MACHINE VISION FOR ENHANCED DETECTION AND MANAGEMENT OF DIABETIC RETINOPATHY

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***Abstract*—The most prevalent eye condition affecting individuals with diabetes is known as diabetic retinopathy, a consequence of elevated glucose levels that damage the delicate blood vessels in the retina. About 80% of people with diabetes who have lived with the condition for a decade or more encounter progressive vision impairment. Establishing regular eye examinations as a primary concern for individuals managing diabetes is crucial, along with maintaining control over their blood sugar levels to prevent irreversible damage to the eyes. This study proposes the utilization of a Convolutional Neural Network-based Machine Learning approach to categorize eye images ranging from No DR to Proliferative DR, the advanced stage of diabetic retinopathy. The input for this system consists of color fundus photos.**

Keywords—Diabetic Retinopathy, Machine Learning, Convolutional Neural Network , Raspberry Pi.

I. INTRODUCTION

Diabetic Retinopathy is a prevalent and potentially vision-threatening complication of diabetes, characterized by damage to the blood vessels in the eye's light-sensitive tissue. Early detection and diagnosis of Diabetic Retinopathy are pivotal for effective treatment and preventing vision loss[1].

There has been a startling rise in the number of diabetics during the last 20 years. Nearly 500 million individuals worldwide, spanning all age groups, have been diagnosed with diabetes, according to the IDF Diabetes Atlas. By 2045, this is anticipated to increase to seven hundred million. It is a problem for world health. Additionally, one in three diabetic individuals may acquire diabetic retinopathy (DR) by 2040, according to the IDF Diabetes Atlas. Damage to the blood vessels behind the retina is a sign of diabetic retinopathy (DR). It is crucial to address this because, if left untreated for an extended period of time, it could cause major consequences including blindness. Currently, medical professionals manually evaluate fundus photos of the eye to determine the extent of DR[2]. This takes a lot of time, and compared to the real number of patients, there are not enough medical personnel accessible. Many individuals do not obtain medical care in a timely manner as a result of these factors. Physicians encourage patients with diabetes to have frequent medical exams of their fundus, although many cases go undiagnosed until the illness worsens. Therefore, having an automated system to aid in the diagnosis of diabetic retinopathy is desirable[2].

Fundus pictures, which offer visual records that detail an individual's retina's current ophthalmic appearance, are used in the majority of investigations in this discipline. These fundus pictures can be utilized to identify DR based on the existence of DR symptoms using many processes, including DR detection, lesion segmentation, and retinal blood vessel segmentation. Examining the presence or absence of many lesions can help determine the diagnosis of DR and its stage at that time. Microaneurysms (MAs), cotton wool spots (CWSs), exudates (Exs) (including soft and hard exudates; SEs and HEs), intraretinal hemorrhages (IHEs), and soft exudates (Exs) are a few of the abnormalities[8].

The advancement of artificial intelligence (AI) methodologies, such as machine learning and deep learning, has made it feasible to detect and segment the affected retinal segments with high performance through retinal grading and detection. Machine learning techniques are frequently applied to the grading and classification of DR data.

II. LITERATURE SURVEY

Authors: Avleen Malhi, Reaya grewal, Husanbir Singh pannu
Research focus: diabetic retinopathy (dr) on retinal image
Published on : January 2023

Description : Diabetic retinopathy is an eye disorder that afects people sufering from diabetes. Higher sugar levels in blood leads to damage of blood vessels in eyes and may even cause blindness. Diabetic retinopathy is identifed by red spots known as microanuerysms and bright yellow lesions called exudates. It has been observed that early detection of exudates and microaneurysms may save the patient's vision and this paper proposes a simple and efective technique for diabetic retinopathy. In the proposed work, grading has been done to know the severity of diabetic retinopathy i.e. Whether it is mild, moderate or severe using exudates and micro aneurysms in the fundus images. An automated approach that uses image processing, features extraction and machine learning models to predict accurately the presence of the exudates and micro aneurysms which can be used for grading has been proposed. The research is carried out in two segments; one for exudates and another for micro aneurysms.

Authors: Wan Mustafa, Aimi Abdul-Nasir, Haniza yazid Research Focus: Diabetic Retinopathy (DR) on Retinal Image Published on : December 2023

Description : Diabetic Retinopathy (DR) on Retinal Image [1] In this paper, the principles of DR was studied which included stages, causes, symptoms, and risks involved with it along with basic concepts of the human eye and body related to DR. This study aims to give the direction for a researcher in order to propose a new DR detection method. According to this study, the main cause of DR is the unusual increase of glucose level. The first signals of DR are tiny capillary dilations known as micro aneurysms. It states that DR advancement causes neovascularization, macular edema and exudates and also the cotton wool spot where at the later phase causes retinal segregation.

