Deep Laterally Recurrent Spiking Neural Networks for Speech Enhancement

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1. Motivation

Compared to human performance ASR systems perform badly in noisy environments

- Traditional signal processing approaches to noise reduction only partially successful
- Lack of spatial information in the encoding of sound e.g. single channel GSM encoding
- Is there some way we can make use of the rich spectro-temporal information to separate speech from noise?

2. Biological Inspiration

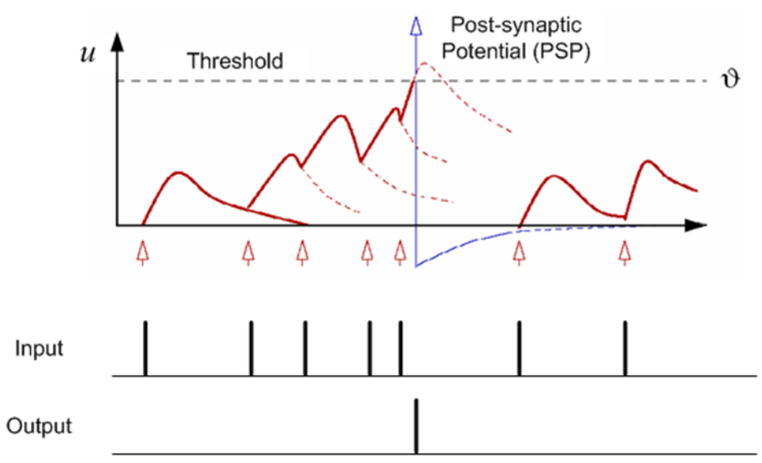
What inspiration can we take from the biology for solving these problems?

- Cochlea is basically an FFT that digitises sound to spiking stimulus
- Known since early '80s that cochlear nucleus is comprised of tonotopically organised lateral inhibitory neurons
- The neurons compete across the frequency bands

3. Spiking Neurons

Temporal code

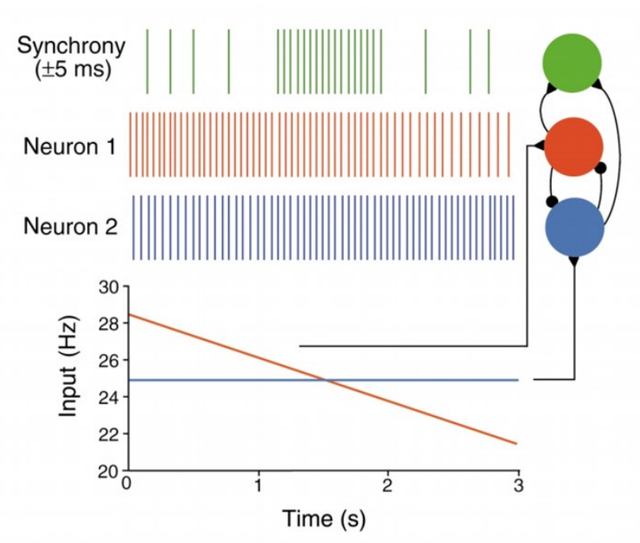
- Individual neurons make decisions about firing based on the timing of the stimuli they receive from other neurons
- Excitation carries information
- Inhibition routes and synchronises stimuli



4. Lateral Recurrent Inhibition

Causes synchrony

- Substantial biological evidence for synchronous activity being crucial to sensory processing systems such as vision and audition
- Lateral inhibitory connectivity binds stimuli together using synchronous (and preferably near-synchronous states)

