A Two-Tract Gedanken Experiment

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Abstract

In this note the authors further clarify the information processing, both classical and quantum, taking place when say a retina is observing a small object.

Consider two uncoupled neural tracts. Let each have two or more axons in it, internally coupled to one another. The equation is (Equation 1 in [1]):

$$C_i \frac{\partial V_i}{\partial t} = G_i^{ax}((1+h_1 cos(\omega_1 t))cos\theta_i)^2 \left[\frac{\partial^2 V_i}{\partial z^2} - \sum_{axons,p} W_{ip} K_p \frac{\partial^2 V_p}{\partial z^2}\right] - G_i^{my} V_i + I_i^{inj,ion} \tag{1}$$

The second tract has a similar equation, except with h_2 and ω_2. In [2], the authors showed that the capacity of a tract (only the $N = 1$ case was discussed whereas a rigorous approach to the present paper will require the general case) depends on the mutual information $I(v_{0i}; v_{Li})$ where the first random variable is the i-th component of the input voltage and the second random variable is the i-th component of the output voltage. Even if both tracts are started off identically, it was argued in [3] that the second tract sees a different metric perturbation. Hence the relevant mutual information for the second tract is $I(v_{0i}; v_{Li,2})$. Thus the destination which is processing both tracts' outputs will have two different random variables presented to it. Theorem 8.1 of [4] gives us precisely the capacity of such a two receiver discrete memoryless broadcast channel.

It is worth noting that in parallel with this classical broadcast, the nodes along the two axon tracts will be performing quantum gates on the ions. In particular the output nodes on the two tracts will be providing different environments to their ions and hence different quantum final states. These two outputs can be considered as Bob and Charlie, with Alice setting off the quantum broadcast problem with an element of entanglement between the two tracts initial node ions [5, 3]. Thus it becomes clear how quantum information is flowing in parallel with classical information.

In future work we hope to investigate how, when the quantum information is finally measured or decoheres, at what critical threshold (say number of quantum ions or states) does it provide a back action on the very nodal voltage

itself. This would then indicate the final readout of the quantum information as a component of the classical information reading. Of course, there may yet be a way for it to continue to flow as quantum information. Another point that needs to be clarified is whether there is a type of "saltatory" quantum conduction from node to node.

References

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