**Simulation Lab #1:**

**Dynamic Simulation of Jumping**

Modeling and Simulation of Human Movement

BME 599

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**Muscular Control Strategies for Maximizing Jump Height**

1. Starting from the static controls (i.e., Simulation\_Lab1\_controls.xml), use the Excitation Editor to select all the nodes for vas\_int\_r and vas\_int\_l (collectively VAS). Then, by dragging or setting a new value for all nodes, increase the excitation of all nodes to maximum and save these controls to a new file (e.g., vas\_modified\_controls.xml). Next, use the Forward Dynamics Tool to start a forward integration using the newly modified controls. Let the integration complete. Briefly describe how exciting VAS affects the joint angles (\*states\_degrees.mot) and the ground reaction force (\*forces.sto).
2. Why do forces in VAS, which are uniarticular knee extensors, accelerate joints they do not span? Explain this dynamic coupling both physically and in terms of the inertia matrix of Eq. (1)?
3. Use the Excitation Editor to reload the static equilibrium controls (i.e., Simulation\_Lab1\_controls.xml). Repeat exercise 1 above for soleus\_r and soleus\_l (SOL).
4. Use the Excitation Editor to reload the static equilibrium controls (i.e., Simulation\_Lab1\_controls.xml). Repeat exercise 1 above for med\_gas\_r and med\_gas\_l (GAS).
5. Use the Excitation Editor to reload the static equilibrium controls (i.e., Simulation\_Lab1\_controls.xml). Repeat exercise 1 above for glut\_max2\_r and glut\_max2\_l (GMAXM) and glut\_max1\_r and glut\_max1\_l (GMAXL) together.
6. Use the Excitation Editor to reload the static equilibrium controls (i.e., Simulation\_Lab1\_controls.xml). Repeat exercise 1 above for bifemlh\_r, bifemlb\_l, bifemsh\_r, and bifemsh\_l (HAMS).
7. Use the Excitation Editor to reload the static equilibrium controls (i.e., Simulation\_Lab1\_controls.xml). Repeat exercise 1 above for add\_mag2\_r and add\_mag2\_l (ADM).
8. By manually editing the muscle excitation histories, find a set of muscle excitation patterns that produce a well-coordinated jump. Try to maximize overall performance which is jump height minus ligament force penalties. Jump height for the model is defined as the height reached by the center of mass above the model’s standing height (0.9633) in meters. The ligament penalty is the integral of ligament joint torques over the duration of the simulation multiplied by a constant (see Anderson and Pandy, 1999 for details). The performance numbers can be computed on your own or you can use the included MATLAB script (i.e., jumpPerformance.m). Record your best performance numbers in your written report, and save the corresponding set of controls to a file (e.g., Simulation\_Lab1\_controls\_best.xml).

ligament penalty =

jump height =

overall performance =

1. If you are able to get the model to jump anywhere near the jump height predicted by the optimal solution (i.e., over 0.37 meters), you should be congratulated. It is not easy to do. In the more likely event that your solution was not as high as the optimal solution, explain why.
2. Choose a muscle to eliminate, and, as you did in exercise 8, make the model jump as high as possible without using this muscle. Save the controls corresponding to your best performance to a file (e.g., Simulation\_Lab1\_controls\_second\_best.xml) and again record your best performance numbers in your written report.

ligament penalty =

jump height =

overall performance =

What is the performance difference between this jump and your best jump when you could use all the muscles? What would you infer is the function of this muscle during jumping?

**Analyses**

1. Plot the vertical ground reaction force (sum of 5 contact point forces per foot) normalized by body weight predicted by your solution and by the optimal solution. The mass of the model is 75.1658 kg, and the acceleration due to gravity is assumed to be 9.80665 m/s2. Include this plot in your report. The vertical ground reaction force (Fy) for the optimal solution is in the file **Simulation\_Lab1\_optimal\_ground\_reactions.xlsx**. Does your ground reaction force have a higher or lower peak? Is the time to lift-off longer or shorter?
2. Plot the resultant articular contact force at the hip normalized by body weight. Include this plot in your written report. Why are the hip contact forces so large?
3. On a plot, superimpose the excitation levels, activation history, and normalized force history predicted by your solution for VAS. To normalize the force predicted by VAS, divide by the force by the maximum isometric strength of VAS (6865 N, see Anderson and Pandy, 1999). Include this plot in your written report. Given what you know about muscle mechanics, explain why the force generated by VAS was less than its isometric strength?