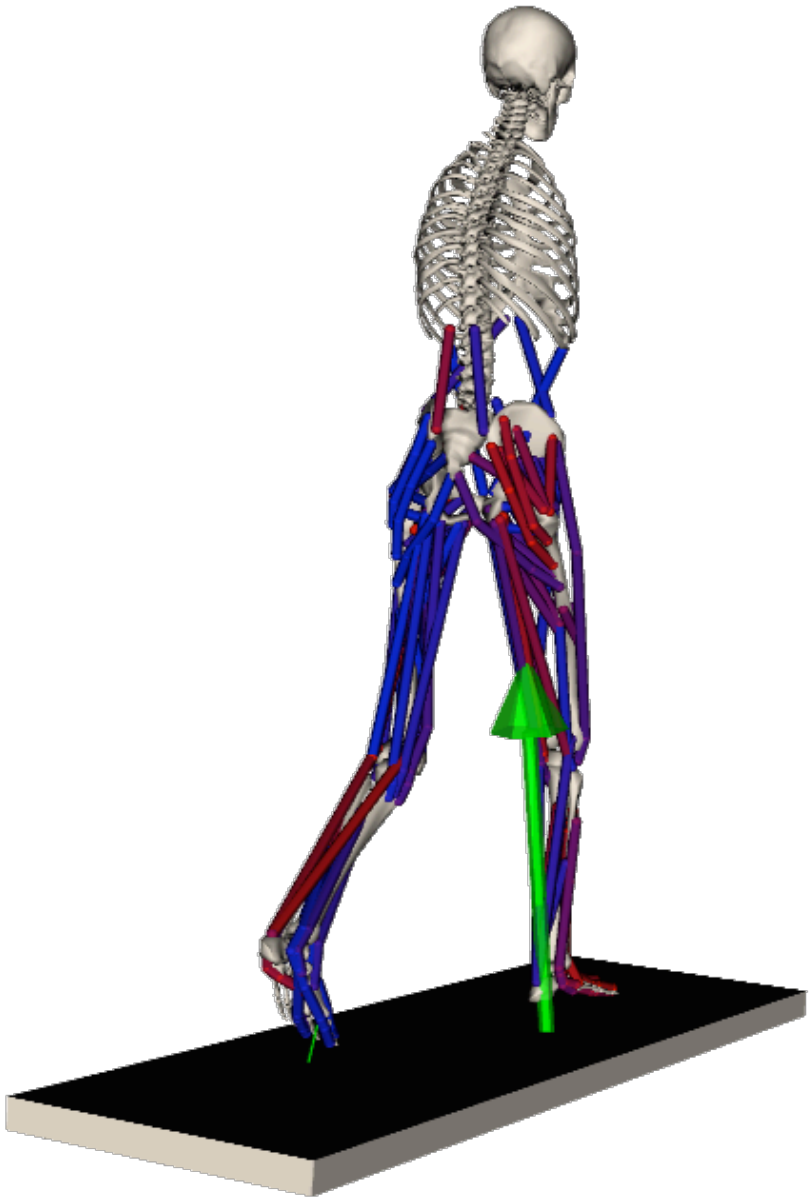
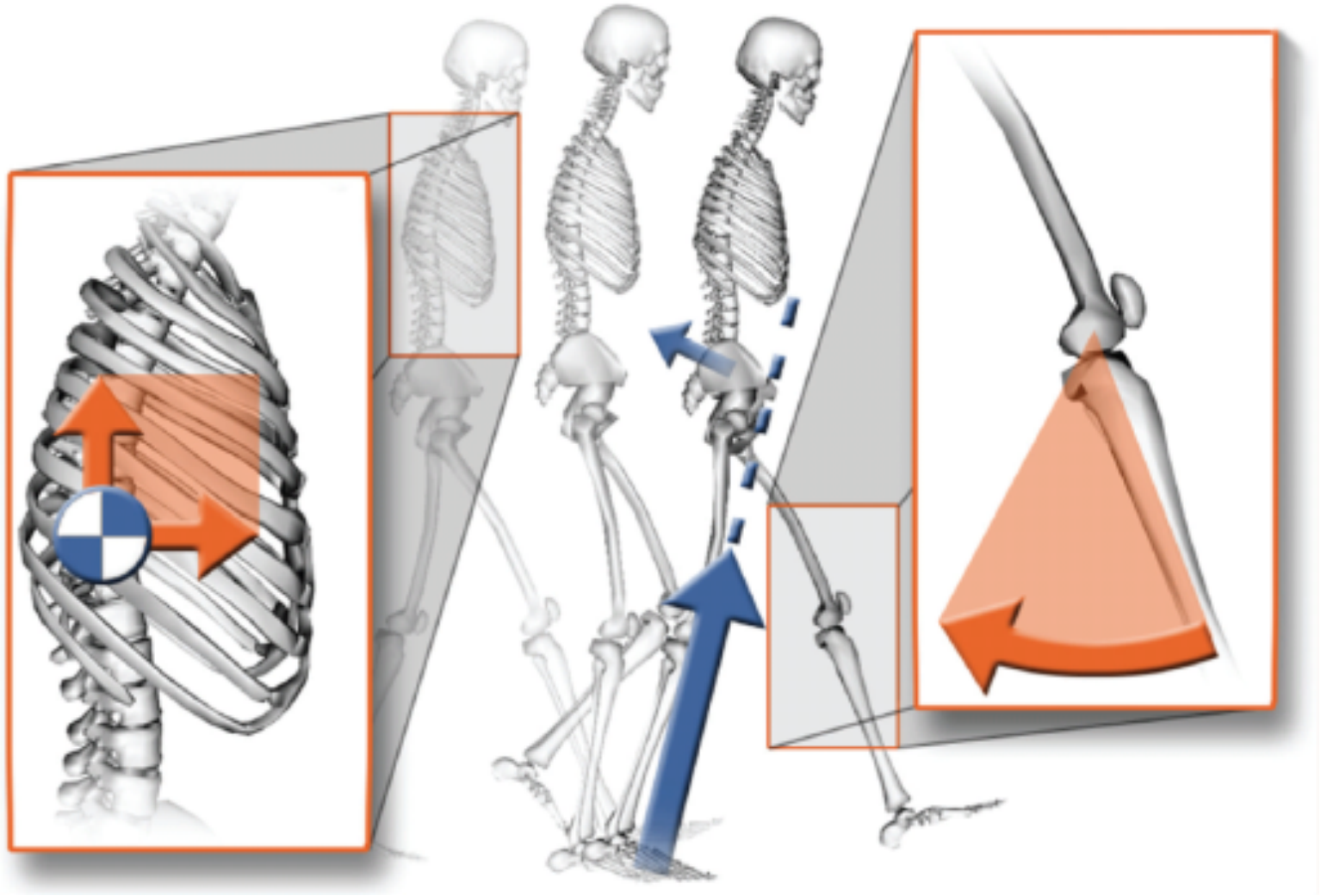


