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HYBRID CONVOLUTIONAL NEURAL NETWORK MODEL FOR AUTOMATIC DIABETIC RETINOPATHY CLASSIFICATION

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ABSTRACT:

Diabetic Retinopathy (DR) is one of the most common complications of diabetes and remains a leading cause of preventable blindness globally. If not diagnosed and treated promptly, it can result in progressive vision loss due to damage to the retina's small blood vessels. Early detection is critical, yet traditional manual screening and diagnosis methods, which rely on the examination of fundus images by ophthalmologists, are often time-consuming, subjective, and susceptible to human error due to the complex and subtle patterns associated with DR, especially in its initial stages.To overcome these limitations, the medical imaging and computer vision communities have explored a wide range of automated diagnostic systems. However, many of the techniques that are currently in use are still unable to adequately capture the complex and diverse characteristics of DR at various severity levels. An innovative and effective deep learning-based automated detection framework for improving diagnostic accuracy and reliability is presented in this study. Our method for robust feature extraction combines the advantages of two powerful convolution neural network architectures, ResNet50 and InceptionV3. These models are pre-trained and fine-tuned to identify relevant patterns from retinal fundus images. The features extracted from both models are fused at the feature level, combining the complementary information captured by each architecture. This fused feature representation is then fed into a custom-designed CNN classifier for final DR classification. Using a publicly accessible data set of labeled fundus images, we trained and validated our model to ensure reproducibility and compare it to previous approaches. The experimental results demonstrate the effectiveness of our proposed framework, achieving notable performance metrics: an accuracy of 96.85%, sensitivity of 99.28%, specificity of 98.92%, precision of 96.46%, and an F1score of 98.65%. Our model has the potential to be used in real-world clinical settings because these results significantly outperform several current cutting-edge methods, particularly in the early detection of DR.

KEYWORDS:Preventable,Blindness,Ophthalmologists, Adequately,Reproducibility.

1. INTRODUCTION:

Diabetic retinopathy, a vascular disorder of the retina, manifests in diabetic patients. The prevalence of this condition among Americans is projected to double from 7.7 million to 14.6 million between 2010 and 2050, with Hispanic Americans experiencing a particularly severe increase from 1.2 million to 5.3 million. The duration of diabetes plays a pivotal role in the onset of retinopathy, as longer durations correlate with higher risks of its development. Alarmingly, many diabetes patients remain unaware of the potential for diabetic retinopathy, leading to delayed diagnosis and treatment. Traditionally, ophthalmologists manually diagnose diabetic retinopathy, a time-consuming process requiring specialized expertise in analyzing digital color fundus images. However, delays in diagnosis can result in inadequate follow-up and misinformation for patients. Computer-aided diagnosis has garnered attention as a more efficient alternative.Non-proliferative diabetic retinopathy (NPDR) entails retinal swelling, leakage from blood vessels, macular edema, and subsequent vision impairment. Proliferative diabetic retinopathy (PDR), the most severe stage, involves the

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development of new blood vessels in the retina, leading to complications such as vitreous bleeding and scar tissue formation.Existing models struggle to detect diabetic retinopathy early on due to high computational costs and low performance. To address these challenges, various techniques, including deep learning (DL)based approaches, have been proposed for automatic detection from fundus images. In this study, we introduce a novel DL model utilizing InceptionV3 and Resnet50 for feature extraction, followed by classification using IR-CNN. Additionally, we explore image enhancement and data augmentation methods to enhance model performance. Our proposed DL model demonstrates superior efficiency in early diabetic retinopathy diagnosis compared to existing techniques, focusing on critical disease aspects to ensure high recognition accuracy.

2. LITERATURE REVIEW:

Overview of diabetic retinopathy and its detection

Diabetic retinopathy is a common complication of diabetes that can lead to vision loss and even blindness. Early detection and treatment of diabetic retinopathy is critical to preventing permanent vision loss. In recent years, more and more studies have focused on using computer-aided diagnosis (CAD) systems to aid in detecting and diagnosing diabetic retinopathy.This literature review provides an overview of diabetic retinopathy and its detection, focusing on recent advances in CAD systems. Many studies have used deep learning techniques such as convolutional neural networks (CNN) to detect diabetic retinopathy from fundus images and obtained encouraging results. These CNN-based systems (1–5) have been shown to have high sensitivity and specificity, some even outperforming human experts. In addition to the CNN method, other machine-learning techniques have also been used to detect diabetic retinopathy, including support vector machines (SVM), decision trees, and random forests (11). Some studies have also explored image processing techniques to extract features from fundus images, which are input to machine learning models. Despite the promising performance of CAD systems for the detection of diabetic retinopathy, there are still some challenges that need to be addressed. A significant challenge is the lack of large-scale and diverse datasets to train and validate these systems. Another challenge is the generalization performance of these systems across different populations and imaging modalities. In conclusion, CAD systems based on deep learning and other machine learning techniques show great potential in detecting and diagnosing diabetic retinopathy. However, further research is still needed to address unresolved challenges and optimize the performance of these systems for clinical applications

