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# Quantum reservoir computing in finite dimensions

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Quantum reservoir computing (QRC) is a machine learning technique where complex quantum systems are exploited to solve temporal tasks, such as predicting chaotic time series and complex spatiotemporal dynamics. Most existing results in the analysis of QRC systems with classical inputs have been obtained using the density matrix formalism. This paper shows that alternative representations can provide better insights when dealing with design and assessment questions. More explicitly, system isomorphisms have been established that unify the density matrix approach to QRC with the representation in the space of observables using Bloch vectors associated with Gell-Mann bases. It has been shown that these vector representations yield state-affine systems (SAS) previously introduced in the classical reservoir computing literature and for which numerous theoretical results have been established. This connection has been used to show that various statements in relation to the fading memory (FMP) and the echo state (ESP) properties are independent of the representation, and also to shed some light on fundamental questions in QRC theory in finite dimensions. Our conclusions can be summarized as: the necessary and sufficient condition that makes a quantum reservoir valuable is strictly contractive dynamics towards input-dependent fixed points.

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