10th International Workshop

Neural Coding 2012

Book of Abstracts

Prague, Czech Republic,
September 2–7, 2012

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Effectiveness of information transmission in the brain-like communication models

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The efficiency of information transmission by brain is one of the major interests that have been recently studied, both through data analysis and theoretical modeling [1, 2, 3]. Recent attempts to quantify information transmission have concentrated on treating neuronal communication process in the spirit of Shannon information theory. It was developed as a mathematical, probabilistic framework for quantifying information transmission in communication systems [4].

The fundamental concept of this theory is *mutual information*, which quantifies the information dependence of random variables or stochastic processes. If $\{X\}$ and $\{Z\}$ are input (e.g. stimuli) and output (e.g. observed reaction) stochastic processes, then mutual information between them is given as: $I(X;Z) := H(X) + H(Z) - H(X,Z)$, where $H(\cdot)$ are entropies [5]. Entropies of processes with unknown distributions (containing output process Z) have to be estimated and we accomplished it with Strong estimator [3, 6] as it is reliable and computationally fast. Maximal mutual information, called channel capacity, $C = \sup_{p_X} I(X;Y)$, reflects the upper bound on amount of information that can be communicated over the channel.

For neuron model we chose that proposed by Levy & Baxter [3, 7]. Our *brain-like* neural network model (Fig. 1) consists of number of paired *excitatory* E and *inhibitory* I neurons. Such two neurons constitute a *node* (E,I). Output of one neuron within a given node becomes input of the other one in the next discrete moment. Inhibitory neurons act to hold back activation of excitatory neurons they are paired with. Each node $(E,I)_i$ is connected with neighboring nodes $(E,I)_{i-1}$ and $(E,I)_{i+1}$ through output of neuron E_i. Other nodes can be connected through *long-range connections*. Some or all neurons E_i can be connected to the source of information, i.e a discrete, one-zero (*spike* or *no-spike*) stochastic process.

We search for maximal values of mutual information between input process $\{X\}$ and outputs of excitatory neurons $\{Z\}$s. We ran multiple simulations for architectures presented in Fig. 1. The information source parameters were as follows: *firing-rate* $0 \le f_r \le 1$ in steps of 0.05 and sequences of 1 000 000 bits were generated to reach high accuracy. Parameters associated with neurons were:

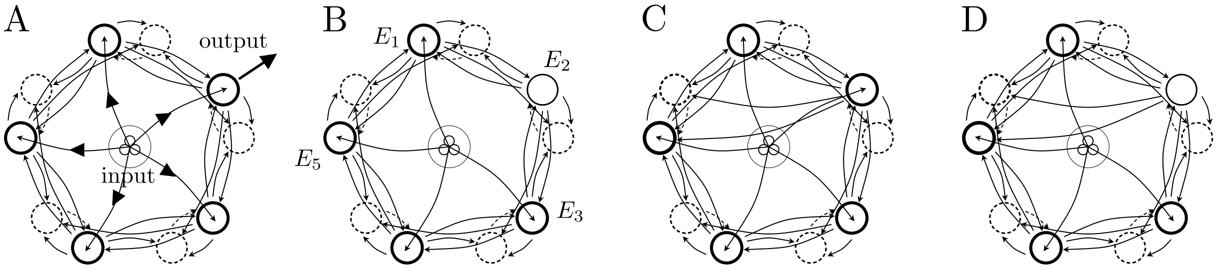

Figure 1: All *brain-like* neural architectures we studied. Each one has five nodes and source of size three. **A**, a *symmetric* case. **B**, E_2 has no access to the source of information. **C**, symmetric case with added *long-range* connection from E_2 to E_5. **D**, a combination of B and C.

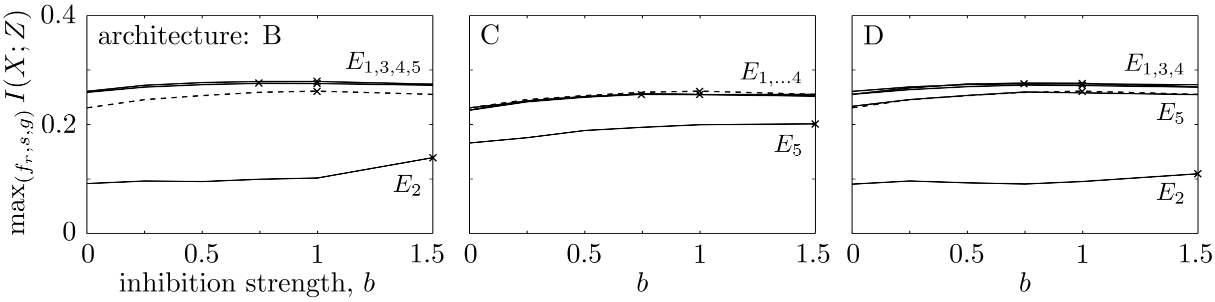

Figure 2: Mutual information between input process X and outputs of E neurons for architectures B, C, D (*symmetric* architecture result drawn with dashed line), maximized over: firing-rate f_r, synaptic success s and activation threshold g. Optimal values for each neuron marked with $\times$.

synaptic success $0 \leq s \leq 1$ in steps of 0.05, *activation threshold* $g \in \{0.2, 0.3, 0.5, 0.7, 0.9, 1, 1.2, 1.6\}$ and *amplitude fluctuations* were distributed uniformly on interval $[0;1]$. Neural network was parametrized with *inhibition strength* $b \in \{0, 1/4, 1/2, 3/4, 1, 3/2\}$ (relative to excitatory neurons strength).

Results are presented in Fig. 2. Most neurons reach the optimal information transmission around point where inhibition balances excitation, i.e. for $b = 1$. Generally, neurons are least efficient if there is no inhibition at all, i.e. for $b = 0$.

Efficiency of transmission of excitatory neuron lacking access to the source of information is decreased even by 62%, while other neurons efficiency rises by 7–13%, depending on inhibition strength. Long-range connection, if it originates from neuron having access to the source, brings 23–27% loss to target excitatory neuron transmission efficiency. If the connection originates from neuron without access to the source, the efficiency of target neuron is unchanged.

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Bibliography

[1] Rieke, F., Warland, D., de Ruyter van Steveninck, R., Bialek, W. (1997) *Spikes. Exploring the Neural Code*. MIT Press, Cambridge, MA.

[2] Sejnowski, T.J., van Hemmen, J.L. (2006) *23 problems in systems neuroscience*. Oxford University Press, Oxford.

[3] Paprocki, B., Szczepanski, J. (2011) Efficiency of neural transmission as a function of synaptic noise, threshold, and source characteristics, *BioSystems*, **105(1)**: 62–72.

[4] Shannon, C. (1948) A mathematical theory of communication, *Bell System Technical Journal*, **27**: 379–423, 623–656.

[5] Ash, R. (1965) *Information Theory*. Interscience, New York.

[6] Strong, S.P., Koberle, R., de Ruyter van Steveninck, R.R., Bialek, W. (1998) Entropy and information in neural spike trains, *Physical Review Letters*, **80**: 3197–200.

[7] Levy, W.B., Baxter, R.A. (2002) Energy-efficient neuronal computation via quantal synaptic failures, *The Journal of Neuroscience*, **22**: 4746–4755.