Review of deep learning models for diabetic retinopathy detection

In recent years, with the development of deep learning, deep learning-based diabetic retinopathy (DR) detection models have received more and more attention. This paper reviews related research literature and introduces their main features and contributions. First, some studies have implemented automatic detection of DR using a convolutional neural network (CNN). Some models use transfer learning technology to apply pre-trained models to DR detection and achieve good results. For example, the model proposed by Bhardwaj et al. achieved a detection accuracy of 90.51% when processing images. However, these models may ignore some detailed information because traditional convolutional neural networks mainly focus on local features, and it is difficult to notice the long-range image information of images. Second, some studies introduce attention mechanisms into DR detection models. These models can adaptively focus on important image parts and achieve better performance. Some researchers employ attention mechanisms to select the most representative image regions to improve the accuracy of DR detection. Deep learning models have broad application prospects in DR detection.

Overview of EfficientNet and Swin Transformer

EfficientNet and Swin Transformer are two models that have received much attention in deep learning in recent years. EfficientNet is an efficient convolutional neural network model the Google research team proposed in 2019. It achieves higher model efficiency by combining different network depths, widths, and resolutions. Swin Transformer is a new type of Transformer model proposed, which improves model performance by introducing a local window attention mechanism and cross-stage information exchange. This article will review the development history and characteristics of the EfficientNet and Swin Transformer models and their application to image classification tasks. The article proposes a new visual Transformer network architecture, Swin Transformer, which introduces a translation window mechanism and achieves efficient image feature extraction through a hierarchical attention mechanism. Swin Transformer has achieved good results on multiple computer vision tasks and performs better than other traditional CNN and Transformer models. The emergence of EfficientNet has solved the contradiction between the model size and the amount of calculation in the deep neural network to a certain extent. It uses compound scaling to balance model complexity and performance by adjusting network depth, width, and resolution. Compared with other models, EfficientNet's performance on the ImageNet dataset has smaller parameters, less calculation, and higher classification accuracy. In addition, EfficientNet is also widely used in other computer vision tasks, such as target detection, semantic segmentation, etc. Swin Transformer is a new type of Transformer model that has emerged recently. Compared with the traditional Transformer model, the Swin Transformer introduces a local window attention mechanism and cross-stage information exchange, improving the model's computational efficiency and accuracy. It can adapt to different vision tasks by extending different modules. Vaswani et al.indicated that multi-head attention can learn feature representations at different levels since the multi-head attention mechanism can weigh features at different levels in parallel to learn richer and representative feature representations. Therefore, compared with traditional attention mechanisms, multi-head attention mechanisms can better capture the complexity and diversity of input data. Both EfficientNet and Swin Transformer are models that have received much attention in the field of deep learning, and they have good performance on tasks such as image classification. In the future, with the continuous development of deep learning technology, these two models are expected to be applied to a broader range of fields.

Review of hybrid models for diabetic retinopathy detection

In recent years, deep learning-based methods have made significant progress in diabetic retinopathy detection. Among them, the emergence of the hybrid model has further improved the detection accuracy of diabetic retinopathy. This paper reviews the research progress of hybrid models in detecting diabetic retinopathy. The paper presents a hybrid model for the classification of diabetic retinopathy (DR), a common complication of diabetes that can lead to vision loss or blindness. The proposed hybrid model combines a convolutional neural network (CNN) and a long short-term memory (LSTM) network to extract features from retinal images and analyze temporal image changes. The study was performed on a dataset of retinal images obtained from the Kaggle diabetic retinopathy detection competition. The proposed hybrid model achieved 96.1% accuracy in classifying DR severity levels, outperforming other state-of-the-art models, and their proposed hybrid model can be used for early detection and management of DR, reducing vision loss in diabetic patients and the risk of blindness. The paper proposes a hybrid deep-learning model for classifying diabetic retinopathy. Trained and tested their model on a publicly available dataset of retinal images, achieving 95% accuracy in classifying diabetic retinopathy. The paper proposes a hybrid deep learning model, which consists of two stages. In the first stage, retinal images are preprocessed to remove noise and enhance contrast. Then, a CNN extracts relevant features from the preprocessed image. In the second stage, an LSTM network is trained to classify images based on the extracted features. The proposed model was tested on publicly available datasets and achieved an accuracy of 87.5% in detecting DR. The results show that the proposed hybrid neural network model outperforms existing CNN-based or traditional feature-extracted DR detection methods.

