Deep Learning, Neuromorphic network, and Implementations

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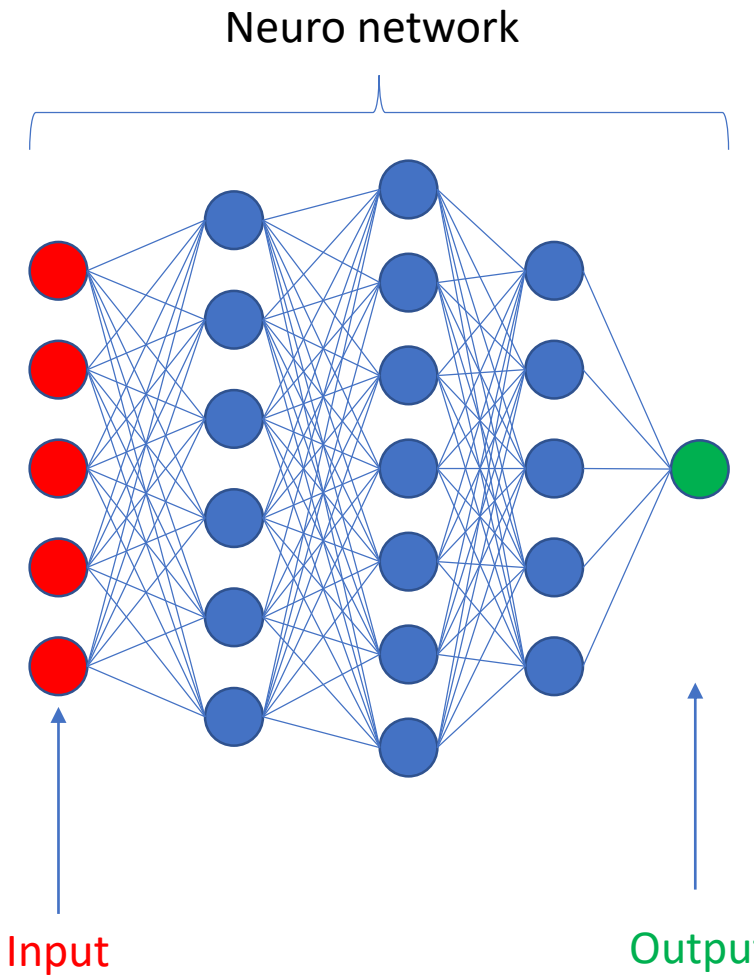
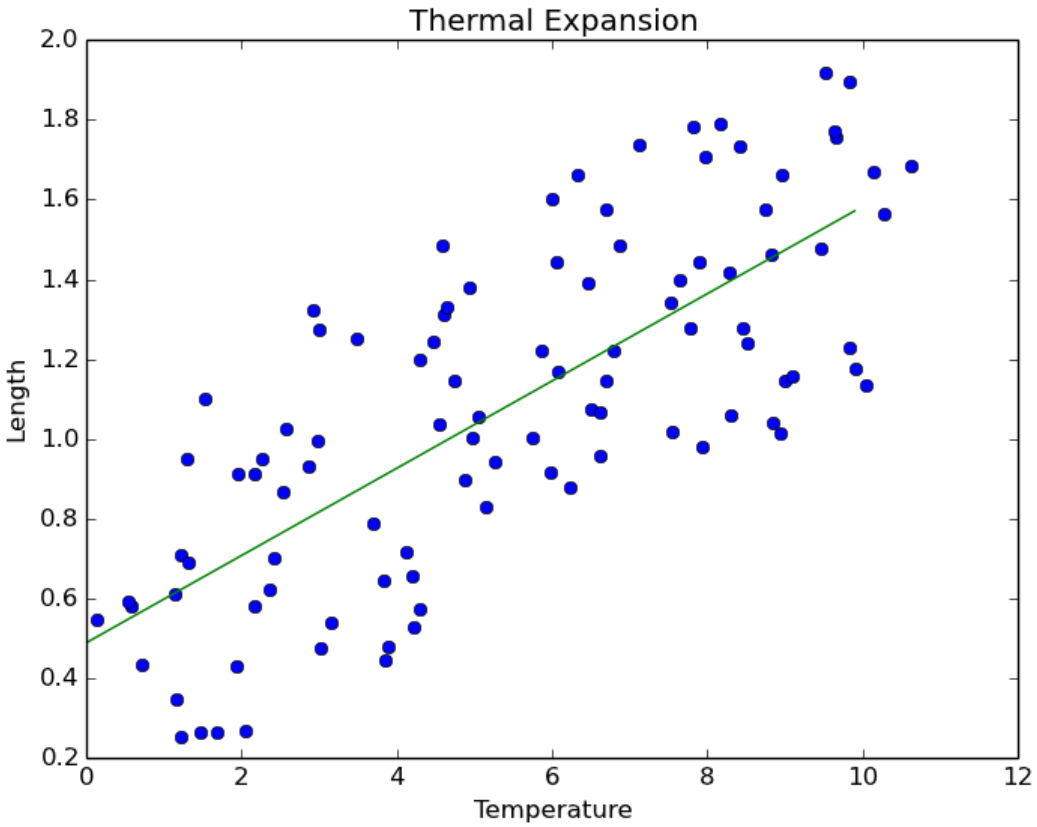
What is neuro network?



