

# Entropy Rate and Statistical Complexity of Dynamical Neurons

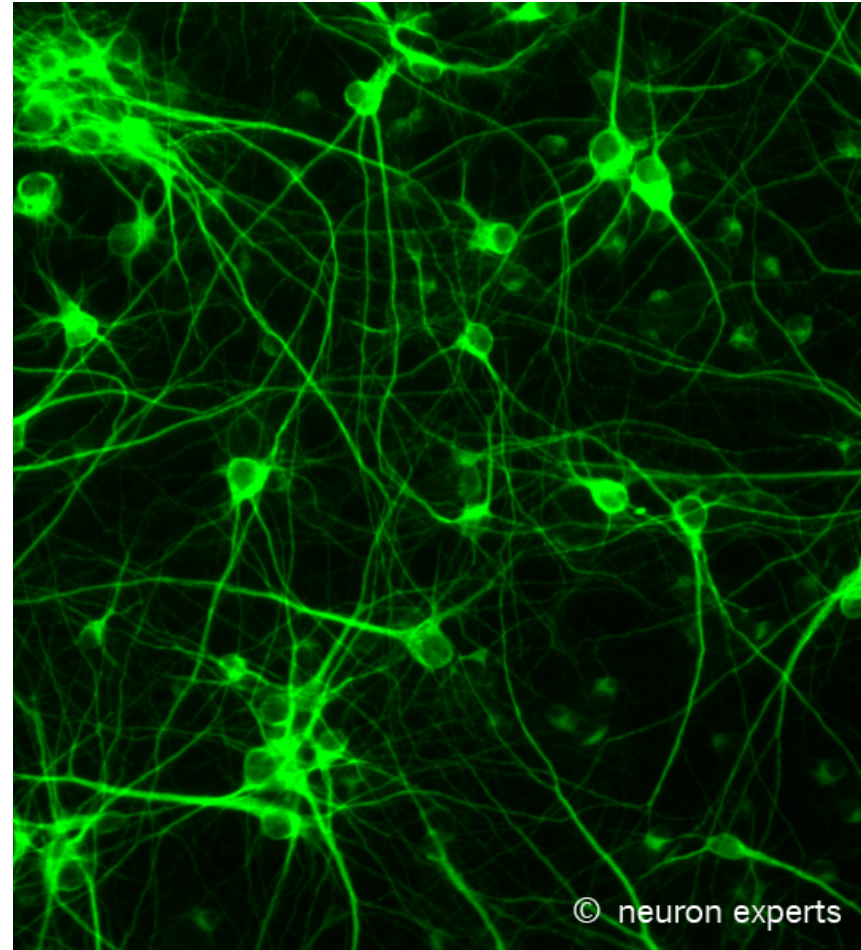
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# Spiking Neurons

- Membrane Potential = differences in ion concentrations
- Input  $\rightarrow$  change in membrane potential
- Spiking
  - Neuron quiet: '0'
  - Neuron fires: '1'

