Histopathological Image Analysis Using VNet for Breast Cancer Detection and Classification

Breast cancer remains one of the most prevalent and life-threatening diseases among women worldwide. Early and accurate diagnosis is vital for effective treatment and improved survival rates. Histopathological analysis of breast tissue is considered the gold standard for cancer detection; however, manual examination by pathologists is time-consuming, prone to inter-observer variability, and requires considerable expertise. To address these challenges, this study proposes an automated framework for the prompt identification and classification of breast cancer histopathological images using a VNet-based deep learning classifier. The VNet architecture, originally designed for medical image segmentation, has been adapted and optimized in this work to classify breast tissue images into benign and malignant categories. The network utilizes volumetric convolutions and residual connections to effectively learn spatial hierarchies and morphological features from high-resolution histopathological images. The dataset used for training and evaluation includes a wide range of breast tissue samples, encompassing various cancer subtypes and normal tissue, ensuring the model's generalizability and robustness. Preprocessing techniques such as color normalization, noise filtering, and patch extraction are applied to enhance input data quality. The VNet classifier is trained using a supervised learning approach, leveraging annotated images to learn class-specific features. The performance of the proposed model is evaluated using standard metrics, including accuracy, precision, recall, F1-score, and area under the ROC curve (AUC). Experimental results demonstrate that the VNet classifier achieves a classification accuracy exceeding 95%, outperforming several traditional and deep learning-based methods. This work highlights the potential of the VNet model as a powerful diagnostic tool in digital pathology workflows. The proposed system offers a rapid, consistent, and highly accurate solution for breast cancer screening, which can support pathologists in clinical decision-making and reduce diagnostic errors.