Title: PINN's and nonlocal models

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Abstract:
This mini-symposium aims to integrate Physics Informed Neural Networks (PINNs) with nonlocal, nonlinear PDEs to address complex physical phenomena characterised by long-range interactions, memory effects, and anomalous diffusion. Traditional numerical methods face severe challenges when solving such models due to the inherent computational cost and the curse of dimensionality. By leveraging PINNs - deep neural networks that embed the governing physics directly into their loss functions - a mesh-free, scalable alternative that can handle the integral operators defining nonlocal interactions as well as the strong nonlinearities present in many practical problems is adopted.

Nonlocal PDEs extend classical models by incorporating integral operators that capture effects from distant regions, making them essential for describing processes such as nonlocal wave propagation in heterogeneous media, anomalous transport in porous materials, and complex reaction-diffusion dynamics in biological systems. However, the combination of nonlocality and nonlinearity results in stiff, high-dimensional equations that are difficult to solve with conventional finite difference or finite element methods. PINNs offer a promising solution by ensuring that the approximated solutions satisfy both the observational data and the underlying physical laws, thereby regularising the learning process and reducing the reliance on dense training datasets.

This innovative approach includes transformative computational techniques that not only improve the accuracy and efficiency of simulations but also extend the applicability of machine learning methods to a broader range of scientific problems. In bridging the gap between advanced mathematical modelling and state-of-the-art deep learning, this research aims to deliver a new generation of solvers that can tackle previously intractable nonlocal, nonlinear PDEs. Ultimately, the integration of PINNs with nonlocal PDE theory has the potential to revolutionise simulation practices across multiple disciplines, paving the way for enhanced predictive capabilities and deeper insights into complex physical systems.