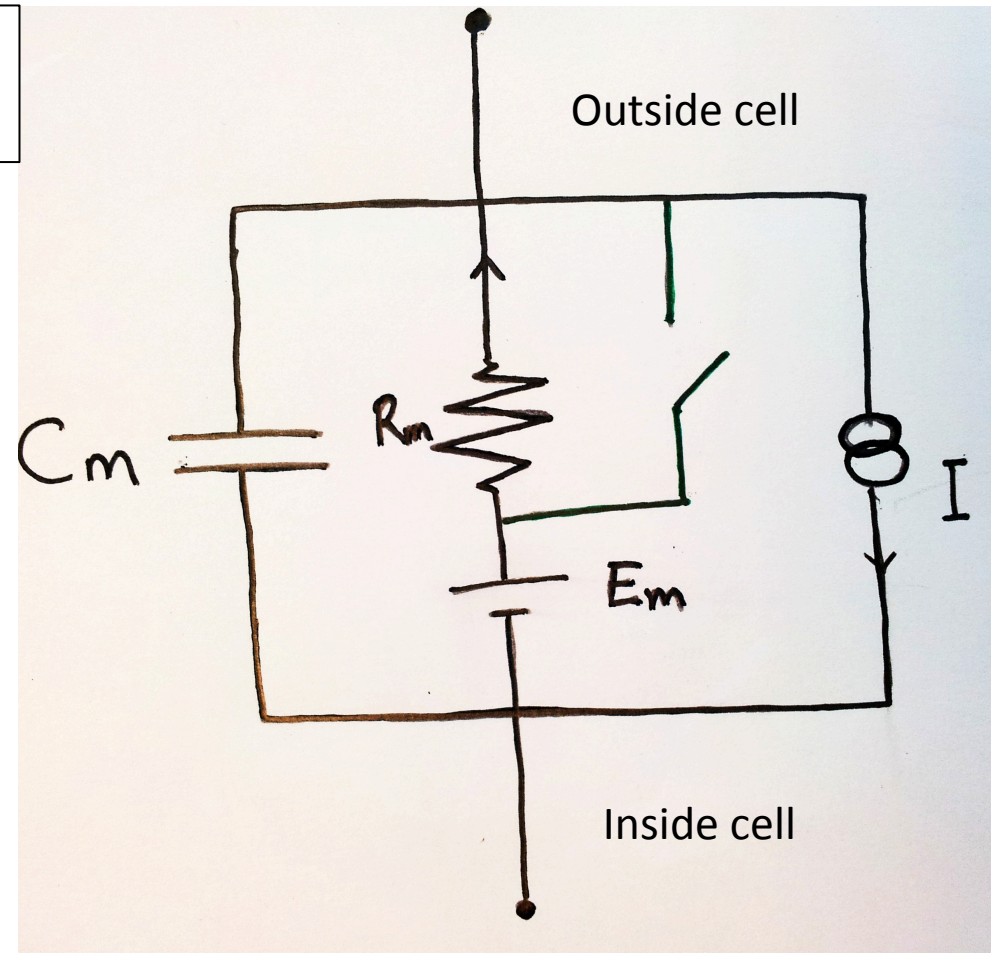


# Linear Integrate and Fire Neuron

$$\text{LIF: } C_m \frac{dV}{dt} = -\frac{V - E_m}{R_m} + I$$

- When  $V$  reaches  $V_{\text{threshold}}$
- switch is closed
  - $V$  is reset to  $E_m$

$C_m$  = membrane capacitance  
 $R_m$  = membrane resistance  
 $E_m$  = resting potential  
 $I$  = electrode current

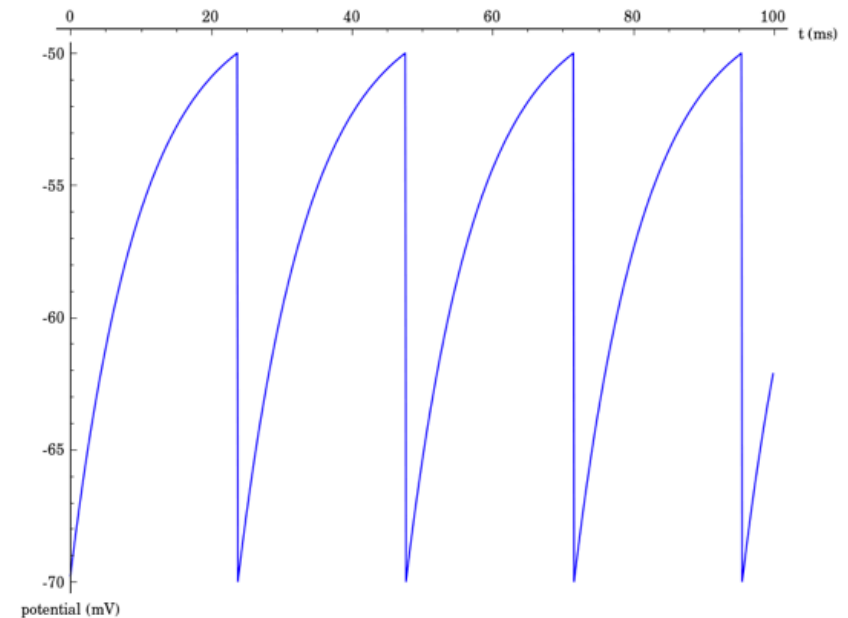


# Linear Integrate and Fire Neuron

$$\text{LIF: } C_m \frac{dV}{dt} = - \frac{V - E_m}{R_m} + I$$

- When  $V$  reaches  $V_{\text{threshold}}$
- switch is closed
  - $V$  is reset to  $E_m$

