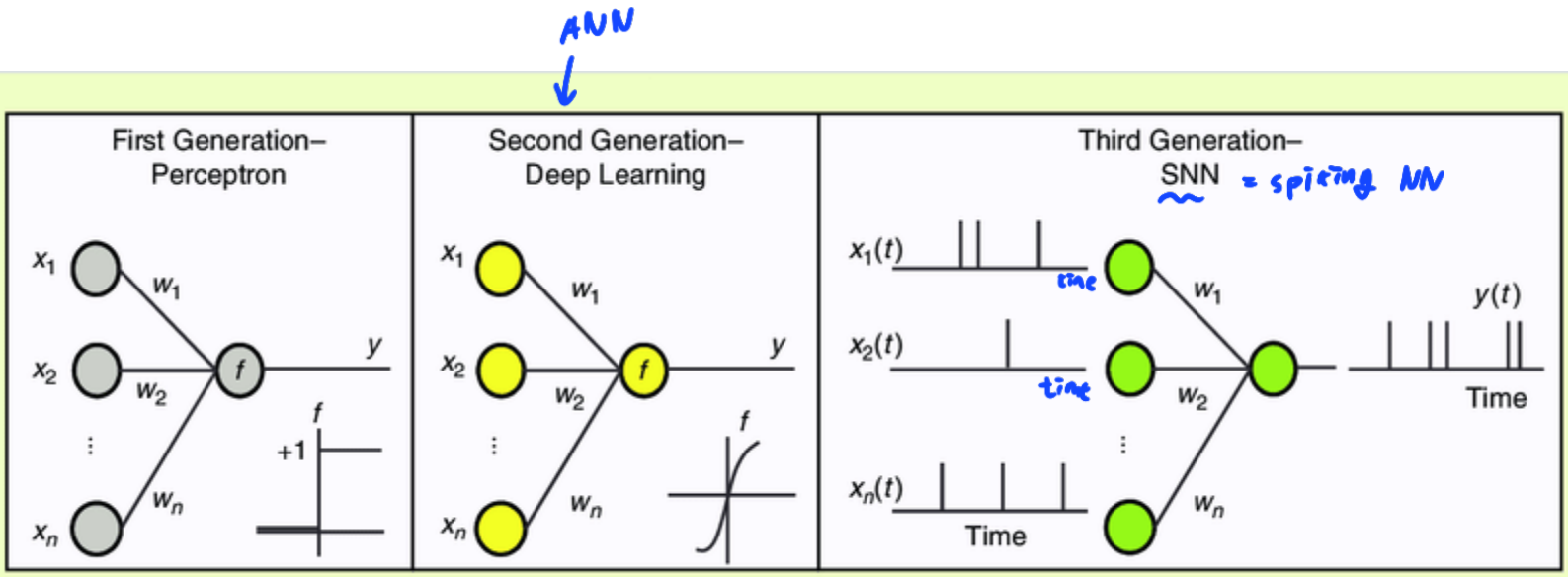
2021 Spring

Artificial Intelligence & Deep Learning

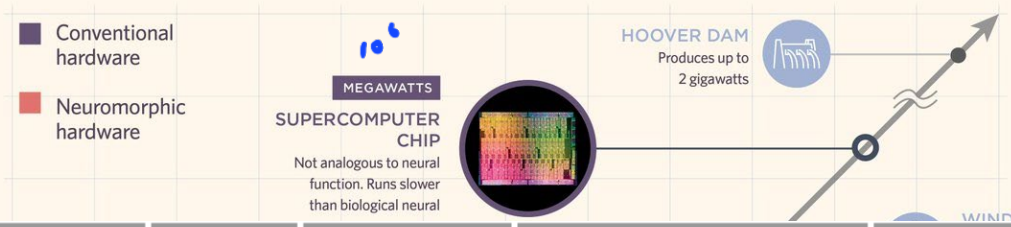
Prof. Minsuk Koo

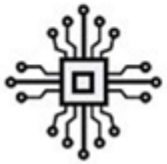
Department of Computer Science & Engineering
Incheon National University

