A Joint View of Computation and Learning

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Abstract

Control theory is a versatile tool. In controls thinking, one works with system transfer functions as modules. In this note, the authors propose to apply Willems' behavioral approach to interconnections, feedback and control to the quantum setting where metric perturbations direct the quantum computation occurring in axon tracts. Partial feedback loops are induced and learning can go on in parallel.

In systems [1] and control theory [2], parts of systems are broken down into various sub-system blocks. Each sub-system block interacts with others to perform its part in the overall system operation. Normally, we write transfer functions for each block. These transfer functions, when interconnected, combine in specific ways and so one gets the transfer function of the overall system. Further analysis of the system transfer function can then be done for stability, bounded-ness of outputs and so on. Transfer function in hand, one knows how the system will respond to any given input. With such a versatile model, one can then predict system responses to various input conditions and use the model as a "module" or part of a larger system. Unbounded complexity can thus be managed in this manner.

In this vein, we can model the orchestration of brain quantum computation [3], where a universe of gravitational waves plays the piano of our brain, by breaking the computational process down into the following system and sub-system blocks:

1. Generator of Metric Perturbations.

2. Axon Tract

2a. Node of Ranvier

2ai. Ion at the Node

The signal emitted by the generator of metric perturbations is a gravitational wave. The signal applied to the node of Ranvier, a subsystem of the axon tract is the transduced voltage [4]. The ion at the node picks up this voltage and its quantum trajectory or behavior gets modified accordingly. Via the electric field generated, the behavior of distant ions at other nodes of Ranvier gets affected ever so slightly and, at the quantum level, the axon tract's information processing gets modified. With initial conditions in the form of modified temporal dynamics, the axon tract interacts differently with future impinging metric perturbations. Thus there is a partial feedback loop [2] within the axon tract.

In Willems' behavioral approach [5], behaviors are akin to the various trajectories that system signals can take. In related work [6] he also introduces a "tearing and zooming" approach to modeling control systems. The above mentioned multi-partite classical-quantum system can be a ground for application of Willems' methods. The modularization involved (see Figure 1 which shows a block diagram for the classical part of the problem) may help in scaling up the setup to the case of a very large number of generators, tracts, nodes and ions. An analysis of such a very large system will ultimately be necessary to extract testable neuro-behavioral predictions based on our model of brain quantum computation. It would also be interesting to consider the overlap of Willems' approach with the simulation of system dynamics, including the classical trajectories.

The advantages of the behavioral approach are many. First of all, Willems' development is considered to be a beautiful approach to control systems. Neat categorization of parts into signals, voltages and systems among others, behaviors for the systems and an algebraic approach which is rigorous are some of the other advantages. M. R. James, V. P. Belavkin and co-authors [8, 9] have already systematized quantum control,

