Onset Detection with Spiking Neural Network

Huang-Yu, Yao
Institude of Systems Neuroscience

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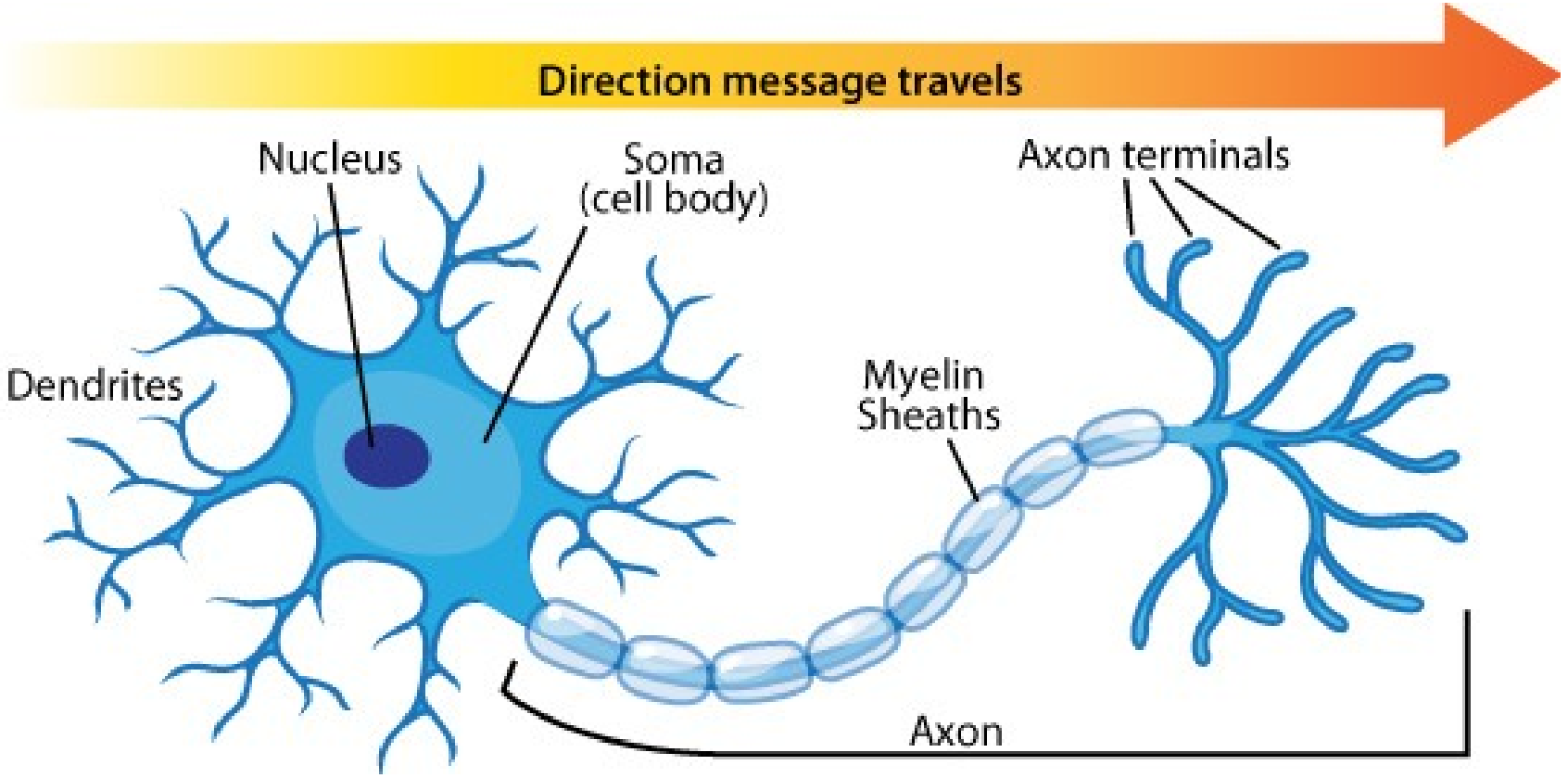
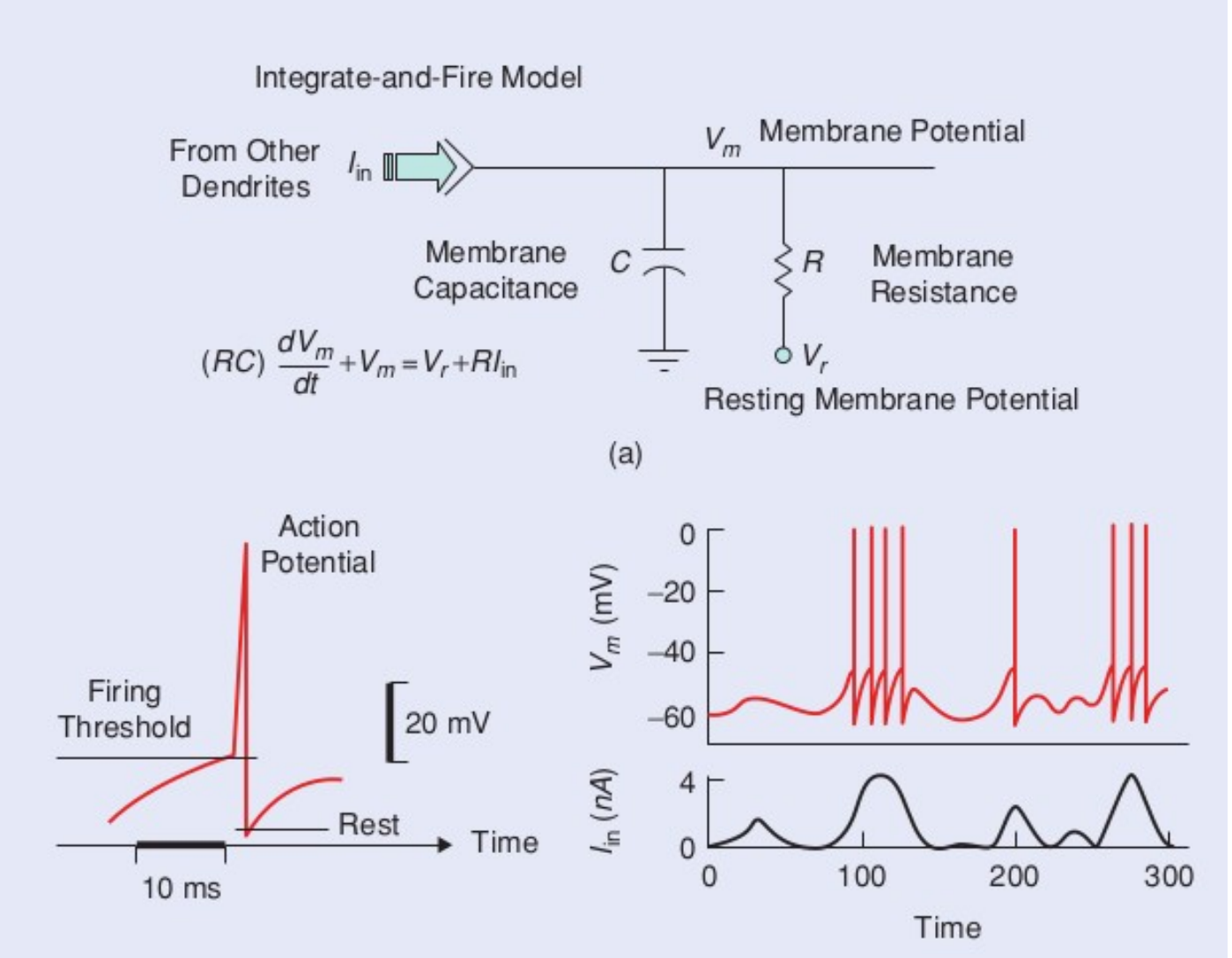
Biological neuron