Regular current input  $I$



# Linear Integrate and Fire Neuron

$$\text{LIF: } C_m \frac{dV}{dt} = - \frac{V - E_m}{R_m} + I$$

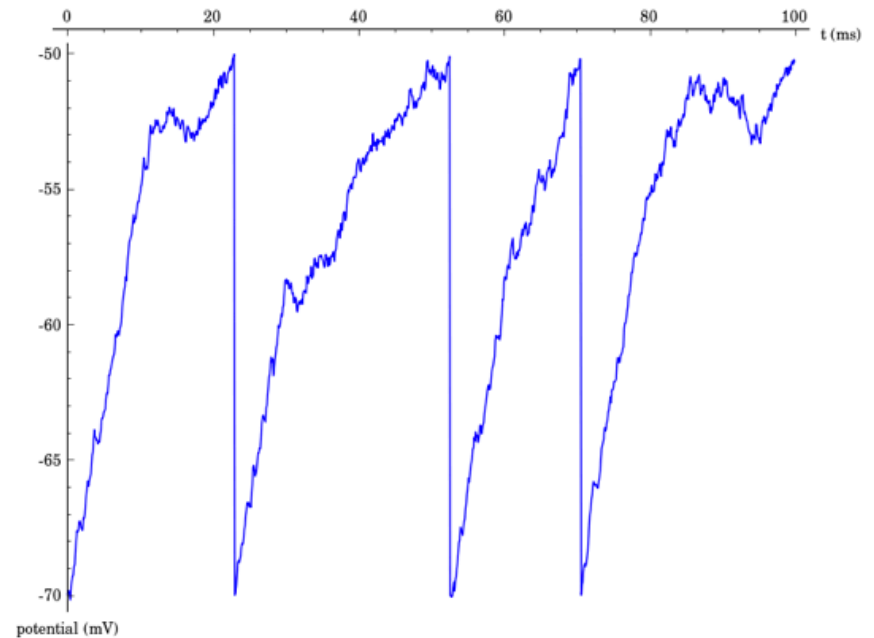
When  $V$  reaches  $V_{\text{threshold}}$

- switch is closed
- $V$  is reset to  $E_m$
- the neuron fires

Make binary string:

- check for spike in some time interval
- spike  $\rightarrow$  '1'
- no spike  $\rightarrow$  '0'

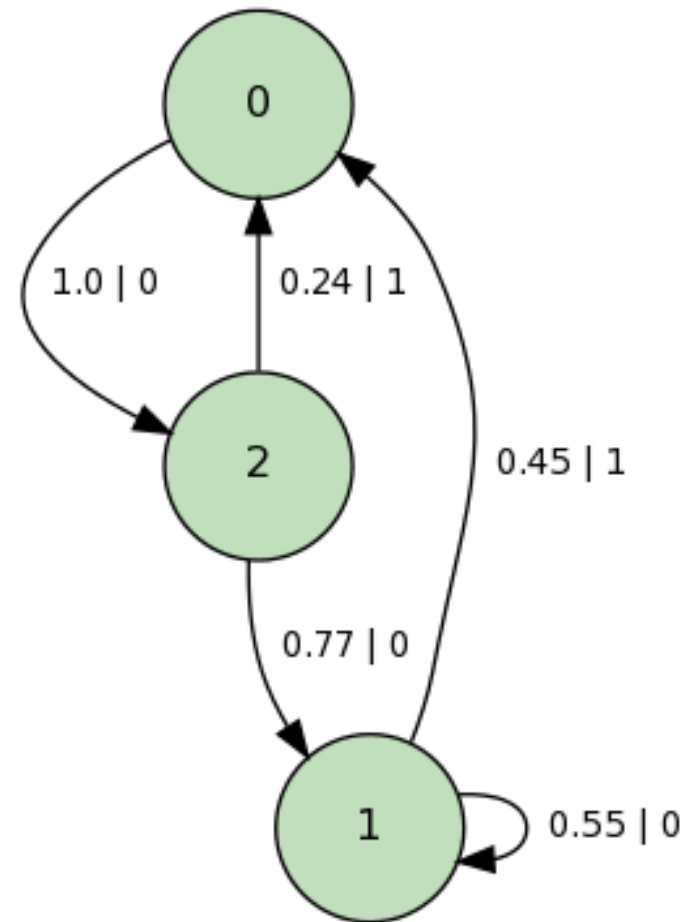
Irregular current input  $I$  (white noise)



```
['0', '1', '0', '0', '0', '0', '1', '0', '0', '1', '0', '0', '0', '1',  
'0', '0', '1', '0', '0', '0', '0', '0', '0', '0', '1', '0', '0', '0',  
'1', '0', '0', '0', '0', '0', '1', '0', '0', '0', '1', '0', '0', '0',  
'0', '1', '0', '0', '0', '0', '0', '1', '0', '0', '0', '1', '0', '0',
```

