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Deep Learning Meets Sparse Regularization

Deep learning has been wildly successful in practice and most state-of-the-art artificial intelligence systems are based on neural networks. Lacking, however, is a rigorous mathematical theory that adequately explains the amazing performance of deep neural networks. In this talk, I present a new mathematical framework that provides the beginning of a deeper understanding of deep learning. This framework precisely characterizes the functional properties of trained neural networks. The key mathematical tools which support this framework include transform-domain sparse regularization, the Radon transform of computed tomography, and approximation theory. This framework explains the effect of weight decay regularization in neural network training, the importance of skip connections and low-rank weight matrices in network architectures, the role of sparsity in neural networks, and explains why neural networks can perform well in high-dimensional problems.