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Discrete extended Kalman filter based on linearized dynamics of multibody system

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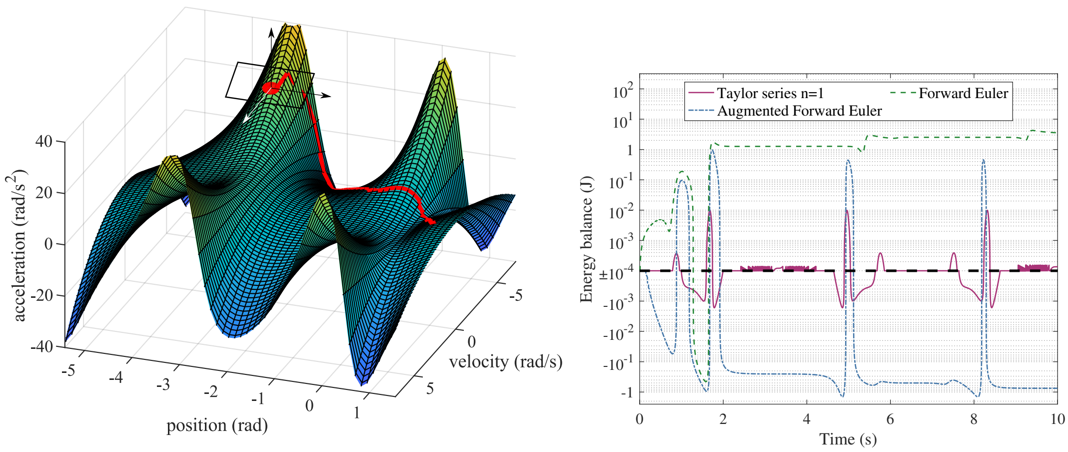
ABSTRACT

The increasing level of automation in modern mechanical systems sets high quality and reliability requirements for the measurement signals. Information fusion techniques such as Kalman filters can be used to enhance the quality of the data collected. In the field of multibody dynamics, the extended Kalman filter and the unscented Kalman filter are the commonly used Kalman filter variants [1]. This study provides a novel linearization-based method for the state transition part of the discrete extended Kalman filter. In previous studies, forward Euler integration scheme is used in the formation of the state transition model [2]. This study uses the coordinate partitioning method to produce a nonlinear state-space with independent positions and velocities as the state-variables. The nonlinear state-space is linearized on each time step and the linearized response is solved using an exponential integration scheme.

The proposed method was investigated using a classical four-bar mechanism as a numerical example. Figure 1a illustrates the nonlinear behavior of the independent acceleration as a function of independent position and velocity and the formation of the tangent frame. The novel method was compared with two forward Euler-based methods. The methods were compared by their energy balance throughout the simulation. The energy balance plots with different methods are shown in Figure 1b indicating the novel method, referred to as the Taylor series, to be more accurate in comparison with the forward Euler-based methods.



(a) Tangent frame of the nonlinear state-space.

(b) Energy balance with different methods.

Figure 1: Linearization of a four-bar mechanism.

Keywords: Discrete extended Kalman filter, Linearized dynamics, Exponential integration, Discretization

REFERENCES

[1] PASTORINO, R. State estimation using multibody models and non-linear Kalman filters. *International Journal of Non-Linear Mechanics 53*, 13 (2013), 83–90.

[2] SANJURJO, E. Testing the efficiency and accuracy of multibody-based state observers. In *ECCOMAS Thematic Conference on Multibody Dynamics* (2015).