CHAPTER 6

CONCLUSION AND FUTURE DIRECTION

This research presents a broad study of the use of DL models to classify DR, which is important in early detection and management of DR. The research is carried out in three phases. In the first phase, the models from classic architectures such as VGG16 to more contemporary architectures like the DenseNet121 and EfficientNetV2L, are finetuned and evaluated. In the second phase, five CNN models are customized and evaluated. In the third phase, a hybrid model is articulated based on EfficientNetV2L and custom CNN model-5 to utilise the advantages of both the models.

6.1 Finetuning and evaluation of classic DL models

The first part of the study focused on analysing five well-established DL models for DR grading. Models including VGG16, ResNet-50, InceptionV3, DenseNet121, and EfficientNetV2L are finetuned and evaluated using accuracy, precision, recall and F1 score. The Finetuned EfficientNetV2L, performed better compared to other finetuned models with an accuracy of 92%, precision of 91%, recall of 92%, and an F1-score of 92%.

6.2 Customizing and evaluation of CNN models

In the second part of the study, five CNN architectures are customized and analysed. Among the five custom CNN models, custom CNN Model-5 , performed better compared to other custom CNN models with an accuracy of 88%, precision of 86%, recall of 84%, and F1-score of 84%.

6.3 Building a hybrid model and evaluation

In the third part of this work, a hybrid model combining the EfficientNetV2L architecture and customised CNN model-5 is proposed. The proposed hybrid model is better than the existing hybrid model and all other models with an accuracy of 94%, precision of 94%, recall of 93%, and F1-score of 94% with 441,087 trainable parameters and 1.6 seconds of inference time where the existing hybrid model has an accuracy of 75%, precision of 73%, recall of 75%, and F1-score of 71% with 2,361,860 parameters and 3 seconds of inference time.

The proposed hybrid model is superior because it efficiently balance TL and task-specific feature learning. Employing EfficientNetV2L, a strong pretrained backbone that has the capability of capturing deep, abstract, generalisable features and custom CNN model-5 for local fine-grained pattern detection in the database, the architecture engages both the global and domain representation strengths. Its two-branch structure allows the model to learn a greater number of discriminative features, thus enhancing classification performance and strength of generalisation. Utilisation of separable convolution layers in the personalised CNN efficiently simplifies parameter complexity without weakening feature learning capability, facilitating faster computation. Finally, GAP in both branches maintains spatial information but minimises overfitting risk, resulting in better generalisation on novel data.

Apart from the architectural benefit, the training approach of the proposed hybrid model also boosts its performance. Freezing pretrainded EfficientNetV2L layers allows its pre-existing feature representations without impairing the capacity of the custom CNN to learn specifically for DR images. Precisely tuned hyperparameters like a small learning rate for stabilised optimisation, dropout of 30% for regularisation, and application of the Adam optimiser for adaptive optimisation enhance model stability and convergence rate. The balance of high accuracy, fast inference, and fewer parameters than existing hybrid and other models provides enhanced prediction performance through an optimized and scalable automatic algorithm for DR stage classification.

6.4 Future Scope

The scope of the hybrid model for DR classification can be improved by the following aspects:

- **Integration with Clinical Data**: Incorporating demographic and clinical tests along with retinal imaging can significantly improve the prediction of DR.

- **Real-Time Application**: Deploying the hybrid model in real-time applications with edge computing can achieve real-time onsite diagnosis, particularly for resource-limited areas.

- **Generalisation to Other Medical Diagnoses**: The architecture of the hybrid model may have the potential to generalise to other medical conditions or imaging tasks, e.g., cancer identification or cardiovascular diseases.
- **Longitudinal Studies and Predictive Modelling**: Adding time-series data would assist the model in predicting disease progression and improve early intervention and treatment options.
- **Federated Learning**: Applying federated learning to train a model across hospitals will improve the model accuracy and maintain privacy by not exchanging patient information.

These approaches will strengthen and expand the hybrid model's application to various medical image tasks for better diagnosis and treatment.