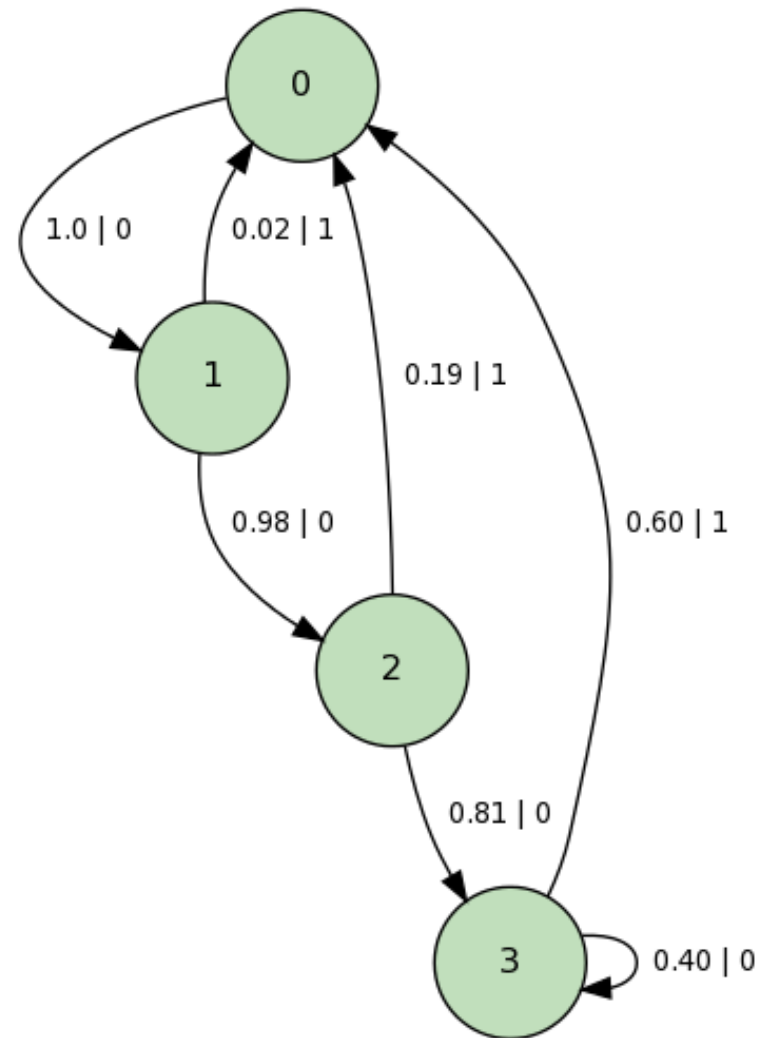
## Parse Tree – inferred eM

- Morph length: 3
- Tree length: 16



## Bayesian Inference

- Prior Library of renewal processes
- Bayesian Inference → consider machines with more than 6 states.



probability for this model: 0.987895

## Next steps:

- More realistic models
  - Quadratic Integrate and Fire Model
  - Izhikevich Model
- Couple neurons together?