A complex network that takes input(s) and generates output(s).

Where does it come from? Step 1

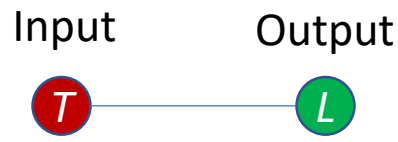


Learning: what's the relation between temperature and length?

Model: $L = a * T + b$

Least square fit: (Linear regression) to find a and b, using the available **data**.

Learned: $L = a * T + b$, able to make prediction



Simple network

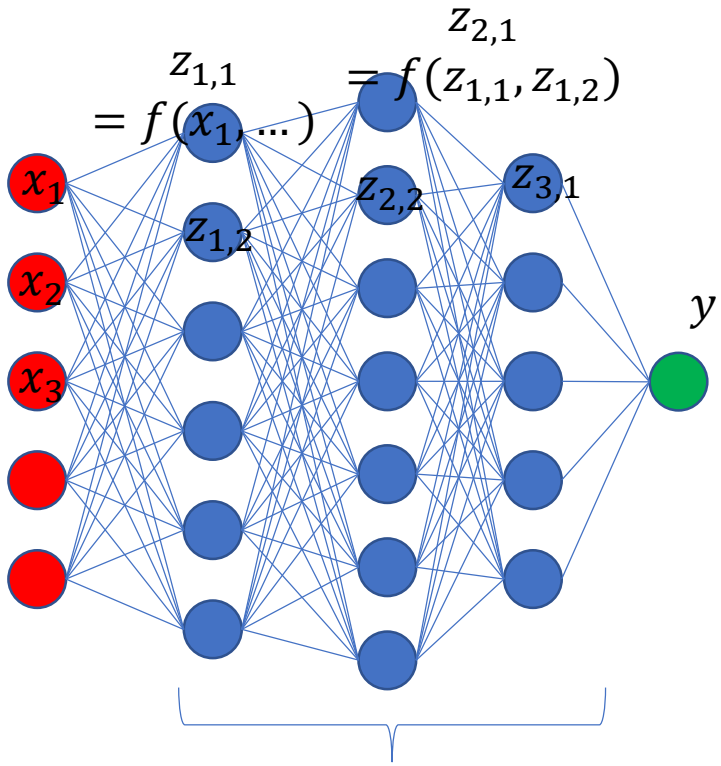
Step 2: more complex problems

Approach 1: theoretical (complex, analytical) models:

