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# Binding of Audio Elements in the Sound Source Segregation Problem via a Two-Layered Bio-Inspired Neural Network

Preliminary Example

Ramin Pichevar, Jean Rouat and Romain Balleraud *

Dept. of Electrical & Computer Eng., Université de Sherbrooke, Sherbrooke, QC, Canada.
DSA-ERMERTIS, UQAC, Chicoutimi, QC, Canada.
* Institut National des Télécommunications, Evry, France.

# The Computational Auditory Scene Analysis

- Monaural Speech Segregation based on psychoacoustics.
- Also used for double-vowel segregation.
- Based on some cues such as harmonicity and onset/offset time.
- Implemented either by expert systems or by neural networks.

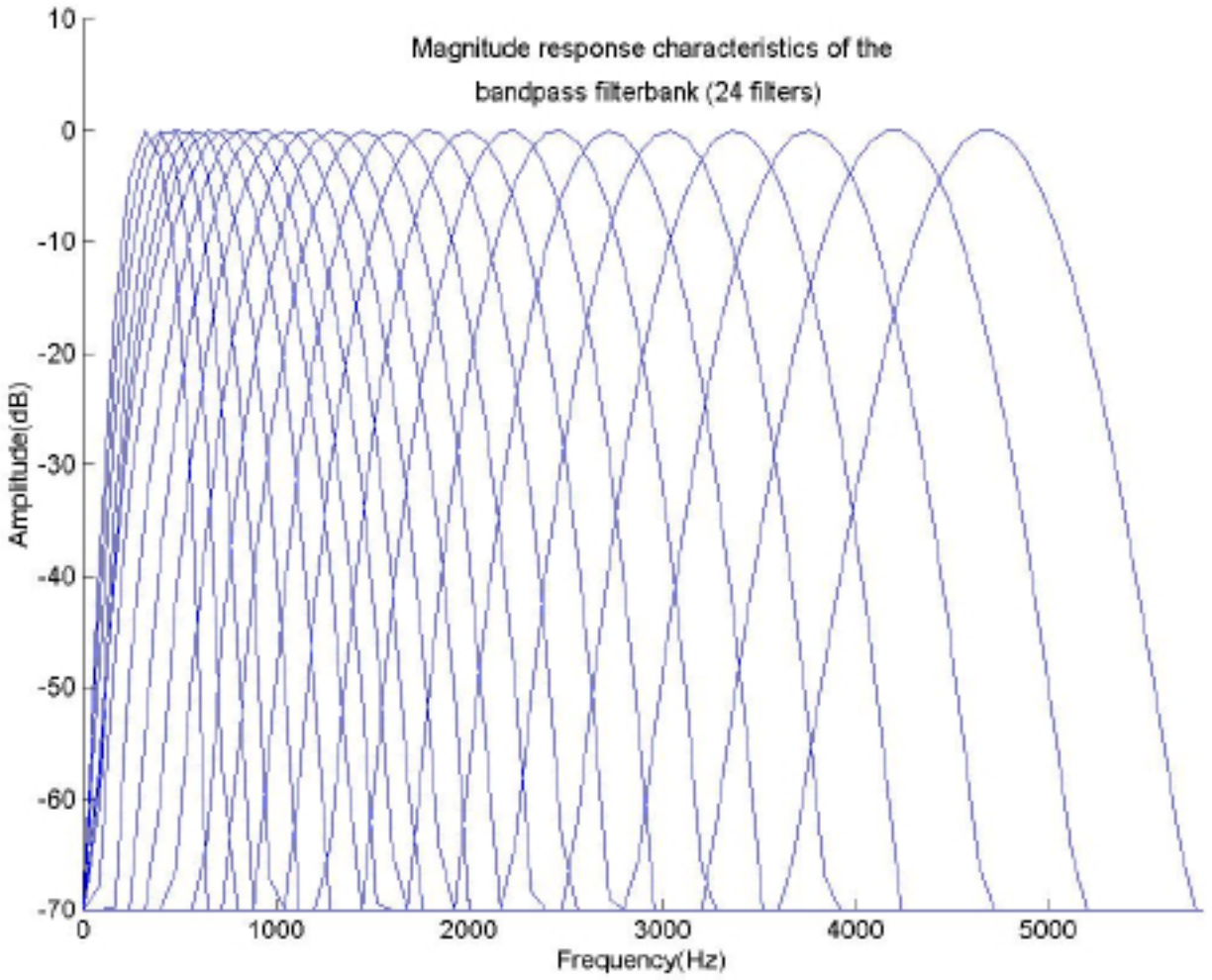
# Bio-inspired neural network

- Dynamic neurons in contrast with static conventional neural nets.
- Autonomous
- Closer to biological (real) neurons
- Solve the binding problem [Von der Malsburg]
- Relaxation oscillators, spiking neurons, chaotic neurons.