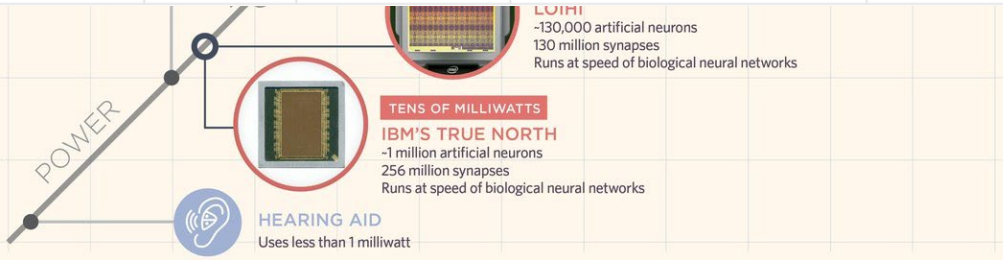
The Generations of Neural Network Models



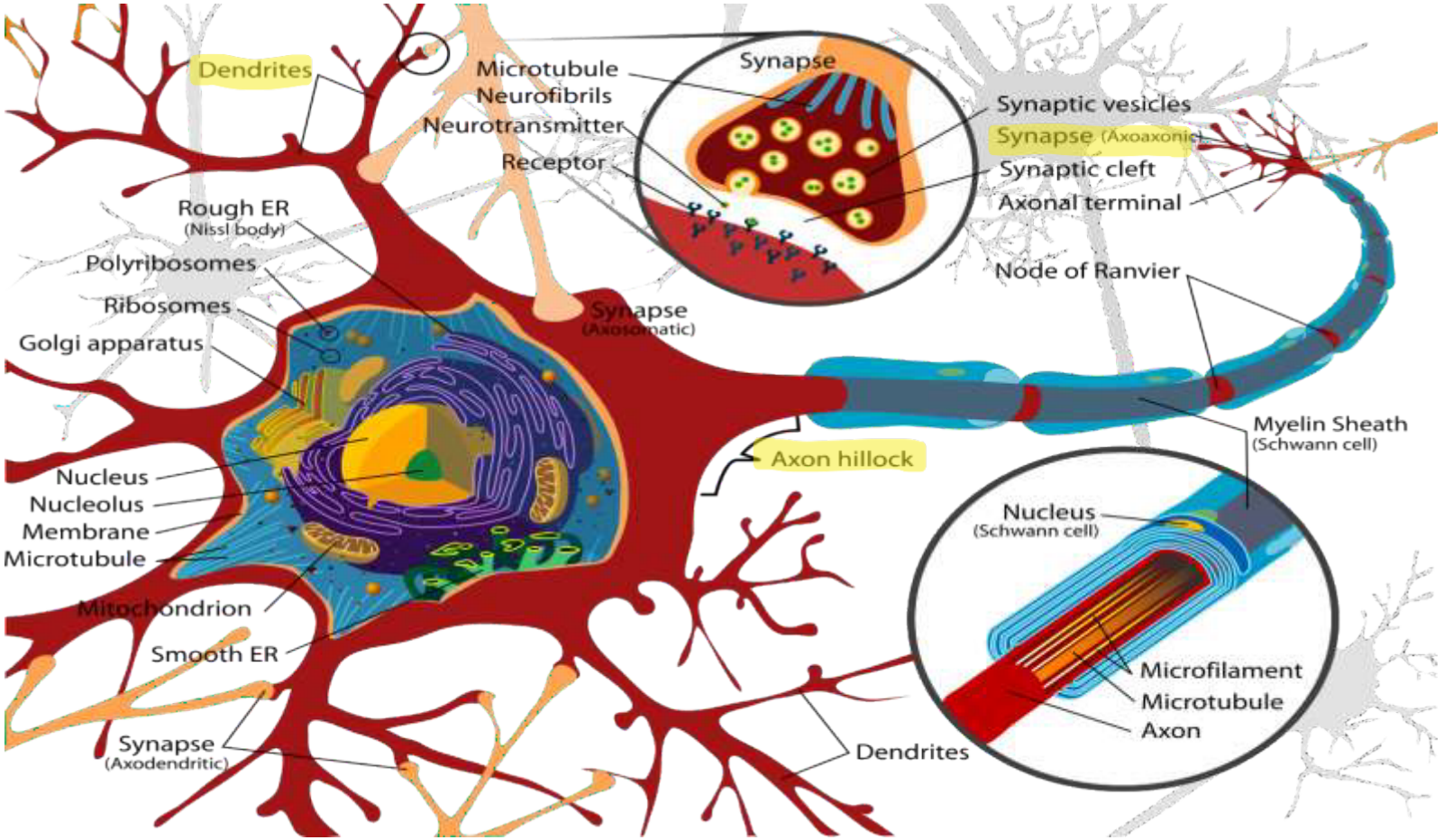
Energy Efficiency



	Weight	Space	Processor Speed	Energy Efficiency
	3 pounds (1.4 kg)	1/6 basketball (80 cubic inches or 1,300 cm^3)	Up to 1,000,000 trillion operations per second	20 watts
	150 tons	Basketball court (cabinets over 4,350 square feet, or 400 m^2)	93,000 trillion operations per second	10 million watts

