Spiking neural networks to model Hydra nerve nets

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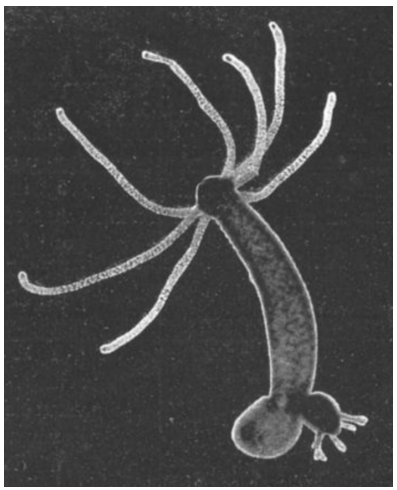
Slide Title

Definition

Introduce ANNs, why they suck for bio, introduce SNNs, mention why they're better.

Evolutionary History of H. vulgaris

- *Hydra* are small, freshwater hydrozoans (family Cnidaria)
- Believed to have originated around 60 Mya [3]
- Cnidarians first appeared around 580 Mya, haven't changed much since
- Ideal for studying development of common features across animals



Nerve Nets

- *Hydra* have diffuse nerve nets rather than a CNS
- Once mature, a constant density gradient of neurons is maintained [2]
-

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How we'll adapt the model for Hydra

Neuron Model

- Leaky integrate-and-fire model:

$$\frac{dV_m}{dt} = \frac{1}{C_m}\left(-\frac{(V_m - V_m^{eq})}{R_m} + I_{ext}\right)$$

- Computationally simpler than Hodgkin-Huxley
- Models neuron as RC circuit with leak term
- Doesn't explicitly specify spiking behavior or refractory period, but easy to implement using iterative ODE methods
- Possible implementation:

```
if V(t+1) > threshold:
   V(t)   <- spike
   V(t+1) <- hyperpolarize
if t < refractory period:
   V(t+1) <- hyperpolarize
```

Antagonistic Neural Circuits

- Assume each neuron of RP1 emits an inhibitory neurotransmitter E_{RP1} when spiking, and similarly for CB with E_{CB}. Using normalized concentrations, the model is:

$$\frac{dV_{RP1}}{dt} = \frac{1}{C_{RP1}}\left(-\frac{(V_{RP1} - V_{RP1}^{eq})}{R_{RP1}} + I_{ext}\,(1 - E_{CB})\right)$$

$$\frac{dV_{CB}}{dt} = \frac{1}{C_{CB}}\left(-\frac{(V_{CB} - V_{CB}^{eq})}{R_{CB}} + I_{ext}\,(1 - E_{RP1})\right)$$

$$\frac{dE_{RP1}}{dt} = d_{RP1}E_{RP1} \qquad \frac{dE_{CB}}{dt} = d_{CB}E_{CB}$$

Antagonistic Neural Circuits (cont.)

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Maybe tensor stuff?

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It'd be cool to build this, gather real data, and test. Cool to adapt to larger and more complex organisms.

References

[1] Hydra imaging

[2] Hydra constant density

[3] Hydra origination date