$$y = f(x_1, x_2, x_i \ldots)$$

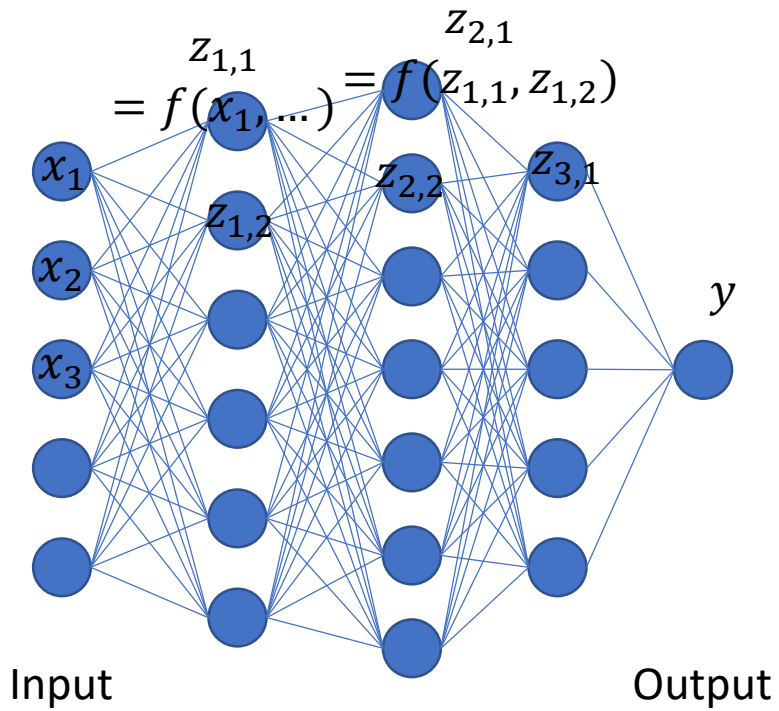
Refine model using principles (Classical mechanics, quantum mechanics, …)

Approach 2: empirical (numerical) models



Hidden layers, “**deep** learning” with **multilayers**

Deep learning, neuro network



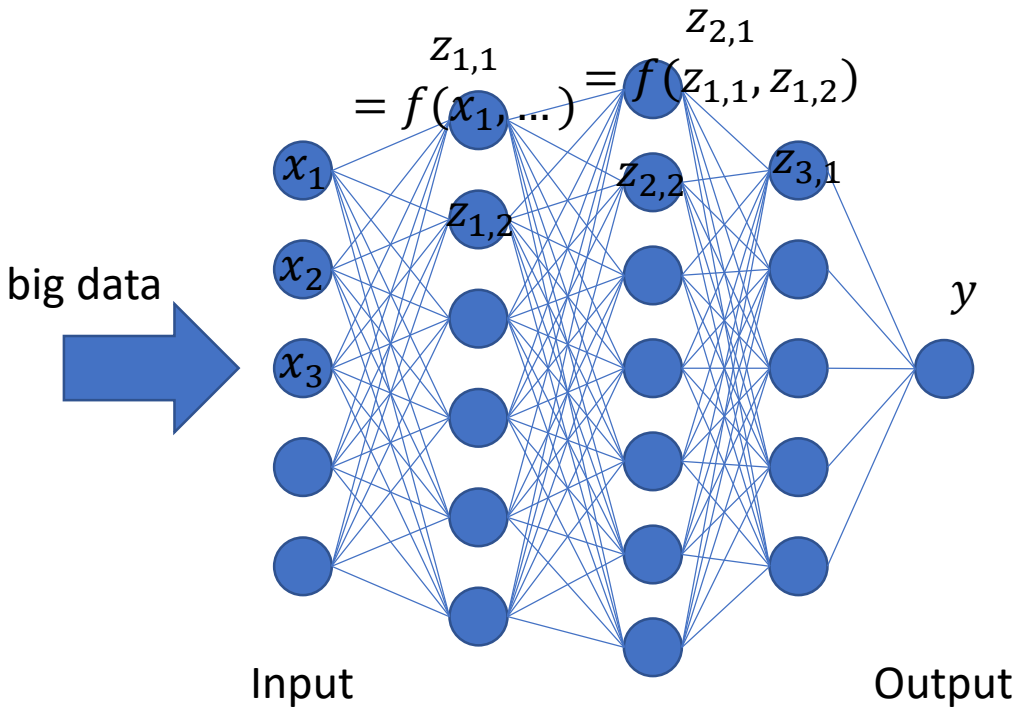
Logical function: (output between 0 or 1)

