Research Papers on 'Computer'

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Paper 1:

Fault-Resilience of Dissipative Processes for Quantum Computing

Date: 2025-02-27

Time: 18:50:37

Authors:

James Purcell, Abhishek Rajput, Toby Cubitt

Summary:

- Dissipative processes have long been proposed as a means of performing computational tasks on quantum computers that may be intrinsically more robust to noise. In this work, we prove two main results concerning the error-resilience capabilities of two types of dissipative algorithms: dissipative ground state preparation in the form of the dissipative quantum eigensolver (DQE), and dissipative quantum computation (DQC). The first result is that under circuit-level depolarizing noise, a version of the DQE algorithm applied to the geometrically local, stabilizer-encoded Hamiltonians that arise naturally when fermionic Hamiltonians are represented in qubits, can suppress the additive error in the ground space overlap of the final output state exponentially in the code distance. This enables us to get closer to fault-tolerance for this task without the associated overhead. In contrast, for computation as opposed to ground state preparation, the second result proves that DQC is no more robust to noise than the standard quantum circuit model.

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Paper 2:

Shadow measurements for feedback-based quantum optimization

Date: 2025-02-27

Time: 18:36:30

Authors:

Leticia Bertuzzi, João P. Engster, Evandro C. R. da Rosa, Eduardo I. Duzzioni

Summary:

- Improving the performance of quantum algorithms is a fundamental task to achieve quantum advantage. In many cases, extracting information from quantum systems poses an important challenge for practical implementations in real-world quantum computers, given the high resource cost of performing state tomography. In this scenario, randomized measurements emerged as a promising tool. In particular, the classical shadows protocol allows one to retrieve expected values of low-weight Pauli observables by performing only local measurements. In this paper, we present an implementation of the recently introduced Feedback-based algorithm for quantum optimization (FALQON) with the Ket quantum programming platform, for solving the MaxCut optimization problem. We employ classical shadows for the feedback routine of parameter estimation and compare this approach with the direct estimation of observables. Our results show that depending on the graph geometry for the MaxCut problem, the number of measurements required to estimate expected values of observables with classical shadows can be up to 16 times lower than with direct observable estimation. Furthermore, by analyzing complete graphs, we numerically confirm a logarithmic growth in the required number of measurements relative to the number of observables, reinforcing that classical shadows can be a useful tool for estimating low-locality Pauli observables in quantum algorithms.

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Paper 3:

Geometric Machine Learning on EEG Signals

Date: 2025-02-27

Time: 18:19:47

Authors:

Benjamin J. Choi

Summary:

- Brain-computer interfaces (BCIs) offer transformative potential, but decoding neural signals presents significant challenges. The core premise of this paper is built around demonstrating methods to elucidate the underlying low-dimensional geometric structure present in high-dimensional brainwave data in order to assist in downstream BCI-related neural classification tasks. We demonstrate two pipelines related to electroencephalography (EEG) signal processing: (1) a preliminary pipeline removing noise from individual EEG channels, and (2) a downstream manifold learning pipeline uncovering geometric structure across networks of EEG channels. We conduct preliminary

validation using two EEG datasets and situate our demonstration in the context of the BCI-relevant imagined digit decoding problem. Our preliminary pipeline uses an attention-based EEG filtration network to extract clean signal from individual EEG channels. Our primary pipeline uses a fast Fourier transform, a Laplacian eigenmap, a discrete analog of Ricci flow via Ollivier's notion of Ricci curvature, and a graph convolutional network to perform dimensionality reduction on high-dimensional multi-channel EEG data in order to enable regularizable downstream classification. Our system achieves competitive performance with existing signal processing and classification benchmarks; we demonstrate a mean test correlation coefficient of >0.95 at 2 dB on semi-synthetic neural denoising and a downstream EEG-based classification accuracy of 0.97 on distinguishing digit- versus non-digit- thoughts. Results are preliminary and our geometric machine learning pipeline should be validated by more extensive follow-up studies; generalizing these results to larger inter-subject sample sizes, different hardware systems, and broader use cases will be crucial.

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Paper 4:

SecureGaze: Defending Gaze Estimation Against Backdoor Attacks

Date: 2025-02-27

Time: 17:33:49

Authors:

Lingyu Du, Yupei Liu, Jinyuan Jia, Guohao Lan

Summary:

- Gaze estimation models are widely used in applications such as driver attention monitoring and human-computer interaction. While many methods for gaze estimation exist, they rely heavily on data-hungry deep learning to achieve high performance. This reliance often forces practitioners to harvest training data from unverified public datasets, outsource model training, or rely on pre-trained models. However, such practices expose gaze estimation models to backdoor attacks. In such attacks, adversaries inject backdoor triggers by poisoning the training data, creating a backdoor vulnerability: the model performs normally with benign inputs, but produces manipulated gaze directions when a specific trigger is present. This compromises the security of many gaze-based applications, such as causing the model to fail in tracking the driver's attention. To date, there is no defense that addresses backdoor attacks on gaze estimation models. In response, we introduce SecureGaze, the first solution designed to protect gaze estimation models from such attacks. Unlike classification models, defending gaze estimation poses unique challenges due to its continuous output space and globally activated backdoor behavior. By identifying distinctive characteristics of backdoored gaze estimation models, we develop a novel and effective approach to reverse-engineer the trigger function for reliable backdoor detection. Extensive evaluations in both digital and physical worlds demonstrate that SecureGaze effectively counters a range of backdoor attacks and outperforms seven state-of-the-art defenses adapted from classification models.

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