Generating Muscle-Actuated Simulations

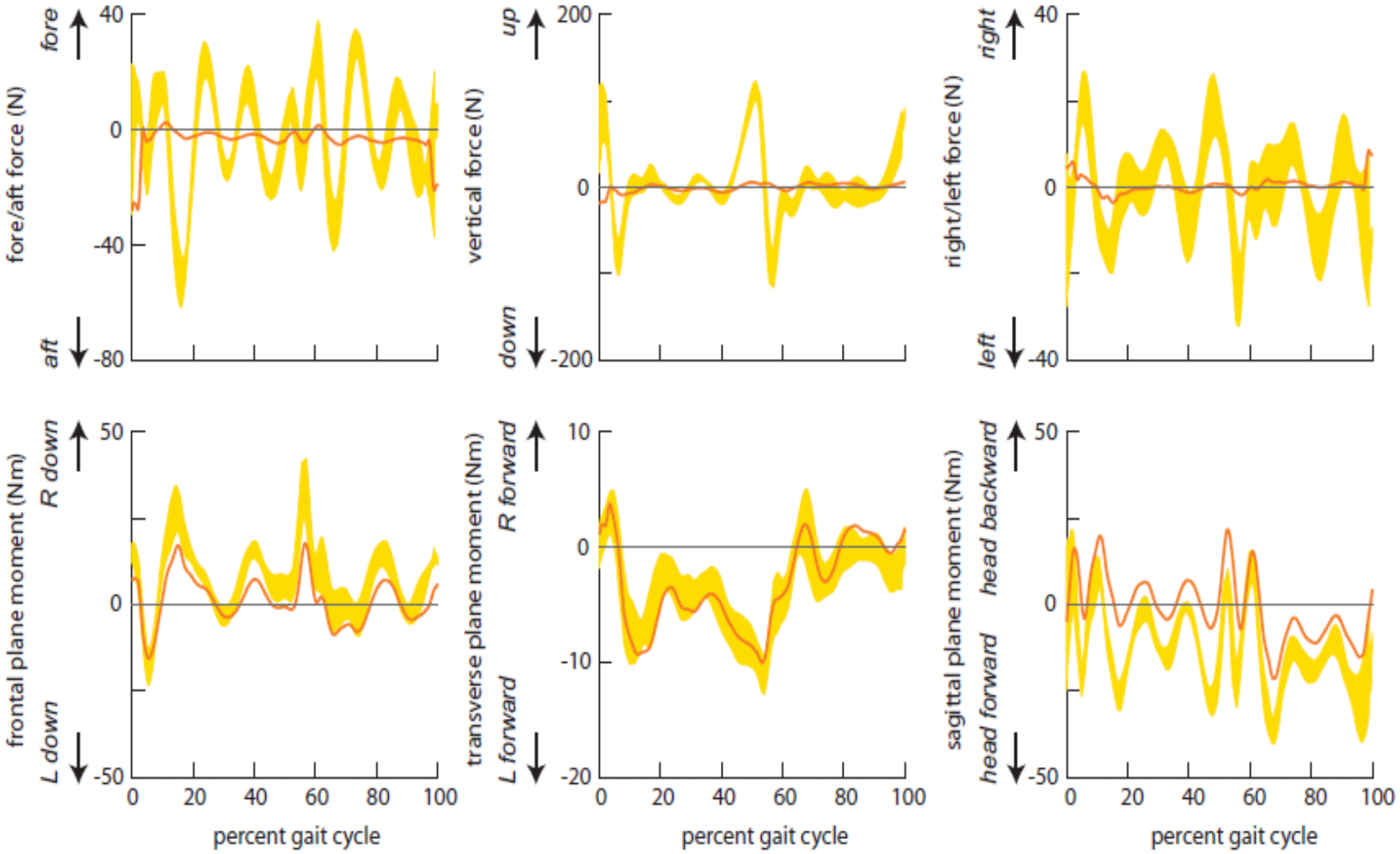


Reducing Residuals

Why reduce residuals?

