

Izhikevich Neuronal Spiking model

Izhikevich et al. 2003, 2004

- This model provides a computationally efficient approach to replicate the rich spiking dynamics of cortical neurons (single neuronal level and large-scale network level).
- This model explains the different firing patterns for different current impulses that the neurons might receive.

Model Characteristics:

- Dynamic model
- Deterministic model
- Continuous in time
- Single scale model
- Mechanistic model (derived from bifurcation analysis)

Model Variables and Parameters:

v – membrane potential

u – membrane recovery variable

a – time scale of u

b – sensitivity of u , to subthreshold fluctuations in v
 c – after-spike reset value of v
 d – after-spike reset of u

Salient features:

- 2 Variable model** – Uses two dimensional system of ODEs involving membrane potential and membrane recovery variable.
- Change in model parameters could **explain 20 different cortical spiking dynamics**.
- Most computationally efficient model – 13 flops to simulate 1ms of neuronal spiking.

Limitations:

- Not biophysically exact (due to membrane potential resetting function and unaccountability of specific ion concentration variations).
- Cannot effectively explain amplitude encoding of information (due to the resetting function, as $dt \rightarrow 0$, the $v(\text{firing}) \rightarrow 30 \text{ mV}$).

Model Equations:

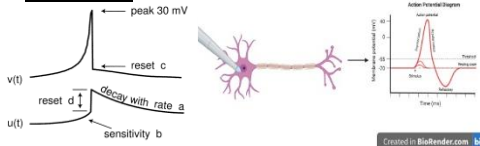
$$\frac{dv}{dt} = 0.04v^2 + 5v + 140 - u + I \quad \text{and} \quad \frac{du}{dt} = a(bv - u)$$

Voltage resetting ($v \geq 30 \text{ mV}$):

$$v \leftarrow c$$

$$u \leftarrow u + d$$

Model Results:



Created in BioRender.com

