



Focal-AttentionNet: A novel AI-driven framework integrating holographic imaging for head and neck cancer diagnosis

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Abstract

Head and neck cancer (HNC) remains a significant global health concern, with traditional diagnostic techniques such as biopsies and endoscopy often limited by procedural complexity and delayed detection. To support early diagnosis, a novel imaging dataset is curated from clinically acquired samples, comprising 3,915 digital holographic images capturing three-dimensional tissue structure and 3,912 bright-field images reserved for future comparative analysis. Building on this dataset, the present study proposes Focal-AttentionNet, a novel Deep Learning (DL) framework that integrates digital holographic imaging with State-of-the-Art (SOTA) neural networks for early and accurate classification of HNC tissue samples. The images are systematically annotated and pre-processed to support binary classification of normal and abnormal tissues. The proposed model leverages DenseNet201 integrated with a Convolutional Block Attention Module (CBAM) thereby employing class weighting for imbalance handling along with a customized focal loss function for robust loss computation. Experimental results demonstrated that Focal-AttentionNet outperformed several baseline models, including ResNet50-Focal, InceptionV3-Focal, other DenseNet variants, achieving prediction accuracy of 98.14%. It also demonstrated excellent sensitivity, specificity, and consistently strong performance across key evaluation metrics such as the F1-score, cohen's kappa, and other confidence metrics. Beyond quantitative evaluation, the study enhances model interpretability through qualitative analysis using t-distributed Stochastic Neighbor Embedding (t-SNE) visualization of latent feature representations to assess class separability and attention-based maps to highlight the discriminative regions driving model predictions. Both quantitative performance outcomes and qualitative interpretability assessments are well aligned, jointly validating the model's decision-making process and reinforcing its clinical reliability. Collectively, this work sets a benchmark in applying DL to holographic imaging for HNC, marking the first study to combine attention-based interpretability in HNC diagnosis.

Keywords Convolutional neural networks · Deep learning · Early diagnosis · Focal-AttentionNet · Head and Neck cancer · Holography

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