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Deep Learning-Based Tumor Grade Classification Using ADC Maps in Breast MRI

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Breast cancer is the most prevalent cancer worldwide, and its early diagnosis is essential for effective treatment strategies and improved patient survival. Cancer grading is critical when assessing tumor aggressiveness and guiding targeted therapeutic intervention. Breast tumors are generally classified as benign or malignant. Malignant tumors are cancerous, while benign tumors are non-cancerous, with additional grading required to assess clinical risk. The research aim is to develop and evaluate a convolutional neural network for automated classification of low-risk and high-risk breast tumor grades using ADC (Apparent Diffusion Coefficient) maps derived from breast MRI (Magnetic Resonance Imaging) data obtained from The Cancer Imaging Archive. ADC maps were generated in MATLAB by merging two different diffusion-weighted (DW) images acquired with two different diffusion sensitization levels. Tumor Regions of Interest (ROIs) were manually outlined under the supervision of a radiologist using the drawpolygon function in MATLAB for each patient separately. Furthermore, 590 tumor masks were extracted from the dataset and used to train and evaluate the Convolutional Neural Network (CNN) model implemented in Python on Google Colab. The proposed design includes supervised learning and quantitative performance evaluation using classification and segmentation metrics. The model achieved a test accuracy of 82.73% with a final test loss of 0.3811. Sensitivity was 87.27% and 78.18% for high-risk and low-risk grades, respectively, with specificity values of 78.18% and 87.27%. Precision scores were 80.00% and 86.00%, and F1-scores were 83.48% and 81.90%. The model demonstrated excellent segmentation performance with Dice Similarity Coefficient (DSC) values of 83.48% and 81.90% and Intersection over Union (IoU) values of 71.64% and 69.35% for each stage. The model achieved AUC-ROC values of 0.9173 and 0.9173. These findings demonstrate reliable tumor grade classification, supporting clinical decision-making. Limited dataset size remains a constraint, and future work could focus on expanding the dataset.

Keywords: ADC map, Breast MRI, Convolutional neural network, Tumor grade