Brainstorming Week on Membrane Computing (BWMC 2023)
23-27 January 2023, Sevilla Spain

n-dimensional encoding by SN P systems with multiple channels

José M. Sempere
Valencian Research Institute for Artificial Intelligence (VRAIN)
Department of Information Systems and Computation
Universitat Politècnica de València

jsempere@dsic.upv.es

@ChemaSempere

jsempere.webs.upv.es

Use SN P systems with multiple channels to encode information from an n-dimensonal source (images, RGB, n-valued functions, ...)

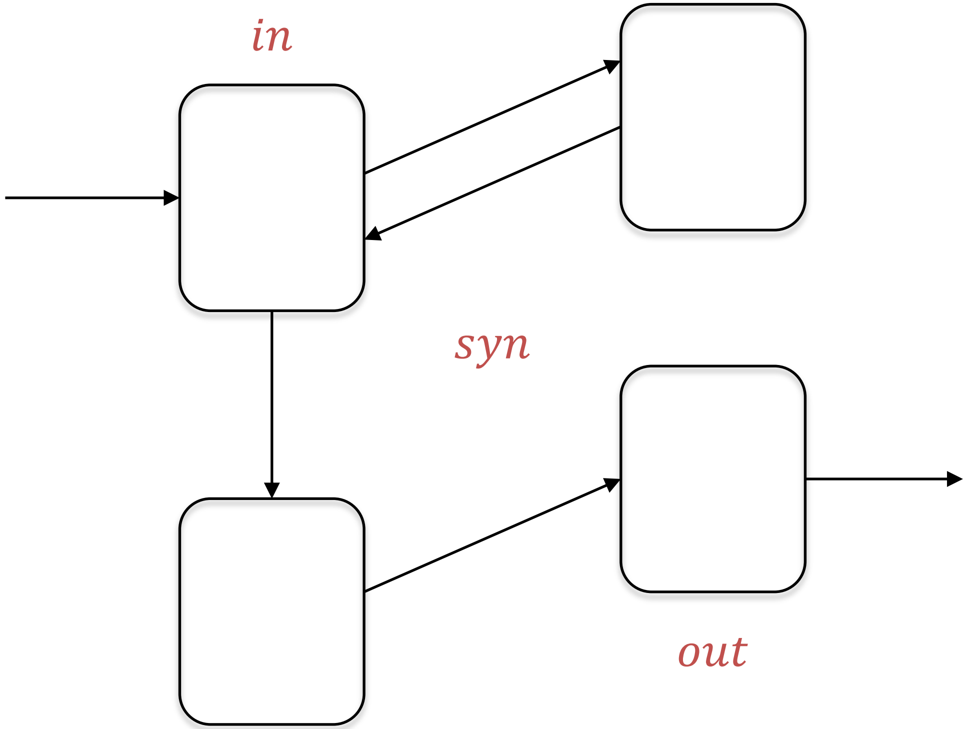
An idea based on the previous works:

- Families of Languages Associated with SN P Systems: Preliminary Ideas, Open Problems. Gh. Păun, José M. Sempere. Bulletin of The International Membrane Computing Society, Number 2, pp 161-164. 2016.
- Families of Languages Encoded by SN P Systems. José M. Sempere. In 18th International Conference on Membrane Computing (CMC 2017) (Bradford, UK). Marian Gheorghe, Grzegorz Rozenberg, Arto Salomaa, Claudio Zandron (eds.), LNCS Vol.10725, pp 262-269, Springer. 2018.
- Spiking neural P systems with multiple channels. H. Peng, J. Yang, J. Wang, T. Wang, Z. Sun, X. Song, X. Luo, X. Huang. Neural Netwqorks 95, pp 66-71. 2017.