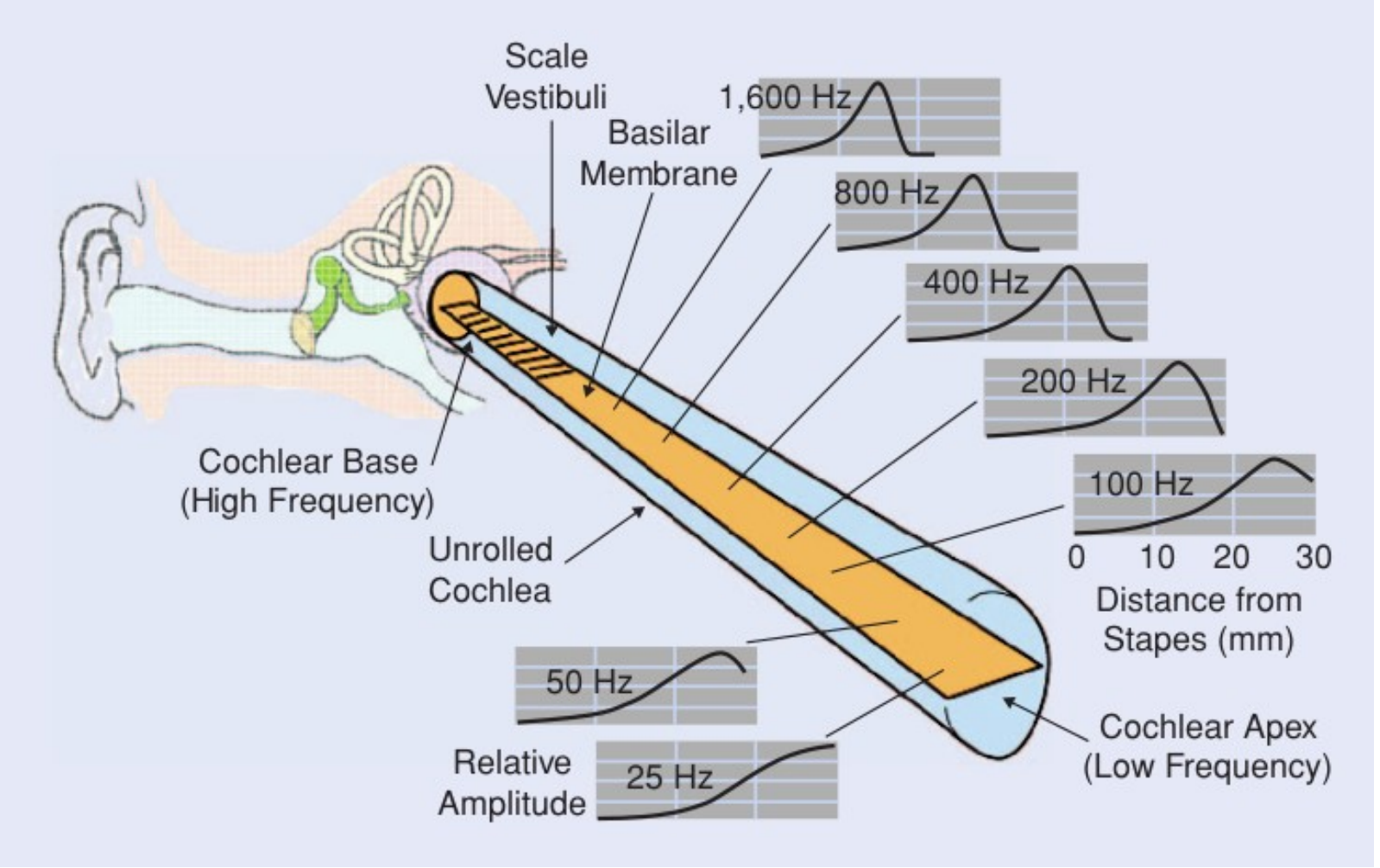
https://askabiologist.asu.edu/neuron-anatomy

