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RETINAL VESSEL SEGMENTATION USING DEEP LEARNING TECHNIQUES

FINAL PROJECT

Participants

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PURPOSE

Diabetic retinopathy (DR) is a leading cause of preventable blindness worldwide. Early detection through retinal imaging is essential for timely treatment and vision preservation. This study aims to develop and evaluate a deep learning model for automated detection and classification of diabetic retinopathy stages from retinal fundus images to support clinical decision-making.

METHODS AND MATERIALS

We utilized the DRIVE dataset comprising 40 retinal images from diabetic patients with varying stages of DR (20 for training and 20 for testing). Convolutional neural networks based on U-Net architectures—specifically U-Net, nnU-Net, Swin-UNet (a combination of U-Net and Swin Transformer), and SAM—were trained after applying data augmentation techniques to enhance model generalizability. For each training image, five augmented instances were generated, expanding the training set to 120 images (20 original + 100 augmented). This training set was further split into training (90%, 108 images) and validation (10%) subsets, while the test set remained unchanged (20 images). Model performance was evaluated using accuracy, sensitivity, specificity, F1 score, Jaccard Index, and the Dice coefficient as a custom metric.

RESULTS

Among the models, nnU-Net outperformed others despite being only partially trained for 210 epochs due to GPU limitations. It demonstrated superior ability to capture thin retinal vessels compared to the other models. We anticipate that full training on a more powerful GPU could further improve its performance, potentially enabling detection of nearly all vessels, including the thinnest ones. On the test set, nnU-Net achieved an accuracy of 0.97, sensitivity of 0.79, specificity of 0.85, F1 score of 0.817, Jaccard Index of 0.69, and Dice coefficient of 0.815. Statistical analysis confirmed the significance of these results ($p < 0.05$).

CONCLUSION

The deep learning model provides a reliable and efficient tool for early detection of diabetic retinopathy from retinal images. Its deployment in clinical settings may facilitate timely diagnosis, reduce the workload of specialists, and improve patient outcomes through earlier intervention.

CLINICAL RELEVANCE / APPLICATION

Automated detection of diabetic retinopathy has the potential to enhance screening programs, especially in resource-limited settings, by enabling widespread access to early eye care and preventing vision loss among diabetic populations