Overall, this paper presents a method to improve the classification accuracy of diabetic retinopathy using a hybrid deep-learning model. The proposed hybrid model improves the accuracy and efficiency of DR screening, ultimately allowing for earlier disease detection without delaying the treatment of the condition. This paper Butt et al. discusses the use of deep learning techniques to detect diabetic retinopathy from fundus images. Diabetic retinopathy is a complication of diabetes that causes damage to blood vessels in the retina, which can lead to vision loss. It proposes a hybrid deep learning approach combining convolutional neural network (CNN) and recurrent neural network (RNN) to detect diabetic retinopathy. They used a dataset of 1,500 fundus images to train and test their model. The results showed that the hybrid deep learning approach achieved high accuracy in detecting diabetic retinopathy. The proposed hybrid deep learning method can be an invaluable tool for early detection and diagnosis of diabetic retinopathy, helping to prevent vision loss in diabetic patients. The article is a decision tree and support vector machine (SVM) classifier hybrid. Decision tree classifiers are used for feature selection, while SVM classifiers are used for classification. The system was trained and tested on a dataset of retinal images collected from diabetic patients, and these results demonstrate that the proposed system is effective in detecting diabetic retinopathy from retinal images, helping ophthalmologists and healthcare professionals in early detection and a tool for diagnosing diabetic retinopathy, potentially reducing the workload of ophthalmologists and improving diagnostic accuracy. This article proposes a deep learning multi-label feature extraction and classification model based on a pre-trained convolutional neural network architecture. Then, transfer learning is applied using three state-of-the-art convolutional neural network architectures to train a subset of images and identify and classify lesions through parameter adjustment. The model is suitable for implementation in daily clinical practice and supports large-scale DR screening projects. Lahmar et al. conducted an empirical evaluation of the performance of multiple deep hybrid architectures for automatic binary classification of reference diabetic retinopathy.

3. **EXISTING SYSTEM:**

In the existing system, manual detection methods for diabetic retinopathy (DR) are predominantly used, which are labor-intensive and prone to errors. Ophthalmologists manually analyze digital color fundus images to diagnose DR, which is a time-consuming process requiring specialized expertise. However, this approach often leads to delays in diagnosis, resulting in inadequate follow-up and misinformation for patients. Additionally, existing automated techniques struggle to effectively capture the nuanced features of DR, particularly in its early stages. These methods face challenges such as high computational costs and low performance, limiting their effectiveness in early detection of DR.

3.1 DIS ADVANTAGES

1) this approach often leads to delays in diagnosis, resulting in inadequate follow-up and misinformation for patients.

2) These methods face challenges such as high computational costs and low performance, limiting their effectiveness in early detection of DR.

4.PROPOSED SYSTEM:

The proposed system introduces a novel approach for DR detection using a hybrid Convolutional Neural Network (CNN) model. This model leverages the strengths of two deep learning architectures, ResNet50 and Inceptionv3, for feature extraction from fundus images. These extracted features are then fused and inputted into a CNN for classification of DR. The proposed system aims to overcome the limitations of the existing methods by providing a more efficient and accurate automated detection process for DR. Additionally, the proposed system explores techniques such as image enhancement and data augmentation to further improve its performance. Evaluation of the proposed system using a publicly available dataset demonstrates superior performance compared to existing methods, achieving high accuracy, sensitivity, specificity, precision, and F1 score in DR classification.

4.1 ADVANTAGES

1) The proposed system explores techniques such as image enhancement and data augmentation to further improve its performance.

2) Evaluation of the proposed system using a publicly available dataset demonstrates superior performance compared to existing methods, achieving high accuracy, sensitivity, specificity, precision, and F1 score in DR classification.

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5.**SYSTEM ARCHITECTURE:**

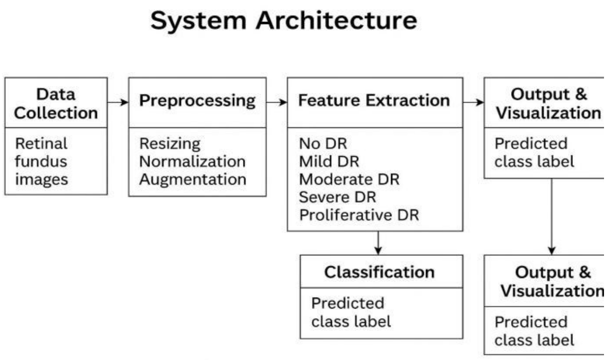

Fig 5.1 System Architecture

6.RELATED WORK :

- **Graphical User Interface(GUI) Module**
- **Data Handling Module**
- **Generative Adversarial Network(GAN) Module**
- **CNN-Based Prediction Module**

6.1 Graphical User Interface (GUI) Module:

The user-friendly interface allows doctors and researchers to upload retinal images for classification. It typically includes options to upload fundus images, trigger the prediction process, and view the classification results.

