Directions and Strategies

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Simplified Mathematical Model equation for Biological Neuron Model:

$$\begin{aligned} w_{i1}S_1(t) + \ldots + w_{iN}S_N(t) > \theta_i : \quad S_i(t+1) = 1 \\ w_{i1}S_1(t) + \ldots + w_{iN}S_N(t) < \theta_i : \quad S_i(t+1) = 0 \end{aligned} \tag{1}$$

The field effectively splits into two directions

1. Operation and
2. Learning

Operation:
It aims to solve the equation with respect to the evolution of the neuron states, with prescribed or constant choices of synapses and thresholds. So, the dynamic variables are neurons and the synapses and thresholds are the parameters.

Learning:
It aims to find the possible modes of the operation equation that would be allowed if the synapses and thresholds are varied in a given architecture and to find the learning rules that will generate the values such that the resulting network will meet some specified performance criterion. So, the dynamic variables are the synapses and thresholds, whereas the neuron states induce constraints and operation targets.

Operation		Learning	
variables:	neurons	variables:	synapses, thresholds
parameters:	synapses, thresholds	parameters:	required neuron states

In reality this separation is not perfect. In the field of learning theory only part of the system's neuron states are specified and the remaining neuron states will be solved, there even exist non-trivial but solvable models in which both the neurons and synapses/thresholds evolve in time.

In dealing with mathematical models to describe phenomena in biology, physics, economics or any other discipline, the equations involved are most easily solved in extreme limits for the control parameters. It is also applicable for Neural Network models with respect to the system size N (Biologically - $N \approx 10^6$ and Engineering - $N \approx 10^3$).

The strategy of a model solver is to identify the global observables which characterize the system state at a macroscopic level. For example: In statistical mechanics one is not interested in knowing the positions and velocities of individual molecules in a gas, but rather in knowing the values of global observables like pressure

The operation a neural network performs depends on its program: the choice made for architecture, synaptic interactions and thresholds (equivalently, on the learning rule used to generate these parameters).