Authors: Aravinda H, Dinesh M, Neha M Patil, Srinivas halvi Research focus: diabetic retinopathy (dr) on retinal image published on : July 2021

Description : Diabetic retinopathy is the most common eye disease of diabetic patients which occurs due to high glucose levels leading to the damage of small blood vessels in the retina. About 80% of all patients who have had diabetes for 10 years or more are affected, leading to progressive vision loss. It is highly significant to prioritize eye check-up for chronic diabetic patients and to maintain their blood sugar levels under control so that they can prevent their eyes from getting damaged beyond cure. In this paper, we are proposing a machine learning technique using a convolutional neural network which will classify the eye images ranging from no dr to proliferative dr i.e., last stage of diabetic retinopathy. A visual attention layer is added as the top layer of the pre-trained model focusing on the weighted features helping in image classification. Images will be classified into 5 categories i.e., no dr, mild dr, moderate dr, severe dr, proliferative dr.

III. Data pre-processing

A. *Development of user-friendly interfaces:*

A specialized software interface can facilitate user engagement by assisting users with image capturing and possibly providing clear results visualization. Integration with current medical equipment: By integrating the system with current ophthalmic equipment, image acquisition might be streamlined and possibly automated completely. Working together with medical professionals. Working together with physicians and other healthcare providers helps guarantee that the system is implemented correctly and that the results are interpreted appropriately within the clinical workflow.Maintaining the Integrity of the Specifications[3].

B. *Image Classification By CNN*

It has long been acknowledged that a thorough and automated approach to DR screening is necessary. With colour fundus photos as input, this project seeks to be an automated detection system to detect the level of diabetes and avoid blindness due to DR. It does this by using machine learning, image categorization, and pattern recognition. Classifications of fundus images can be achieved by a variety of imaging modalities and machine learning algorithms, with deep learning being more effective in distinguishing between healthy and diseased images. When classifying fundus images with different degrees of DR, deep convolutional neural networks (DCNNs) have the potential to boost interobserver agreement and improve diagnostic efficiency[3].

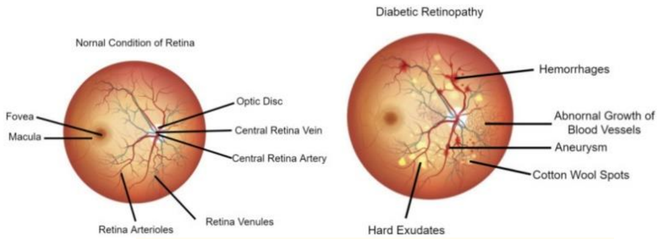

Figure. 1. Visualization of a healthy retina and an unhealthy retina

IV. Methodology

The configuration in its entirety are shown in Figure 2. It comes with a hard disk, monitor, keyboard, Raspberry Pi 4 Model B, +20D lens, and other accessories. A specially designed program that utilizes Bluetooth to complete file transfer transfers the fundus photos captured with a smartphone camera to the Raspberry Pi. The micro-HDMI to HDMI cable is used to link the monitor to the microprocessor. The external hard disk, which is attached to a USB port, houses the transmitted photographs. Keyboards and mice are examples of peripherals used to access the images. An adapter that provides 5V and 3A is used to power the Raspberry Pi.

● To have a better look into the patient's eyes, eye drops are utilized to dilate (widen) their pupils.

● The two most common medications used to dilate pupils are homatropine and tropicamide.

● The drops are supposed to have a noticeable effect on the pupil for up to half an hour.

● A +20D lens is used to see the patient's eye's fundus. 50mm of lens above the eyes is maintained. In certain cases, a +90D lens may also be utilized.

● The fundus image is taken with a smartphone camera. The viewing may be modified by varying the distance between the lens and the camera.

●The region is illuminated by the smartphone's flash configuration.

● The Raspberry Pi receives the captured image data via Bluetooth.

● A specially designed application is used to transfer data, and it transfers photographs in their original quality.

● A single directory contains all of these photos.

● The Raspberry Pi is linked to the monitor via a Micro HDMI to HDMI connection.

● The mouse and keyboard are connected to the USB ports on the Raspberry Pi. An external hard drive attached to a USB port will store the photos, which may be accessed at any time. The processor is powered by a power adapter.