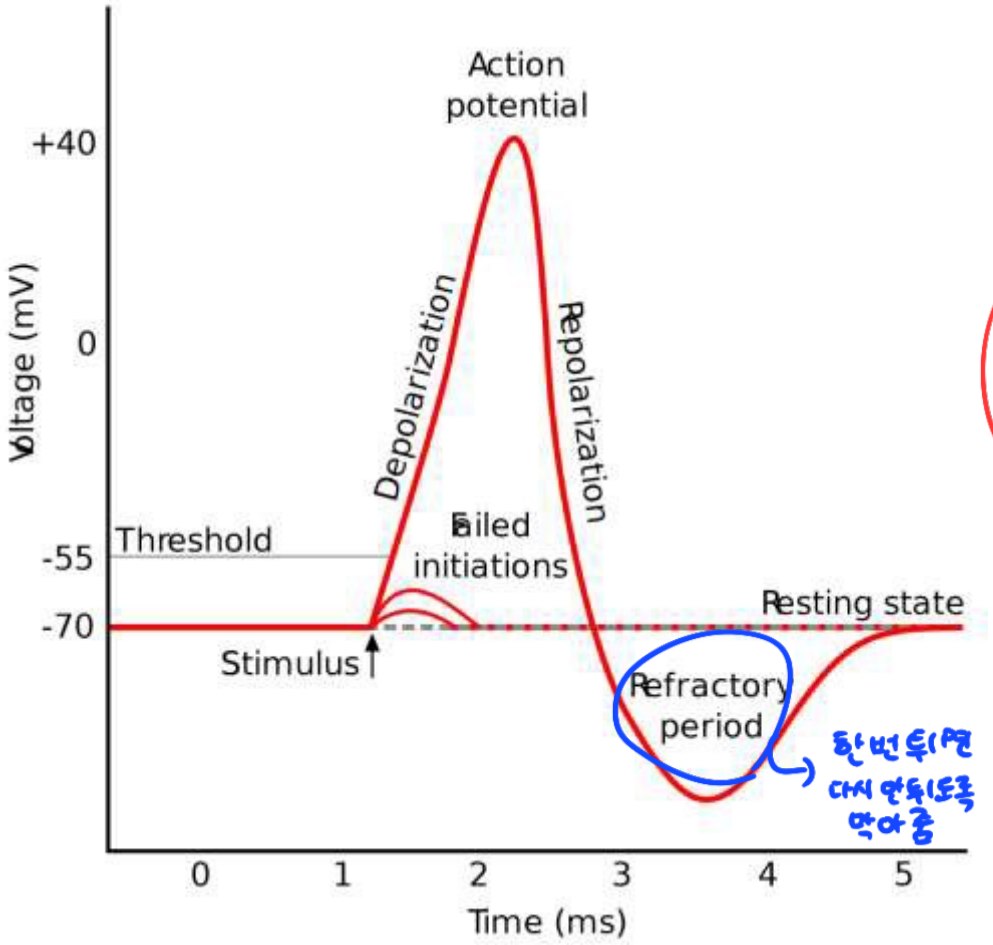


Neuron

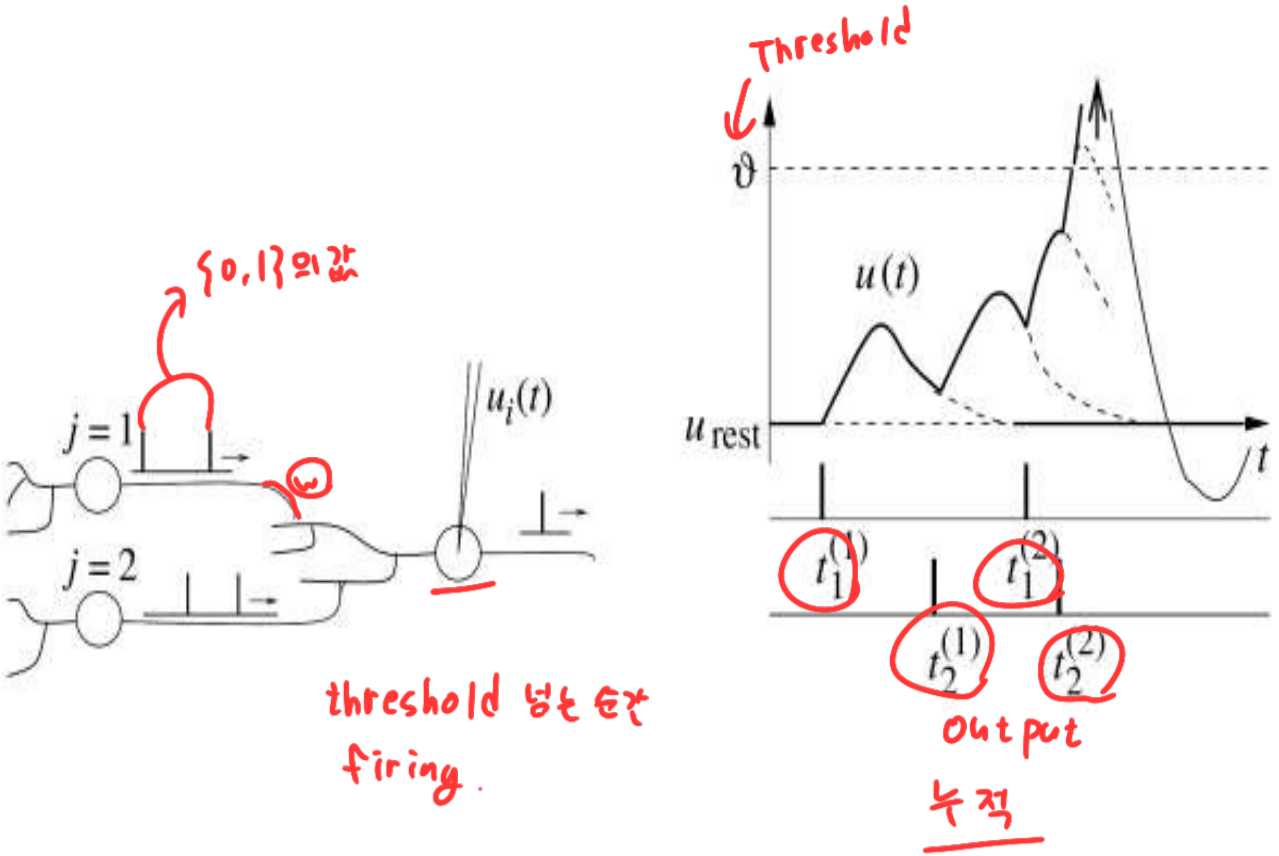

Dendrites
Microtubule
Neurofibrils
Neurotransmitter
Receptor
Synapse
Synaptic vesicles
Synapse (Axoaxonic)
Synaptic cleft
Axonal terminal
Rough ER
(Nissl body)
Polyribosomes
Ribosomes
Golgi apparatus
Synapse
(Axosomatic)
Node of Ranvier
Myelin Sheath
(Schwann cell)
Axon hillock
Nucleus
Nucleolus
Membrane
Microtubule
Mitochondrion
Smooth ER
Synapse
(Axodendritic)
Dendrites
Nucleus
(Schwann cell)
Microfilament
Microtubule
Axon

Potential of Neuron

~ spike



Presynaptic Spikes



Spiking Neuron Models: Single Neurons, Populations, Plasticity. Cambridge University Press. 2002. Page 5.

