Principles of the Brain’s communication network
and possible applications

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Abstract

The goal of this presentation is multi-fold:
- **Summarize some basic facts about brain science**
- The first measurement neural spike propagation by Helmholtz (Frog)
- Hodkins and Huxley explain spike propagation (1950 Nobel Prize)
- Review HH-50's discovery
- Explain how this can be implemented in electronics
- Applications of spike communication on silicon
- Densities approach or even surpass those of the brain
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The PDFs cited here is: https://auditorymodels.org/index.php?n=Main.Publications
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Overview of Human brain

Neurons:

- Properties of Neurons
- The anatomy of the neuron has
  - The brain’s communication network is based on action potentials (spikes)
  - Each neuron is typically part of a large network
  - The brain contains an estimated 10^{11} (100 billion) neurons
  - Personal lives of Golgi vs. Cajal
Overview of Human brain

Neurons:

- Properties of **NEURONS**
  - The **ANATOMY** of the neuron has an input **DENDRITE**, an output **SYNAPSE**, and a cell body.
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  - Each neuron is typically part of a large **NETWORKS OF NEURONS**.
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Helmholtz first measures spike propagation

**Figure:** Helmholtz’ system for measuring neural spike speed in 1830

**Figure:** First oscillogram of a neural spike.
HH-50 voltage-clamp experiment on Squid nerve
HH-50 neural-clamp Results

(a) $V(t)$ vs. $t$

(b) Ion currents $J_K(V_j, t)$, $J_{ion}(V_j, t)$, $J_{Na}(V_j, t)$

(c) Conductances $G_{Na}(V_j, t)$, $G_K(V_j, t)$
3 Diode model of a neural spike

```
.dtrans 0 5e-3 0 1e-7
PULSE(0 .155e-4 1e-6 1e-6 5e-5 5e-2 1)
```

```
R_src 50
V_in

Di
R_K_src .1
V_k .090

Di
R_Na .1
4.9575nV

Di
R_Na_src .5
V_Na .050

C_myelin 1e-6
R_K 5000
```
Conclusions

Summary of the properties of NEURONs

- Gated channels: $\text{Na}^+$, $\text{K}^+$, $\text{Cl}^-$
- Neurotransmitter signaling: TYPES
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Copies of my documents

https://jontalle.web.engr.illinois.edu/Public