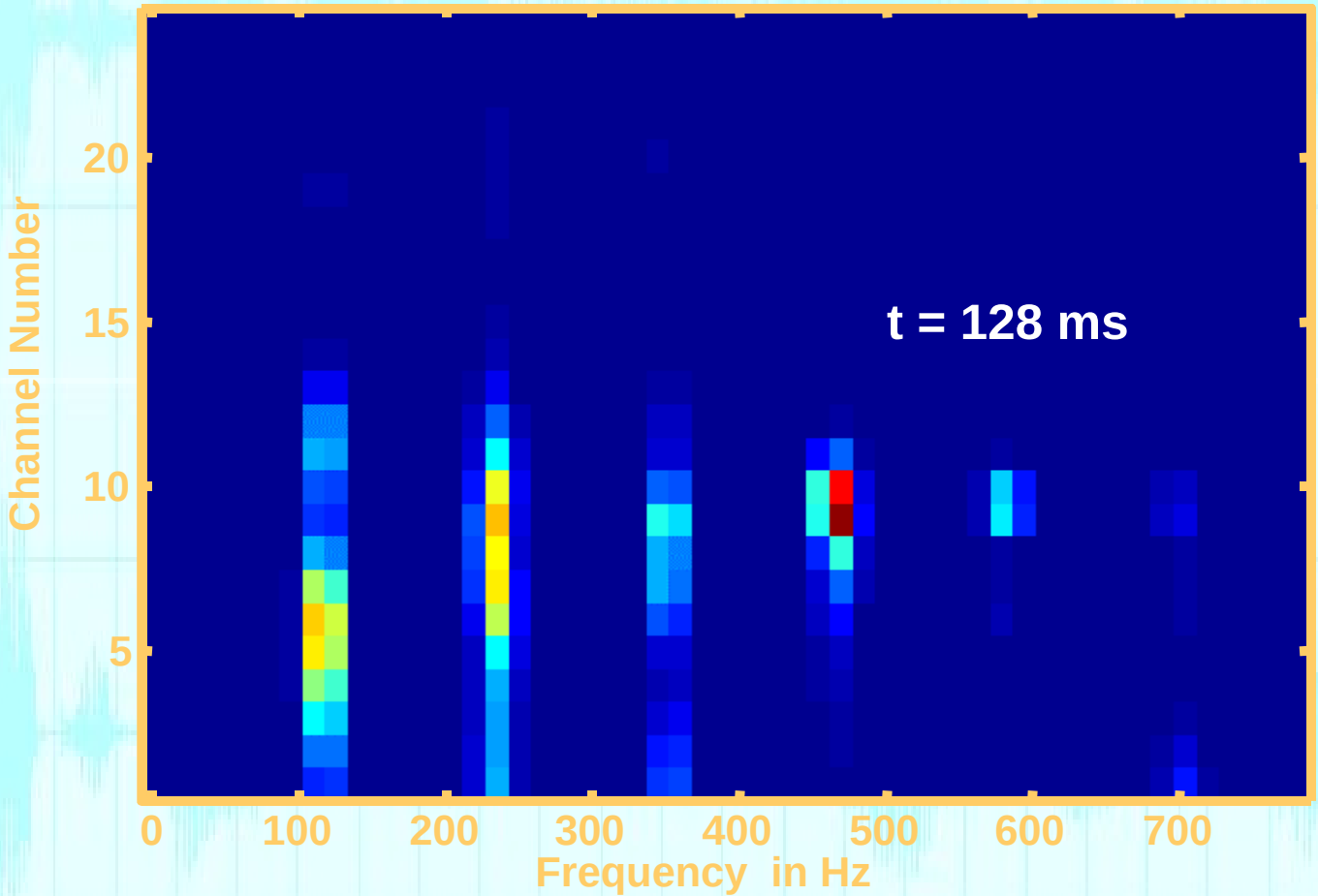
# Cochleotopic/AMtopic Map (CAM)

- For each time frame: bidimensional representation of the input signal.
- The STFT of the envelopes of the cochlear filterbank outputs for high-frequency channels (unresolved harmonics) and the STFT of the signal for low-frequency channels (resolved harmonics).

