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Classification of Vitreomacular Adhesion Types Using Deep Learning Models on Optical Coherence Tomography Images

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Introduction/Background

In recent years, Deep Learning (DL) approaches have received considerable interest in ophthalmology due to their ability to promptly diagnose diseases and aid clinicians in decision-making. Using DL models on Optical Coherence Tomography (OCT) images for detecting and classifying Vitreomacular Adhesion (VMA) is still in the early stages. This research aims to design an automated system to classify two types of VMA, Focal VMA and Broad VMA, from Diabetic Macular Oedema (DME) patients using OCT images.

Methods/Intervention

This retrospective study analyzed 302 OCT images from 202 DME patients collected at Chennai Eye Hospital (January 2015 to June 2022), approved by the Vision Research Foundation Institutional Review Board. Two optometrists graded the images, categorizing 107 as Focal VMA and 195 as Broad VMA. Data augmentation and resampling addressed data imbalance, and the data was normalized and resized. VGG16, InceptionV3, and XceptionNet models using transfer learning with pre-trained ImageNet weights, classified the VMA types with 80% of the data for training and 20% for validation. Grad-CAM was used to visualize the regions of interest that influenced the model's decisions. Model performance was assessed by accuracy, sensitivity, specificity, AUC, and F1-score.

Results/Outcome

All three models performed well. VGG16 illustrated 84.19% accuracy with 84% Sensitivity, 83% Specificity, 84% AUC score, and 84% F1-Score. InceptionV3 showed slightly better accuracy of 84.40% with 84% sensitivity and specificity, 84% AUC score, and 84% F1-Score. The XceptionNet model outperformed all with 85% accuracy. The sensitivity, specificity, AUC score, and F1 scores were 85%, 84%, 85%, and 85%, respectively.

Conclusion

DL models correctly classified Focal VMA and Broad VMA from OCT images. Transfer learning reduced the program execution time. Among all the models, XceptionNet performed slightly better. The DL models utilized in this research show the potential to automate the diagnosis of various vitreomacular interface disorders with higher accuracy and a streamlined diagnostic process.

Statement of Impact

The study demonstrates that deep learning models, particularly the XceptionNet model, can accurately and efficiently classify vitreomacular adhesion types in diabetic macular edema patients using OCT images, achieving up to 85% accuracy. This automation significantly improves diagnostic speed and accuracy, facilitating better treatment planning and clinical workflow efficiency.

Table 1: Comparison of Performance Metrics for VGG16, InceptionV3, and XceptionNet Models in Classifying Vitreomacular Adhesion Types

Model	Accuracy (%)	Sensitivity (%) (VMA_Broad)	Specificity (%) (VMA_Broad)	Sensitivity (%) (VMA_Focal)	Specificity (%) (VMA_Focal)	ROC-AUC (%)	F1 Score (%)
VGG16	84.19	84.48	83.9	84.62	83.76	84	84
InceptionV3	84.4	84.26	84.55	84.19	84.62	84	84
XceptionNet	**84.83**	**84.98**	**84.68**	**85.04**	**84.62**	**85**	**85**

*Note: All values are percentages.

Footnotes:

a. Sensitivity (VMA_Broad): True positive rate for Broad Vitreomacular Adhesion.

b. Specificity (VMA_Broad): True negative rate for Broad Vitreomacular Adhesion.

c. Sensitivity (VMA_Focal): True positive rate for Focal Vitreomacular Adhesion.

d. Specificity (VMA_Focal): True negative rate for Focal Vitreomacular Adhesion.

e. ROC-AUC: Area under the Receiver Operating Characteristic curve.

f. F1 Score: Harmonic mean of precision and recall.