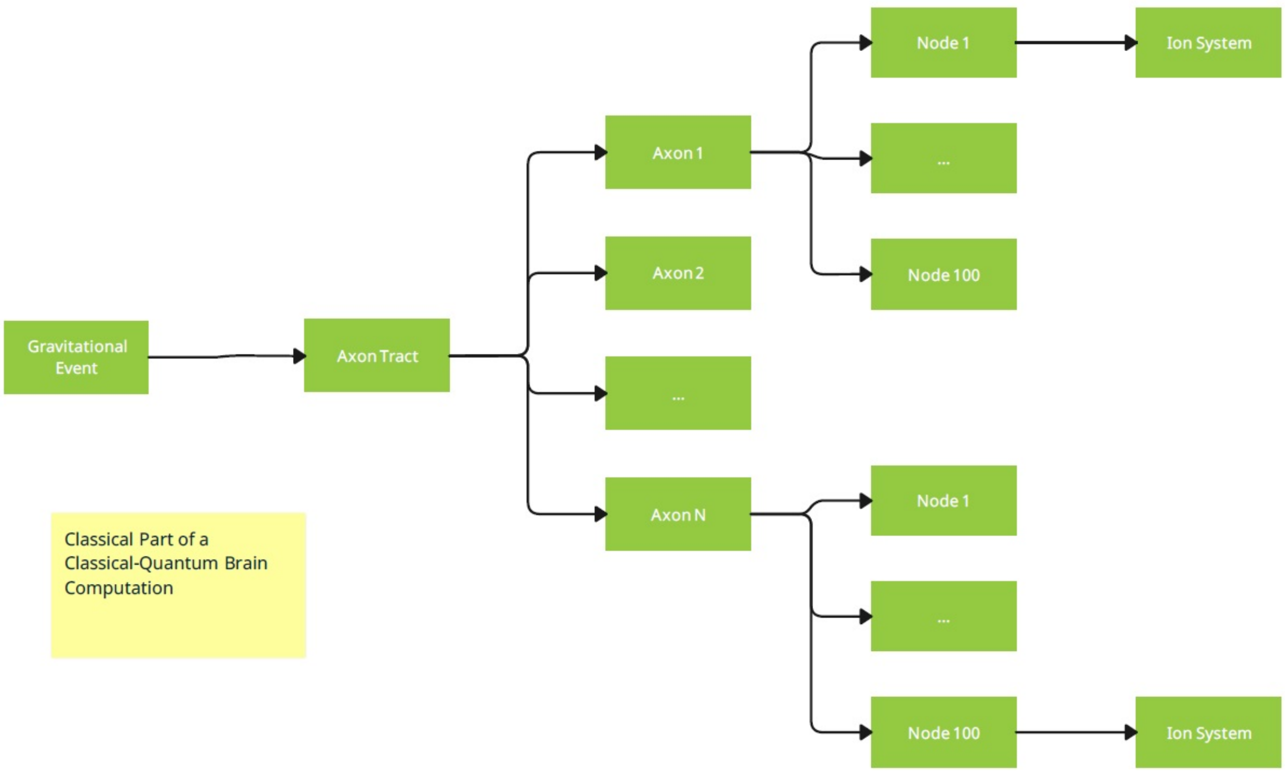

Figure 1: Classical part of a c-q computation in the brain.

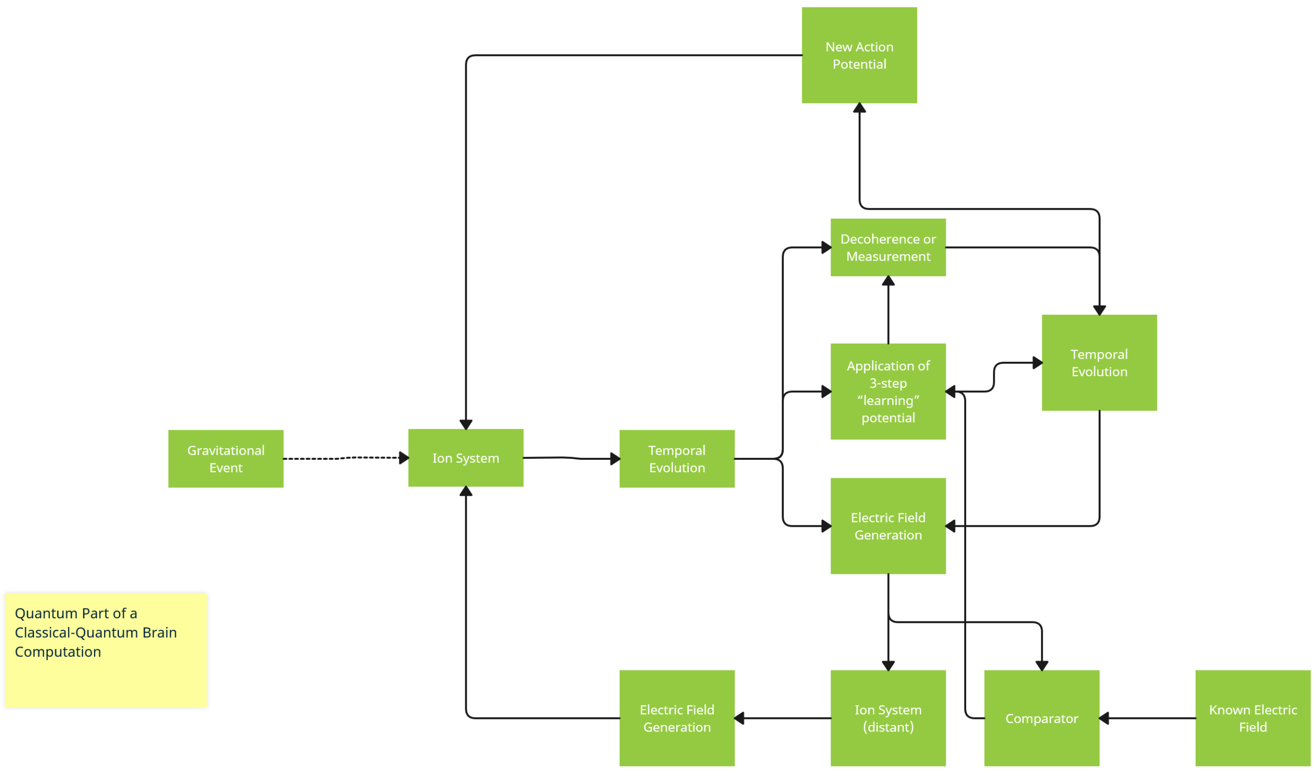

Figure 2: Quantum part of a c-q brain quantum computation with parallels to the quperceptron [7] setup.

particularly in the behavioral framework, and so cross-application of their results to our setting might be feasible.

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