A Projection-Based Neurodynamic Approach to l_1-Regularized Optimization: Stability and Applications

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Abstract

Sparse optimization problems, particularly the l_1-regularized least squares problem (LASSO), lie at the heart of modern signal processing and data science. Recurrent neural network (RNN) based solvers have emerged as an attractive framework for these problems owing to their inherent parallelism and real-time capability. However, most existing neurodynamic models handle the non-smooth l_1 penalty by decomposing each variable into its positive and negative components, which doubles the problem dimension and incurs unnecessary computational overhead. In this talk, we introduce an efficient one-layer recurrent neural network that directly solves the LASSO problem in its original variable space. The key idea is to exploit a Prox-Projection identity that replaces the l_1 subgradient with a simple projection operator, thereby completely eliminating the need for variable splitting. The resulting architecture is substantially simpler and more memory-efficient than its dimension-doubling counterparts. We prove that the proposed network is globally asymptotically stable under general conditions and globally exponentially stable when the objective satisfies a strong convexity assumption. Numerical experiments on image restoration confirm the theoretical findings, showing competitive accuracy with markedly improved computational efficiency.

Keywords: LASSO, l_1-Regularization, Projection Neural Network, Recurrent Neural Network, Lyapunov Stability, Sparse Optimization.

References

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*This research was supported by Naresuan University.
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