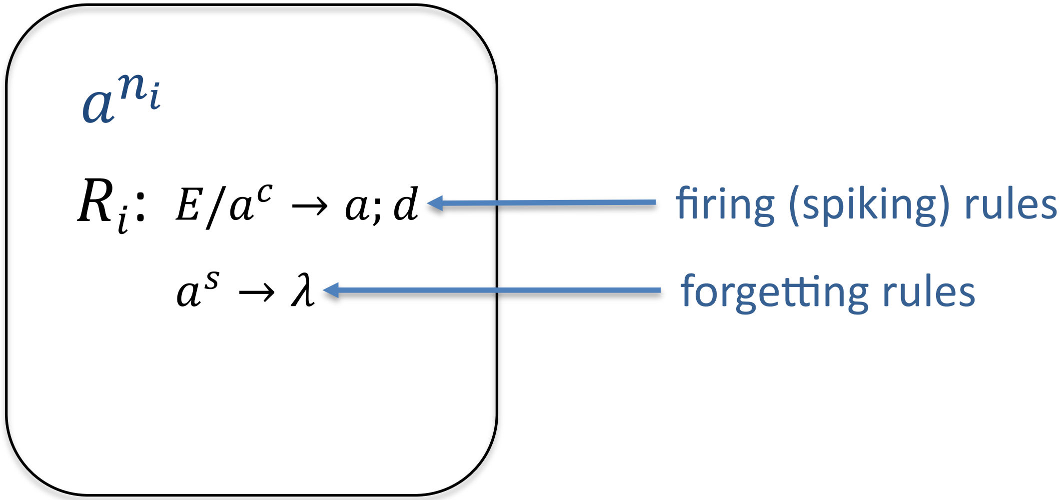
Basics of SN P systems

$$\Pi = (O, \sigma_1, \sigma_2, \dots, \sigma_m, syn, in, out)$$

$O = \{a\}$



$\sigma_i = (n_i, R_i)$



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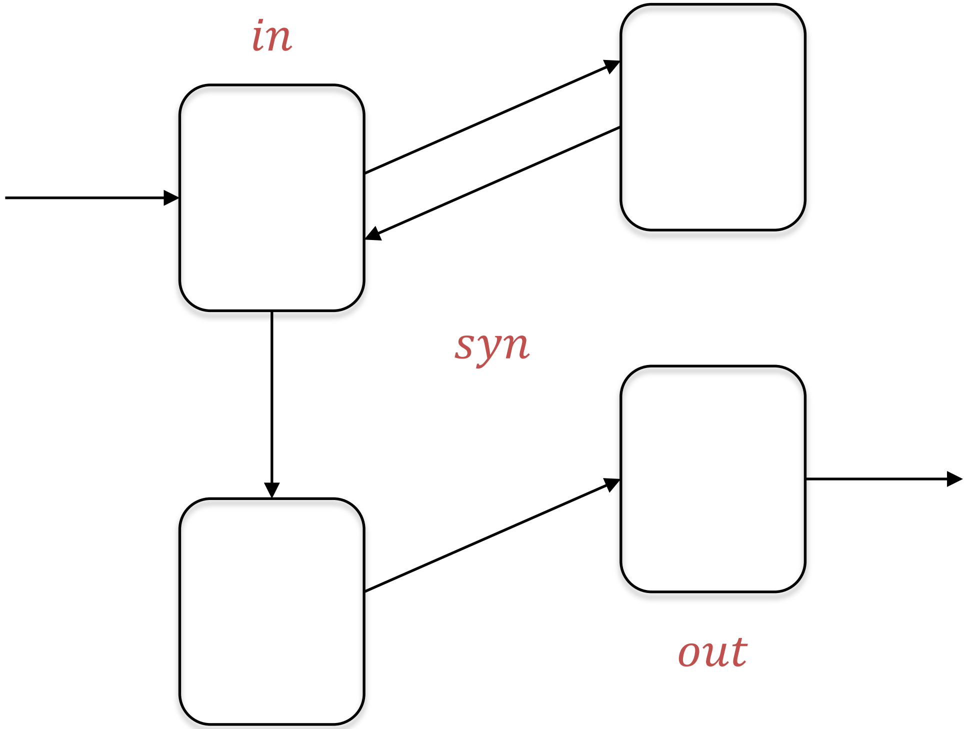


time →

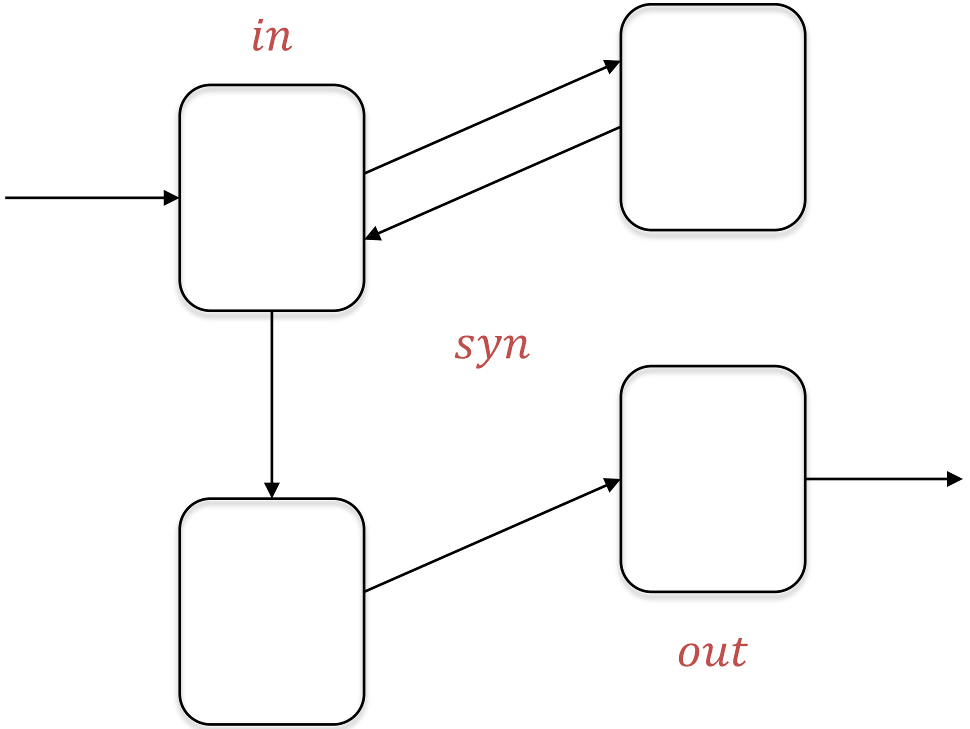
. . . 1 1 0 0 1 0 1 0 0 1 0 1 ***spike train***

