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Parameterized Quantum Circuit Semantics Through Enriched Categories

It is well-known that combinatorial circuits are modeled mathematically by string diagrams in a monoidal category. Given a gate set Σ, the circuits over Σ can be thought of as string diagrams in the free monoidal category generated by Σ. In this model, circuit semantics are then given by monoidal functors out of this free category. For quantum circuits, this functor is often valued in the category of unitary matrices. This model suffices for concrete quantum circuits, but fails to describe parameterized families of quantum circuits, such as those which arise in the analysis of ansatz circuits. In this talk, we introduce an approach to parameterized circuit semantics, which is based on enriched category theory. This framework subsumes many constructions from quantum information, such as parameterized rotations and conditional operations. We show that many of the properties exhibited by these constructions arise from more fundamental categorical concepts, such as enrichment over Cartesian and monoidal closed categories.