

CusToM: a Matlab toolbox for musculoskeletal simulation

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Software

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Summary

Customizable Toolbox for Musculoskeletal simulation (CusToM) is a MATLAB toolbox aimed at performing inverse dynamics based musculoskeletal analyzes (Erdemir et al. 2007). This type of analysis is essential to access mechanical quantities of human motion in different fields such as clinics, ergonomics and sports. CusToM exhibits several features. It can generate a personalized musculoskeletal model, and can solve from motion capture data inverse kinematics, external forces estimation, inverse dynamics and muscle forces estimation problems as in various musculoskeletal simulation software (Damsgaard et al. 2006) (Delp et al. 2007).

According to user choices, the musculoskeletal model generation is achieved thanks to libraries containing pre-registered models (Muller et al. 2015). These models consist of body parts osteoarticular models, set of markers or set of muscles to be combined together. From an anthropometric based model, the geometric, inertial and muscular parameters are calibrated to fit the size and mass of the subject to be analyzed (Muller et al. 2016) (Muller, Pontonnier, and Dumont 2017) (A. Muller et al. 2017). Then, from motion capture data (extracted from a c3d file thanks to (Barre and Armand 2014)), the inverse kinematics step computes joint coordinates trajectories against time (Lu and O'Connor 1999). Then, joint torques are computed thanks to an inverse dynamics step (???). To this end, external forces applied to the subject have to be known. They may be directly extracted from experimental data (as platform forces) or be estimated from motion data by using the equations of motion in an optimization scheme (Fluit et al. 2014). Last, muscle forces are estimated. It consists in finding a repartition of muscle forces respecting the joint torques and representing the central nervous system strategy (Crowninshield 1978) (Antoine Muller et al. 2017) (Muller, Pontonnier, and Dumont 2018).

For a large set of musculoskeletal models and motion data, CusToM can easily performs all of the analyzes described above. CusToM has been created as a modular tool to let the user being as free and autonomous as possible. The osteoarticular models, set of markers and set of muscles are defined as bricks customizable and adaptable with each other. The design or the modification of a musculoskeletal model is simplified thanks to this modularity. Following the same idea, some methods are defined as adaptable bricks. Testing new cost functions in the optimization schemes, changing performance criteria or creating alternative motion analysis methods can be done in a relatively easy way.

A user interface has been developed to facilitate the data management and the model definition during a given study.

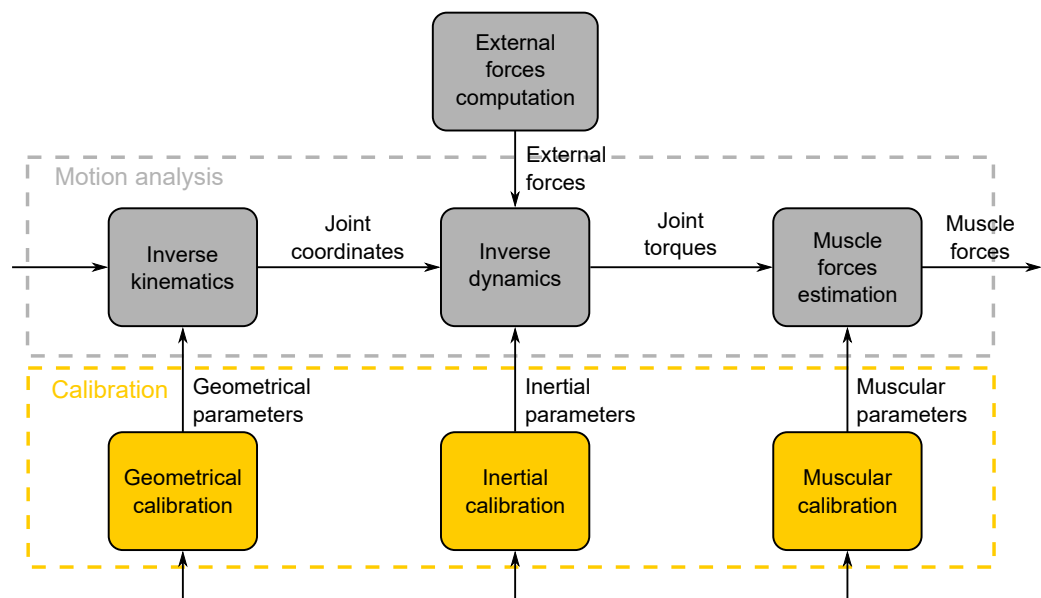


Figure 1: CusToM pipeline

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