$$t = a_{1,1,1}x_1 + b_{1,1,1} + a_{1,2,1}x_2 + b_{1,2,1} + \cdots$$

$$z_{1,1} = \frac{1}{1 + \exp(-t)}$$

Nonlinearity

Role of **big data**



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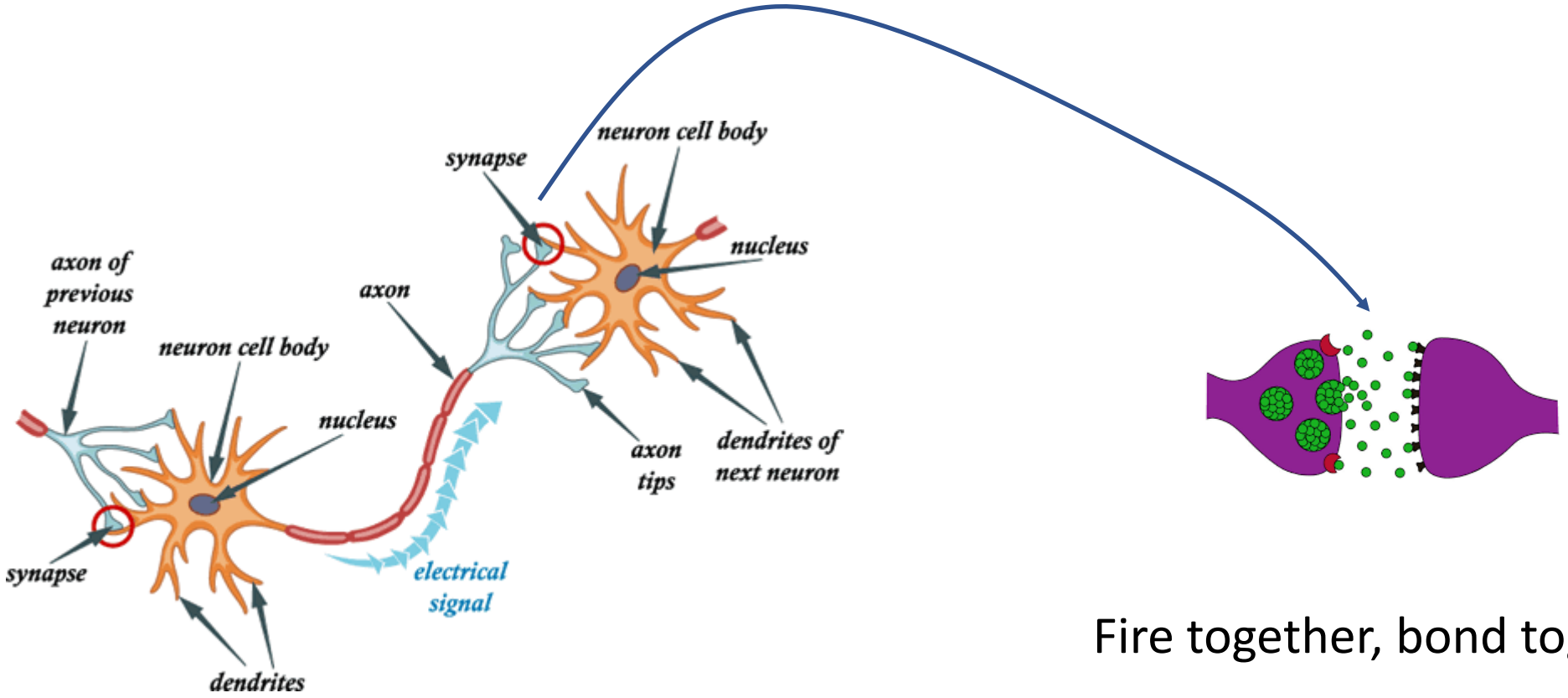
Fitting using bigdata (regression) to get the parameters:

