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Quantum Extreme Reservoir Computing for brain tumour MRI classification

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Medical imaging provides a demanding test for quantum machine learning because clinically relevant images are much larger and structurally richer than standard benchmarks (MNIST). In this work, we study quantum extreme reservoir computing (QERC) for binary brain-tumour classification using the Br35H MRI dataset, with images resized to 150 × 150 pixels. Since such inputs cannot be encoded directly into a small quantum reservoir, we compare principal component analysis with two autoencoder-based compression schemes.

The results show that reconstruction quality alone is not a reliable guide to downstream quantum classification. An autoencoder can reproduce the images well while mapping them into a narrow region of latent space, thereby supplying the quantum encoder with insufficiently varied inputs. We quantify this concentration using the participation ratio and find that broader latent distributions generally produce better and more stable classification. Batch normalization improves performance by spreading the latent variables more evenly before quantum encoding.

These results show that the compression method is not simply a preprocessing choice. For this type of quantum image-classification pipeline, it must both retain useful information and generate latent variables that can be encoded effectively by the quantum reservoir.

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