Analog machines to train learning models

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Since the 1980s, recurrent neural networks (RNN) have become a topic of great interest. The early works on neural networks consisted of simple systems of a few neurons that were commonly simulated using analog electronic circuits or electrical networks. The transition from equations to circuits was done directly without proper justification or subsequent formalization.

Recently, a result has been published that formalizes the equivalence RNN$\asymp$EN, starting from the Hopfield-type network paradigm [1]. This result establishes a dictionary between both worlds, showing how the mapping should be done for a pre-trained RNN, i.e., when all parameters (weights and biases) are fixed.

Analog machines have gained significant relevance in recent years due to their potential efficiency compared to digital machines, as well as technological advancements that allow for miniaturization and control.

Given that the majority of resources: energy, computational power, and eventually time, in machine learning (ML) models are primarily used during the training stage, we propose using analog machines that, in their temporal evolution, allow for the training of ML models. We will provide a general recipe that will be applied to a particular ML model.

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[1] Caruso, M., Jarne, C. *Recurrent Neural Networks as Electrical Networks, a Formalization*, DCAI 2022. Lecture Notes in Networks and Systems, **585**, Springer https://doi.org/10.1007/978-3-031-23210-7_10F (2023).

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