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Dipartimento di Scienze Matematiche "G. L. Lagrange"
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Online seminar

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Hosted on: Zoom

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The Impact of Artificial Intelligence on Parametric Partial Differential Equations

Prof. Canuto introduces the seminar.

Abstract

High-dimensional parametric partial differential equations (PDEs) appear in various contexts including control and optimization problems, inverse problems, risk assessment, and uncertainty quantification. In most such scenarios the set of all admissible solutions associated with the parameter space is inherently low dimensional. This fact forms the foundation for the so-called reduced basis method.

Recently, numerical experiments demonstrated the remarkable efficiency of using deep neural networks to solve parametric problems. In this talk, after an introduction into deep learning, we will present a theoretical justification for this class of approaches. More precisely, we will derive upper bounds on the complexity of ReLU neural networks approximating the solution maps of parametric PDEs. In fact, without any knowledge of its concrete shape, we use the inherent low-dimensionality of the solution manifold to obtain approximation rates which are significantly superior to those provided by classical approximation results. We use this low-dimensionality to guarantee the existence of a reduced basis. Then, for a large variety of parametric PDEs, we construct neural networks that yield approximations of the parametric maps not suffering from a curse of dimensionality and essentially only depending on the size of the reduced basis.

Finally, we present a comprehensive numerical study of the effect of approximation-theoretical results for neural networks on practical learning problems in the context of parametric partial differential equations. These experiments strongly support the hypothesis that approximation-theoretical effects heavily influence the practical behavior of learning problems in numerical analysis.

Biography

Gitta Kutyniok has a Bavarian AI Chair for "Mathematical Foundations of Artificial Intelligence" in the institute of mathematics at the Ludwig Maximilian University of Munich. She is known for her research in harmonic analysis, deep learning, compressed sensing, and image processing. Kutyniok graduated in mathematics and computer science at Paderborn University in 1996. She completed the doctorate at Paderborn in 2000, supervised by Eberhard Kaniuth. From 2000 to 2008 she held short term positions at Paderborn University, the Georgia Institute of Technology, the University of Giessen, Washington University in St. Louis, Princeton University, Stanford University, and Yale University. In 2008 she became a full professor at Osnabrück University, and in 2011 she was given the Einstein Chair at the Technical University of Berlin. In 2018 she added courtesy affiliations with computer science and electrical engineering at TU Berlin. In October 2020 she moved to the Ludwig Maximilian University of Munich. Since taking her position in Berlin she has also visited ETH Zürich, and taken an adjunct faculty position at the University of Tromsø.

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