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A Hybrid Quantum–Classical Framework for Image Analysis and Facial Expression Recognition

Abstract
Context: Image analysis and boundary detection are critical in diagnostic and monitoring systems where intensity variations must be resolved under noise and limited resolution. Quantum image pro□cessing, using superposition and interference principles, offers novel representations and operations for structured analysis, which can complement classical approaches in imaging-intensive experimental setups.
Purpose: This study investigates a hybrid quantum–classical framework for facial image analysis and facial expression recognition, explicitly motivated by applications where accurate detection of spatial patterns is crucial for experimental diagnostics and monitoring.
Methods: Facial images are enhanced using histogram equalization and adaptive thresholding to maximize contrast and improve separability prior to quantum-inspired processing. The enhanced images are then encoded using a gridding-based representation analogous to block-based quantum image models, enabling localized subsystem analysis. Facial expressions are characterized through graph-based observables derived from facial landmark points, and classification is performed using classical and quantum-inspired classifiers.
Findings: Thresholding-based preprocessing improves image quality by enhancing contrast and segmentation boundaries, while gridding-based segmentation enables localized analysis and stable feature extraction. Experiments conducted on a subset of the FFHQ dataset achieve approximately 90% accuracy in small-scale evaluations. The workflow demonstrates potential for reliable pattern recognition in image-intensive diagnostic environments.
Significance: The results demonstrate that hybrid quantum–classical frameworks can effectively bridge classical image processing and quantum-inspired algorithms, providing scalable and robust tools for monitoring, diagnostics, and structured analysis in imaging-intensive experimental systems.
Keywords: Quantum image processing; hybrid quantum–classical frameworks; quantum-inspired mod□els; image gridding; experimental diagnostics; pattern recognition
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Author: SHARMA, Anshu (Patna Women's College)

Co-authors: Dr N/A, Amrita (Patna Women's College); Ms RAJ, Anshika (Patna Women's College); Dr KHADANGA, Ganesh (National Informatics Centre, New Delhi)

Presenters: Dr N/A, Amrita (Patna Women's College); Ms RAJ, Anshika (Patna Women's College); SHARMA, Anshu (Patna Women's College)