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Towards a mathematical understanding of modern machine learning: theory and algorithm

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Modern machine learning (ML) has achieved unprecedented empirical success in many application areas. It has got the reputation of being a magical black box. However, ML is very fragile. Much of this success involves trial-and-error and numerous engineering tricks. Foundational research is needed for the development of robust and reliable ML. The first part of this talk will focus on some recent mathematical understanding and development of neural network training. Two frequently observed ML phenomena are analyzed -- ``Dying ReLU" and ``Plateau Phenomenon". Based on the insights gained from analysis, new algorithms are proposed that overcome these issues.
The second part will present the first mathematical theory of physics informed neural networks (PINNs) -- one of the most popular deep learning frameworks for solving PDEs.

Two classes of PDEs are considered: linear second-order elliptic and parabolic. By adapting the Schauder approach and the maximum principle, the consistency of PINNs is proved.