New Approaches for Training Quantum Neural Networks

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In recent years there has been a growing appreciation for the fact that vanishing gradient problems have the potential to wreck havoc on most neural networks. In contrast, the problems that appear in these networks' purported classical analogues due to small gradients are vastly less problematic. This raises two questions: "have we identified the correct classical analogues of our quantum neural networks?" and "are there better ways of performing optimization of our quantum neural networks?" In this talk I will present progress towards both of these questions. First, I will provide a new approach based on the quantum information bottleneck which uses ideas from quantum information theory to track and optimize the amount of relevant information about a concept flowing through part of a neural network. I show that, under certain assumptions about the input probability distribution, gradients can be computed for this objective function in polynomial time and because of its interpretation it allows a direct comparison between quantum and classical neural networks. Second, I will show a new approach to training neural networks that eschews the quantum / classical hybrid optimization used in existing quantum neural networks and variational algorithms that maps optimization of the quantum system to a dynamical quantum simulation problem. This avoids the O(1/epsilon) scaling of amplitude / probability estimation and in effect makes the problem of small gradients no worse than it is in classical neural networks that use backpropagation.