**Simulation Lab #5:**

**Muscle-Actuated Simulation of Kicking**

Modeling and Simulation of Human Movement

BME 599

Laboratory Developers: Jeff Reinbolt, Hoa Hoang, B.J. Fregley, Kate Saul Holzbaur, Darryl Thelen, Silvia Blemker, Clay Anderson, Allison Arnold, Scott Delp

# VI. Inverse Dynamics

1. Open Simulation\_Lab5.osim and load the kicking motion Simulation\_Lab5.mot:

How many degrees of freedom does this model have? What are the generalized coordinates? What quantities are constrained in the model? Which degrees of freedom are locked for this motion?

Plot the kinematics of the kick.

2. Perform an inverse dynamic analysis.

What happens to the muscles during the animation? Are they used in this analysis?

3. Plot the results of the simulation.

Overlay plots of hip moment vs. time and knee moment vs. time.

At what times in the motion cycle do the peak moments occur? Compare these times with the kinematic data. What events in the kinematic data correspond with the timing of the peak moments? Using your knowledge of dynamics, explain your findings.

4. Use the Analyze tool to perform an inverse dynamics analysis.

How do the result of the Analysis compare to the Inverse Dynamics Tool?

# VII. Forward Dynamics

2. Create a settings file (Simulation\_Lab5\_Setup\_Forward.xml) to run the forward dynamic simulation.

Include the text of the settings file in your report.

3. Create an initial states (.sto) file based on the format from the Simulation\_Lab4 containing time, generalized coordinates, and muscle activations and lengths (for muscle actuators only).

Include your initial states file in your report.

5. Guess activation patterns to replicate the nominal kicking motion (Simulation\_Lab5.mot).

Record your final muscle activation patterns in the table below:

|  |  |  |  |
| --- | --- | --- | --- |
| **Muscle** | **Time of onset (s)** | **Time of offset (s)** | **Activation level** |
| Glut\_max2\_r |  |  |  |
| Rect\_fem\_r |  |  |  |
| Med\_gas\_r |  |  |  |

Describe briefly (one paragraph) the process you used to determine muscle activations.

How do the kinematic results from your muscle-actuated simulation compare to the nominal motion (Simulation\_Lab5.mot)?

Describe how the muscle forces combine to produce hip and knee moments calculated in the inverse dynamics phase of this lab.

Why is it difficult to guess activation patterns that generate the nominal motion?

# VIII. Exploration Phase

There are two ways to access and use the Joint Reaction analysis tool (or any analysis). Describe these two ways.

Create a plot of the X and Y components of the joint reaction forces acting at the hip (on the femur). Create a second plot of the muscle forces.

What portion of the hip reaction loads can be attributed to muscle forces? What other forces in the system contribute to the hip reaction loads?