Spiking Neuron Models

Miscellaneous models:

- **Hodgkin-Huxley** model
- **Izhikevish** model
- **Leaky Integrate-and-Fire (LIF)** model
- Spike Response model (SRM)

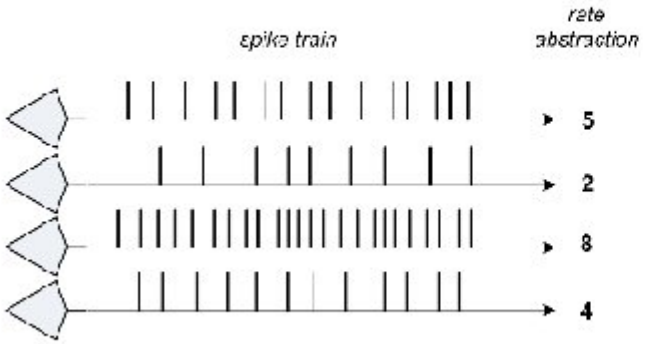
……

Neural Coding Schemes

- **Rate** Coding
- **Temporal** Coding
- **Sparse** Coding

Rate Coding & Temporal Coding

- Rate Coding

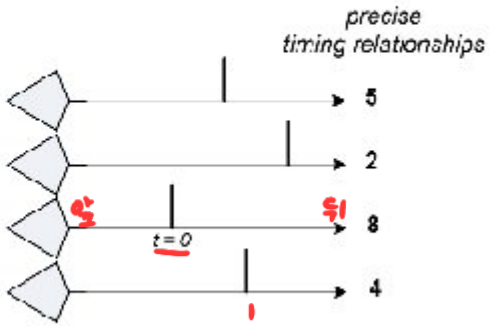


포아송 분포를 따름

값의 크기에 따라 발생 횟수 달라짐

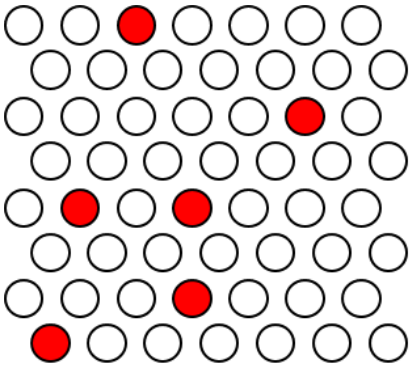
- Temporal Coding

inverse coding method: $x_i = t_i - t_{min}$

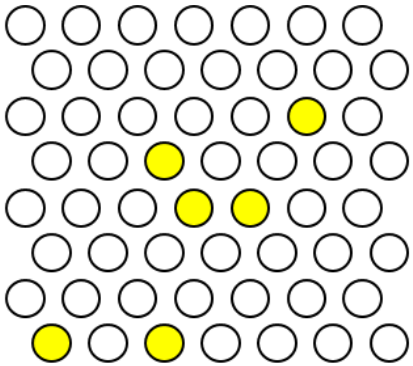


값이 클수록 앞에 있다.

