SPECIMEN FORMAT FOR THESES OF MONTH

Faculty	:	Dr. R. Vijayabhanu
Department	:	Computer Science
Branch/ Area:	:	Image Processing
Sub Subject Heading:	:	Medical Image Processing
Candidate's Name	:	Ms. S. Valarmathi
Candidate's Address with email	:	11/12, Langarcana Street - 2, Flower market backside, Coimbatore – 641001, Tamil Nadu, India. Email: valarmathis313@gmail.com
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University's Name & Address : Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore – 641043, Tamil Nadu, India.

Abstract within 300 words:

Deep learning (DL) techniques provide optimized solutions in a wide range of applications, such as natural language processing, face recognition, speech recognition, image analysis, and much more. Recently, the insights gained from deep learning techniques have aided the healthcare industry, especially in the medical imaging sector. This study focuses on improving the classification performance of diabetic retinopathy stages, which assists ophthalmologists in decision-making. Diabetic Retinopathy (DR) is an eye disease that affects the vision of a diabetic patient and can lead to blindness in its advanced stages. A digital photograph of a retina is used for screening patients with DR and Glaucoma diseases. Deep learning models aid in the classification of retinal images, providing optimized solutions. The objective of this study is to improve the classification performance of diabetic retinopathy stages using an optimized convolutional neural network-based ensemble classification and regression framework. A deep learning technique, Convolutional Neural Networks (CNNs), is employed in the form of pre-trained resnet-34 for DR stage classification. The contributions of this research work primarily focus on the preprocessing and augmentation phase, where a two-stage image preprocessing framework is proposed that involves a wavelet-based hybrid denoising method to eliminate Gaussian and Salt-and-pepper noises present in retinal fundus images followed by contrast enhancement, and augmentation to balance the dataset classes. As a part of feature extraction and classification, three different CNN-based deep learning models have been developed. These models aim to improve the performance of DR multi-class classification. The contributions in this section include, 1. Application of the Multi-Scale Attention (MSA) mechanism to a pre-trained CNN model, ResNet-34 (Residual Neural Network), in combination with a gradient-boosting classifier for DR classification tasks. 2. The utilization of Special Generative Adversarial Networks (SGAN) to generate realistic retinal images is followed by ensemble classification and regression blocks, as well as a Multilayer Perceptron (MLP) classifier for DR stage classification tasks. 3. Mine Blast Algorithm (MBA) enhancement to select the optimal set of hyper-parameters for tuning the deep learning model, thereby improving the classification performance of DR stages.

i) Major objectives :

The Primary Objective is to improve the classification performance of DR using an optimized Convolutional Neural Network (CNN) based ensemble classification and regression framework.

The secondary objectives are listed below,

- To develop an image preprocessing framework that eliminates retinal fundus image noises and enhances the image contrast to achieve improved classification performance.
- To deploy augmentation strategies that address class imbalance issues to improve classification performance.
- To enhance CNN architecture that captures subtle diabetic retinopathy image features to improve the classification performance.
- To develop an enhanced optimization technique that searches for the best set of CNN hyper-parameters to improve the classification performance.

ii) Hypothesis:

An optimized Convolutional Neural Network (CNN) based ensemble classification and regression framework will improve the classification performance of Diabetic Retinopathy stages compared to existing methods.

iii) Methodology:

Initially, the process begins with data acquisition. In this research work, two different datasets, the APTOS 2019 Blindness Detection and the IDRiD, are used. Then, Pre-processing is performed in two stages: 1. De-noising and Contrast enhancement 2. Augmentation. During image de-noising, various techniques, such as median, wiener, DWT, and DWD_K-SVD (proposed technique), are applied. The objective of performing pre-processing is to eliminate Gaussian and salt & pepper noises and highlight DR features for better DR diagnosis. The Mean Square Error (MSE), Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index Measure (SSIM) are the three-performance metrics used in this study to assess the DWT_K-SVD method. During the contrast enhancement process, HE, AHE and CLAHE approaches are applied. The PSNR, SNR and SSIM are the three-performance metrics used in this study to assess HE, AHE and CLAHE methods. Then, augmentation is performed using a pipeline of operations such as random rotation, horizontal flip, vertical flip, and translation. These are the most used augmentation techniques in medical imaging. Three different works are proposed for feature extraction and classification: the MSA-ResNetGB model, SGAN-ECR model and SGAN-OECR model.