1. Residuals are non-physical and necessary only to account for errors
2. Want muscles to account for all movement
3. To have confidence in muscle contributions

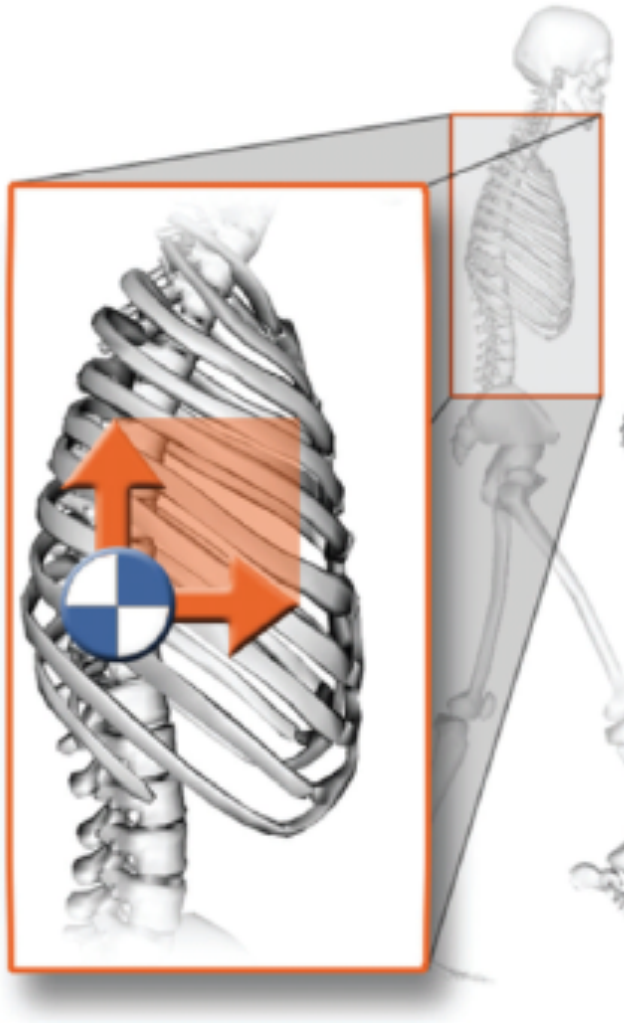
Sample residual reduction during gait



How can you reduce residuals?

- Torso is most massive and error prone to estimate
- Location of Torso mass center also difficult to estimate

1. Adjust mass distribution including Torso COM location

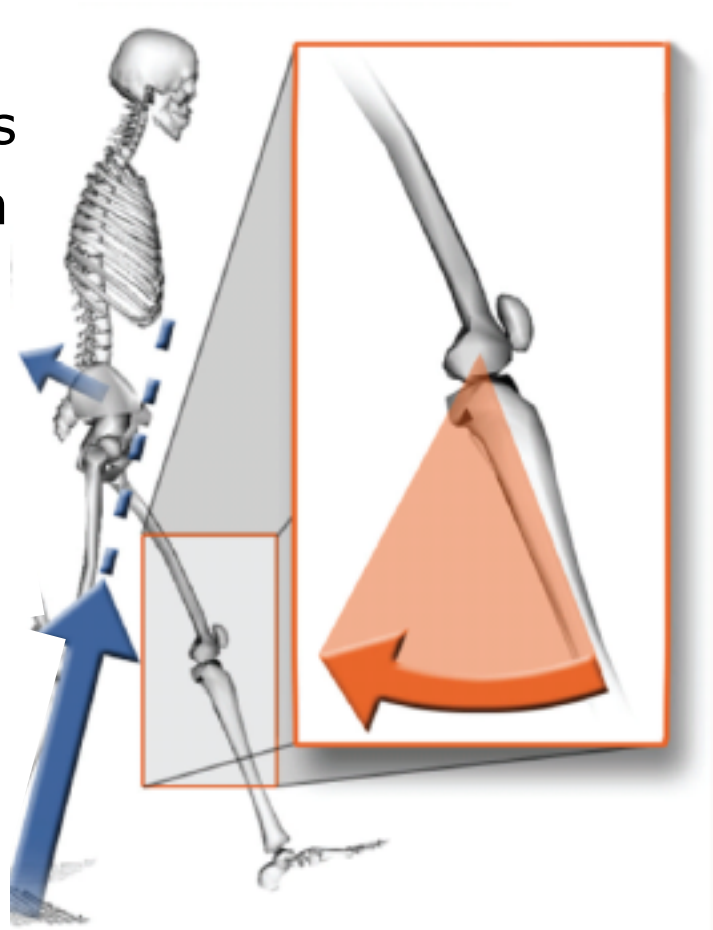


How can you reduce residuals?

