Noisy Random Boolean Formulae - a Statistical Physics Perspective

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Typical properties of computing circuits composed of noisy logical gates are studied using the statistical physics methodology. A growth model that gives rise to typical random Boolean functions is mapped onto a layered Ising spin system, which facilitates the study of their ability to represent arbitrary formulae with a given level of error, the tolerable level of gate-noise, and its dependence on the formulae depth and complexity, the gates used and properties of the function inputs. Bounds on their performance, derived in the information theory literature via specific gates, are straightforwardly retrieved, generalized and identified as the corresponding typical-case phase transitions. The framework is employed for deriving results on error-rates, function-depth and sensitivity, and their dependence on the gate-type and noise model used that are difficult to obtain via the traditional methods used in this field.

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