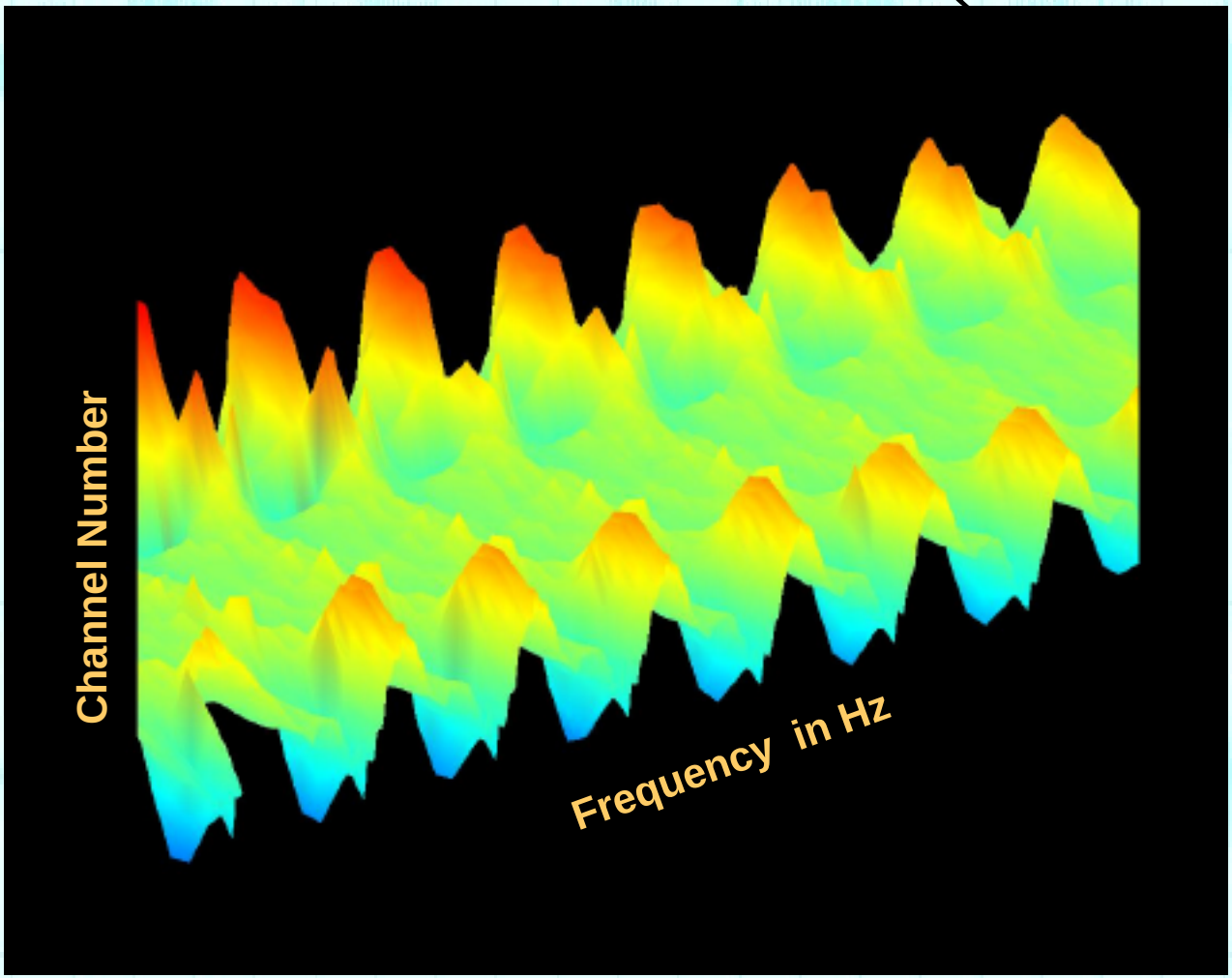
# Filterbank Magnitude Response



# CAM for the sound /di : /



# 3-D View of the CAM (for /di:/)



# Neural Architecture

- Two-layered neural network.
- First layer:

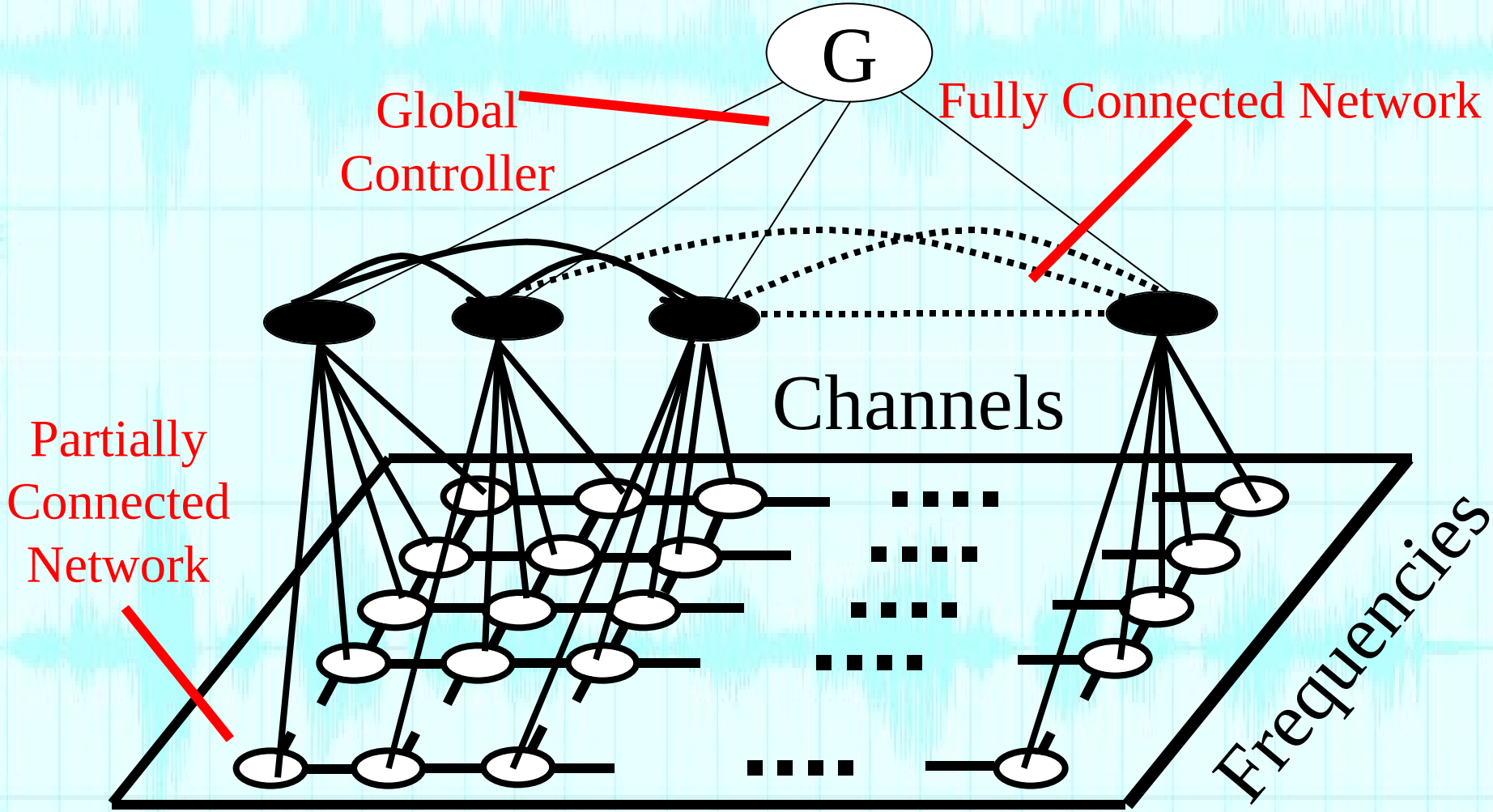
  2-D relaxation oscillators [Wang]

  Segmentation of audio objects.
- Second layer:

  Array of spiking neurons.

  Binding of audio objects.