- Joint kinematics estimated from marker position has inaccuracies
- Differentiation of kinematics can yield non-physical accelerations

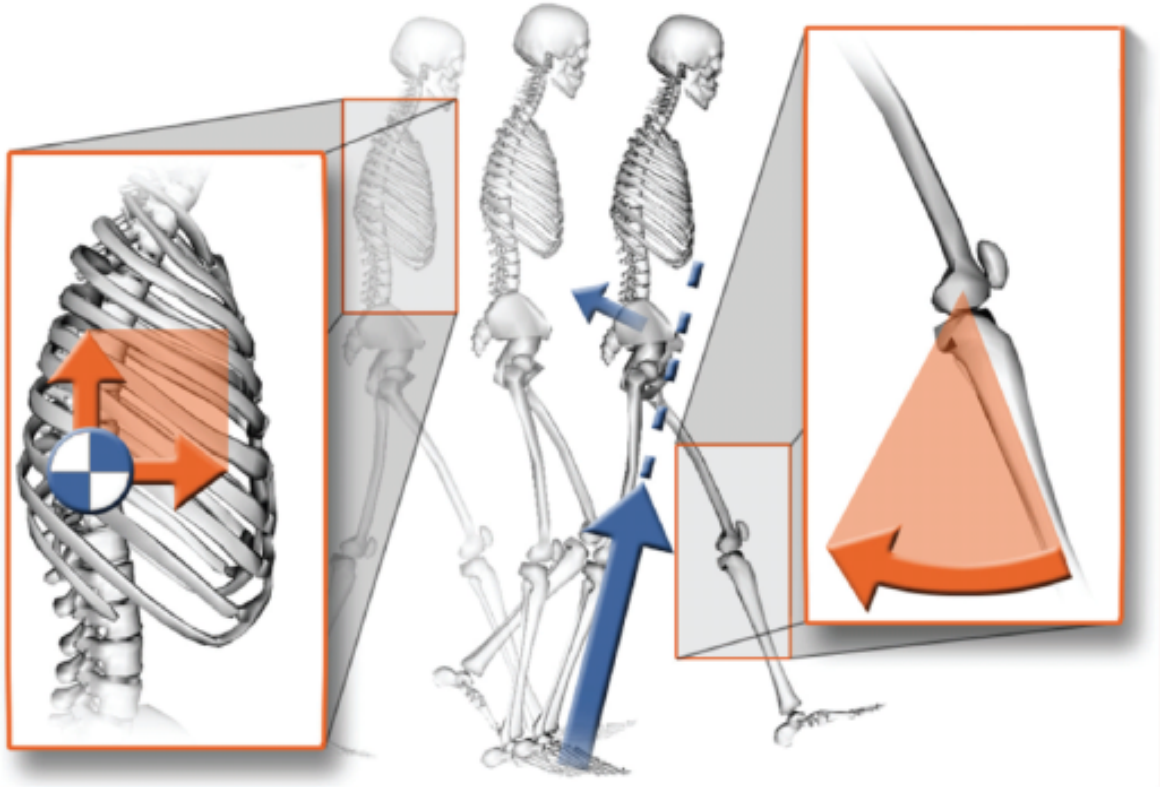
1. Adjust mass distribution including Torso COM location

2. Adjust kinematics slightly while satisfying equations of motion



RRA tracks kinematics using CMC with no muscles.

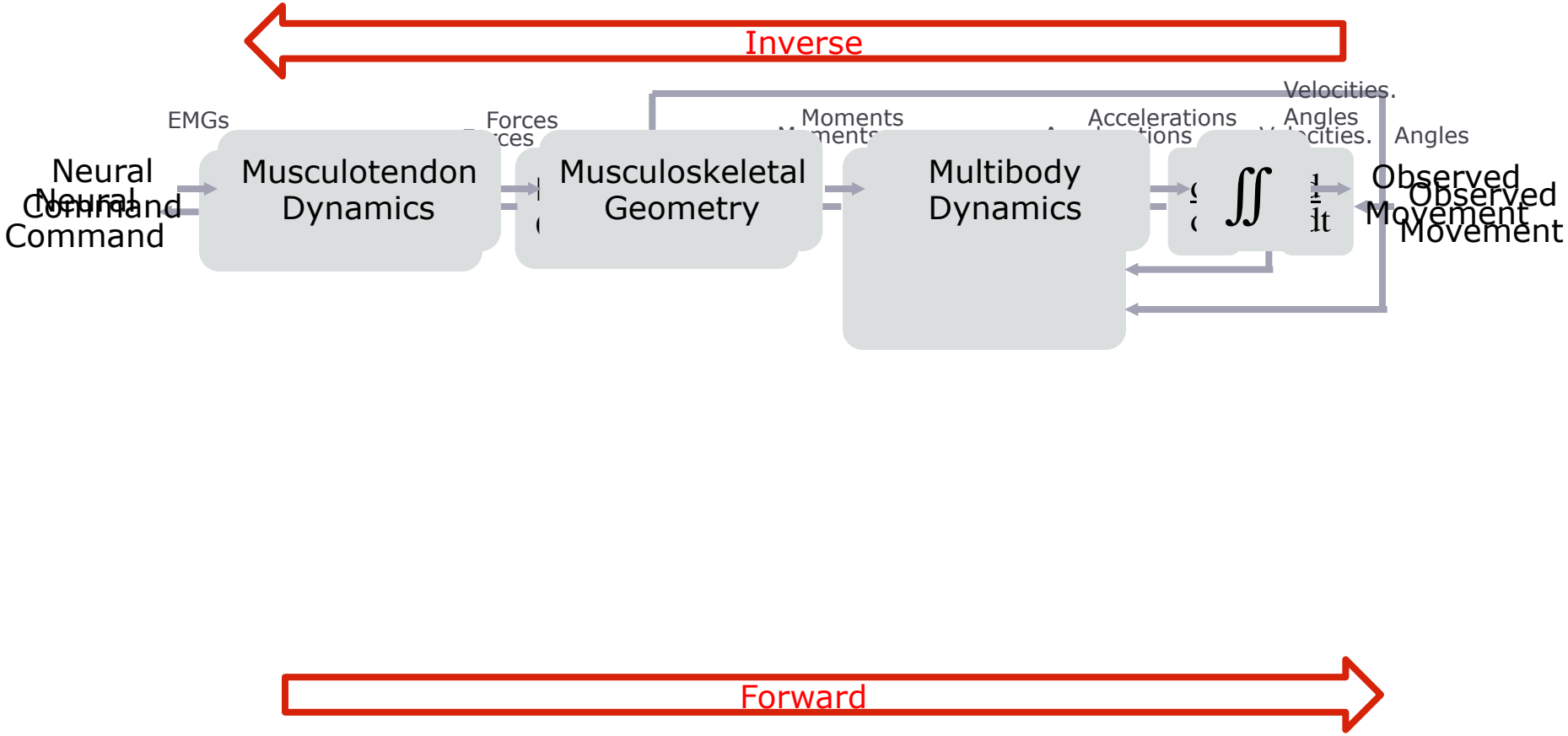
Residual Reduction Algorithm (RRA)