output neuron emits an spike

output neuron does not emit an spike

Basics of SN P systems

$$\Pi = (O, \sigma_1, \sigma_2, \ldots, \sigma_m, syn, in, out)$$



For every halting computation the spike train is a binary string that belongs to the language generated by the system

$$L_1(\Pi)$$

time →

. . . 1 1 0 0 1 0 1 0 0 1 0 1   ***spike train***

output neuron emits an spike

output neuron does not emit an spike

Encoding the spike train: The bounded case

Let B= {0,1}

$w = w_1 w_2 \dots w_p \in \{0,1\}^*$

$k^{w = w_1 w_2 \dots w_p 0^t}$

$t = \min\{n \geq 0 : |w0^t| \text{ is a multiple of } k\}$

$k^{w = x_1 x_2 \dots x_s}$

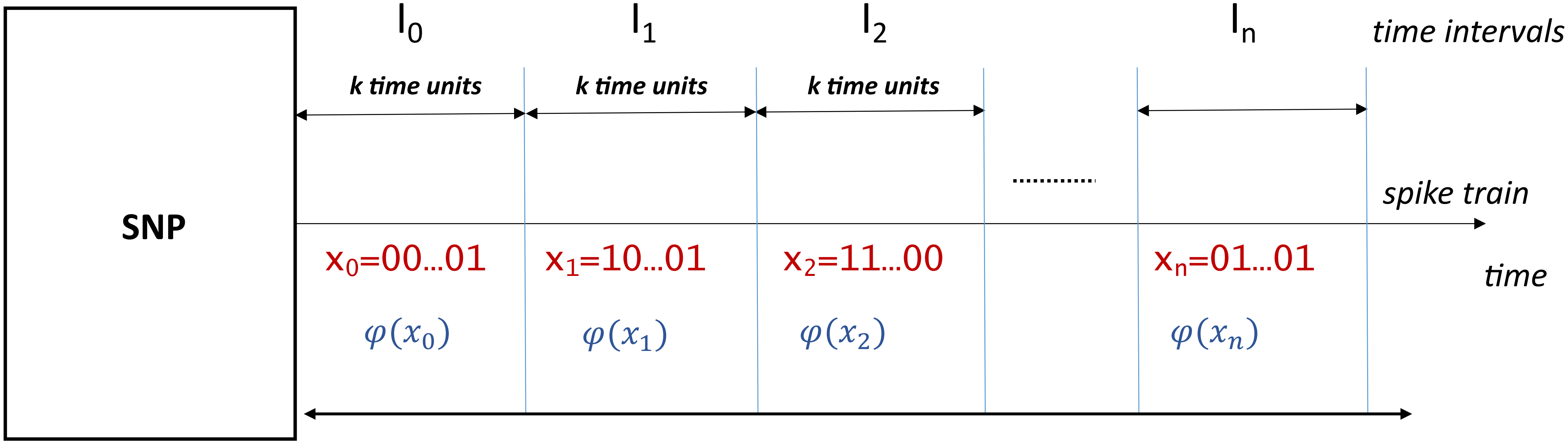
$|x_i| = k \quad 1 \leq i \leq s$

$\varphi_k : B^k \to V_k$

$$L_{\varphi_k}(\Pi) = \{\varphi_k(k^w) : w \in L_1(\Pi)\} = L_k(\Pi)$$

$$F(\Pi) = \{L_k(\Pi) : k \geq 1\}$$

Encoding the spike train: The bounded case



$$\varphi(x_0)\varphi(x_1)\varphi(x_2)\dots\varphi(x_n)$$

$$V_k = \{a_0, a_1, \dots, a_{2^k-1}\}$$

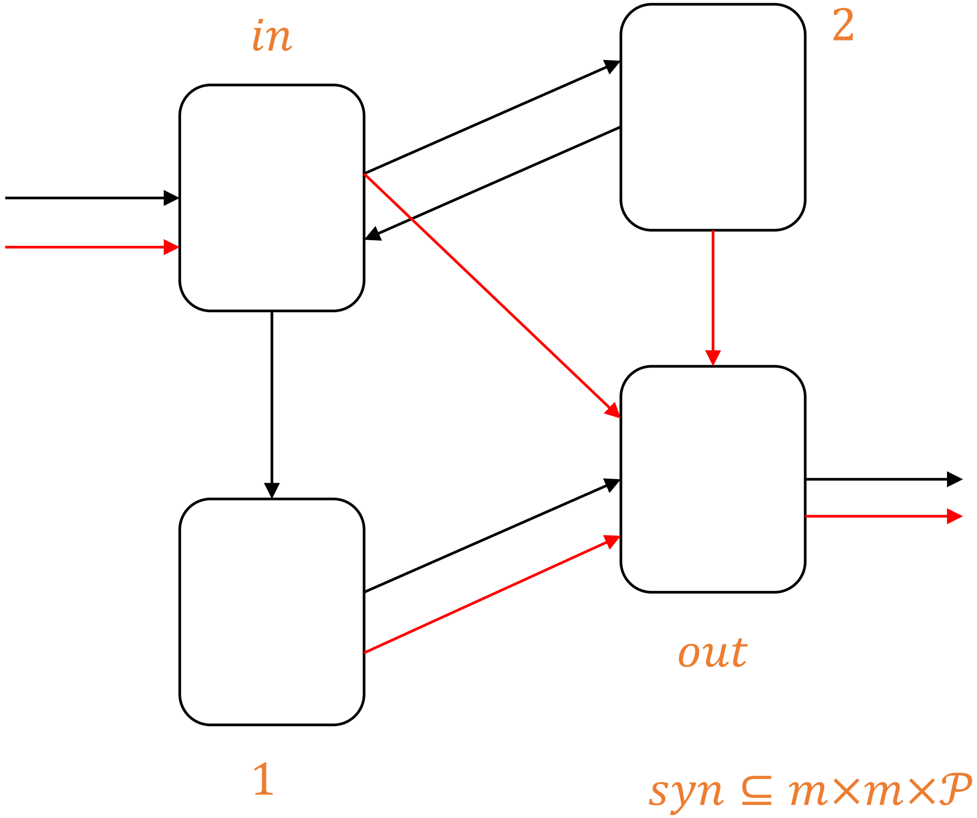
$$\varphi_k: B^k \to V_k$$

$$L_{\varphi_k}(\Pi) = \{\varphi_k(k^w) : w \in L_1(\Pi)\} = L_k(\Pi)$$

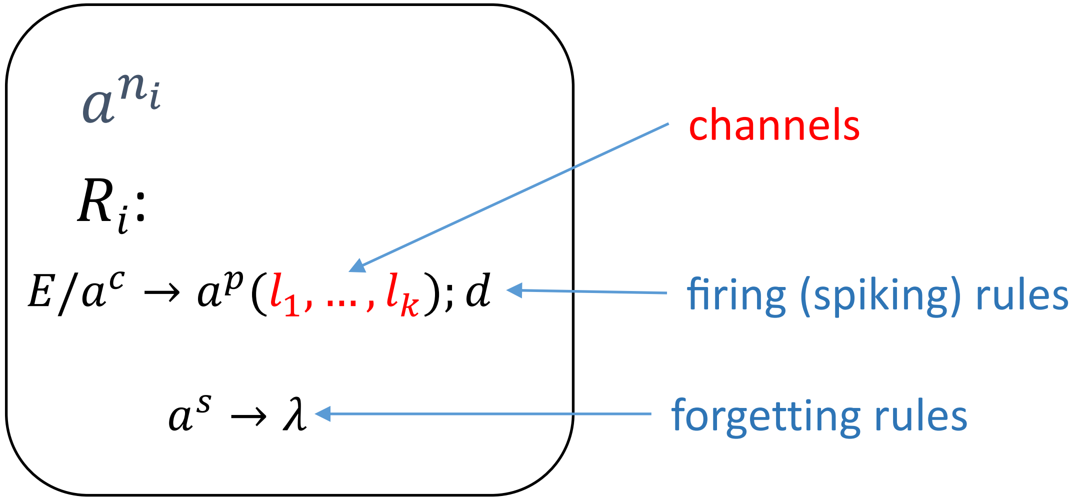
Basics of SN P systems with multiple channels (Peng et al. 2017)

