ABSTRACT

Brain tumors are serious neurological disorders with high morbidity and mortality, requiring rapid and accurate diagnosis. Magnetic Resonance Imaging (MRI) is the primary modality for brain tumor evaluation due to its high soft tissue contrast without ionizing radiation. However, manual interpretation of MRI remains subjective and prone to inter-observer variability, highlighting the need for automated classification methods to support Computer-Aided Diagnosis (CAD) systems. This study investigates the impact of hybrid feature extraction on brain tumor classification accuracy and evaluates the effectiveness of Principal Component Analysis (PCA) for dimensionality reduction without compromising performance using Subspace k-Nearest Neighbor (Subspace kNN) classification.

The study utilized 6,000 T1-weighted brain MRI images from the public BRISC 2025 Kaggle dataset, comprising four classes: glioma, meningioma, pituitary, and no tumor. Preprocessing included resizing images to 224×224 pixels, grayscale conversion, and contrast enhancement via Contrast Limited Adaptive Histogram Equalization (CLAHE). Feature extraction employed a hybrid approach combining Histogram of Oriented Gradients (HOG) and deep learning features from MobileNet. Features were normalized using StandardScaler and reduced with PCA retaining 95% variance. Classification was performed with Subspace kNN using 30 estimators, 40% subspace proportion, and k = 1.

Results indicate that the HOG + MobileNet + PCA combination achieved the highest performance with accuracy of 97.5% and AUC of 0.998. PCA effectively reduced feature dimensionality while substantially improving computational efficiency. This hybrid approach demonstrates strong potential for fast and accurate CAD systems in multi-class brain tumor classification using MRI images.

Keywords: brain tumor, MRI, hybrid features, PCA, Subspace kNN,