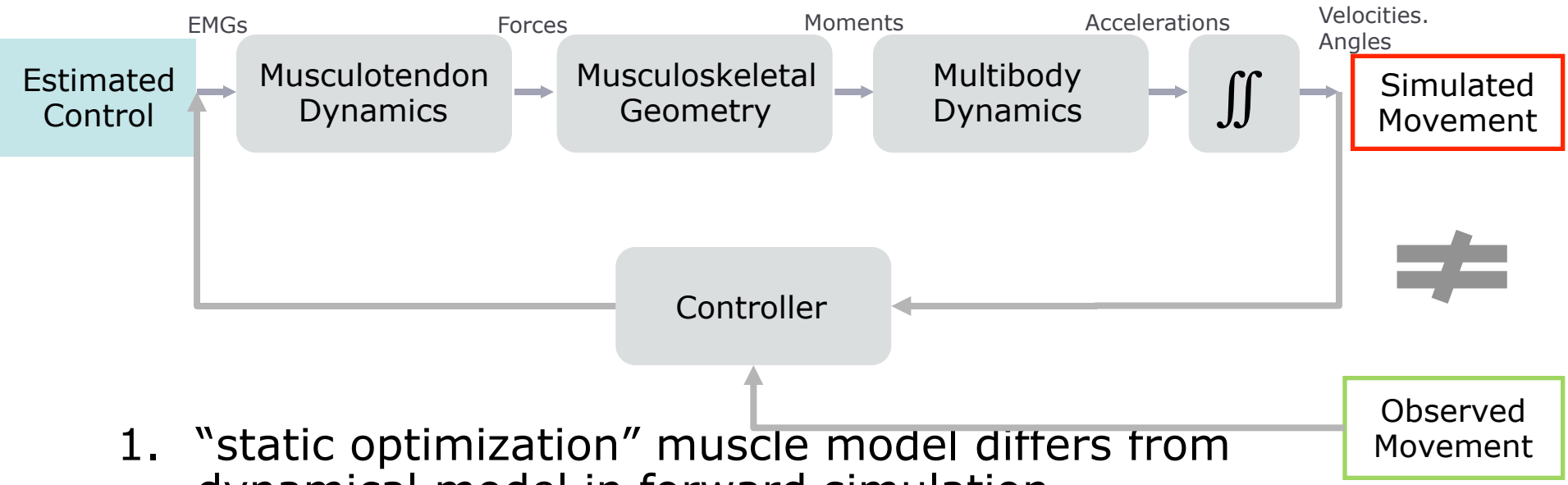
TIPS & TRICKS
Keep optimal forces for residuals low (increase control bounds if necessary)
Lower weight on kinematics that track closely or have low confidence in measurement
Make mass adjustments and run RRA again - repeat until residuals no longer change

