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Universal approximation theorem and error bounds for quantum neural networks and quantum reservoirs

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Universal approximation theorems are the foundations of classical neural networks, providing theoretical guarantees that the latter are able to approximate maps of interest. Recent results have shown that this can also be achieved in a quantum setting, whereby classical functions can be approximated by parameterised quantum circuits. We provide here precise error bounds for specific classes of functions and extend these results to the interesting new setup of randomised quantum circuits, mimicking classical reservoir neural networks. Our results show in particular that a quantum neural network with $\mathcal{O}(\varepsilon^{-2})$ weights and $\mathcal{O}(\lceil \log_2(\varepsilon^{-1}) \rceil)$ qubits suffices to achieve accuracy $\varepsilon > 0$ when approximating functions with integrable Fourier transform.

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