$$\Pi = (O, \sigma_1, \sigma_2, \ldots, \sigma_m, syn, in, out)$$

$O = \{a\}$ Ch $= \{1,2, \ldots, l\}$



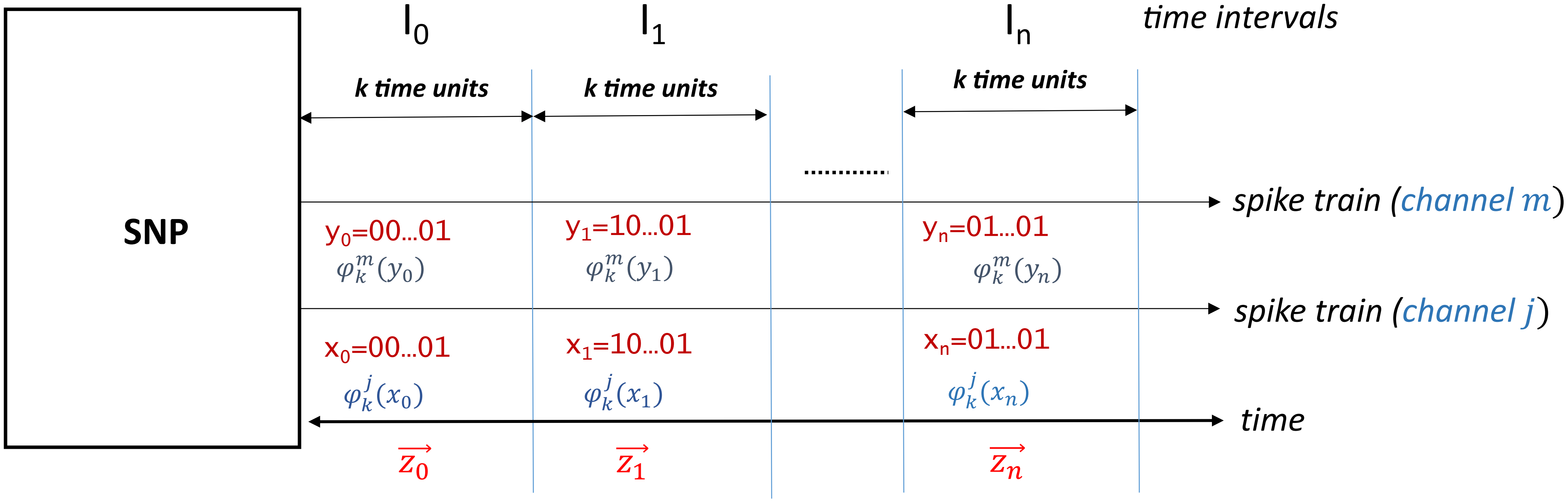
$$\sigma_i = (n_i, R_i)$$



$syn \subseteq m \times m \times \mathcal{P}(l)$

Two neurons can be connected through more than one channel (i.e. $(1, out, \{1,2\})$)