Spiking neural model



R. Munkong and B. Juang, "Auditory perception and cognition," in IEEE Signal Processing Magazine, vol. 25, no. 3, pp. 98-117, May 2008.

Auditory periphery



R. Munkong and B. Juang, "Auditory perception and cognition," in IEEE Signal Processing Magazine, vol. 25, no. 3, pp. 98-117, May 2008.

Previous work

IEEE TRANSACTIONS ON NEURAL NETWORKS, VOL. 15, NO. 5, SEPTEMBER 2004 1125

Robust Sound Onset Detection Using Leaky Integrate-and-Fire Neurons With Depressing Synapses

Leslie S. Smith, *Senior Member, IEEE,* and Dagmar S. Fraser

***Abstract*—A biologically inspired technique for detecting onsets in sound is presented. Outputs from a cochlea-like filter are spike coded, in a way similar to the auditory nerve (AN). These AN-like spikes are presented to a leaky integrate-and-fire neuron through a depressing synapse. Onsets are detected with essentially zero latency relative to these AN spikes. Onset detection results for a tone burst, musical sounds and the DARPA/NIST TIMIT speech corpus are presented.**

***Index Terms*—Depressing synapse, integrate-and-fire neuron, onset detection.**

I. Introduction

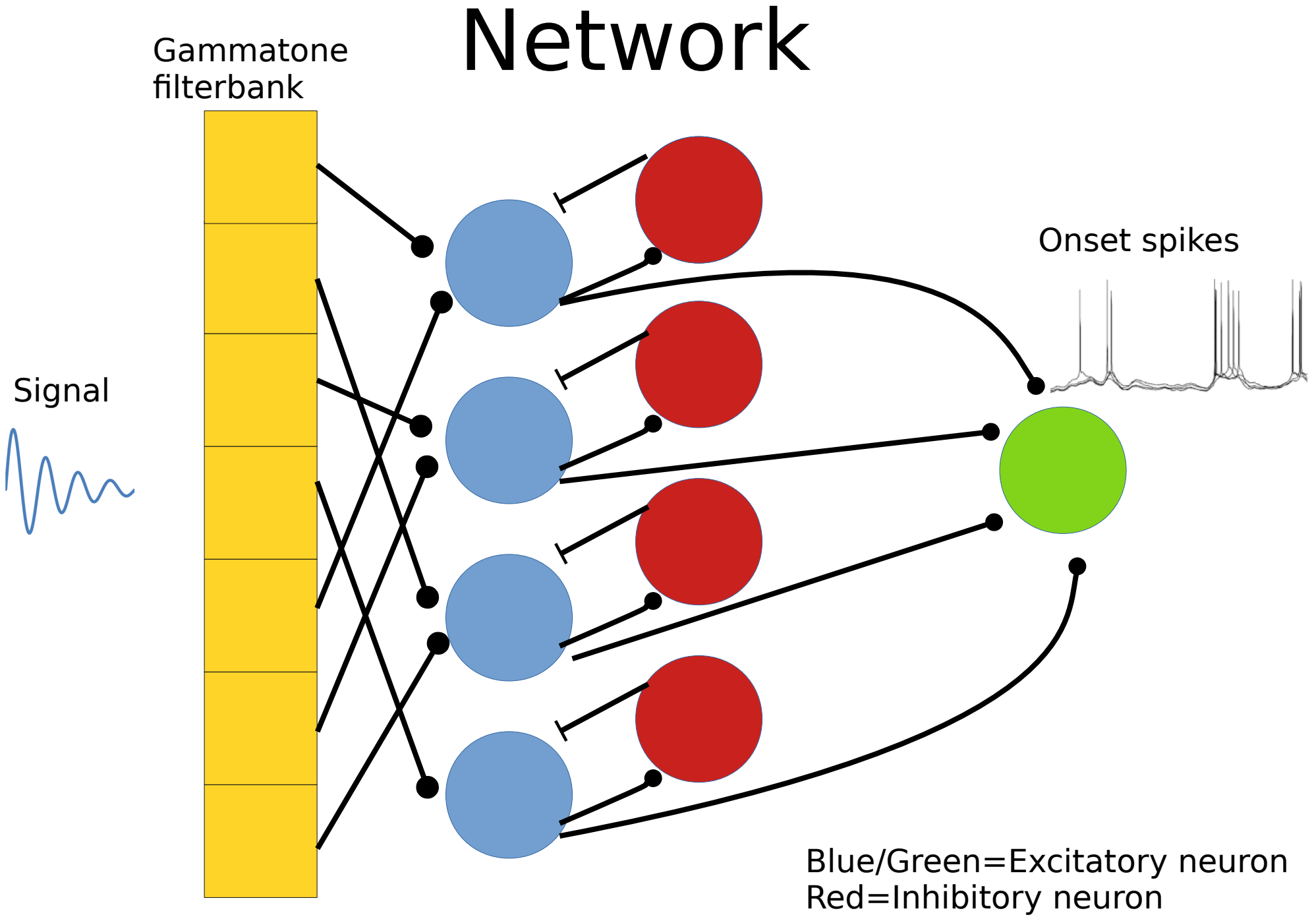
THIS PAPER describes a biologically inspired technique for *onset detection.* Onsets occur at the start of certain perceptible changes in a sound. In [1], the term *onset detection* refers to the detection of discrete events in acoustic sig- in the cochlear nucleus spiking strongly at stimulus start [2], [3]. Therefore, modeling aspects of the early auditory system (the cochlea, auditory nerve (AN), and cochlear nucleus) might offer engineering insight into early auditory processing. From an ecological perspective there are good reasons to believe that onsets provide a useful cue. The onset comes at the start of the sound (or at the beginning of some change in the sound), and is, therefore, useful for priming a response. Initial onsets are relatively undamaged by reverberation, since the first onset in the received signal will normally be from the direct path, and those onsets caused by reflections will generally be smaller. Indeed, these are normally ignored by animals when they estimate the location of a sound source. (This is known as the precedence effect, or law of the first wavefront [4].) Other cues such as offsets are severely smeared out in time in reverberant environments.