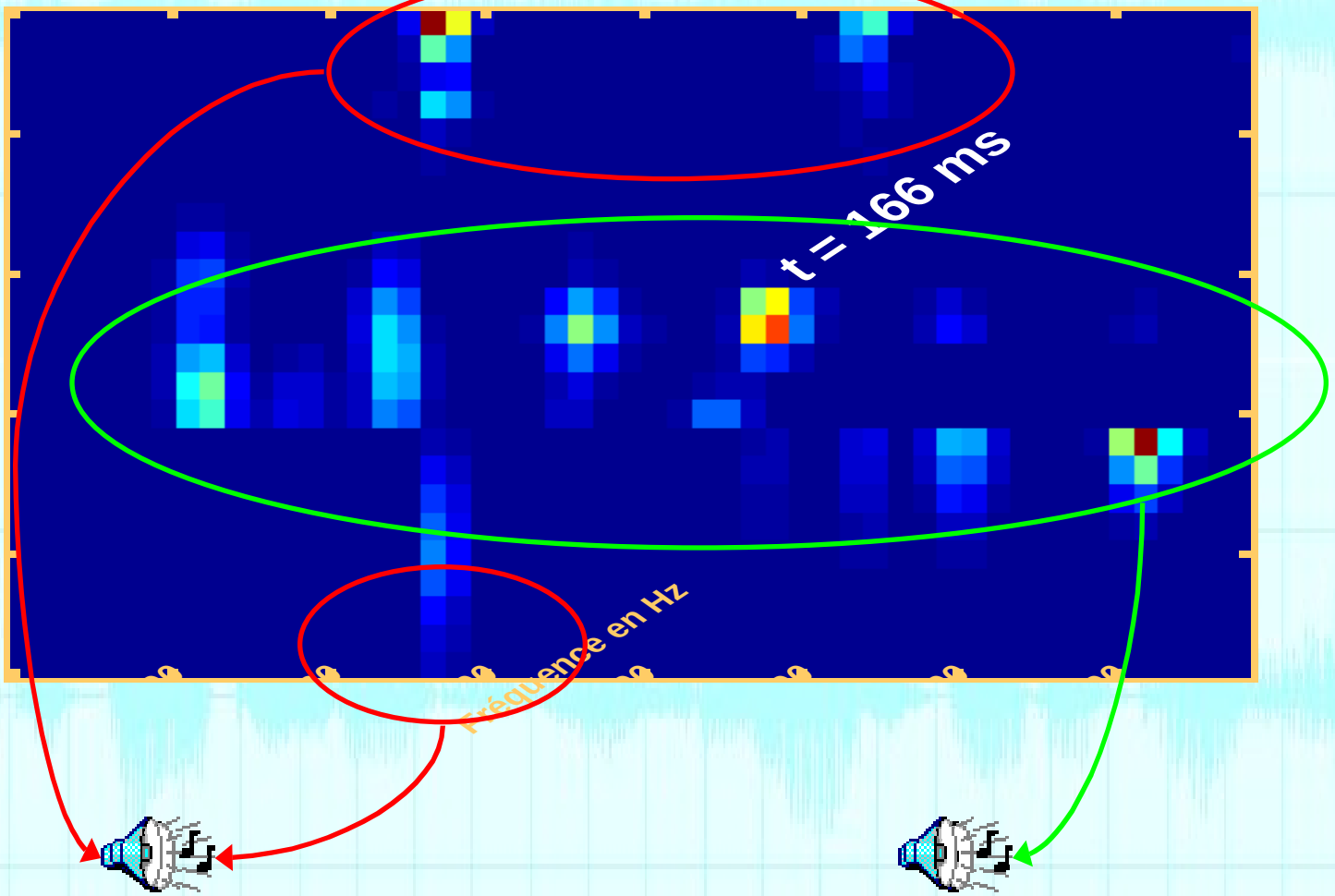
# Schematics of the Neural Architecture



# Binding and Separation

- Separation is based on harmonicity (distance between harmonics on the CAM)
- Second layer sums the outputs of the first layer.
- Second layer is binding channels based on coherence of information. Different sources yield different synchronization.