Encoding the spike trains: The bounded case

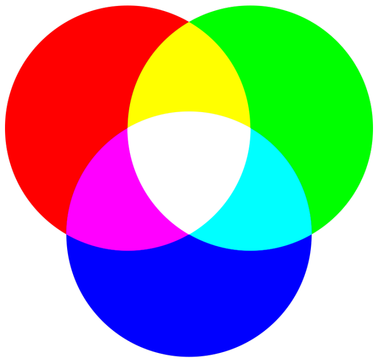


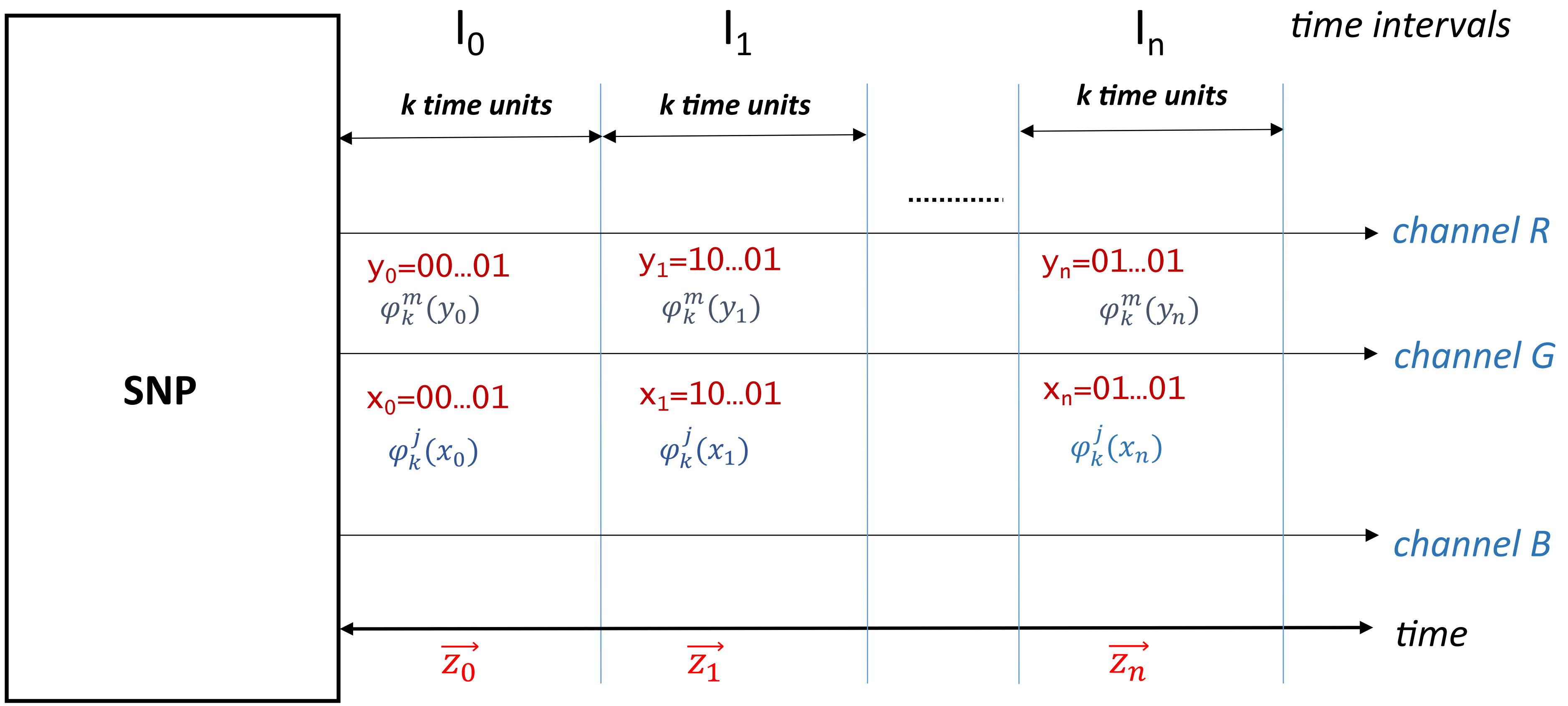
$V_k = \{a_0, a_1, \ldots, a_{2^k-1}\}$

