CTRNN Continuous-Time Recurrent Neural Network

The clj-ctrnn library simulates CTRNNs using the *forward Euler method* for approximating a series of solutions to the ordinary differential equation that govern neuron membrane potentials. The equation is:

$$\dot{y}_i = \frac{1}{\tau_i}\left(-y_i + \sum_{j=1}^{N} w_{ji}\sigma(y_j + \theta_j) + I_i\right) \tag{1}$$

where:

τ_i:	time-constant of post-synaptic neuron
y_i:	membrane potential of post-synaptic neuron
w_{ji}:	weight of connection between pre-synaptic neuron j and post-synaptic neuron
$\sigma(x)$:	the sigmoid activation function in equation 2
y_j:	membrane potential of pre-synaptic neuron j
θ_j:	bias (input sensivity) of pre-synaptic neuron j
I_i:	any external input (such as a sensor reading) to post-synaptic node

$$\sigma(x) = \frac{1}{1 + e^{-x}} \tag{2}$$

For each step in time, t, with $t < \tau_i$, clj-ctrnn will

1. Approximate the rate of membrane potential change, $\frac{\Delta y}{\Delta t}$, for all neurons

2. Synchronously update all membrane potentials $y_{i+1} = y_i + \frac{\Delta y}{\Delta t} \cdot t$

3. Commit the new network state