

THE USE OF EXTREME LEARNING MACHINES AND RANDOM PROJECTION METODS FOR FOR SOLVING DIFFERENTIAL EQUATIONS

FRANCESCO CALABRÒ^{*,†}, SALVATORE CUOMO^{*} AND DAVIDE
ELIA DE FALCO[†]

^{*}Università degli Studi di Napoli "Federico II", Dip. Matematica e Applicazioni
Napoli, Italy
{francesco.calabro,salvatore.cuomo}@unina.it

[†]Scuola Superiore Meridionale, Area MPHS
Napoli, Italy
de.defalco@ssmeridionale.it

ABSTRACT

The application of Extreme Learning Machines (ELMs) to the numerical solution of differential equations has experienced remarkable growth in recent years. Starting from the pioneering Physics-Informed Extreme Learning Machine (PIELM) framework, an increasingly broad family of methods has emerged, extending the original formulation to more complex differential models, inverse problems, domain decomposition strategies and adaptive techniques. At the same time, several approaches originally developed under different names and motivations can be interpreted within the same random projection paradigm, highlighting a common mathematical structure that deserves further investigation.

This mini-symposium aims to bring together researchers working on ELM-based and related random projection methods for differential equations, with the objective of discussing their theoretical foundations, computational properties, and practical applications. Particular attention will be devoted to the convergence behavior of these methods. Although they are not high-order methods in the classical polynomial approximation sense, growing theoretical and numerical evidence indicates that they often exhibit spectral-like convergence, placing them among the closest physics-informed learning approaches to traditional spectral methods. This distinctive behavior originates from the use of a fixed, randomly generated hidden layer that defines a rich approximation space while preserving the computational efficiency characteristic of ELMs.

The mini-symposium welcomes contributions addressing theoretical analysis, numerical algorithms, and applications of ELM-based methods for ordinary, partial,

stochastic and integro-differential equations. Contributions employing ELMs or related random feature techniques as components of broader numerical frameworks are equally encouraged. The goal is to provide a forum where researchers can exchange ideas, identify common principles underlying existing methods, and discuss future directions for this rapidly evolving research area.

SPEAKERS

1. Victorita Dolean-Maini (TU Eindhoven, The Netherlands): ELM-FBPINNs: an efficient multilevel random feature method.
2. Suchuan -Steven- Dong (Center for Computational and Applied Mathematics, Department of Mathematics, Purdue University USA): Spectral extreme learning machine for partial differential equations and applications.
3. Vikas Dwivedi, (CNRS, Creatis Biomedical Imaging Laboratory, INSA-Lyon, France): Curriculum learning-driven PIELMs for fluid flow simulations.
4. He Yang (University of Leeds, Leeds, UK): Physics-Informed Extreme Learning Machine (PIELM) for Stefan problems.
5. Qinghui Zhanga (Guangdong Province Key Laboratory of Computational Science, Sun Yat-Sen University, Guangzhou, China): Extended physics-informed extreme learning machine for linear elastic fracture mechanics.
6. Karol Struniawski (Warsaw University of Life Sciences, Institute of Information Technology, Poland): Extreme learning machines framework with python and TensorFlow.
7. Davide Elia De Falco (Scuola Superiore Meridionale, Napoli, Italy): Least squares with equality constraints extreme learning machines for the resolution of PDEs.
8. Enrico Schiassi (Università di Bologna, Italy): Use of ELMs in Physics-Informed Machine Learning, Estimates on the generalization error in learning ODE solutions.