

## **THERMODYNAMIC NEURAL NETWORK**

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### **ABSTRACT**

Idealized models of physical systems, such as the Ising model, have long played a central role in developing an understanding of the natural world. In this work, we describe a thermodynamically motivated neural network model that self-organizes to transport charge associated with internal and external potentials while in contact with a thermal reservoir. As compared to other models, the Thermodynamic Neural Network (TNN) model is distinguished by its electric circuit inspiration and its treatment of charge as a conserved quantity. Although learning is the primary objective of the model, the motivation is not the statistical generalization of a training set, the replication of a function, or the storage of a memory; rather, learning is viewed as adaptation to improve equilibration with external potentials and a thermal reservoir. The model integrates concepts of conservation, potentiation, fluctuation, dissipation, adaptation, equilibration and causation to illustrate the thermodynamic evolution of organization in open systems. A key conclusion of the work is that the transport and dissipation of conserved physical quantities drives the self-organization of open thermodynamic systems.

Keywords: self-organization; open thermodynamic systems; neural networks; dissipative adaptation; causal learning; multiscale complex systems; thermodynamic evolution