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DYNAMIC OPTIMISATION: A SOLUTION TO THE INVERSE DYNAMICS PROBLEM OF BIOMECHANICS USING MISER3

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Abstract. The inverse dynamics problem of biomechanics is to find the forces and resultant joint moments (RJMs) acting on and between body segments given the position co-ordinates of the body segments in time. Using the RJMs obtained by the latter method does not reproduce the movement to fit the data accurately, in a forward simulation. The position co-ordinates has experimental error from the filming process, from the digitising process and from body segment parameters not being known accurately. This position data has to be differentiated twice usually after some smoothing technique applied to the position data. Using MISER3, an optimal control package which allows for constraints on controls and states, the paper shows how joint torques can be computed so that the reproduced motion of the body segments of the model are close to the data points. In particular, the method produces very different torques than the usual method employed to calculate them. A comparison between fitting to (x, y) data or segment angle data derived from the (x, y) data shows that the derived angle data is best. One of the reasons for this is that errors in segment length matter less when using the segment angles. The method is demonstrated with the impact phase of the Yurchenko vault.
Keywords. Dynamic optimisation; Inverse dynamics; Biomechanics; Yurchenko layout vault; Simulation.
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1 Introduction

The study of human movement often requires the recording of the motion using either film or video. For a mechanical analysis of movement, time histories of the kinematic variables defining the system are required. Inverse dynamics is the procedure in which the motion data are used to estimate resultant joint moments which may be used to reproduce the movement in a forward simulation. Typically, if only angular acceleration data are available, iterative solutions of the Newton-Euler equations of motion for each body segment are obtained beginning with the distal-most segment. This method tends to produce noisy joint torque estimates due to inherent systematic and