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DEVELOPMENT OF A MULTIBODY-BASED METHODOLOGY FOR SIMULATION OF BIOMECHANICAL SYSTEMS USING NATURAL COORDINATES

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Summary: Methodologies based on movement simulation have being used to predict with success the outcome of surgical procedures, design new rehabilitation protocols, among other applications, as these allow to test in silico the outcome of new variables and inputs without the constraints associated with a motion lab. However, and despite the recent evolution in technology, the motion simulation of more intricate systems, such as the human body, is still an issue due to the complexity of the problem to solve.

This work aims the development of a methodology to simulate three-dimensional human movement using a multibody dynamics formulation with natural coordinates. For that purpose an optimal control approach is considered, enabling to estimate simultaneously the kinematics and dynamics of the system, while minimizing a cost function based on physiological criteria. The equations of motion, as well as other path constraints will be treated as equality or inequality constraints of the optimization problem. In order to decrease the computational requirements, the state variables, associated with the model kinematics, will be defined as the drivers of the mechanical system. During the simulation, the generalized coordinates are computed using an inverse kinematic analysis considering as inputs the optimized drivers. Both the state and control variables are also discretized and interpolated using B-Splines, decreasing the number of variables to optimize. The influence of different optimizations strategies and cost functions will also be evaluated by comparing the output of the simulations with data acquired experimentally.

The methodology was assessed by applying it in the study of two simplified biomechanical models representative of the human arm. The first model considers two degrees-of-freedom to depict the extension-flexion movement of the elbow and shoulder and the second one 11 to represent the three-dimensional movement of the upper arm, lower arm and trunk. Preliminary results indicate that the proposed methodology allow to depict with success the movement in study, predicting also its dynamics. The simulation outputs also show that cost functions based on dynamic effort criteria tend to produce good results when studying daily human movements.