● Launch the camera feed and take fundus photos.

● Send the data to the model so it can be classified.

● Utilizing the previously stored photos, categorize the image.

● CNN is used throughout the entire procedure. Five classes—No diabetic retinopathy, Mild diabetic retinopathy, Moderate diabetic retinopathy, Severe diabetic retinopathy, and proliferative diabetic retinopathy—are intended to be distinguished from fundus photos.

1.LOAD DATASET: There are 1002 uploaded pictures. These pictures are from the website Kaggle.

2. TRAINING A CNN FOR DIABETIC RETINOPATHY DETECTION : A sizable collection of retinal pictures with various stages of retinopathy is needed to train a CNN for the identification of diabetic retinopathy. Next, these photos are separated into test, validation, and training sets. The validation set is used to choose the best-performing model and avoid overfitting, while the training set is used to modify the CNN's weights. The final trained model is assessed using the test set.

3. IMAGE PRE-PROCESSING: Here, the pre-processing of the supplied image data requires the imported libraries. TensorFlow, NumPy, and Preprocess input are the imported libraries. Keras. Applications.inception_v3 is the source of the backend import.

A library called TensorFlow is used for machine learning. The model is trained using the neural network software Keras.

Backend libraries enable direct integration of backend operations with Keras. Convolution neural networks, such as the pre-trained model Inception V3, are a kind of neural network used in Deep Learning. It is made up of 48 deep neural network layers. It scales the input image's pixels from -1 to 1.

This library's input picture parameters are (299,299,3), which correspond to height, width, and channels. tensor or an array in NumPy. Saturation, contrast, and brightness are all adjusted. Mode of color A batch of input photos can be pre-processed to a NumPy array or tensor using the preprocess input function. Saturation, contrast, and brightness are all adjusted. To set to RGB, utilize the color mode. By using the preprocess input function, these photos will be encoded and stored as an array. The photos are rotated and cropped to a consistent size in order to perform affine changes. They undergo homogeneous scaling and resizing. The CNN is trained and the complete database is expanded in order to generalize the fundus image features to cover every scenario.

The practice of artificially producing fresh training data from an existing dataset is known as augmentation. The augmentation method involves flipping the images on the horizontal axis in an upward or downward manner. Rotating the photos 90 degrees counterclockwise at their center point. Flipping the images left-right along the vertical axis. Upscaling the pictures to 512 by 512.

4. Machine learning: It is a type of artificial intelligence that enables computers to learn from data without being explicitly programmed. It has been used in various fields, including healthcare, to improve diagnosis and treatment. Raspberry Pi, on the other hand, is a credit-card-sized computer that can be used for a wide range of projects, including machine learning applications. The benefits of using machine learning and Raspberry Pi for diabetic retinopathy detection include faster and more accurate diagnosis, reduced costs, and improved patient outcomes[7].

A. *ATTENTION MODEL*

Pre-trained models serve as the foundation for the construction of this model. The models that were pre-trained include InceptionV3, InceptionResNetV2, and VGG16. To apply these pre-trained models to our image dataset, a technique known as transfer learning is modified to employ only the weights and a few CNN layers. The process of transferring the pre-trained model parameters from a publicly accessible dataset is known as transfer learning. Multiple layers of normalization and a visual attention layer take the role of the initial layers in these models. The last layers, which carry out the classification, are kept. Within the same network module, the inception model computes 1x1, 3x3, and 5x5 convolutions as a multilevel feature extractor[9].

In order to produce corresponding output based on the portion of the input that was being focused, the attention mechanism is employed to focus on those sections of the input data. The primary foreground or weighted characteristics are the primary focus, not the background or blank spaces. By concentrating on important regions of an image, attention enables neural networks to be configured to produce recognition or prediction outcomes.

The activation function for the convolution of the output between 0.0 and 1.0 is set up as a sigmoid function. The input values for this activation function are stored between 0 and 1. Thus, applying this function results in an output with a value between 0 and 1 for each pixel. The regions of attention are those with values of 1 multiplied by values close to 1, since these produce outputs that are closer to the original values.

B. *SMARTPHONE APPLICATION - 'EYECAM':*

"Eye Cam" is a proprietary application designed to take fundus images and transfer them to the microprocessor. The Android program has the ability to take pictures of the eyes with the smartphone's camera, give the image files names, and then send the files via Bluetooth from within the application. The Android Studio program is used in the development of the application. It's an Android integrated development environment that Google offers. It is predicated on the IntelliJ IDEA program from JetBrains. The Android Studio V4.1 is used to create the application. The application cannot be used without user authorization to access the camera and storage. The size of the application is 27.27 MB[5].