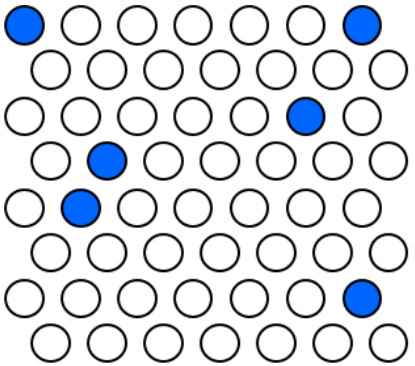
Sparse Coding



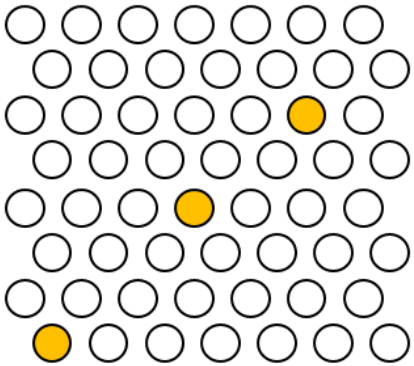
Cat



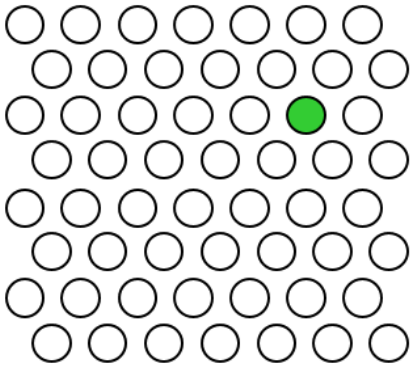
Dog



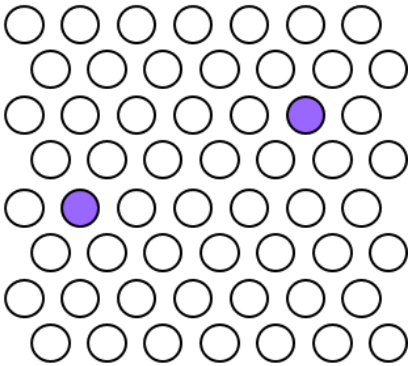
Fish



Cat ∩ Dog



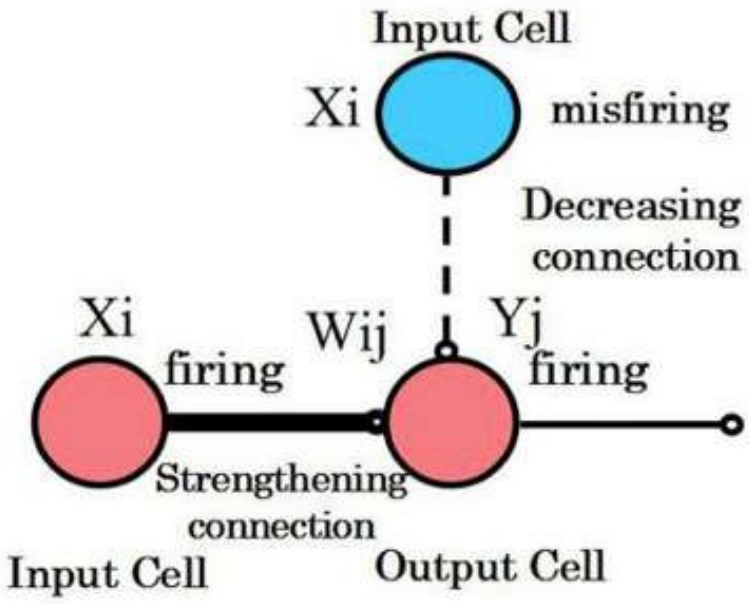
Dog ∩ Fish



Cat ∩ Fish

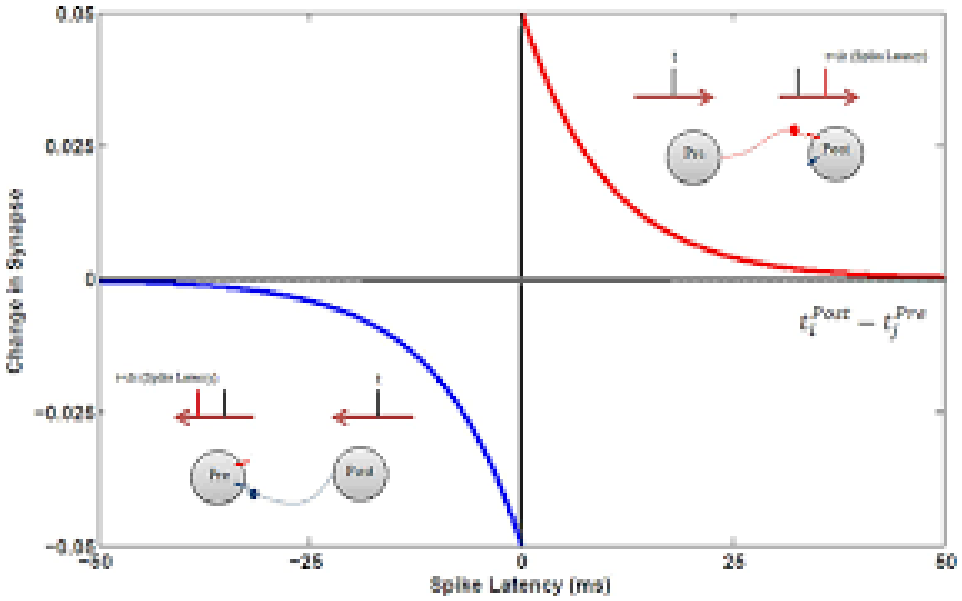
Hebbian Learning Rule

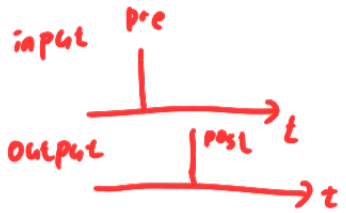
- "When an axon of cell A is near enough to **excite** a cell B and **re peatedly** or **persistently** takes part in **firing** it, some growth proc ess or metabolic change takes place in one or both cells such that A's **efficiency**, as one of the cells firing B, is **increased**.“*



Donald O. Hebb, The Organization of Behavior: A Neuropsychological Theory. 1949 & 2002. Page 62.

