

# Seminar

SciML Lab · CDS

Wednesday, November 6, 2024

16:00–17:30

Seminar Room 1

Mathematical Institute

University of Cologne

Weyertal 86–90

**Speaker:**

**Prof. Dr. Uwe Naumann**

**RWTH Aachen University**

Center for  
Data and  
Simulation  
Science

## DIFFERENTIAL INVERSION

Differential inversion denotes the computation of a Newton step of a differentiable function (also: residual) with invertible Jacobian. The residual is assumed to be implemented as a differentiable program, implying applicability of algorithmic differentiation (AD).

Inspired by adjoint AD, the product of the inverse Jacobian with a vector can often be evaluated efficiently by a backpropagation-like algorithm. We distinguish between structural and symbolic approaches to reducing the computational cost of

this method. The former aims to exploit sparsity of invertible local Jacobians for a given decomposition of the residual into differentiable elemental functions. A case study based on banded elemental Jacobians is discussed in [1]. The latter applies analytic insight into the mathematical properties of the residual. An application to differential inversion of the implicit Euler scheme is presented in [2]. A reduction of the computational cost by an order of complexity can be reported for both scenarios.

[1] U. Naumann: A Matrix-Free Exact Newton Method. *SIAM Journal on Scientific Computing* 46 (3), A1423-A1440, 2024.

[2] U. Naumann: Differential Inversion of the Implicit Euler Method. Under Review. See also arXiv preprint arXiv:2409.05445, 2024.