The first model, namely the MSA-ResNetGB model, enhances the performance of DR stage classification. The high-level features are extracted for classifying the different DR stages based on the severity levels. The ResNetGB encoder, multi-scale feature extraction analysis, MSA strategy, decoder and classification units are the various processes involved in this model. Accuracy, precision, recall and F1- score are the performance metrics used to evaluate the MSA-ResNetGB model.

The second model, namely SGAN-ECR, was proposed to overcome the limitations present in the MSA-ResNetGB model and to enhance the classification performance by generating and training synthetic images along with the original images. The ensemble classification regression model provides a better generalization ability for classifying DR stages based on severity. The various processes involved in the proposed SGAN-ECR model are SGAN-based image augmentation, the structure of SGAN and DR stage classification using ensemble classification regression model. The metrics of MSA-ResNetGB is used to evaluate the SGAN-ECR model.

The third model, namely SGAN-OECR, was proposed to optimize the hyperparameters of the MSA-ResNet classification and regression model. The various processes involved in the proposed SGAN-OECR model are configuring the MSA-ResNet structure's hyper-parameters by using an enhanced mine blast algorithm to tune the hyper-parameters. The metrics of MSA-ResNetGB are used to evaluate the SGAN-OECR model. In the end, the performance of all three models is assessed and compared using the selected metrics. Each of these models was trained separately on both the original images and pre-processed images, and the outcomes were then presented for analysis.

iv) Findings:

In this study, a two-stage image preprocessing framework was developed, consisting of image denoising and augmentation. The noise removal, image enhancement, and correction procedures had positive effects on the image analysis results. The proposed DWT_K-SVD method performed well on both the APTOS and IDRiD datasets, with MSE values of 0.17 for both, PSNR values of 44 dB and 45 dB, and SSIM values of 0.9 and 0.92 for the APTOS and IDRiD datasets, respectively.

The first model in this study incorporates a Multi-Scale Attention (MSA) strategy on top of multi-scale and multi-level features to improve the performance of diabetic retinopathy (DR) stage classification. The enhancement of Convolutional Neural Network (CNN) architectures played a crucial role in recognizing subtle signs of DR, including soft and hard exudates (EXs), microaneurysms (MAs), and hemorrhages (HEs). The proposed MSA-ResNetGB model performed well on both the APTOS and IDRiD datasets compared to other pretrained CNN models, with accuracy values of 94.40% and 98.18%, precision values of 94.53% and 91.48%, recall values of 94.40% and 91.57%, and F1-Score values of 94.43% and 91.45% on the APTOS and IDRiD datasets, respectively.

The second model in this study introduces a novel approach, namely the SGAN-ECR, designed to overcome the limitations of the MSA-ResNetGB model and enhance its classification performance. The key objective of the SGAN-ECR is to generate high-contrast retinal fundus (RF) images for classifying DR stages based on severity levels. The SGAN-ECR model outperformed the MSA-ResNetGB model on both datasets, with accuracy values of 97.81% and 96.12%, precision values of 95.95% and 96.31%, recall values of 97.98% and 93.73%, and F1-Score values of 96.90% and 94.77% on the APTOS and IDRiD datasets, respectively.

The third model proposed in this study is the SGAN-OECR, which is designed to efficiently assign hyperparameter values automatically. The classification efficiency was optimized by thoroughly investigating factors such as RF image resolution and tuning CNN hyperparameters, including learning rate, number of iterations, network depth, and batch size. An Enhanced Mine Blast Algorithm (EMBA) was developed to optimize the hyperparameter values for the MSA-ResNetGB model. The SGAN-OECR model outperformed both the MSA-ResNetGB and SGAN-ECR models, with accuracy values of 98.21% and 97.09%, precision values of 98.12% and 97.37%, recall values of 96.42% for both datasets, and F1-Score values of 97.86% and 96.86% on the APTOS and IDRiD datasets, respectively. The findings demonstrate that the SGAN-OECR model achieved superior DR stage classification performance compared to the other proposed models, MSA-ResNetGB and SGAN-ECR.

Examiners

Internal Examiner:

Dr.J.Avanija

Professor,

Department of AI & ML,

Mohan Babu University,

Tirupati, Andhra Pradesh - 517102, India.

External Examiner:

Danilo Pelusi

Associate Professor,

Faculty of Communication Science,

University of Teramo,

Teramo, Italy.