Behind Computed Muscle Control

Model Dynamics



Muscle-Driven Forward Simulation



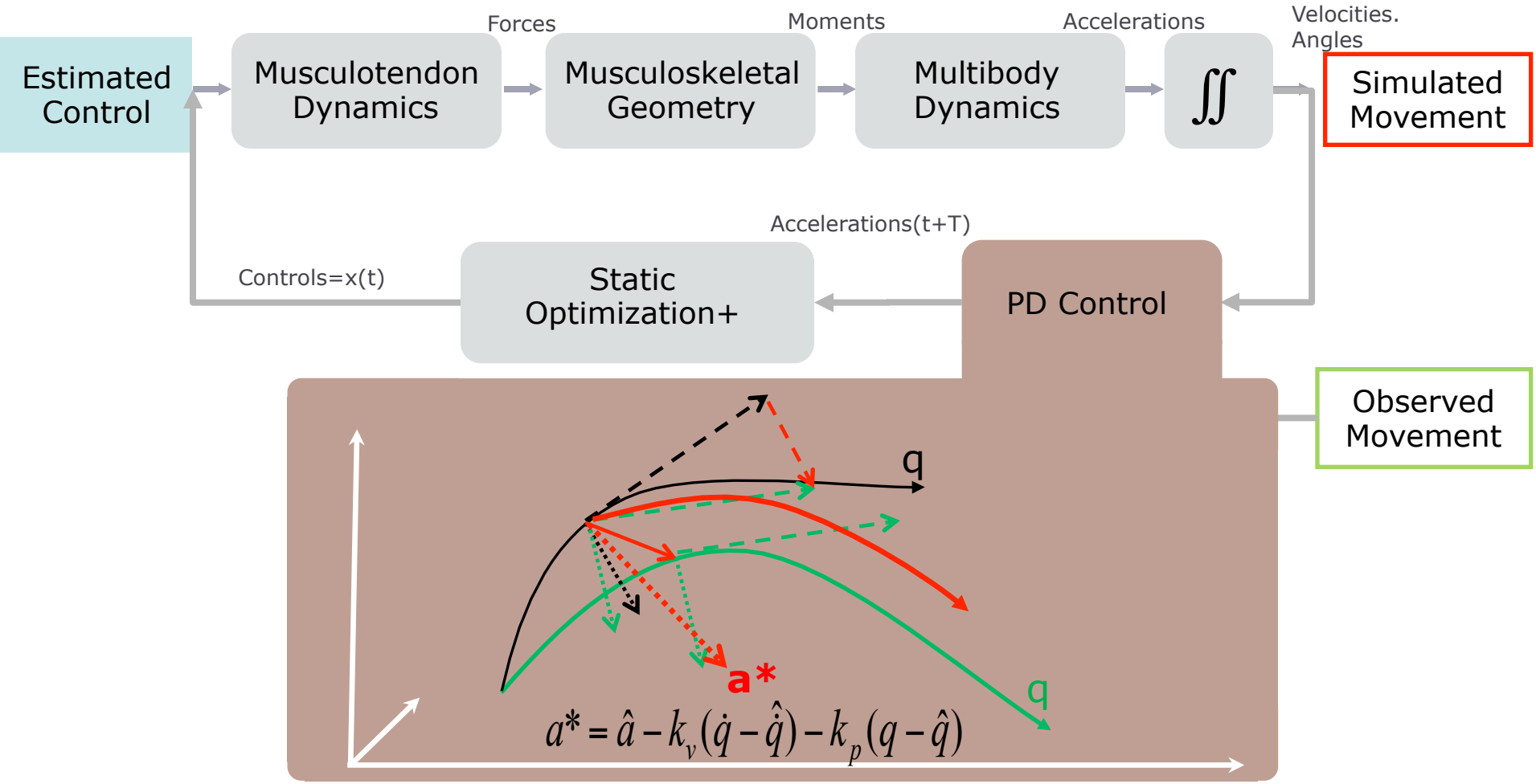
1. "static optimization" muscle model differs from dynamical model in forward simulation.

Solution: Close the loop!

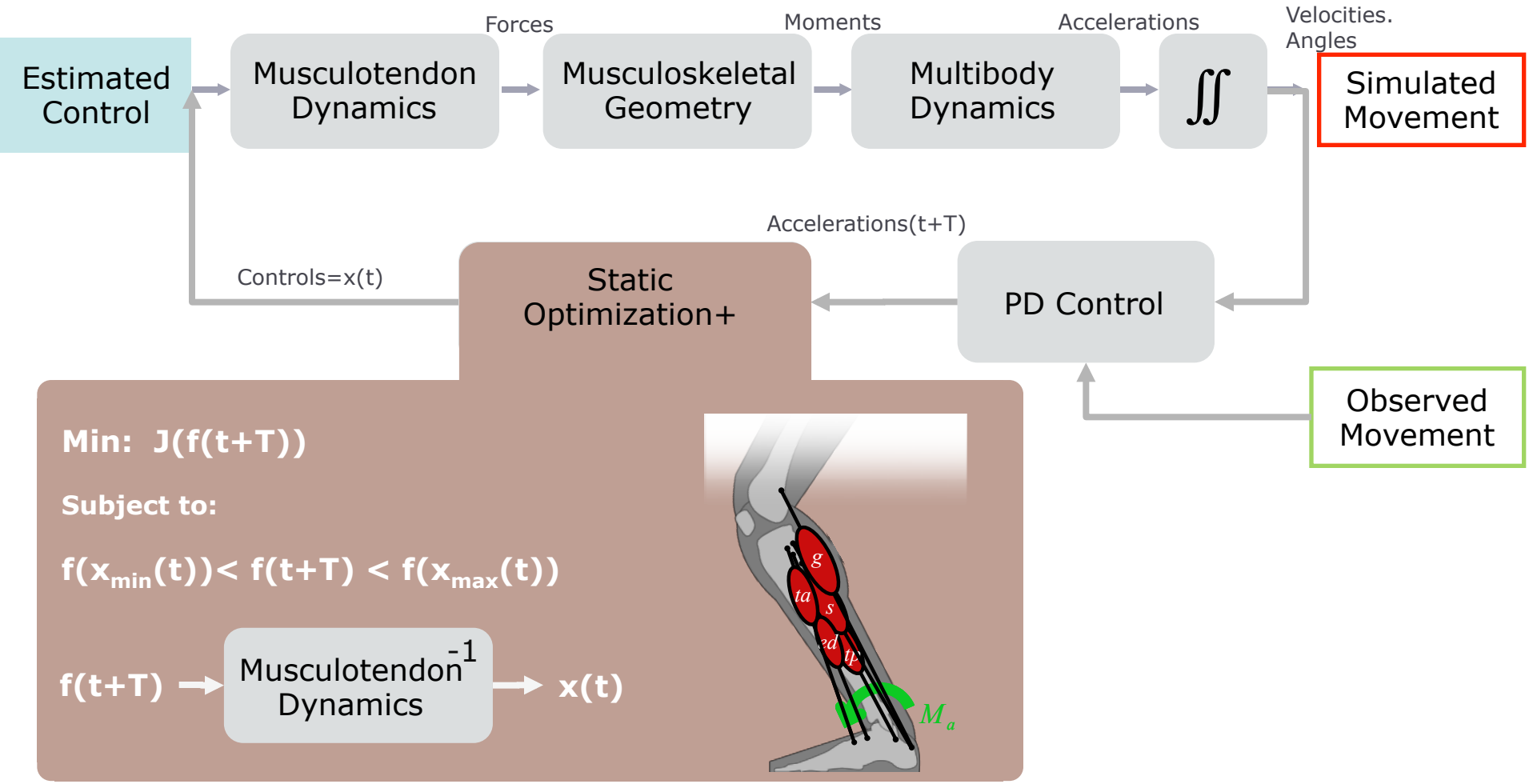
2. Acceleration data is discrete and noisy.

