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A function space random feature model for PDE solution maps

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We propose a supervised learning methodology for use of the random feature model as a data-driven surrogate for operators mapping between spaces of functions. Although our methodology is quite general, we consider operators defined by partial differential equations (PDEs); here, the inputs and outputs are themselves functions, with the input parameters being functions required to specify a well-posed problem and the outputs being solutions of the problem. Upon discretization, the model inherits several desirable attributes from this function space viewpoint, including mesh-invariant approximation error and the capability to be trained at one mesh resolution and then deployed at different mesh resolutions. We demonstrate the random feature model's ability to cheaply and accurately approximate the nonlinear parameter-to-solution maps of prototypical PDEs arising in physical science and engineering applications, which suggests the applicability of the method as a surrogate for expensive full-order forward models arising in many-query problems.

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