Avenue to Learn by the deadline. Include all details of how you came to your answers, both by including a mathematical description as well as any associated code and output. It is difficult to provide partial marks without evidence of steps taken.

Grading: Assignment 3 will be 8% of your final grade. If you did not write midterm 1, assignment 3 will be 15% of your final grade.

* You are free to use whatever means you would like to answer the questions (Matlab, Excel, by hand). Please append your analysis code to the assignment (if applicable), but also provide a solution documents (separate from code) that outlines your approach and gives your answers to the questions posed.

Question 1: The Gait Cycle (3 points)

Background: In instrumented, laboratory-based gait analysis, we often use force platforms embedded within the walkway to measure the three-dimensional forces placed on the ground by a person as they walk across the room. These force platforms provide very accurate, calibrated force information. The vertical ground reaction force in particular provides an indication of when a person makes contact with the ground, and how much vertical force the person is applying to the ground when they walk.

Figure 1. Research participant walking over two force plates.

Scenario: You are a biomechanics researcher in a clinical gait analysis lab. Your lab has a 6 meter walking with two force plates embedded in the walking. A research participant visits your lab for gait testing. After a brief warm up, she walks down the walkway, stepping sequentially on the two force plates as she walks.

In the attached file 'woman gait analysis data.xls', under the 'force plate data' tab, you will find time series data showing the time-varying vertical reaction force as measured by Force Plate 1 and Force Plate 2. This data is calibrated in Newtons of force (N). Please answer the following questions based on the data presented in this file.

Question 1.1 (0.5 pts)
Provide a figure plotting the vertical ground reaction force measured on force plate 1 and force plate 2 as a function of time.

Question 1.2 (0.25 pts)
What is the sampling frequency of the data?

Question 1.3 (0.25 pts)
What force plate does the woman step onto first?

Question 1.4 (0.5 pts)
If the woman steps onto force plate 1 with her right foot and onto force plate 2 with her left foot, what is the maximum vertical force applied by the woman to the ground during walking gait, and which foot applies more force to the ground (left or right)? What is the difference in maximum vertical ground reaction force between the right and left foot?

Question 1.5 (0.5 pts)
You have the participant stand on a scale to measure her body mass before leaving the lab. Her mass is 62 kg. What is the maximum vertical ground reaction force of the right and left foot expressed as a percentage of her body mass (in N/kg)? What is the maximum vertical ground reaction force in number of body weights (unitless)?

Question 1.6 (0.25 pts)
What is the time duration of the stance phase for her right and left foot?

Question 1.7 (0.25 pts)
One indication of gait asymmetry between limbs is a significant difference in step duration. If we would accept a greater than 10% difference in step duration as indicating asymmetry, does this woman display an indication of asymmetry?

Question 1.8 (0.5 pts)
What is the duration of the double support phase toward the end of stance phase of the right foot?

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Question 2: Center of Mass Kinematics (3 points)

Scenario: In the laboratory, you also have a passive optoelectronic motion capture system. You take a passive retroreflective marker and place it on the sacrum of the research participant. The sacrum represents a relatively good approximation of the center of mass of a person. You then ask her to walk down the walkway again while you record the 3D position of the sacrum marker relative to a pre-defined global coordinate system embedded in one of the force plates on the ground in the laboratory.

The file 'woman gait analysis data.xls' has a tab called 'Sacrum marker data' that provides the 3D (x,y,z) coordinates of the sacrum markers as the woman walks down the walkway in the lab.

Question 2.1 (0.5 pts)
Please plot the x,y, and z coordinates of the sacrum marker relative to time.

