Why the $#!%@ is my simulation failing?

Tim Dorn, 3-19-2012

Insufficient muscle strength

\[ F^M = a^M \cdot f \left( l^M, V^M \right) \]

What causes insufficient muscle strength?

- Low max-isometric muscle force
- Poor active fiber-length operating region
  - Poor value for tendon slack length \( l^0 \)
  - Poor value for optimal fiber length \( l^o \)
- High passive muscle stiffness

Reserve Actuators

Torque actuators at every DOF that represent un-modeled behaviors and errors

Activated when muscles fail to reproduce the desired torque

Allows the simulation to “succeed” for debugging

Optimal force acts like a penalty weighting

\[
\min \sum_{a=1}^{\text{AllActuators}} \left( \frac{F^a - F^a_{\text{opt}}}{F^a_{\text{opt}}} \right)^2
\]

Used in CMC and static optimization

Larger \( F^a_{\text{opt}} \) : encourages the use of the actuator (i.e. Muscles)
Smaller \( F^a_{\text{opt}} \) : discourages the use of the actuator (i.e. Reserves)

Tip: keep the optimal force of the reserve actuators as low as possible

If your reserves are “large”...

1) Check passive muscle force (i.e., quadriceps). Large passive forces may induce active forces in the antagonistic muscles (i.e., hamstrings) which may not be desired.

2) Check normalized fiber length during the experimental motion. Modify \( l^0 \) to shift the curve vertically. Is the muscle operating near \( l^o \) when force is required? (useful to have EMG for this). What muscle parameters do we / don’t we have confidence in?

3) “Can’t I just uniformly increase FoM 10X? That would surely get rid of my reserves”. Not always. Passive muscle forces may increase if FoM is increased, causing greater problems.
High muscle-joint dimensionality problem

where one muscle actuates many degrees-of-freedom

E.g. HAMS:  
- knee flexion / extension
- hip flexion / extension
- hip adduction / abduction
- hip internal / external rotation

Tip: penalize the reserve highest in the planes you have confidence in

Low optimal force  |  Medium optimal force  |  High optimal force

http://opensim.stanford.edu/support/support_index_test.html

Appendix: Muscle Architecture