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COMPUTER SCIENCE COLLOQUIUM

Quantum Information Effects

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Abstract:

We study the two dual quantum information effects to manipulate the amount of information in quantum computation: hiding and allocation. The resulting type-and-effect system is fully expressive for irreversible quantum computing, including measurement. We provide universal categorical constructions that semantically interpret this arrow metalanguage with choice, starting with any rig groupoid interpreting the reversible base language. Several properties of quantum measurement follow in general, and we translate (noniterative) quantum flow charts into our language. The semantic constructions turn the category of unitaries between Hilbert spaces into the category of completely positive trace-preserving maps, and they turn the category of bijections between finite sets into the category of functions with chosen garbage. Thus they capture the fundamental theorems of classical and quantum reversible computing of Toffoli and Stinespring.