$$\{a_{i,j,k}, b_{i,j,k} \dots\}$$

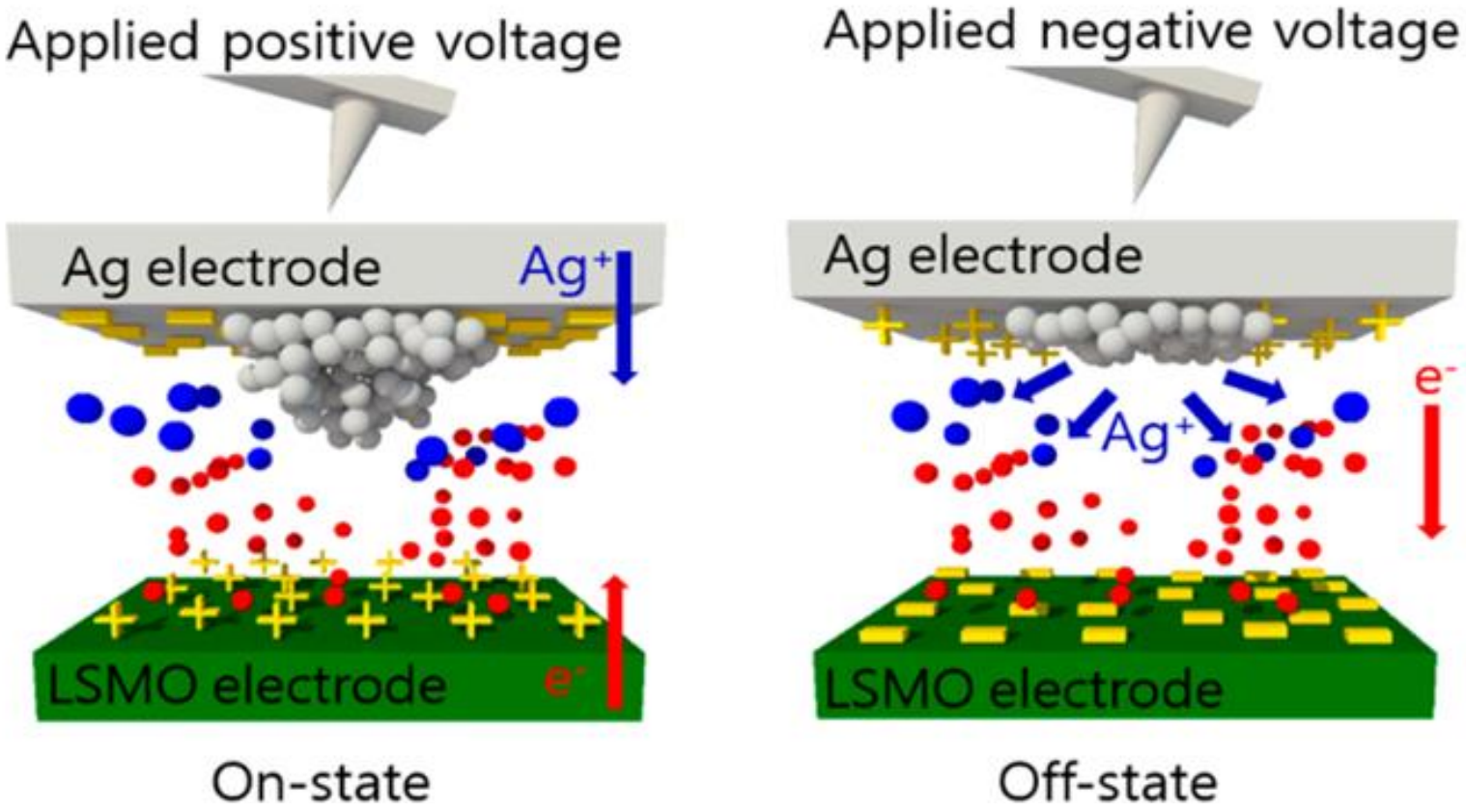
The main work is to finding $\{a_{i,j,k}, b_{i,j,k} \dots\}$ quick enough.