3. A nonlinear dynamical systems can be chaotic.

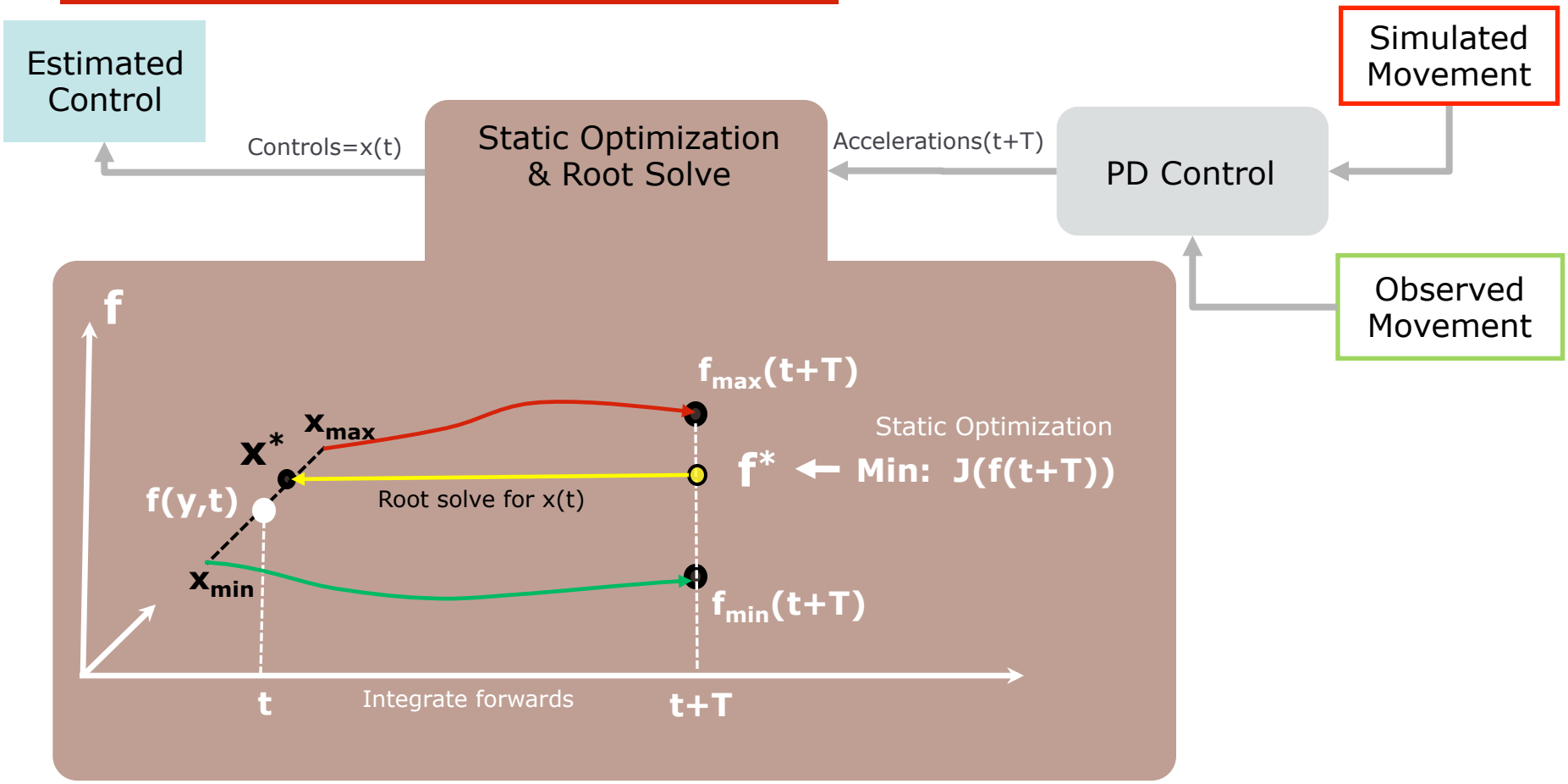
Computed Muscle Control (CMC)