$\varphi_k^p : B^k \to V_k$

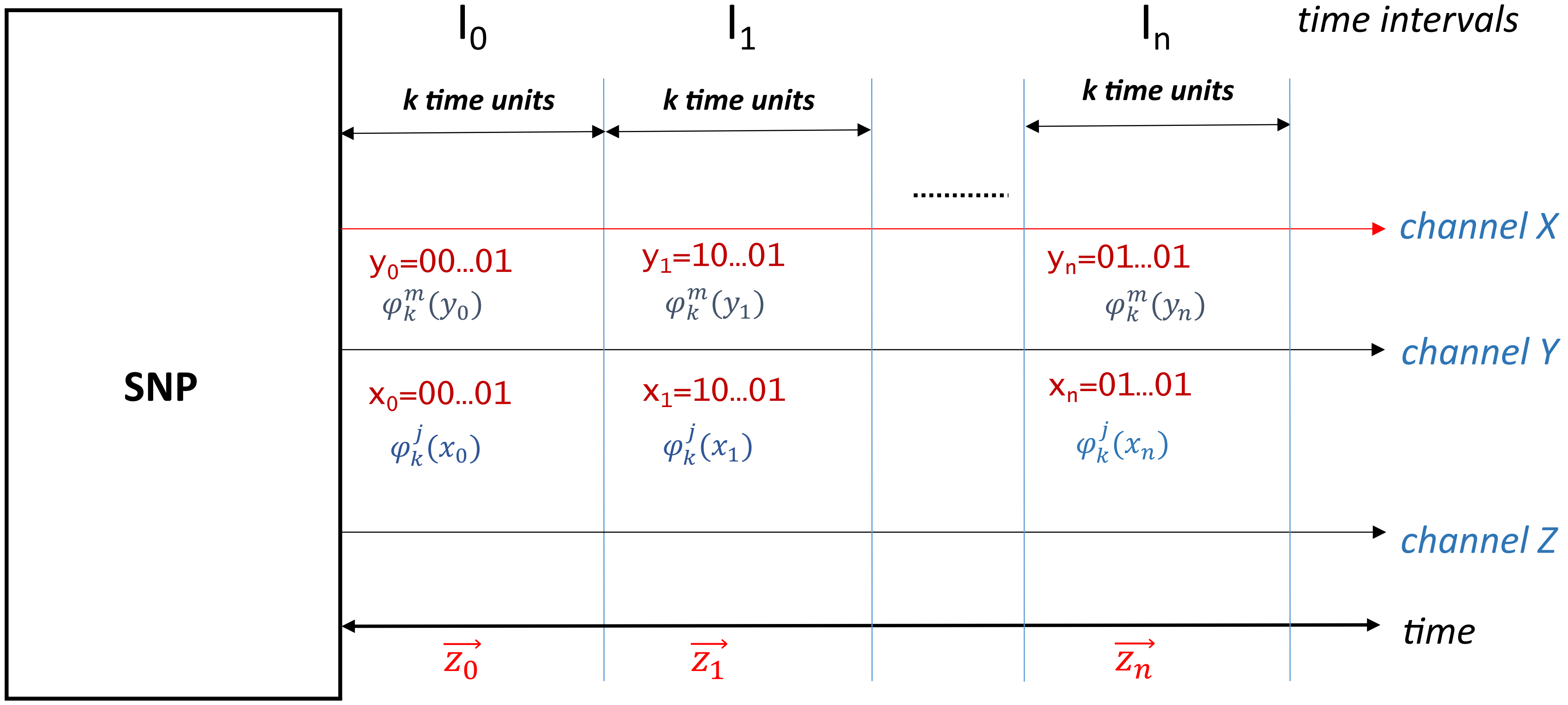
$\varphi(\overrightarrow{z_0})\varphi(\overrightarrow{z_1}) \ldots \varphi(\overrightarrow{z_n})$