Tools

- Gammatone filter – cochlea and auditory nerve fiber

- SNN simulator – higher level neural circuit

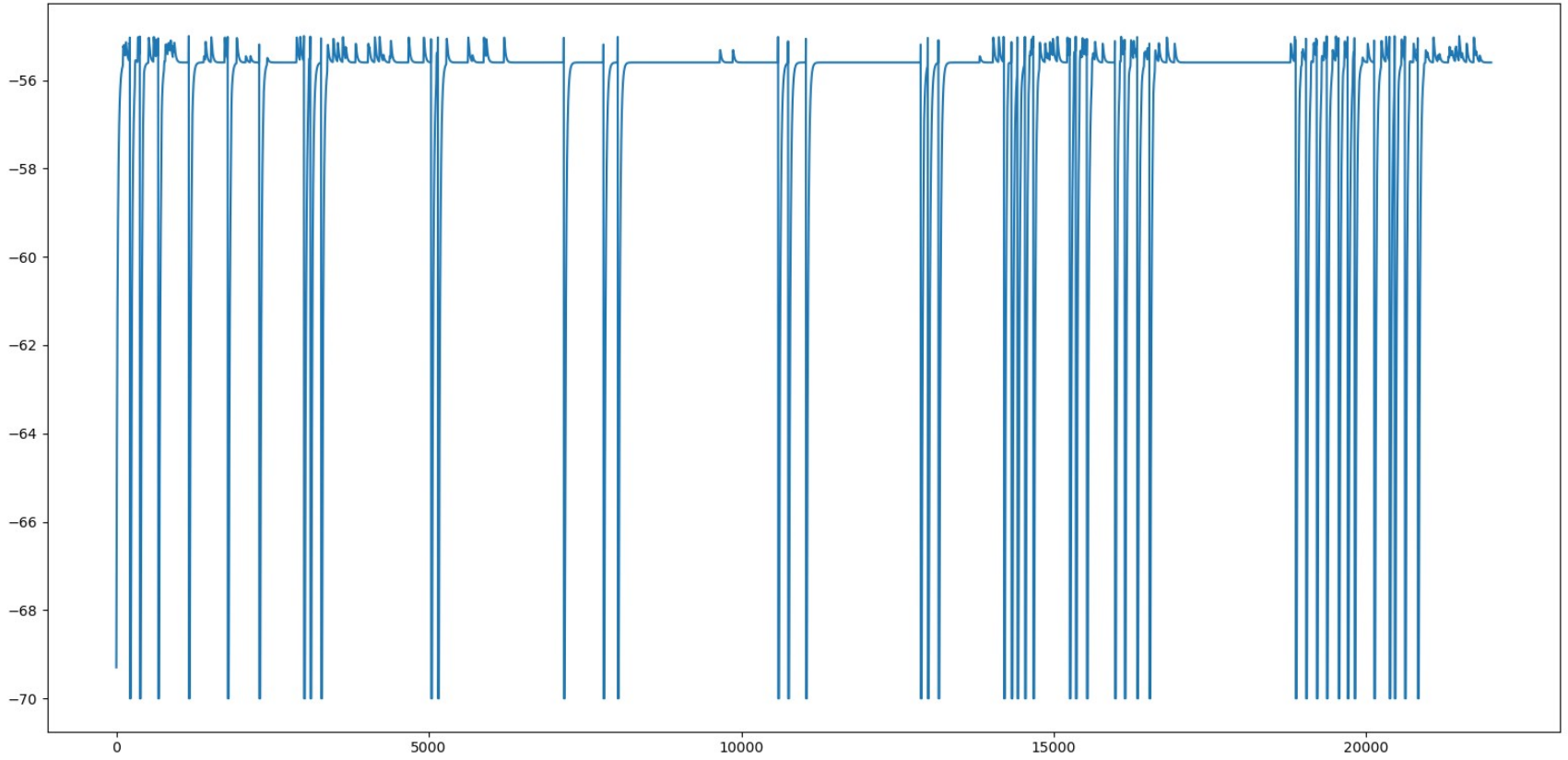
Network


Gammatone
filterbank
Signal
Onset spikes
Blue/Green=Excitatory neuron
Red=Inhibitory neuron