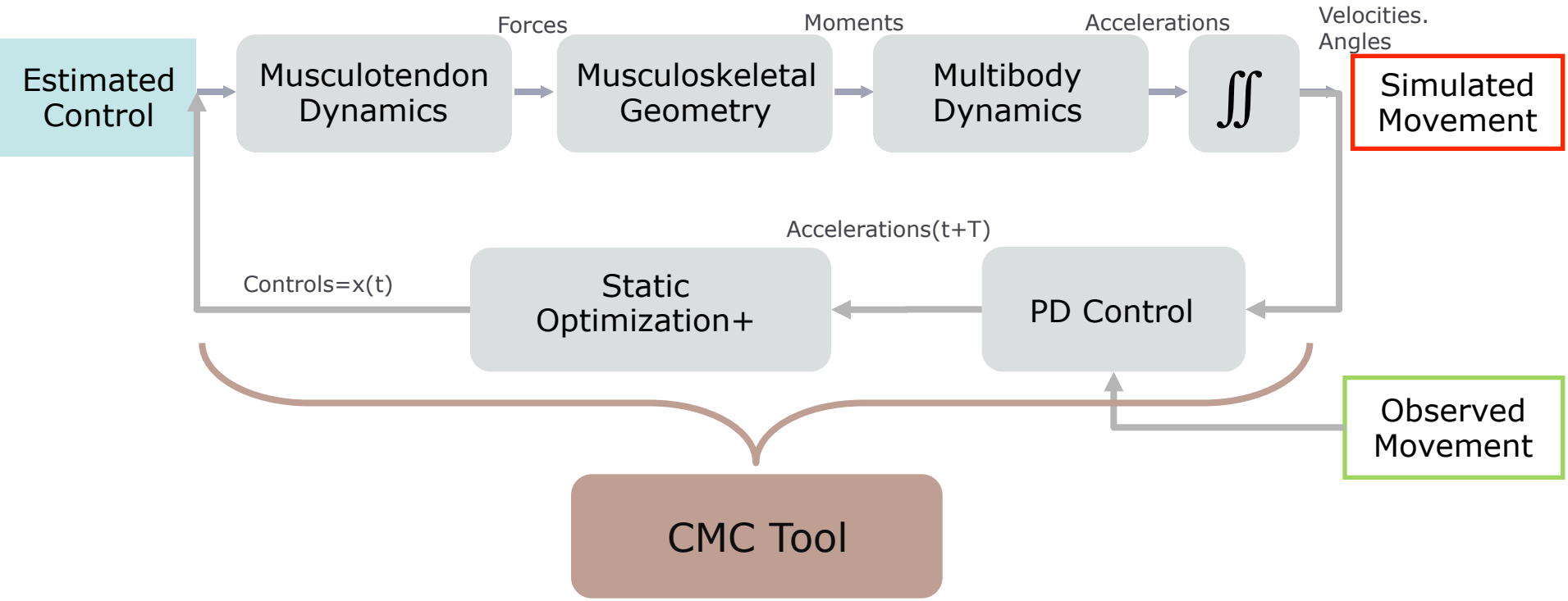
Computed Muscle Control (CMC)



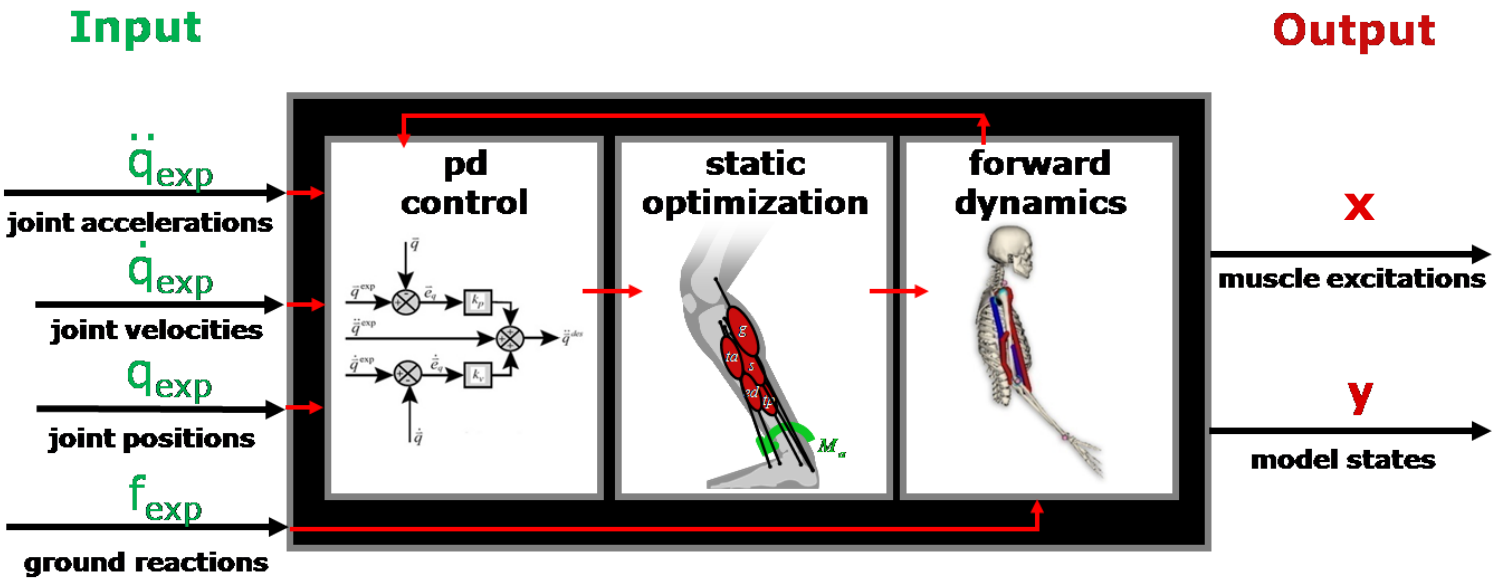
Inside the CMC Algorithm



Computed Muscle Control Tool:



Computed Muscle Control



TIPS & TRICKS
Track RRA output not IK
Increase max excitation of reserves if CMC is failing
Compare to EMG and constrain excitations where there is a mismatch