Two-Page Summary Preparation for QTS. Important: Do Not Use Symbols, Special Characters, or Math in the title

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Describing of dynamics of a quantum system is an actual problem. Often the system is affected by environmental degrees of freedom and the dynamics became complicated. In this case, the quantum system is called open.

A quantum Markovian process is a special case of dynamics of an open quantum system. The dynamics of Markovian semigroup process are given by [1, 2]:

$$\frac{d}{dt}\rho_S = \mathcal{L}\rho_S = -i[H, \rho_S] + \sum_{i,j=1}^{N^2-1} \gamma_{ij}(F_i \rho F_j^\dagger - \frac{1}{2}\{F_j^\dagger F_i, \rho_S\}),$$

where ρ_S is the density matrix of the system S, H is the Hamiltonian, γ_{ij} is the element of positive definite matrix, F_i is the element of a complete orthonormal basis, N is dimension of a Hilbert space of the system S.

In this work, we consider the scheme of the experiment, in which projecting measurements are performed over the quantum system sequentially at regular intervals. In the work, the approach of the paper [3], that reconstructs the dynamics of the open quantum system via machine learning from the known measurements, is being developed. The algorithm finds the Hamiltonian H and the matrix (γ_{ij}) of the equation (1) via likelihood maximization estimation. The numerical implementation of the algorithm uses the TensorFlow library, which allows to speed up the reconstruction of the dynamics via parallelization of the calculations.

Let us consider the reconstruction of the quantum random telegraph noise model. In the model, the subsystem S interacts with the environment B through the subsystem M. The dynamics of the subsystem S is non-Markovian, but the composite subsystem $S + M$ has the Markovian dynamics. The dynamics are described by the master-equation [4]:

$$\begin{aligned}\frac{d}{dt}\rho_{S+M} = & -i[H_S \otimes \sigma_z, \rho_{S+M}] + \frac{1}{t_c}\left(\sigma_{1-}\rho\sigma_{1+} - \frac{1}{2}\{\sigma_{1+}\sigma_{1-}, \rho_{S+M}\}\right) \\ & + \frac{1}{t_c}\left(\sigma_{1+}\rho\sigma_{1-} - \frac{1}{2}\{\sigma_{1-}\sigma_{1+}, \rho_{S+M}\}\right),\end{aligned}$$

where ρ_{S+M} is the density matrix of the composite subsystem $S + M$, H_S is the hermitian operator acting on the system S, $\sigma_z = |0\rangle\langle 0| - |1\rangle\langle 1|$, $\sigma_{1+} = \sigma_{1-}^\dagger = I_S \otimes |1\rangle\langle 0|$.

The aforementioned algorithm allows us to restore the dynamics of the subsystem S. The density matrix of the subsystem S is given by $\rho_S = \mathrm{tr}(\rho_{S+M})$. The mean components of the Bloch's vector can be found by $\langle\sigma_i\rangle = \mathrm{tr}(\sigma_i\rho_S)$. The length of the Bloch's vector, that characterize a degree of a purity of the state, equals $|r| = \sqrt{\langle\sigma_x\rangle^2 + \langle\sigma_y\rangle^2 + \langle\sigma_z\rangle^2}$. Mean components vs. time and length vs. time graphs are presented in fig. 1.

The developed algorithm is able to restore the dynamics of the open quantum system via the set of results of sequential projecting measurements over the system.

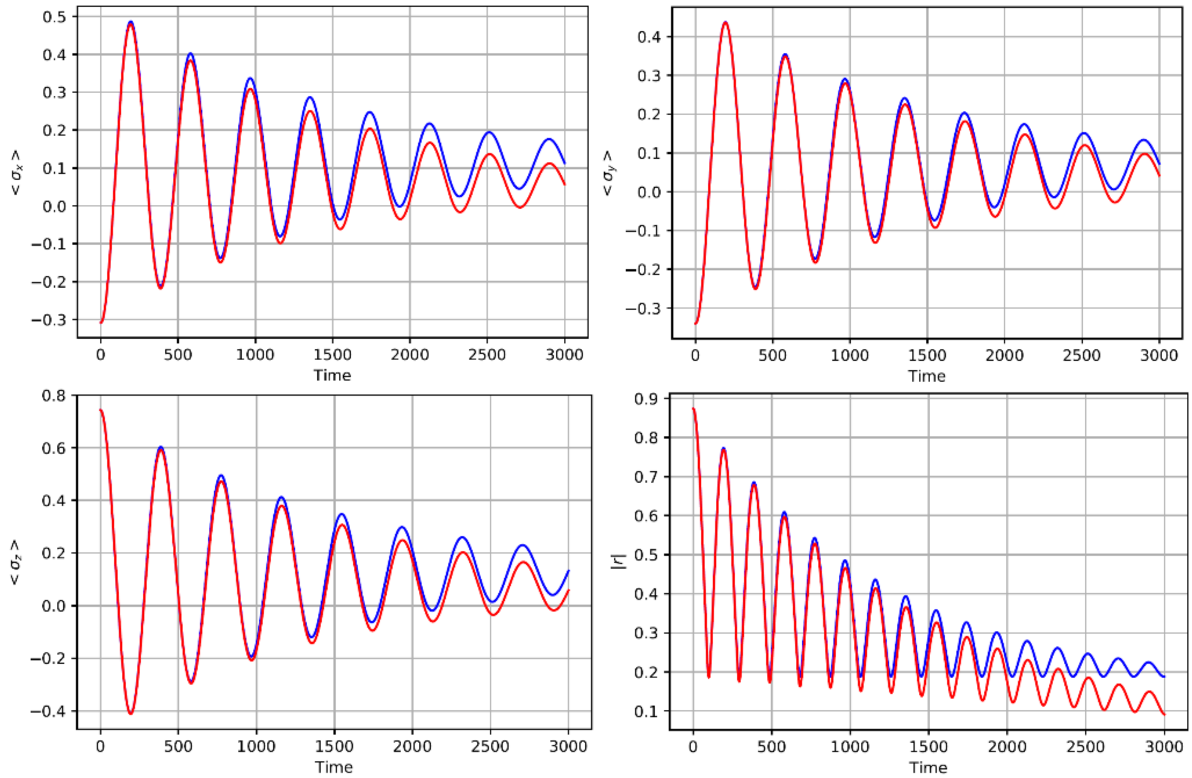

Figure 1: Dynamics of Bloch's vector's components. Blue line: true dynamics. Red line: trained dynamics.

References

[1] *V. Gorini, A. Kossakowski, E.C.G. Sudarshan.*, Completely Positive Dynamical Semigroups of N-Level Systems J. Math. Phys. **17**, 821, (1976).

[2] *Lindblad G.*, On the generators of quantum dynamical semigroups Commun. Math. Phys. **48**, 119, (1976).

[3] *I. A. Luchnikov, S. V. Vintskevich, D. A. Grigoriev, S. N. Filippov.*, Machine learning non-Markovian quantum dynamics arXiv:1902.07019.

[4] *S. Lorenzo, F. Ciccarello, G. M. Palma.*, Composite quantum collision models Phys. Rev. A. **96**, (2017).