Quantum computational advantage combining hybrid quantum–classical systems for NISQ devices with fast gates

1. **Problem statement:**
   It is not until the advantage of quantum computing devices, the possibility to store more states than either 0 or 1 in one qubits, bring the wide variety of formation processing tasks that the computation power makes breakthrough in the new era of information process. The noisy intermediate-scale quantum (NISQ) devices are defined as the quantum computer for which general-purpose quantum error correction is not feasible and ineradicable hardware errors with two-qubit operations of proper size in the classification problem of EEG signals. Meanwhile, the Gaussian boson sampling (GBS) has demonstrated to be capable of providing a highly-efficient approach to large-scale implementations limiting the fast gates operations. Furthermore, with the Variational Quantum Eigensolver (VQE) equipped, the hybrid algorithms are realized with available circuit depth in quantum phase estimation, optimizing through operation minimization.

2. **Methods:**
   The NISQ device is adopted with the wide definition instead of strict size of qubits and two-qubit operations with controlled error rates while the fidelity is computed with regards to circuit depth where the sampling matrix is the GBS matrix, absorbing both the unitary transformation and the squeezing parameters and phases of the Gaussian input state. The VQE is designed on the rate of convergence and the accuracy of the result computed inside each iteration correcting the fidelity and optimizes the circuit in the end.

3. **Results:**
   The counting of the Gaussians are applied with inverse QFT_grover (realizing using the multi-qubits presenting both 0 and 1 states near evenly). And the related combination rabi-fit with mitigation noisy model is composed with the computation of amplitude with phase and the fit of two-qubits. The TP,NP,FP,FN and CV of the training and tested sampled ratio at 3:1 (supervised) is relatively better. The comparison of the (TP,NP,FP,FN) and CV results with aggregated VQE is shown in accordance with the intuition that supervised model gives more accurate and robust classification results. After aggregation, the accuracy somehow is reduced mainly due to lower TP. Because the VQE is not as good as BO according to some articles, future work might take BO into consideration so as to get better fit and classification.

4. **Conclusion:**
   The VQE does help significantly in increasing the efficiency of information process as well as improving accuracy with the correction made by fidelity while fitting the EEG. Furthermore, the supervised model gives better results relatively. The optimization made through each iteration is of large computation cost while the variational methods in return reduces some computation scale.