Entropy Estimate of Neuronal Firings of Modeled Globular Bushy Cells

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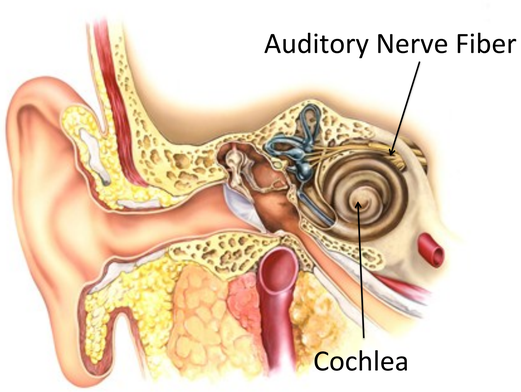
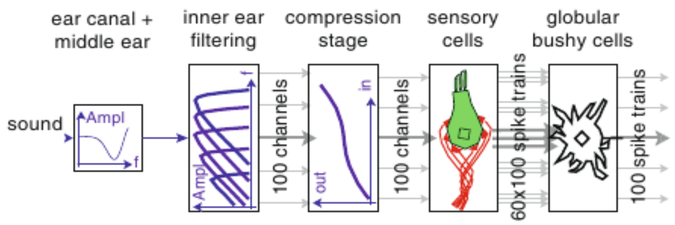
Motivation

•Analyze the relationship between the predictability of the globular bushy cells' responses and the frequency content in the auditory signals using a **time-varying and time dependent entropy estimation.**
•The analysis quantifies the temporal **precision of the neuronal coding** and the **memory in the neuronal response.**

Inner Ear Model



•**Cochlea:** spectral decomposition of the acoustic stimuli in 100 frequency channels.
•**Auditory Nerve Fibers (ANF):** each frequency channel is coded by 60 ANFs.
•**Globular Bushy Cells (GBCs):** One GBC per channel integrates the inputs from the ANFs, improving the timing precision of each individual spike.



A Time-Varying and Time-Dependent Entropy Estimation

Entropy Estimation

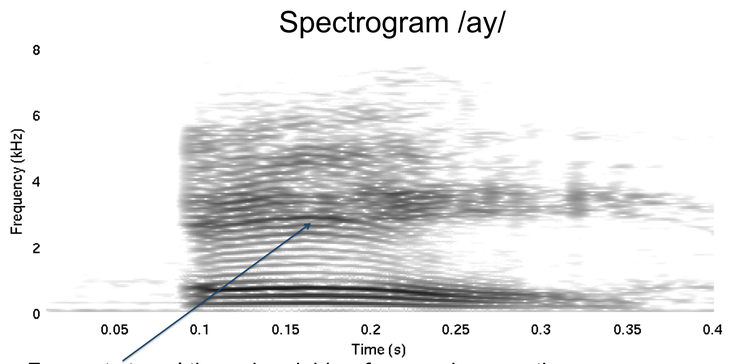
- Discretize spike trains : ***binning***
- Evaluate entropy of a sequence of *N* sliding windows of size *T*

$$H(W_1 \ldots W_N) = \sum_{i=1}^{N} H(W_i | W_1 \ldots W_{i-1})$$

- Considering the property of the conditional entropy "conditional cannot increase entropy"

$$H(W_i | W_1 \ldots W_{i-1}) \leq H(W_i) \implies$$
$$H(W_1 \ldots W_N) \leq \sum_{i=1}^{N} H(W_i)$$

to obtain an upper bound to the entropy estimate, and for each word consider the past values of the codeword.



Aknowledgement

German Ministry of Education and Research and the Alexander von Humboldt Foundation for their financial support

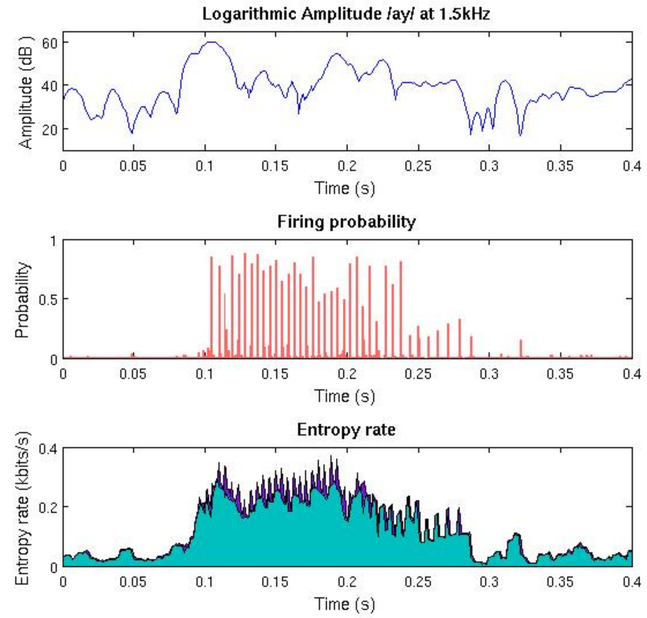
Literature

A. Grigorescu, M. Rudnicki, M. Isik, W. Hemmert, and S. Rini. Improving the entropy estimate of neuronal firings of modeled cochlear nucleus neurons. *Arxiv preprint arXiv:1204.5001*, 2012.

W. Hemmert, M. Holmberg, and U. Ramacher. Temporal sound processing by cochlear nucleus octopus neurons. *Artificial neural networks: biological inspirations–ICANN 2005*, pages 583–588, 2005.

Results

Responses of utterance from the ISOLET data base /ay/ male speaker
CF = 1.5kHz
- Bin size = 1ms
- Window length = 10 ms
- Past size = 20 ms



Conclusions

The time-varying and time-dependent entropy is suitable for analyzing neuronal responses:
• The precise information on the temporal evolution of the frequency content is not provided by the firing probability
• This method shows a high correlation between the entropy estimate and the frequency content of the utterance
• This method provides us with the memory of the neural process