Boulder Lecture 2

FOLLOW-UP Q's: from Lecture 1

~41,000

ATP's per spike : ~~24,000 per neuron~~

~~24,000 ATP per bit~~

all about
the pumps
& vesicle cycling

SQUID GIANT AXON: controls the pump
for jet propulsion in escape

unmyelinated

CONSTRAINTS!

HH ← what matters?
AP shape matters for speed of trans
& all ID

FN model rep's spike train stats very well

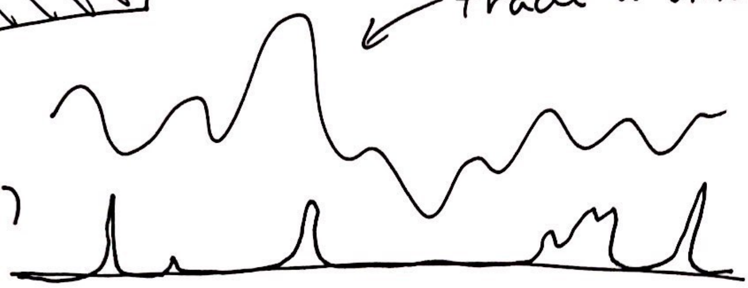
Frankfurt ⟶ Minsk
↓ South
*
Warsaw

Q: DO YOU WANT HANDWRITTEN NOTES?

info'n in spike trains ← {see LaTeX NOTES

CBI 4 → comment on units

trade a stim avg for a time avg.



p(spike)

stim (t)

m (t)

↑ m for "movie"

$$I(m;r) = S(m) - S(m|r)$$

discrete response states

discrete bins in time, Δt

$$S(m|r) = \sum_{r_i} P(r_i)\left[-\sum_{m_i} P(m|r)\log_2 P(m|r)\right]$$

$$P(m|r) = \frac{P(r|m)P(m)}{P(r)}$$

now write:

$$I(m;r) = S(m) - S(m|r)$$

$$= -\sum_{m} p(m)\log P(m)$$

$$+\left[\sum_{r_i} P(r_i)\sum_{m_i} P(m_i|r_i)\log P(m_i|r_i)\right]$$

now assume $r \in \{0,1\}$ ← no spike or spike

$$= -\sum_{m} p(m)\log P(m) + \sum_{m} P(r=1)\left(\frac{P(r=1|m)P(m)}{P(r=1)}\right)\log\left(\;''\;\right)$$

$$+ P(r=0)\left(\frac{P(r=0|m)P(m)}{P(r=0)}\right)\log\left(\;''\;\right)$$

Scanned with CamScanner

$$P(r=0) = 1 - P(r=1)$$

gather terms w/ log $P(m)$

$$I(m;r) = -\sum_m P(m) \log P(m) \left[\cancel{1 - P(r=1|m)} + \cancel{(1 - P(r=1|m))} \right]$$

$$+ \sum_m P(m) \left[P(r=1|m) \log \frac{P(r=1|m)}{P(r=1)} \right.$$

$$\left. + (1 - P(r=1|m)) \log \left(\frac{1 - P(r=1|m)}{1 - P(r=1)} \right) \right]$$

$$= \sum_m P(m) \left\{ P(r=1|m) \log \left(\frac{P(r=1|m)}{P(r=1)} \right) + 1 - p(r=1|m) \log \frac{1 - p(r=1|m)}{1 - p(r=1)} \right\}$$

$$\sum_m P(m) f(m) = \frac{1}{N_t} \sum_t f(t)$$

firing rate

$$P(6=1 | m = m(t_i)) = \mu(t_i) \Delta t$$

$$\Delta t \to 0 \qquad \log(1 - \mu \Delta t) \approx -\mu \Delta t$$

$$\to I(m;r) \approx \frac{1}{N_t} \sum_{t_i} \left[\mu(t_i) \Delta t \log \frac{\mu(t_i)}{\bar{\mu}} \right]$$

in bits per bin

$$\left.\frac{I}{\bar{\mu} \Delta t}\right\} \text{bits per spike} = \frac{1}{\underbrace{\Delta t N_t}_{= T}} \sum_{t_i} \Delta t \frac{\mu(t_i)}{\bar{\mu}} \log \frac{\mu(t_i)}{\bar{\mu}}$$

spikes/sec

$$I(\text{spike};\text{time}) = \frac{1}{N}\sum_{t_i}\left[r(t_i)\,\Delta t \log_2 \frac{r(t_i)}{\bar{r}}\right]$$

$$I = \frac{1}{N}\int_0^T r(t)\,dt \log\left(\frac{r(t)}{\bar{r}}\right)$$

bits per bin

$$I/\bar{r}\Delta t = \frac{1}{T}\int_0^T dt\, \frac{r(t)}{\bar{r}} \log \frac{r(t)}{\bar{r}}$$

bits per spike

$$I/\Delta t = \frac{1}{T}\int_0^T dt\, r(t) \log \frac{r(t)}{\bar{r}}$$

bits/sec