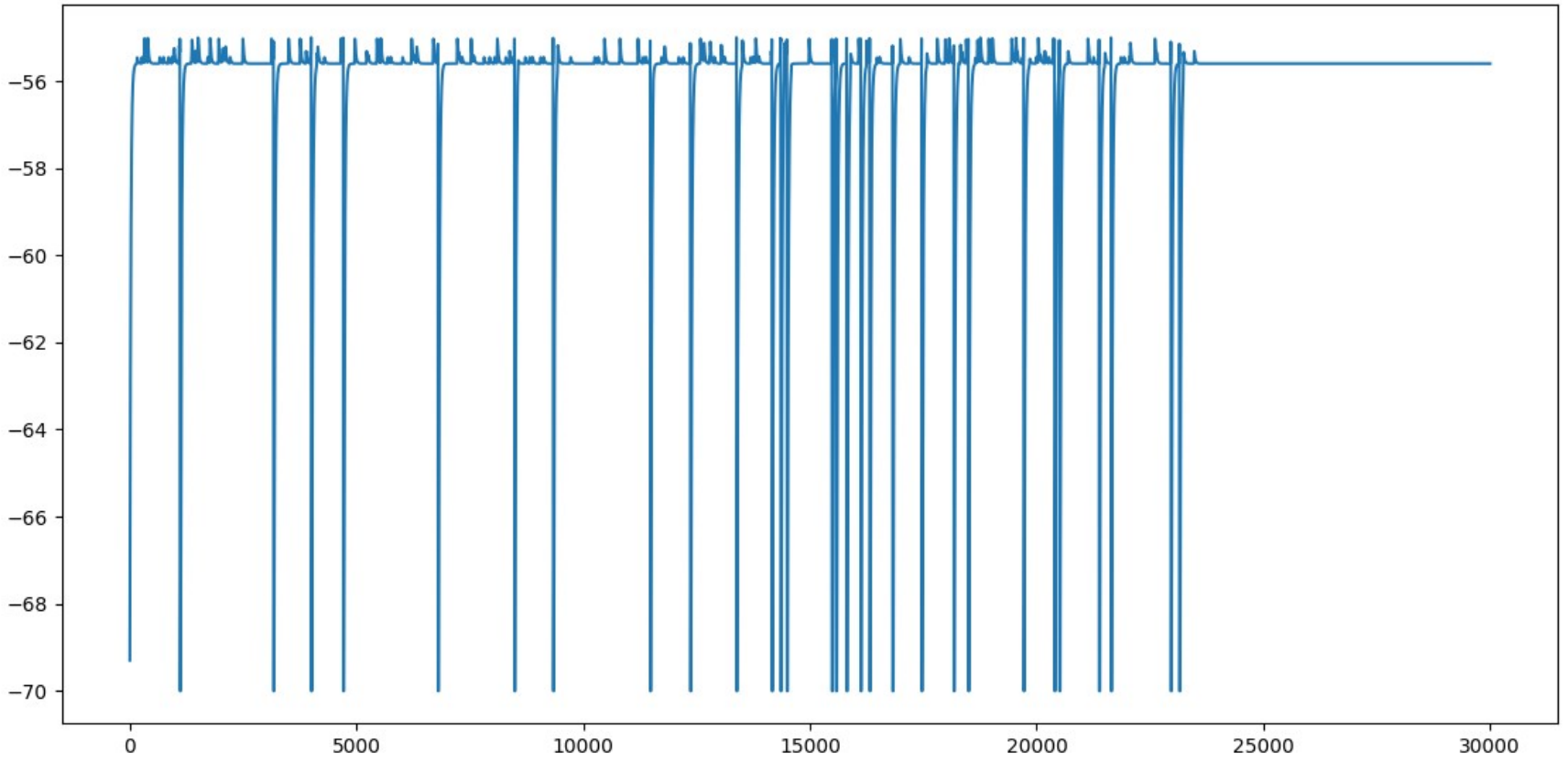
Dataset

- ODB (onset detection database)
  - 19 real recordings in wav format and their onset positions in text format.

Brief result



Another one



Evaluation

- We consider an onset to be correctly matched if a detected onset is reported within 50 ms of the ground truth onset time.

  c: number of correct detections, FP: false positive, FN: false negative

$$P = \frac{c}{c + FP} \quad R = \frac{c}{c + FN} \quad F = \frac{2PR}{P + R}$$

- Merged rate, doubled rate and mean deviation are also provided.

Future works

- Network fine-tuning
- Full dataset evaluation