Spike Timing Dependent Plasticity (STDP)

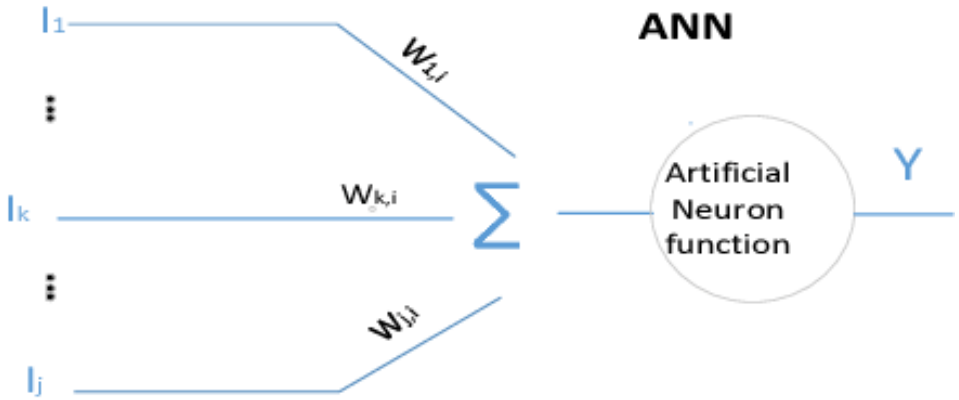


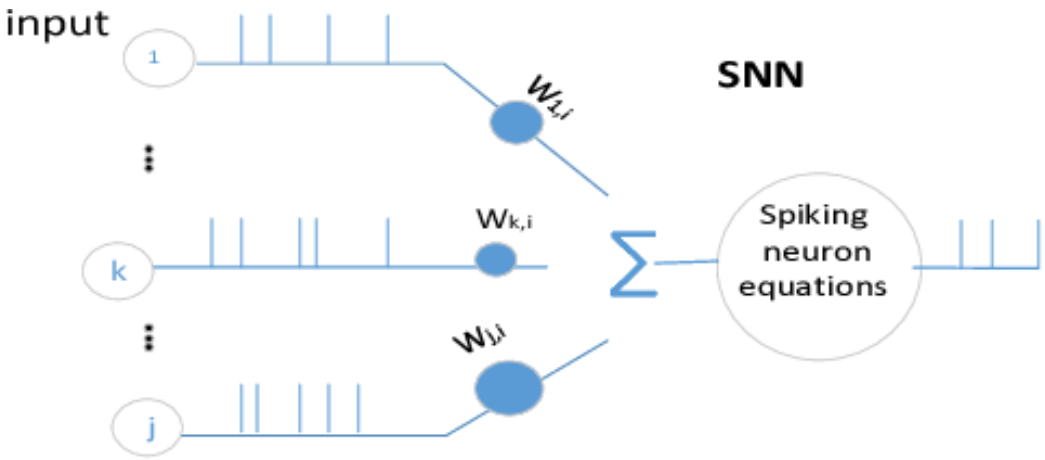


$$\Delta w = \begin{cases} +A_+ \exp\left(-\frac{\Delta t}{t_{pre}}\right) & if\ \Delta t > 0 \\ -A_- \exp\left(+\frac{\Delta t}{t_{post}}\right) & if\ \Delta t \leq 0 \end{cases}$$

$$\Delta t = t_{post} - t_{pre}$$

ANN vs SNN


ANN
I_1
$W_{1,i}$
I_k
$W_{k,i}$
$W_{j,i}$
I_j
Artificial Neuron function
Y


input
SNN
1
$W_{1,i}$
$W_{k,i}$
k
$W_{j,i}$
j
Spiking neuron equations