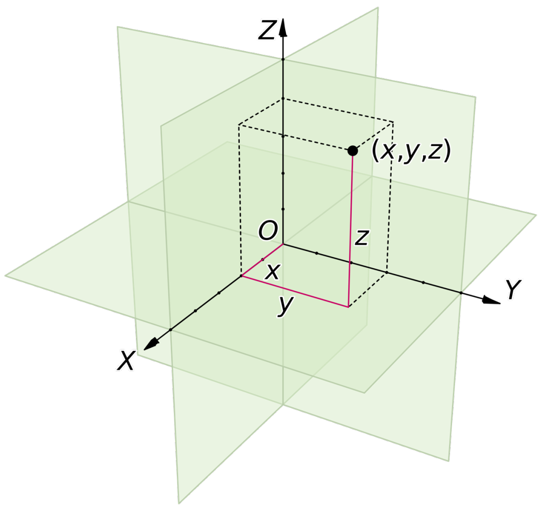
Application I: RGB encoding





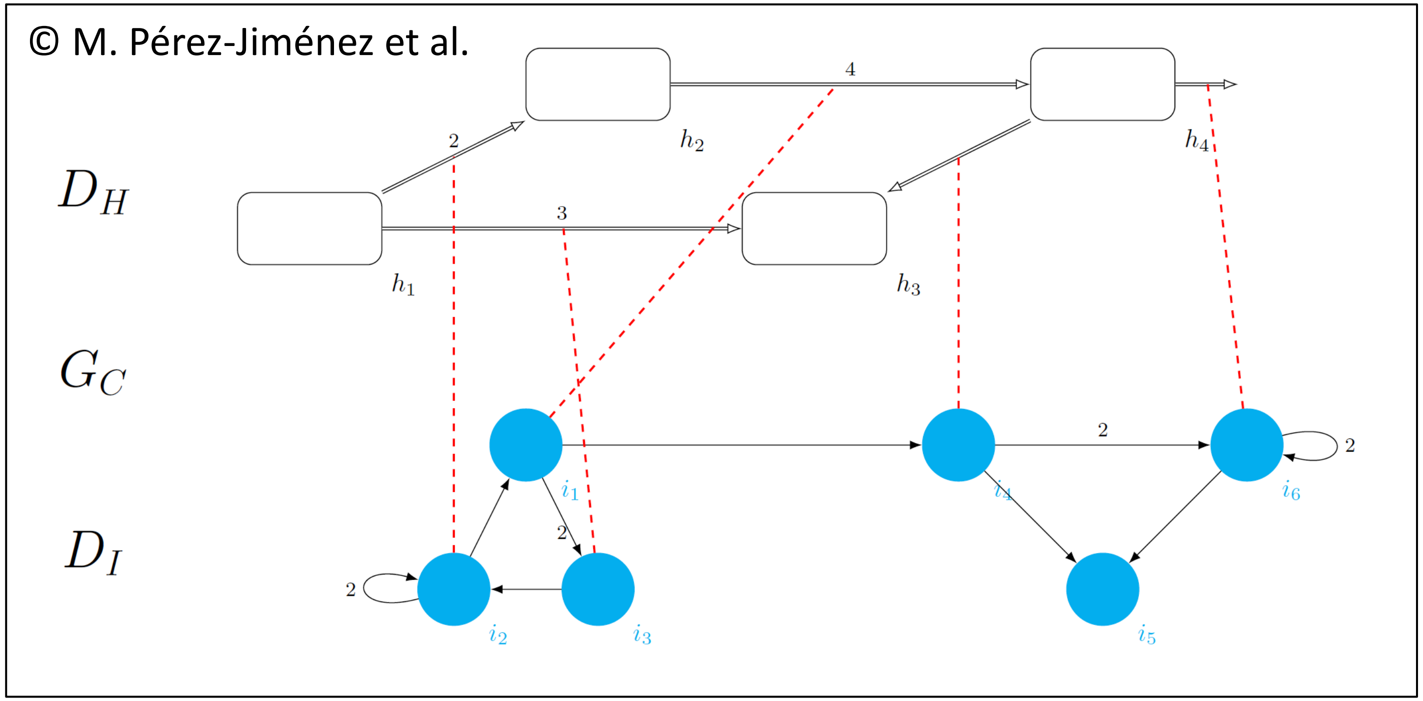
Application II: 3D clustering





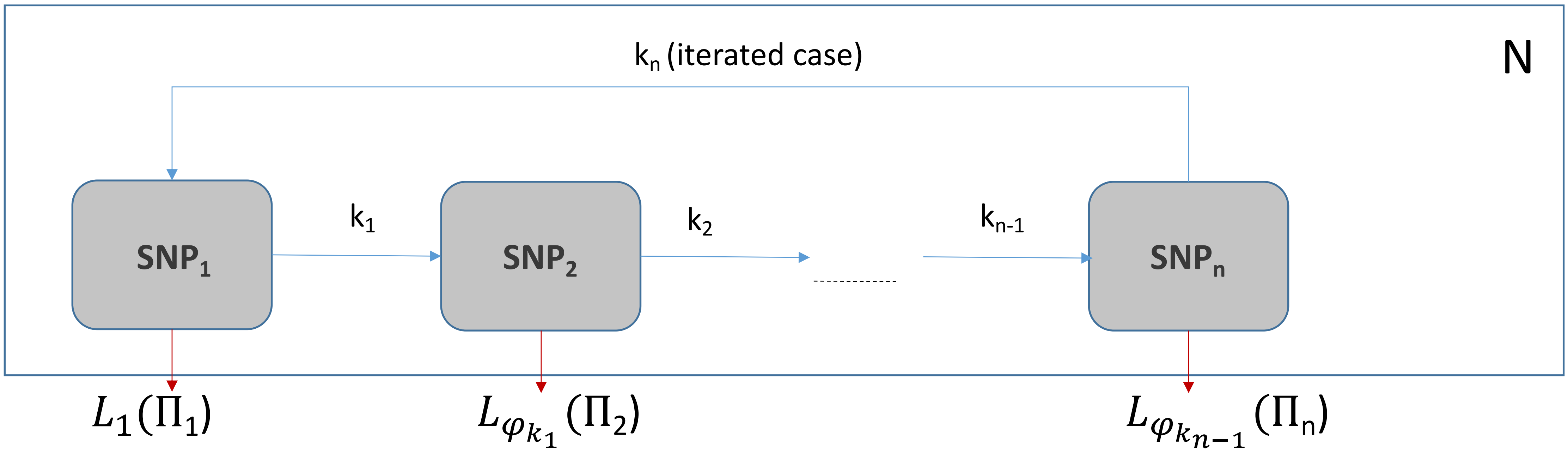
Application III: ¿ connections to virus machines ?

L. Valencia, M.J. Pérez-Jiménez, X. Chen, B. Wang, X. Zheng. Basic virus machines. In J.M. Sempere and C. Zandron (eds) Proceedings of the 16th International Conference on Membrane Computing (CMC16), 17-21 August, 2015, Valencia, Spain, pp. 323-342.



Two kind of channels: channels for behavior (viruses transmition and instructions) and channels for regulation

The network case: A cascading encoder



Work in progress

- SN P with multiple channels encode information as it happens in the living brain (there are different channels in the synaptic connections).

- The system modulates the information by taking an external parameter (the k value in the bounded case) that shows a kind of plasticity in the system.

The following topics arise

  - The decoding problem: From any (encoded) spike train, obtain different binary spike trains in a multidimensional space.
  - A characterization of φ_k

THANK YOU !!!