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Leveraging adaptive convolutional neural networks with semantic segmentation to revolutionize tuberculosis detection and diagnostic precision

Purpose

Tuberculosis (TB) remains a leading cause of infectious disease mortality worldwide. Despite being treatable with antibiotics, TB is often misdiagnosed or untreated, particularly in resource-limited regions. Chest X-rays are crucial for TB diagnosis, but variability in radiological presentations and limited access to trained radiologists reduce their effectiveness. This study aims to enhance TB detection in chest X-rays using deep learning techniques.

Materials and Methods

A Triple Attention-UNet model was trained on 704 chest X-ray images from Montgomery County and Shenzhen Hospital datasets for lung segmentation. The trained customized CNN model was applied to 1,400 chest X-rays, including TB cases and normal controls from the NIAID TB Portal dataset. Segmented lung regions were classified as TB or normal using a custom convolutional neural network. Image contrast was enhanced using a triple attention unet method combined with gamma correction. GradCAM, ScoreCAM were used for visualizing disease.

Results

The Triple Attention-UNet segmentation model achieved 98.18% accuracy, 98.40% recall, 97.45% precision, 91.39% of IOU, Dice coefficient of 96.33%. The classification model demonstrated 99.45% accuracy, 99.29% precision, 99.29% recall, and an AUC of 99.9%. The pre-processing method showed improved image quality with AMBE of 1.14447, entropy 7.3578, CII 86.80, PSNR 29.9624 and SSIM 40.9501.

Conclusions

The integrated segmentation-classification pipeline demonstrates high efficiency in diagnosing TB from chest X-rays, potentially exceeding clinician-level performance. This approach is especially valuable in settings with limited radiological expertise. Additionally, the Triple Attention UNet model outperformed the standard U-Net, underscoring its potential to improve diagnostic accuracy and precision.

Keywords

tuberculosis, deep learning, artificial intelligence ,chest X-ray ,segmentation, classification

Biography

Dr. Sayali A. Salkade is pursuing her Ph.D. in Computer Engineering at Thakur College of Engineering and Technology, Mumbai. She holds Master's and Bachelor's degrees in Computer Engineering from Pune University and has over a decade of academic and research experience.

Her expertise spans AI, Machine Learning, Cloud Computing, and Deep Learning in healthcare. She has published in SCIE, Scopus, and UGC-listed journals, including the Polish Journal of Radiology and Journal of Electrical Systems, Indian Journal of Science and Technology, IJCRT. An invited speaker, reviewer and trainer she has conducted FDPs on AI, Deep Learning and Generative AI bridging research with real-world applications.