

Compositionality of planar perfect matchings, a universal and complete fragment of ZW-calculus

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Titouan Carette, Etienne Moutot, Thomas Perez, and Renaud Vilmart

Abstract: We exhibit a strong connection between the matchgate formalism introduced by Valiant and the ZW-calculus of Coecke and Kissinger. This connection provides a natural compositional framework for matchgate theory as well as a direct combinatorial interpretation of the diagrams of ZW-calculus through the perfect matchings of their underlying graphs.

We identify a precise fragment of ZW-calculus, the planar W-calculus, that we prove to be complete and universal for matchgates, that are linear maps satisfying the matchgate identities. Computing scalars of the planar W-calculus corresponds to counting perfect matchings of planar graphs, and so can be carried in polynomial time using the FKT algorithm, making the planar W-calculus an efficiently simulable fragment of the ZW-calculus, in a similar way that the Clifford fragment is for ZX-calculus. This work opens new directions for the investigation of the combinatorial properties of ZW-calculus as well as the study of perfect matching counting through compositional diagrammatical technics.

Presenter: CARETTE, Titouan

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