6.2 Data Handling Module:

Manages preprocessing, augmentation, and storage of retinal images for model training and testing.Performs resizing, normalization, and filtering to enhance image quality and improve accuracy.

6.3 Generative Adversarial Network (GAN) Module:

GANs are used to generate synthetic retinal images, improving model generalization on limited datasets. Consists of a Generator (creates images) and a Discriminator (validates real vs. fake images).Helps in reducing class imbalance and enhancing feature extraction for better DR classification.

6.4 CNN-Based Prediction Module:

A Convolutional Neural Network (CNN) is trained to classify diabetic retinopathy severity levels. Loads the pre-trained CNN model for DR classification. Takes an input retinal image, processes it, and predicts the severity stage of diabetic retinopathy. Converts CNN outputs into classification labels (e.g., No DR, Mild, moderate, severe)

7. RESULT:

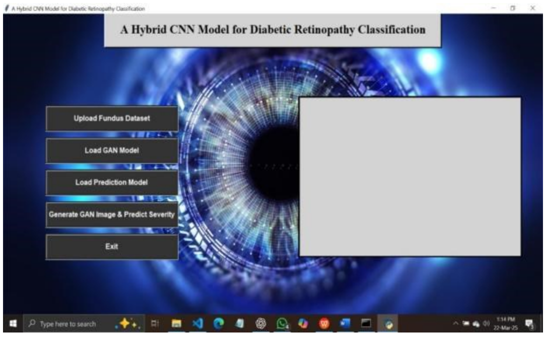

Fig 7.1 Hybrid CNN model for daibetic retinopathy classification main page

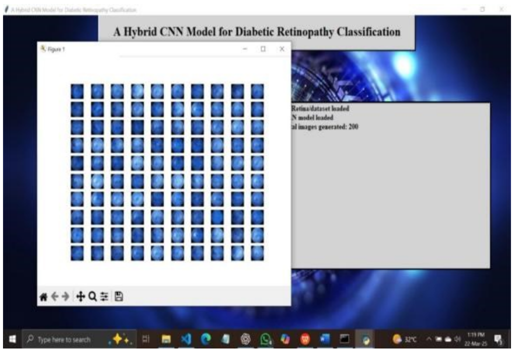

Fig 7.2 Hybrid CNN model for daibetic retinopathy classification preprocess page.

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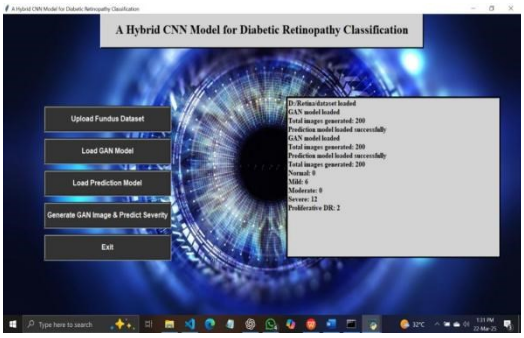

Fig 7.3 Hybrid CNN model for daibetic retinopathy classification page

8. **CONCLUSION:**

Diabetic retinopathy (DR) is becoming one of the most common causes of visual impairment, especially among the working-age population worldwide. This condition occurs due to long-term complications of diabetes, where elevated blood glucose levels and poor blood pressure control can lead to damage in the small blood vessels of the retina. As a result, fluid may leak into the retinal tissues, causing swelling and disruption of vision. Key indicators such as microaneurysms, hemorrhages, hard exudates, and abnormal growth of blood vessels are closely examined by clinicians to assess the severity of the disease. Early diagnosis and intervention are essential to prevent irreversible vision loss. Traditional methods of detection rely on manual screening by ophthalmologists, which can be time-consuming and prone to human error, especially when screening large populations. In recent years, computer-aided diagnosis systems have gained attention for their ability to automate and improve the accuracy of DR detection. In this study, we present a novel deep learning-based approach using convolutional neural networks for the automatic detection of diabetic retinopathy from fundus images. The proposed model combines the strengths of two powerful deep learning architectures, Inceptionv3 and ResNet50, which are used for extracting meaningful features from retinal images. These features are then fused and passed into a custom-built IR-CNN model for classification into different stages of DR. To improve the model's robustness and accuracy, a series of preprocessing steps such as image enhancement, resizing, normalization, and data augmentation were applied to the dataset. Multiple experiments were conducted using publicly available retinal image datasets, and performance was evaluated based on accuracy, precision, recall, and F1-score. The results demonstrate that the proposed approach not only improves classification accuracy but also reduces false predictions when compared to existing state-of-the-art methods. This model shows strong potential for use in real-world screening systems, especially in rural and resource-limited areas where access to eye specialists is limited. By integrating deep learning into medical image analysis, this work contributes to the development of efficient, scalable, and cost-effective solutions for early diagnosis and treatment of diabetic retinopathy.

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Web Resources:

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