V. COMPONENTS

A. *Hardware Components*

1. Phone Camera With 20-D Lens.

Smartphone fundus photography using a 20D condensing lens is based on the same principle as indirect ophthalmias - copy. The viewer's eye is replaced by the display screen of a smartphone. The light source of indirect ophthalmoscope is replaced by the flashlight of a smartphone camera.

2. Processor.

B. *Software Requirement*

1. Visual Studio

It can be employed to develop software applications or tools related to diabetic retinopathy, such as image processing algorithms for analyzing retinal images, database management systems for storing patient data, or telemedicine platforms for remote consultation and diagnosis. These applications can aid healthcare professionals in diagnosing and managing diabetic retinopathy more effectively.

2. Developing Machine Learning Models

Python Integration: visual studio supports python development, which is a popular language for machine learning. Libraries like tensorflow and pytorch can be used within visual studio to build and train models for diabetic retinopathy detection and grading.

Debugging And Visualization Tools: visual studio offers debugging tools to help identify and fix errors in machine learning code. Additionally, libraries like matplotlib and seaborn can be used for data visualization, allowing researchers to understand and analyze the performance of their models.

VI. Flow Chart

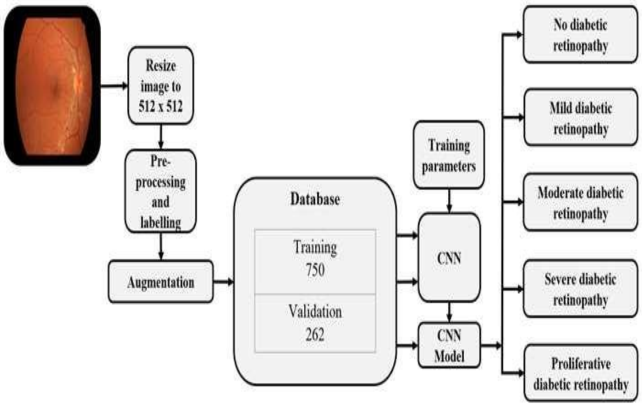

Fig 2: Flowchart of the system

The flow for implementation is:

- Start camera feed and take fundus photographs.
- Pass the data to the model for classification.
- Classify the image using the pre-stored images.

VII. Result

The Inception V3 model can categorize photos into their appropriate categories and provides findings with accuracy up to 92% of the time. Here, a few of the pictures are categorized according to the kinds they belong in. As a result, the model can recognize irregularities and report back by labelling the image as abnormal if any are found. This saves the doctors time by enabling them to analyse the image more accurately.

Here, the trained Inception V3 model was fed three photographs that were taken with the "Eye Cam" application.

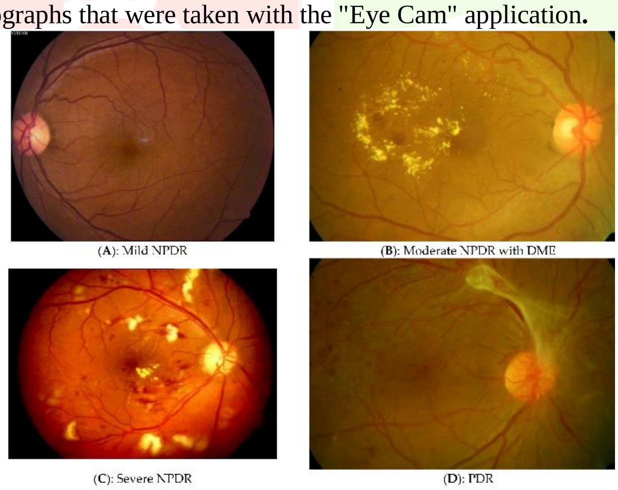

Figure. 3. Result

VIII. Conclusion

In order to learn and categorize the fundus colour photos, a CNN system is developed in this work. Uses TensorFlow and CNN-based image classification to identify diabetic retinopathy. Sort the pictures so the ophthalmologist can diagnose the patient more quickly. Prevents results delays that could have resulted in missed follow-up, misunderstandings, and/or postponed treatment. With the number of people with diabetes rising steadily, there is less need to avoid DR-related blindness. Decreased manual procedures that don't need a doctor to be trained in order to inspect and assess the digital fundus photos of the retina. hence saving time. The "Eyecam" program, which is used to take and share images, saves time.

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