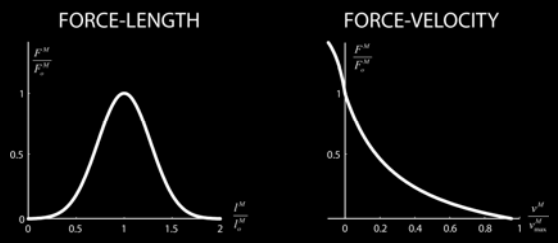
Why the #!%@ is my simulation failing?

Tim Dorn, 3-19-2012

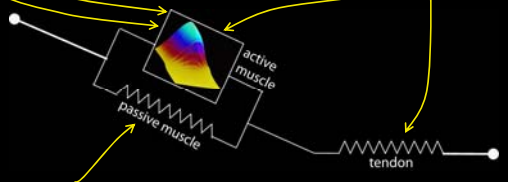
Insufficient muscle strength

$$F^M = a^M \cdot f\left(\tilde{l}^M, \tilde{v}^M\right)$$



What causes insufficient muscle strength?

- Low max-isometric muscle force
- Poor active fiber-length operating region
  - Poor value for tendon slack length l_s^T
  - Poor value for optimal fiber length l_0^M

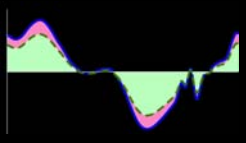


- High passive muscle stiffness

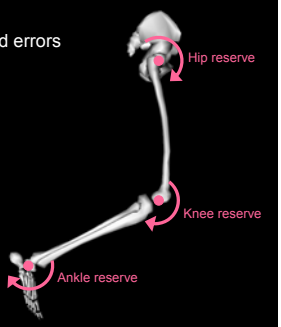
Reserve Actuators

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



$$\tau^{reserve} = a^{reserve} \cdot \tau^{optimal}$$

Optimal_force acts like a penalty weighting

$$\min \sum_{a=1}^{AllActuators} \left(\frac{F^a}{F^a_{opt}} \right)^2$$

Used in CMC and static optimization

Larger F^a_{opt} : encourages the use of the actuator (i.e. Muscles)

Smaller F^a_{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 LsT to shift the curve vertically. Is the muscle operating near LoM when force is required? (useful to have EMG for this). What muscle parameters do we / don't we have confidence in?

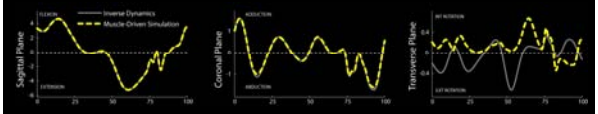
3) "*Can't I just uniformly increase FoM 10X? That would surely get rid of my reserves*". Not always. Passive muscle forces may increase if FoM is increased, causing greater problems.

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