

The Decentralized Perspective on Dynamical System Simulation

Lecture of

Milan Rother,
ICMOS Design,
TU Braunschweig

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Institute of Applied Mechanics
Seminar room (ground floor)
Pockelsstraße 3
38106 Braunschweig

Dynamical systems permeate every aspect of engineering and scientific research, from control systems to advanced physics simulations. Block-based modeling has become the de facto standard for representing these systems, evidenced by widely used tools like Simulink and Modelica. However, much of the available software relies on legacy architectures that limit flexibility and extensibility.

PathSim is an open-source Python package designed with minimal dependencies and a modern API. It represents a fresh approach to dynamical system simulation by reconsidering fundamental architectural principles including a truly decentralized architecture – where individual components maintain autonomy while collaborating through well-defined interfaces. This approach introduces specific implementation challenges, particularly in solver integration, but also yields benefits in modularity and extensibility.

A nice touch is the seamless integration of automatic differentiation (AD) that propagates derivatives through all system dynamics. This enables gradient-based optimization, semi-analytical sensitivity analysis, and uncertainty quantification. Additionally, the framework includes a system for detecting and resolving discrete events while maintaining differentiability through AD.

This talk will follow the chronological development of PathSim, highlighting design decisions, implementation challenges, and the resulting capabilities