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Universal Approximation Depth and Errors of Narrow Belief Networks with Discrete Units

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We generalize recent theoretical work on the minimal number of layers of narrow deep belief networks that can approximate any probability distribution on the states of their visible units arbitrarily well, from the setting of binary units to the setting of units with finite state spaces. In particular we show that a q-ary deep belief network with [(q^n-1)/q(q-1)(n-Log_q(n)-1)] layers of width n is a universal approximator of distributions on {0,1,...,q-1}^n. More generally, we bound the Kullback-Leibler model approximation errors from above, depending on the network's depth and the state spaces of the units in every layer. We provide complementary results for restricted Boltzmann machines with finite state spaces.

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