Full-body optical motion capture with real-time estimation of muscle efforts

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Abstract

Optical motion capture is an essential tool for the study and analysis of human movement. Currently, most manufacturers of motion capture systems provide software applications for reconstructing the movement in real time, thus allowing for on-the-fly visualization. The captured kinematics can be later used as input data for further analyses. However, in biofeedback applications, the results of said analyses, such as joint torques, ground reaction forces, muscle efforts, and joint reaction forces, are required in real time.

In this work, a Kalman filter previously developed by the authors for real-time whole-body motion capture and reconstruction is augmented with inverse dynamics and muscle force optimization, in order to calculate and visualize the muscle efforts and joint reaction forces as the motion is being captured.

The previously existing algorithm provides the kinematics at every time step. Then, the joint torques are calculated by solving the inverse dynamics problem, using force plate measurements along with previously estimated body segment parameters. Once the joint torques are obtained, an optimization problem is solved, in order to obtain the muscle forces that provide said torques while minimizing an objective function. This is achieved by a very efficient optimization algorithm, thoroughly tuned for this specific problem. With this algorithm, it is possible to capture and label the optical markers, reconstruct the motion of the model, solve the inverse dynamics, and estimate the individual muscle forces at every time step, thus providing real-time visualization of the results.