Contribution ID: **1866** Contribution code: **WEPM051** Type: **Poster Presentation**

A novel B-spline FEM framework using Kolmogorov-Arnold networks

Wednesday 4 June 2025 16:00 (2 hours)

Multilayer perceptrons (MLPs) have demonstrated significant advancements in solving partial differential equations, including applications such as the space-charge Hamiltonian in accelerator physics. However, MLPs often lack the interpretability desired in physics and can be challenging to evaluate in a meaningful way.

In this work, we introduce a novel approach utilizing Kolmogorov-Arnold Networks (KAN), designed to enhance interpretability by structuring the layers as a graph where edges represent B-spline basis functions and nodes correspond to their coefficients. The solution to the PDE is expressed as a linear combination of these basis functions, adhering to principles inherent to the finite element method (FEM).

The solution procedure is inspired by the Schwarz additive method, where the graph is divided into smaller, trainable subdomains. By leveraging the inherent properties of B-spline basis functions, the framework supports different orders of basis functions, variable grid sizes, and complex geometries. This modular and interpretable approach offers a promising hybrid framework for solving PDEs across diverse applications in physics and engineering.

Footnotes

Paper preparation format

LaTeX

Region represented

Europe

Funding Agency

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Session Classification: Wednesday Poster Session

Track Classification: MC5: Beam Dynamics and EM Fields: MC5.D02 Nonlinear Single Particle Dynamics Resonances, Tracking, Higher Order, Dynamic Aperture, Code Developments