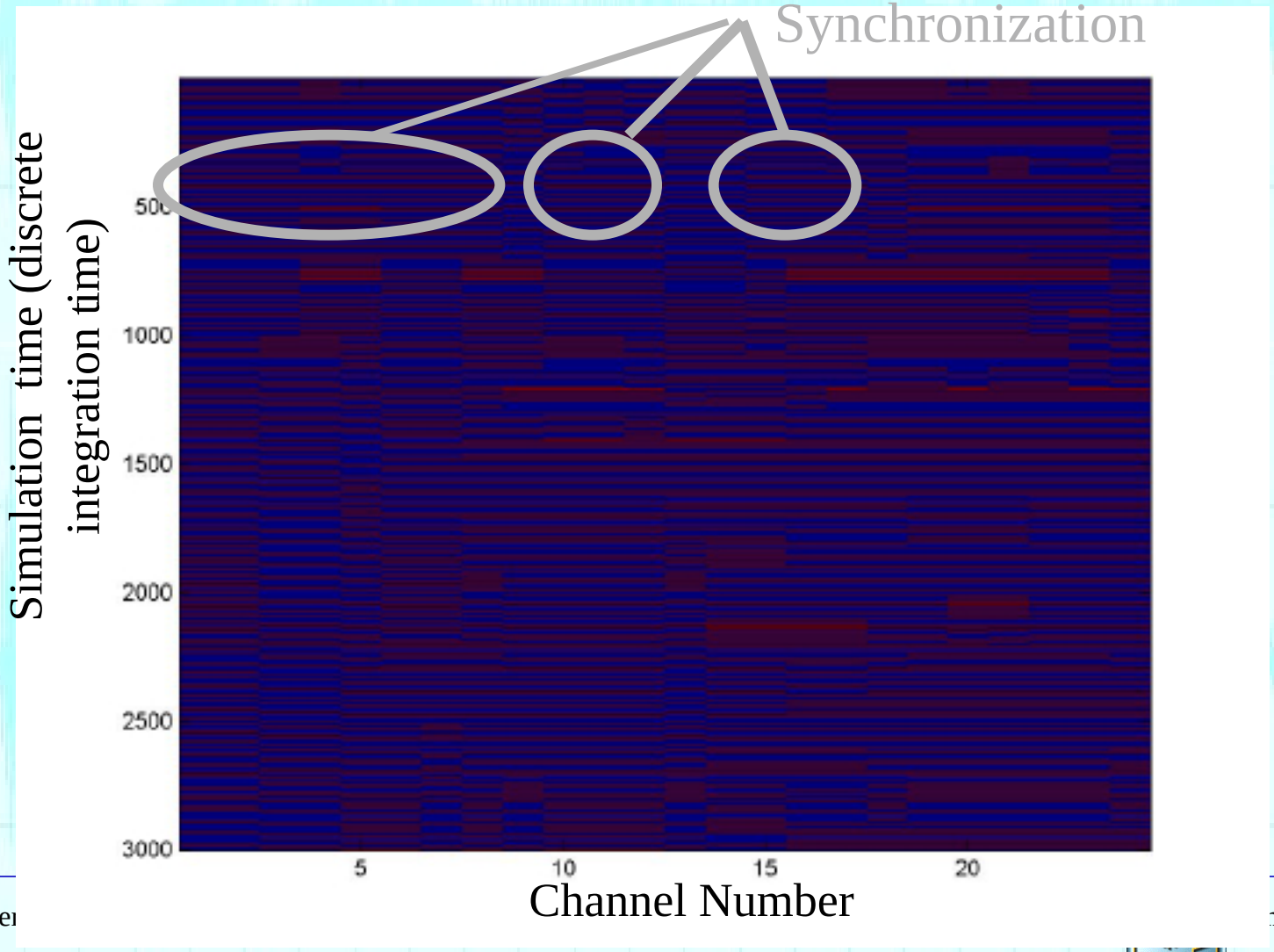
# Male speaker: /a/, female speaker: /i/
# Separation Algorithm at SNR=0dB (Done by the network)




Synthesized /di:/

Synthesized /dae/

# The output of the second layer for only a segment of the vowel



# Results

- Technique used to separate a mixture of /di : / and /da/.

  The PEL (Percentage of Energy Loss) criteria is used to measure the performance of the system.

$$\Sigma_t e^2(t) / \Sigma_t O^2(t)$$

e(t) : difference between resynthesized and original signal

O(t): original signal

# Results (cont.)

- PEL is 24.69%  at SNR=0 dB for the /da/ (compared with much higher values in the literature).
- PEL is 29.72% at SNR=0 dB for the /di:/ .
- But: Be aware that this measure does not take into consideration the perception.

# Further work

- Increase the number of input filters-> better resolution and use perfect reconstruction filters with no overlap.
- Modify the architecture of the network for a better performance.
- Apply technique to other types of sources like consonants or musical instruments.
- COST277: Study (HNM E. Keller) & real time implementation of Spiking N.N. (see demo J-J Rigoni and work by S. Thorpe).

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