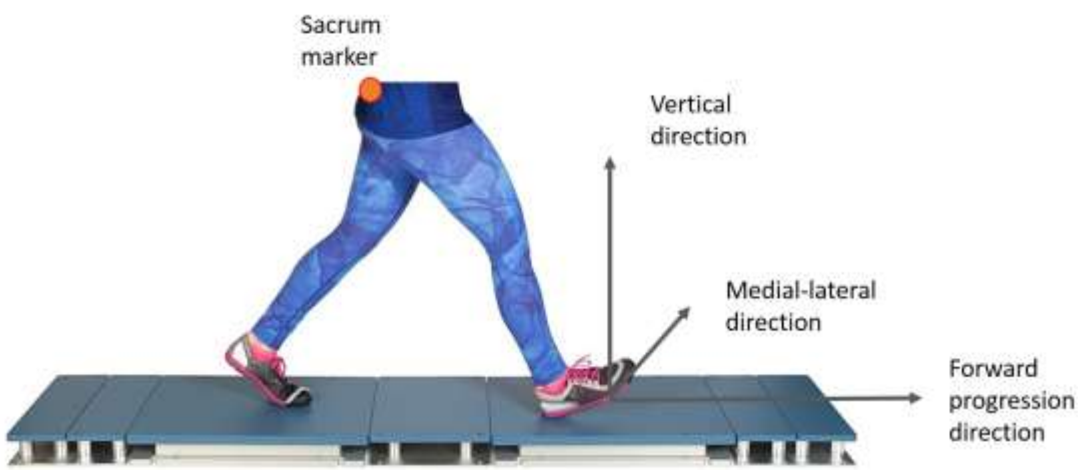

Figure 2. Sacrum marker data collection while walking.

Question 2.2 (0.5 pts)
The global coordinate system is embedded in the ground with one of its 3D axes aligned with the direction of progression of the walking, one aligned medial-laterally, and directed vertically out of the ground (Figure 2). When a healthy person walks, their center of mass tends to move up and down cyclically a small amount. Based on the plotted coordinate data in 2.1, please indicate which direction (forward progression, medial-lateral and vertical) corresponds to x,y, and z respectively.

Question 2.3 (0.5 pts)
How far in the forward progression direction does the woman move from time 0 to time 0.98 sec? What is her average walking velocity over this time?

Question 2.4 (0.5 pts)
What is the range of motion (maximum displacement) of the woman's center of mass vertically and medial-to-laterally while walking?

Question 2.5 (1 pt)
Calculate the instantaneous forward velocity of the center of mass of the participant at each time point as she walks across the floor. Plot this data before and after filtering it. What is her maximum and minimum forward velocity while walking using the filtered data? Please provide details of what filter you used.

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Question 3: Anatomical Coordinates (2 points)

Scenario: You then decide that you would like to capture the research participant's knee range of motion in the sagittal plane while she is walking. And so you place 3-marker triads on visible locations on her shank and thigh. You also place individual markers on anatomical locations: the greater trochanter, the lateral epicondyle, the medial epicondyle, the lateral malleolus, the medial malleolus, and the fibular head. You take a snapshot of the 3D data during a standing calibration trial (woman is standing quietly on one of the force plates) with both triads and all anatomical location markers in place. Then you remove the individual anatomical markers so that only the thigh and shank triads are on the woman. You then ask her to walk down the walkway of the lab while you record the 3D locations of the triad markers continuously as she walks.

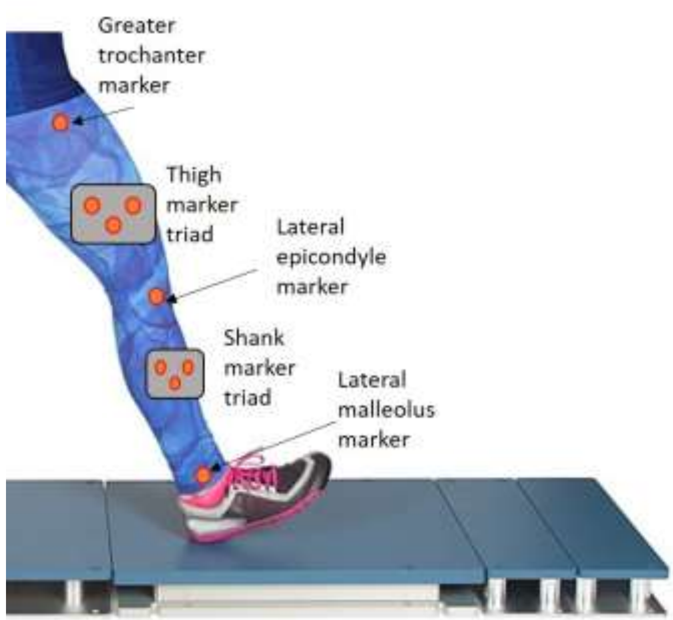

Figure 3.

Question 3.1 (0.5 pts)
What markers will you use to build the technical coordinate system of the thigh and the technical coordinate system of the shank?

Question 3.2 (0.5 pts)
What markers will you use to build the anatomical coordinate system of the thigh and the anatomical coordinate system of the shank?

Question 3.3 (1 pt)
During the first walking trial, the thigh marker triad falls off after a few frames of data are collected. Describe what steps you need to take to fix this problem and continue

with the experiment to be able to calculate her knee range of motion in the sagittal plane while walking? (Note, you do not need to provide details of how you would calculate range of motion, just what you would do during the experiment to ensure that you could calculate this based on the resulting data).

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