A TQFT approach to 3d quantum gravity

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We propose a precise reformulation of 3d quantum gravity with negative cosmological constant in terms of a topological quantum field theory based on the quantization of the Teichmüller space of Riemann surfaces that we refer to as "Virasoro TQFT". We explain how together with standard TQFT surgery techniques this leads to a fully algorithmic procedure for the computation of the gravity partition function on a fixed topology exactly in the central charge. We demonstrate the explicit calculation of gravity partition function for various hyperbolic manifolds, e.g., hyperbolic knots, multi-boundary wormholes, etc. The partition function of those multi-boundary wormholes quantifies the higher moment of the structure constants in a proposed ensemble boundary dual. Meanwhile, we show that the Virasoro TQFT partition function of the figure-eight knot is identical to the partition function computed in the Teichmüller theory, thus giving strong evidence for the equivalence of these TQFTs.