# Federated Quantum Perceptrons

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April 2, 2024

**Abstract**

In this note the author presents a quantum analog of the federated learning scheme.

Consider the usual federated learning structure with a federation consisting of $k$ members. Each of the $k$ members is a perceptron with its own local environment. The local weights are updated as each member learns its local environment. These weight update vectors are then "uploaded" to the global aggregator which then averages (in general: processes) the weight vectors out and broadcasts this averaged weight to each of the members.

Consider an axon tract with $N$ axons. We solve the axon ephaptic coupling problem by visualizing the extracellular medium as a return path and modeling it as a cable in its own right. The return current is a "weighted" sum of the forward currents. As the return cable impulse hops from node to node, it can be thought of as broadcasting at each node, the information borne by the return current. Thus the weighted sum is broadcast to each of the $N$ forward axons. Each of them incorporates this coupling term in their forward calculation.

It was pointed out earlier that each axon tract can be thought of as a learning machine in its own right (see [1]). Thus, the described setup is an approximate form of federated learning when $N$ is large and the tract can be broken up into sub-bundles, each locally unified, but isolated by separation from the other bundles. The return path however links them all up as above.

One can extend this analogy to the quantum setting by simply noting that the three-step quperceptron potential discussed in [2] is under the aegis of an aggregator and broadcast mechanism. Thus we can think of $k$ ion groups in $k$ nodes of Ranvier, each interfacing with and learning their local environment in a mutually consistent manner under the federated *quperceptron* structure described herein.

## References

[1] Aman Chawla and Salvatore Domenic Morgera. On the geometry of interacting axon tracts in relation to their functional properties. *bioRxiv*, 2022.

[2] Aman Chawla. Quantum perceptrons and evolution. March 2024.