IMPACT OF DETAILED SKELETAL MODELS IN THE EFFICIENCY OF FORWARD DYNAMIC SIMULATION

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Introduction

For the simulation of some activities, detailed skeletal models are desirable. However, detailed models have a high number of degrees of freedom (DOF), and may include bodies with very different masses, making the simulation more difficult and less efficient, which can be a concern when real-time performance is required, as, for example, in predictive simulations. This work explores whether detailed models can be used for real-time simulations and seeks to quantify the penalty in efficiency they entail, by comparing the forward dynamic simulations of two multibody skeletal human models with different levels of detail in spine, shoulder and hand, for the same movement (squat and ball throw).

Models and methods

Two skeletal models of different levels of detail were tested for the same captured movement. The first model has 18 bodies linked by spherical joints, yielding 57 DOF [1]. The second model includes a more detailed modeling of spine, shoulders and right hand, leading to 29 bodies and 82 DOF (Figure 1).

The detailed spine model features three additional bodies (vertebrae L5-L3, L2-T12 and T11-T8) linked by spherical joints.

The detailed shoulder model includes, as separate bodies, the clavicle, linked to the thorax by a Cardan joint and to the scapula by a spherical joint, and the scapula, linked to the thorax by a tabulated macrojoint [2], introduced to benefit from the efficiency of the semi-recursive multibody formulation used for the forward dynamic simulation. The macrojoint look-up table has 3 DOF (three inputs), and was built in a preprocess by solving the kinematics of the thorax-clavicle-scapula closed-chain mechanism for any possible combination of the three inputs.

The detailed right-hand model features two additional bodies for modeling the thumb, linked by a spherical and a revolute joint, respectively, to the previous body in the chain, and two more bodies for the rest of the fingers, linked by revolute joints.

For the first model, 36 markers are needed in the motion capture, while, for the second model, 15 additional markers are necessary. The single motion capture was carried out with the 51-marker configuration, and, then, it was processed separately for the two models. The Kalman-filter algorithm used to process the capture [3] is able to, once the chosen set of markers is selected in the first frame, track only that set of markers and ignore the rest. The forward dynamic simulation of the captured movement employed a CTC controller to track the captured trajectories [4], and used the trapezoidal rule as integrator.

Results and discussion

Table 1 shows the CPU-times required for the forward dynamic simulation of the 9.28-s capture using the two models, and the real-time ratios (real-time/CPU-time).

It can be seen that the use of the detailed model entails a severe drop in efficiency. For a 44% increase in the number of DOF, the CPU-time increases in a 151%.

However, for the tested detailed model, the implemented algorithm (macrojoint, semi-recursive formulation) allowed to still keeping the real-time ratio above 1 comfortably, which opens the door to use this kind of detailed models in predictive simulations.

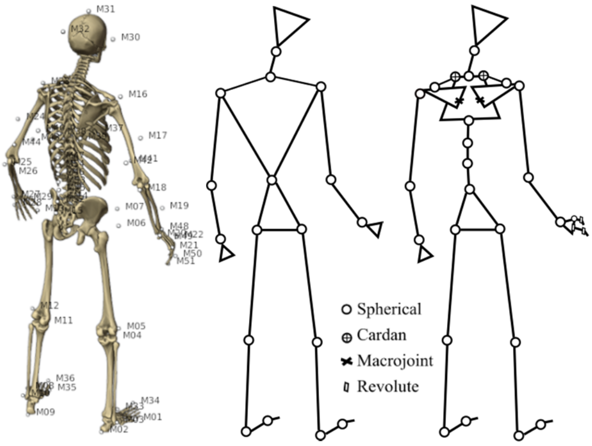

Figure 1: Marker locations and models.

Model	CPU-time (s)	Real-time/ CPU-time
57 dof	0.418	22.2
82 dof	1.048	8.85

Table 1: Simulation times and real-time ratio.

References

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