Biological brain and synapses



Fire together, bond together

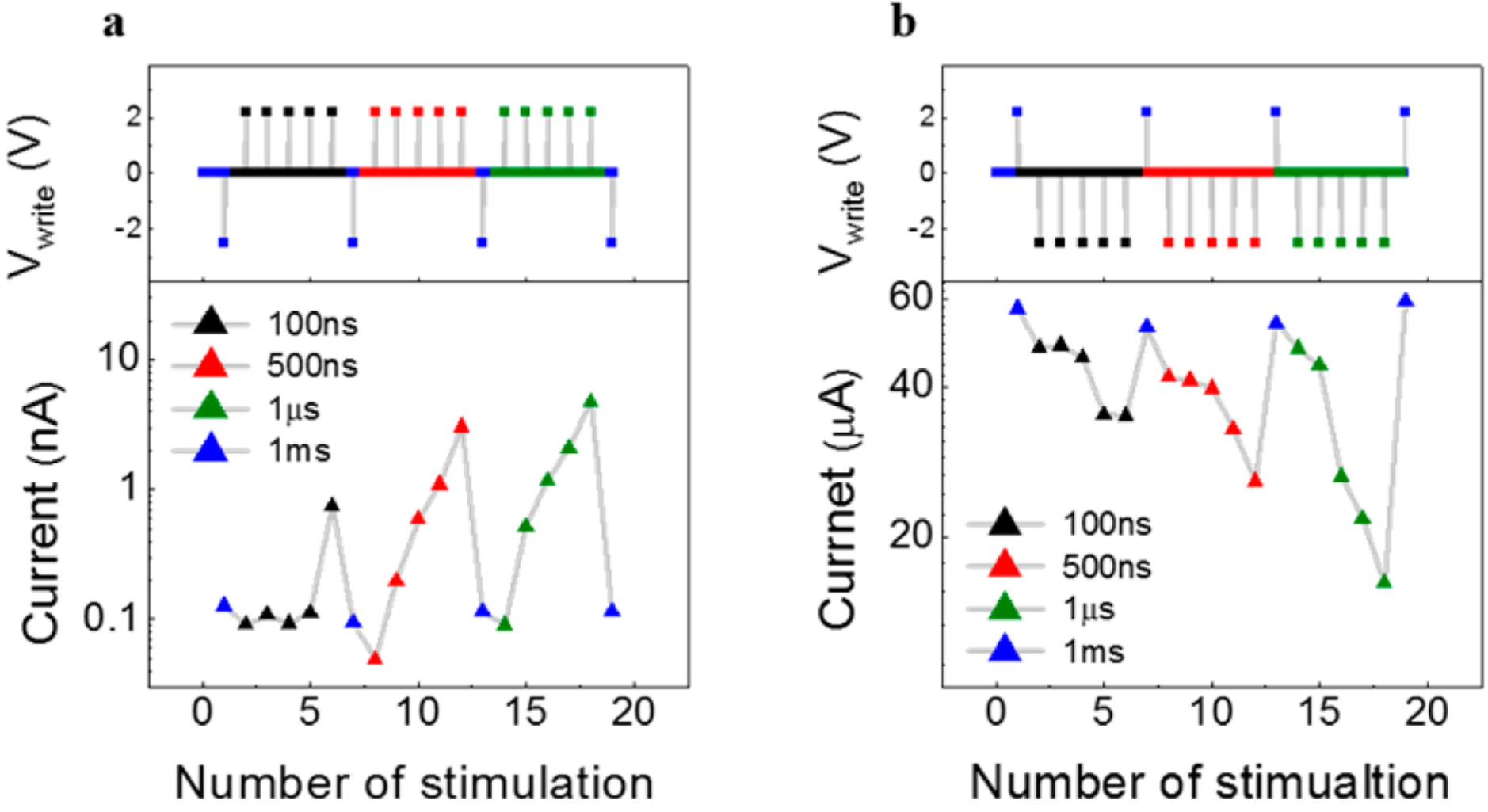
Synaptic devices



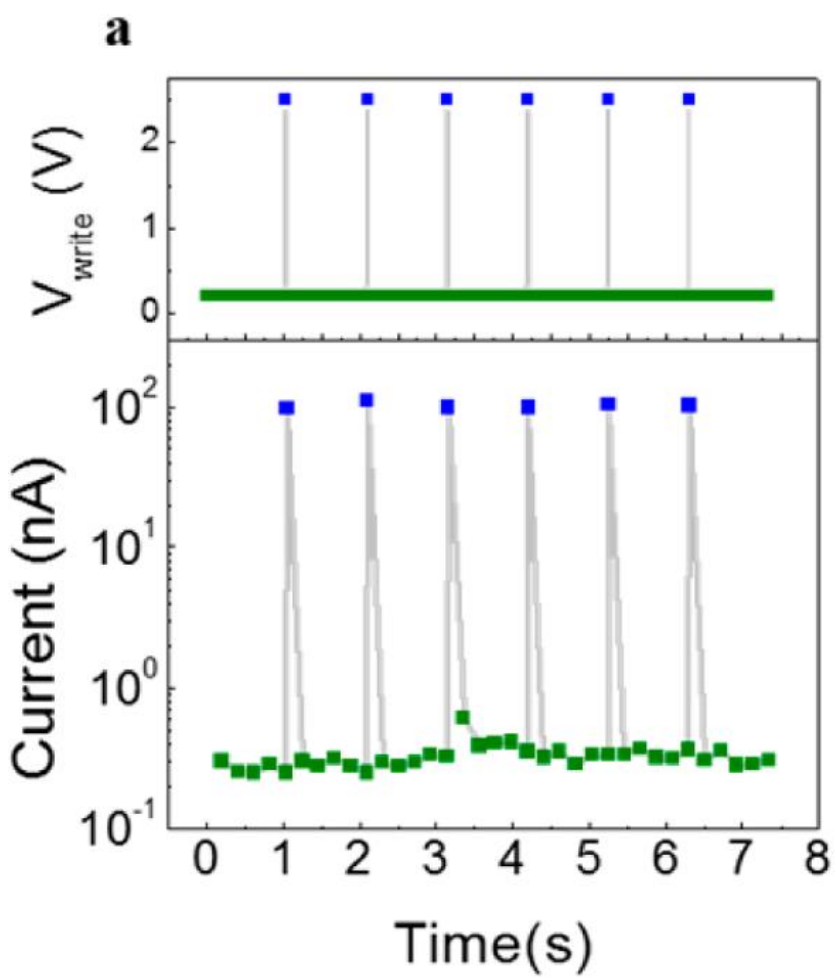
Ag/PZT/LSMO/STO

Nano Lett. 2017, 17, 1949−1955

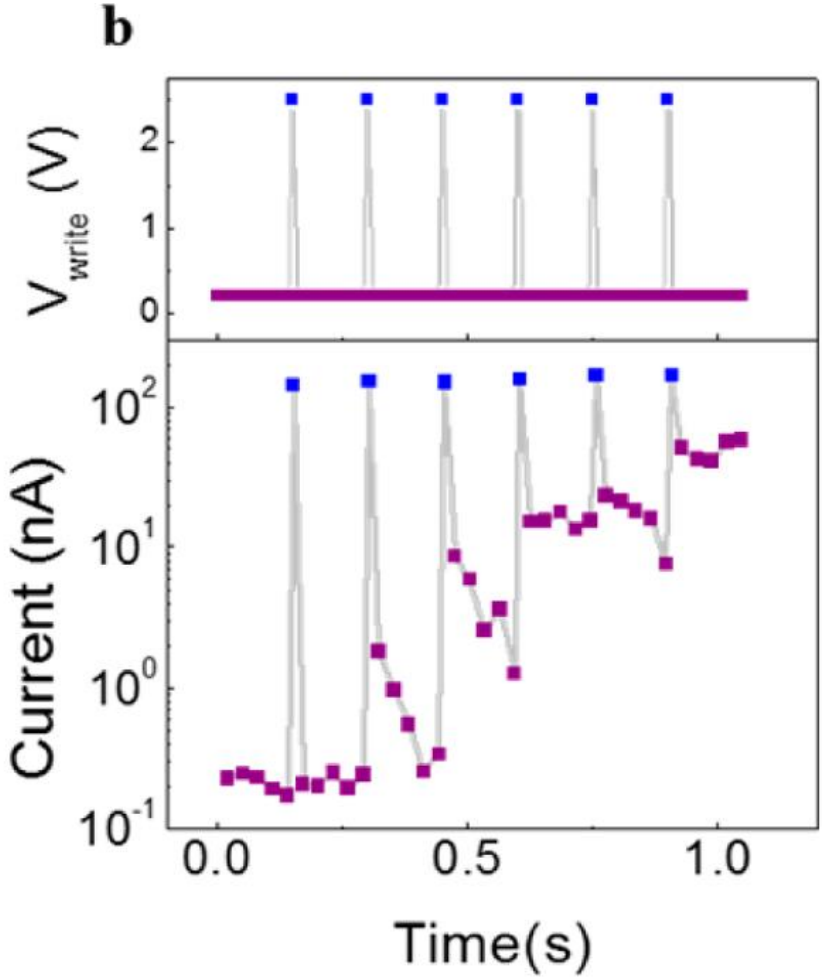
Cumulative effect



Memory retention



Short term



Longer term

Conclusion

- Deep (machine) learning, neuro network, big data are currently implemented using empirical model, heavily relying on computing power.

- The emulation of “true” biological brain using network of synapsis may provide a fast way of implementing neuro network.