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RESEARCH & COLLABORATION PROFILE

KEY WORDS: Numerical Analysis, Finite Element Methods, Numerical Linear Algebra, CFD & HPC, AI for Mathematics, Mathematics for AI



Research Snapshot. Prof. Jang develops and analyses numerical methods for partial differential equations together with the large-scale linear systems they generate, and increasingly couples them with machine learning. His work spans Galerkin approximations of viscoelasticity, randomized and mixed-precision Krylov solvers, adaptive high-order methods for computational fluid dynamics, physics-informed neural networks for history-dependent problems, and explainable AI for energy demand forecasting and efficiency analysis.

RESEARCH EXPERTISE

- **Scientific machine learning & explainable AI:** physics-informed neural networks for Volterra integro-differential equations and inverse identification of material parameters, and interpretable (SHAP-based) deep learning for energy demand forecasting and efficiency analysis.
- **Finite element analysis for PDEs:** a priori and a posteriori stability and error analyses of continuous and discontinuous Galerkin approximations for viscoelasticity, covering internal-variable, fractional-order, and power-law constitutive laws, plus DG-POD reduced-order models.
- **Numerical linear algebra:** randomized orthogonalization and Krylov subspace solvers (GMRES with deflated restarting and augmentation), mixed-precision algorithms, algebraic multigrid, and saddle-point solvers for large sparse systems.
- **Computational fluid dynamics & HPC:** p-adaptive discontinuous Galerkin methods with two-level dynamic load balancing, and fast linear solvers for compressible and incompressible flow simulations on massively parallel architectures.

RECENT RESEARCH HIGHLIGHTS

- **Mixed-precision Krylov solvers (Numer. Linear Algebra Appl. 2026):** developed mixed precision augmented GMRES, combining deflation and augmentation with low-precision arithmetic to accelerate convergence while preserving attainable accuracy.
- **Randomized linear algebra (Numer. Linear Algebra Appl. 2025; Numer. Algorithms 2024):** introduced a randomized orthogonalization process with reorthogonalization and randomized flexible GMRES with deflated restarting, halving orthogonalization cost in large-scale solvers.
- **Finite element theory for viscoelasticity (Numer. Methods Partial Differ. Equ. 2024, J. Comput. Appl. Math. 2022; Adv. Comput. Math. 2021):** established a priori stability and error estimates for internal-variable and fractional-order formulations of dynamic viscoelasticity, with constants that grow linearly rather than exponentially in time.

POTENTIAL COLLABORATION RESEARCH

Best-fit collaborator areas: scientific machine learning & explainable AI | AI for energy systems | computational mechanics & PDE modelling | numerical linear algebra & HPC | CFD

- **1. Scientific machine learning and explainable AI:** PINN solvers and inverse identification for history-dependent PDEs, and interpretable ML for energy demand forecasting and efficiency assessment.
- **2. Joint development and analysis of numerical schemes:** co-design of finite element and discontinuous Galerkin discretizations, with stability and error analysis, for viscoelastic, wave-propagation, and other history-dependent multiphysics problems.
- **3. Large-scale linear solvers:** integration of randomized, mixed-precision, and multigrid-preconditioned Krylov methods into collaborators' simulation codes on HPC and GPU platforms.
- **4. Applied CFD and engineering simulation:** adaptive high-order methods and scalable solvers for compressible and incompressible flows, building on experience with elsA, CODA, and Code_Saturne.

SELECTED RECENT PUBLICATIONS

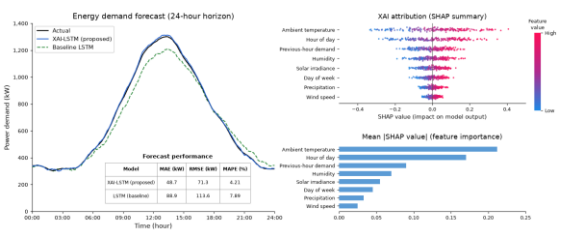
- **AIMS Math. 2026, 11(6), 16511-16533 —** Internal variable reformulation of Volterra integro-differential equations for physics-informed neural networks.
- **Numer. Linear Algebra Appl. 2026, e70117 —** Mixed precision augmented GMRES.
- **Numer. Linear Algebra Appl. 2025, e70029 —** Randomized orthogonalization process with reorthogonalization.
- **J. Comput. Appl. Math. 2022, 412, 114340 —** Finite element approximation and analysis of a viscoelastic scalar wave equation with internal variable formulations.
- **Comput. Math. Appl. 2024, 176, 165-178 —** Two-level dynamic load-balanced p-adaptive discontinuous Galerkin methods for compressible CFD simulations.

CONTACT

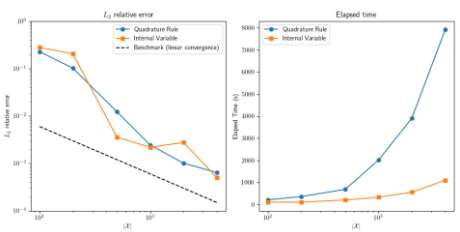
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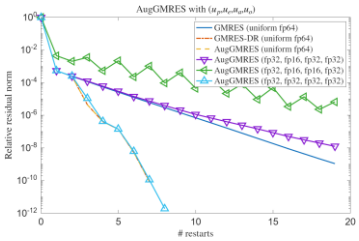
REPRESENTATIVE RESEARCH FIGURES / SCHEMES



Explainable AI for energy:
24 h demand forecast (XAI-LSTM vs. baseline) with SHAP attribution



PINN with internal variables vs. quadrature:
accuracy and cost for Volterra problems



Mixed precision augmented GMRES:
relative residual norm against restarts