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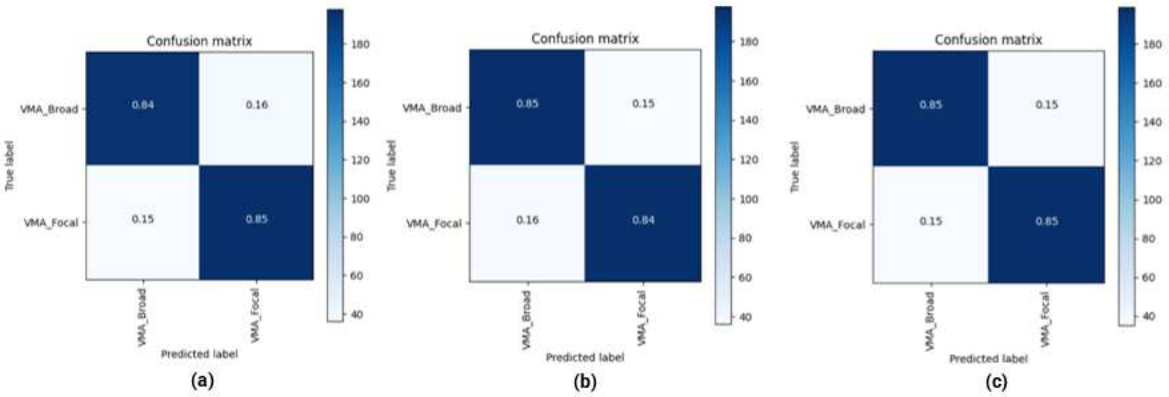

Fig 1. Confusion matrix of (a) vgg16, (b) InceptionV3 and (c) XceptionNet

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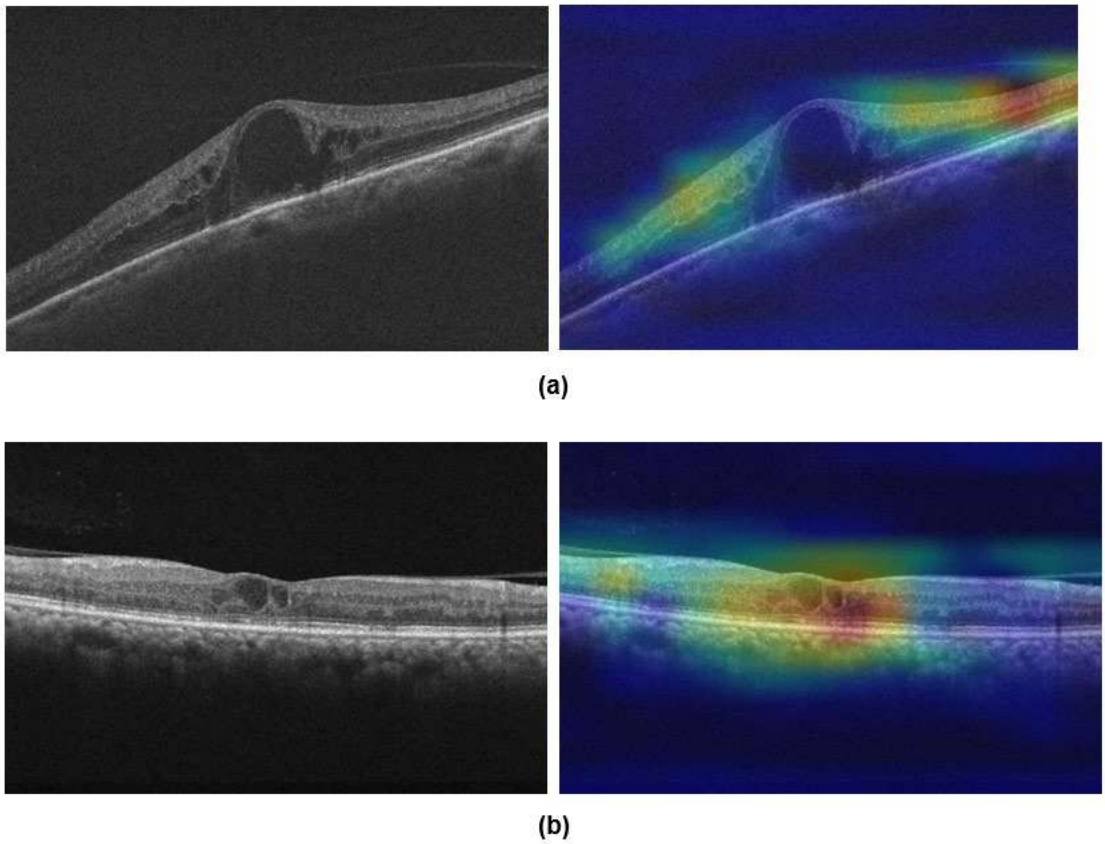

Fig 2. Grad-CAM image of (a) Focal VMA and (b) Broad VMA

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Keywords

Vitreomacular adhesion; Deep learning; Focal VMA; Broad VMA