Modeling and Simulation of Lagrangian Mechanics through Automatic Differentiation and High-Index DAE Solving

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We overview DAETS (Differential-Algebraic Equations by Taylor Series), a C++ solver designed to handle high-index DAEs. We have enhanced DAETS with a Lagrangian facility that automatically generates equations of motion behind the scenes, typically resulting in an index-3 DAE that is then integrated by DAETS. This is achieved through algorithmic differentiation, rather than the commonly used symbolic algebra. Our approach adopts Cartesian coordinates for modeling, with a maximum of nine generalized coordinates per rigid body in 3D and four generalized coordinates in 2D. Our method significantly simplifies the modeling process, requiring only the derivation of a Lagrangian function, algebraic constraints, and external forces. It eliminates the need for deriving equations of motion and transformation to e.g. an ODE system. We illustrate the simplicity of the resulting formulations on several examples.

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