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Evaluating the robustness of the Hopfield Neural Networks against noise in Image Classification

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Abstract

Hopfield neural networks (HNN) are fully connected networks of binary neurons that can store patterns in an energy landscape. Collective properties of large systems are only weakly sensitive to details and this property can be used to test the robustness of HNN to noise. In this work their robustness to various types of noise in classification tasks is evaluated. While HNNs have demonstrated remarkable pattern recognition capabilities through their associative memory properties, their vulnerability to noise-induced parasitic memories remains a significant challenge, particularly in high-dimensional classification problems. We propose a comprehensive framework for evaluating HNN resilience by examining the interplay between noise tolerance and the formation of parasitic attractor states that can compromise classification accuracy. The experiments are conducted on MNIST dataset classifying numbers and on unstained brightfield BALB 3T3 cell images classifying them based on health state. An attention based memory module that allows dynamic associative retrieval and a Hopfield classifier are used to integrate learned memory slots with deep visual features. Validation accuracy of 95.83% was achieved for the classification of cell images. Memory slot ablation is used to determine the essential memory patterns for robust cell classification.

References

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