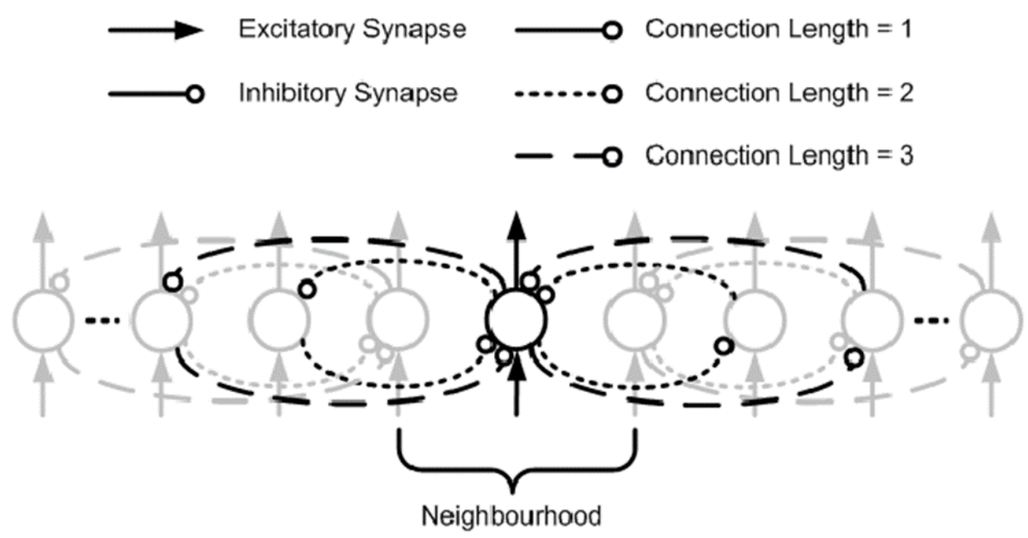


L. F. Abbott, "The timing game," *Nature Neuroscience*, vol. 4, no. 2, pp. 115-116, 2001.

5. Laterally Recurrent Layer

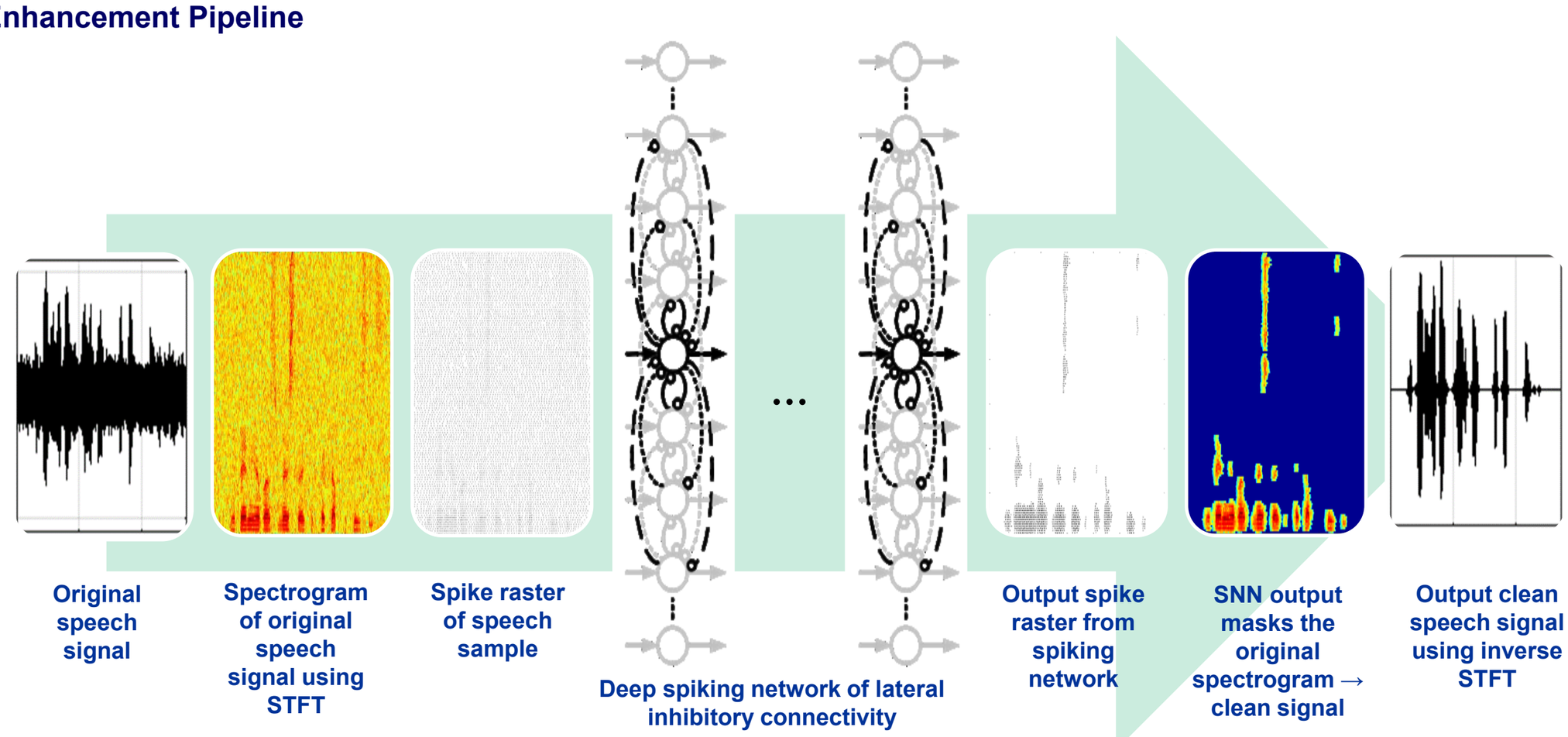
Abbott's idea can be extended…

- Symmetrical connectivity parameterised by two parameters:
  - Connection Length
  - Neighbourhood Radius



Laterally recurrent layer of spiking neurons

6. Speech Enhancement Pipeline



7. Conclusions

Some issues still remain to be resolved:

- Individual neurons make decisions about firing based on the timing of the stimuli they receive from other neurons
- Excitation carries information
- Inhibition routes and synchronises stimuli

Spiking Lateral inhibitory networks can be used to pre-process spectrograms for deep learning-based ASR systems

This work has been carried out in collaboration with Dr Cornelius Glackin, Intelligent Voice Ltd. neil.glackin@intelligentvoice.com