A New Multibody Simulation Research Code - FreeDyn

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Abstract
The present paper introduces the non-commercial academic multibody software FreeDyn (http://www.freedyn.at), which is currently developed at the University of Applied Sciences Upper Austria. Special attention is paid on the efficient computation of the forward motion of highly nonlinear flexible multibody dynamics systems. Equally important is the inverse dynamics computation in order to identify parameters or find optimal control strategies. A fast and accurate simulation code and its open-source release are the main goals.

For the description of flexible bodies in FreeDyn, the most common strategy in multibody systems (MBS), the floating frame of reference formulation (FFRF) [4,6], is utilized. The basic idea of the FFRF is separating the overall motion of the elastic body into a large rigid body motion (or reference motion) and superimposed small deformations [3,5].
For solving the equations of motion of a flexible multibody system, the computation of the Jacobian matrix plays a fundamental role. The presented software includes analytically derived expressions for the matrices in the Jacobian, which leads to significant improvements in terms of computational burden, as compared to the time-consuming numerical computation of the Jacobian. As an additional improvement of efficiency, a simplification of the inertia forces has been performed using Euler parameters for the rotation parametrization. The advantage of using Euler parameters is their singularity-free description of rotations. The latter mentioned analytical investigations as well as the simplifications concerning Euler parametrization in the framework of the MBS-software FreeDyn enable an accurate and efficient computation of nonlinear multibody dynamics described by a system of algebraic and differential equations. In FreeDyn, the well-established Hilber-Hughes-Taylor (HHT) method [1,2] is used for the numerical time integration of the equations of motion. The HHT method, also known as the α-method, serves as a numerical integrator for differential algebraic equations given in an index 3 formulation. Moreover, FreeDyn may also be used for integrating the adjoint system of equations, which allow the application of an extremely powerful approach to solve various optimization problems for multibody systems. The focus of the optimization tool is the solution of inverse multibody dynamics problems, intended as parameter identifications for dynamical systems or optimal control problems, as e.g., finding an optimal trajectory or a solution under the consumption of minimal energy. Instead of the inefficient gradient computation from direct transcription, the adjoint method is persued, which is orders of magnitude more efficient.

The present paper introduces the new MBS-software FreeDyn and its current status of development, details on the implementation of the inverse dynamics tool, the pre- and post-processor, see Fig. 1 and Fig. 2, respectively. The models can be designed from scratch in the pre-processor or can be imported from a CAD-file, see screenshots of the pre-processor of FreeDyn in Fig. 1. Moreover, FreeDyn offers an incorporation of flexible reduced finite element models via an Adams-mtx-file and an interface to Matlab/Simulink which provides access to the functionality of the inverse dynamics tool. Several examples have been performed in order to show its user-friendly applicability and its accuracy and efficiency.

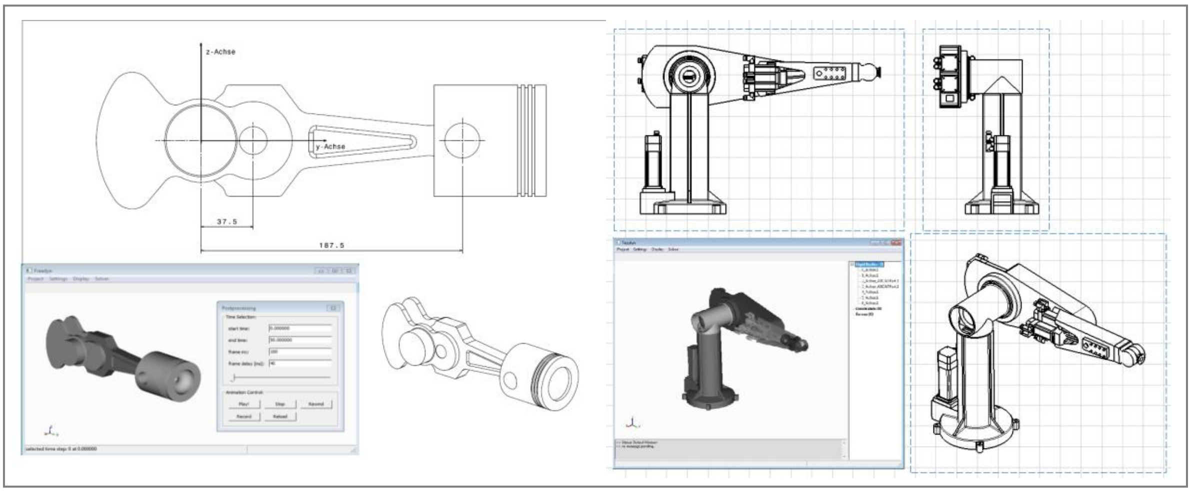

Figure 1: FreeDyn-Preprocessor: Example of a sketch of a slider crank (left) and an example of a six-axis-robot (right) and the according models in the graphic user interface.

Figure 2: FreeDyn-Postprocessor: Example of a flexible slider crank mechanism and its visualization in the graphic user interface.

References

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