Quantum Recurrent Networks

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Recently, many researchers have been studying feedforward quantum circuits, that are quantum circuits without feedback loops. But, in order to physically realize various quantum circuits, it is convenient for us to be able to design quantum circuits that have feedback loops. In this talk, we introduce *quantum recurrent circuits*, which are quantum circuits with feedback loops.

Let C be a quantum recurrent circuit which solves the satisfiability problem for a blackbox Boolean function including n variables with at least probability 1/2. And let s be the size of C (i.e. the number of the gates in C) and t be the number of iterations that is needed for C to solve the satisfiability problem. Then, we show that, for those quantum recurrent circuits, the minimum value of $max(s,t)$ is $O(n^2 2^{n/3})$.

Next, we deal with *quantum recurrent networks* which are quantum neural networks that have certain feedback loops. In the filed of cognitive science, (ordinary) simple recurrent networks are widely used for modeling the natural language processing. A simple recurrent network is a circuit which consists of a finite number of gates, each of which computes an activation function whose range is a closed interval $[0.0, 1.0]$. On computational capabilities of simple recurrent networks, it is known that, if the range of a function computed at each gate is a finite set, the simple recurrent networks can only recognize regular languages.

In this talk, we first introduce *quantum recurrent networks*. Furthermore, we also introduce *quantum neuroidal nets*, which is a quantum analog of the neuroidal nets introduced by L. G. Valiant as a general neural network model for cognitive computations. Then, we observe computational capabilities of quantum neuroidal nets.