

Integrating Multi-Distribution Initialization for Robust CNN Models in Medical Image Recognition

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Abstract

The stability and accuracy of convolutional neural networks (CNNs) for medical image recognition are strongly influenced by weight initialization strategies. Conventional approaches such as He and Xavier initialization often yield inconsistent results across diverse imaging modalities, particularly when data distributions deviate from Gaussian assumptions. To address this limitation, this study introduces a *multi-distribution initialization* strategy that integrates diverse statistical distributions—including normal, uniform, beta, gamma, and exponential—to generate representative starting weights. By combining and rescaling samples from multiple distributions, the method provides a more versatile initialization scheme that improves convergence stability and generalization.

Experimental evaluation was conducted using five Kaggle datasets: breast ultrasound (benign, malignant, normal), brain MRI (glioma, meningioma, pituitary, healthy; tumor vs. no-tumor), chest X-ray (COVID-19, pneumonia, normal), and kidney CT (cyst, stone, tumor, normal). Models were trained under three optimizers (Adam, SGDM, RMSProp) and assessed with classification accuracy, Cohen's Kappa, and runtime.

Results demonstrate that multi-distribution initialization achieves robust performance across modalities, offering stable accuracy and significantly reduced training time in tasks such as chest X-ray and kidney CT classification. Compared to He and Xavier methods, which showed higher variance across datasets, the proposed strategy consistently balanced precision and efficiency. This research establishes multi-distribution initialization as a practical approach for robust CNN training in medical image recognition, with strong potential for deployment in both clinical and computationally constrained environments.

Keywords: CNN, weight initialization, multi-distribution strategy, medical image recognition, generalization, robustness.