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CONVOLUTION NEURAL NETWORK BASED METHOD FOR AUTOMATIC DETECTION OF DIABETIC EYE DISEASE USING THERMAL IMAGES

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Abstract - *Diabetic eye disease is a complexity that affects people having diabetes for a longer time. By affecting the blood vessels it can cause blurry vision or even blindness to the patients. Thus, detecting the eye disease at an early stage can help many of the diabetic patients to get the required treatment and intern increases the survival rate. In the proposed system, the CNN algorithm of machine learning is used to detect the diabetic eye diseased by either using the thermal images. These images are pre-processed by converting them from RGB to GRAY based on which the required features are extracted. To detect the diabetic retinopathy, here the Convolutional Neural Network is used to classify 5 stages of the diseased eye.*

Key Words: CNN, Features, Dye, Retina, Thermal.

1. INTRODUCTION

A diabetic eye disease that is Diabetic retinopathy is a serious issue that can occur to the patient suffering from diabetes. Diabetic Retinopathy can cause severe vision loss or sometimes even blindness if not diagnosed or treated in a stipulated time or duration. The retina is nothing but a light-sensitive tissue situated at the back end of the eye and the changes in its blood vessels cause Diabetic Retinopathy. How much clear your vision is, it completely depends on the retina power. The patient's blood and sugar level are also an important factor in diabetic eye disease as well as blood pressure changes that is high blood pressure and hypertension can also be the reason for the damage of retina and DR causing the blindness to the patient. In the latest survey conducted at the conference of the Central Council of Health and Family Welfare in Oct 2019, it was predicted that around 17% of the entire population of India suffered from Diabetic Retinopathy. Mainly, this paper focuses on the Detection of diabetic retinopathy using thermal images. For this system, an algorithm especially known as Convolutional Neural Network will be used. CNN which is the branch of deep learning having various records for applications in image analysis, including medical imaging.

The disease can be arranged into five levels and necessary action is taken accordingly. Classification can be done into the five levels stated below:

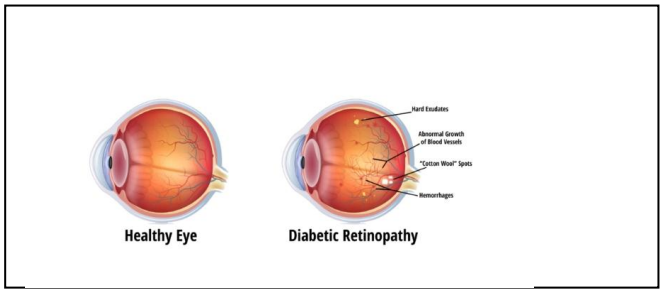
A. ***Normal***: In this stage, the patient is having a healthy eye without the presence of disease.

B. ***Mild***: In this level, balloon-like swelling is developed in the blood vessels of the retina and also may leak fluid into the small areas around the retina.

C. ***Moderate***: In this level, the blood flow ability becomes less as the retina starts swelling to a greater extent and its appearance may also change concerning its symptoms. If not treated well in advance, one may cause vision loss.

D. ***Non-proliferative Severe***: The increasing numbers of blood vessels nourishing the eye have been blocked.

E. ***Proliferative***: This is the final level in which the blood vessels start damaging at a greater rate and affecting the supply of blood.



The walls of the blood vessels which are small in size get damaged due to a high amount of blood sugar of diabetic patients which leads to changes in overall form and working of the blood vessels. The blood vessels of the patient get damaged, leaked and it causes stiffening of the blood vessels known as the microaneurysms. The fluid is assembled in the part called the retina. The retina is mostly used for reading purposes known as the macular edema. In some cases, the retina is captured with its blood supply and grows new defective vessels this process is known as neovascularization. The normal running fluid in the eyes is blocked due to the creation of new vessels producing glaucoma.

For the diagnosis of the diseased eye, this process approaches to thermal images of eyes followed by testing of diseased eye images for the necessary and expected result. After the image classification is done as the diabetic affected or not and if affected then the level of the disease will be displayed.

2. EXISTING SYSTEM

If the person having diabetes for a longer time duration can cause diabetic eye disease, which is a complication that affects the eye. It can lead to blindness. The current diagnosis process takes a lot of time wherein the patient needs to visit the doctor to get their eye scanned and the doctors have to check these scanned images by themselves. Due to these reasons, it becomes exhausting and tiresome for the patients to take appointments regularly in this busy life. Fluorescein Angiography is a way to photograph the blood vessels present behind the eyes. In this method, via your arm a fluorescent dye is injected in the bloodstream. Here the dye used is fluorescein sodium which is a fluorescent chemical compound and is a synthetic dye. In this process, the pupil is dilated using eye drops and the dye is injected in the vein of the patient's arm. After injecting, photos are taken with a gap of 60 seconds interval as the dye enters the back of the eye vessels. There can be many side effects that can occur such as nausea, vomiting, cardiac arrest, etc. The injecting process can also be painful due to the pH of the dye. Indocyanine green angiography is another technique used by a doctor similar to Fluorescein Angiography, which uses another type of dye and the infrared camera is used for imaging purposes. Side effects of this procedure are sweating, itching, headache then it comes to the advanced technology, the system uses machine learning to remove the disadvantages of the existing system.

The analysis of diabetic eye disease can be done by applying cnn on the retinal fundus image dataset [1].

The images which show the parts of the eye such as the retina, macula, posterior pole, etc. are called fundus images. A fundus camera with a microscope which is having a very small power is used to take the fundus images. The individual who requires to take their photos is been seated in front of the camera with their chin resting on a bar. The ophthalmic photographer then takes the photograph by aligning the camera as required. Then the image is classified using various machine learning algorithms as required.

In this paper, the thermal image technique will be focused upon for diabetic retinopathy detection.

3. LITERATURE SURVEY

Diabetic eye disease detection is done very accurately when we make using the thermal images which is a non-invasive technique [2]. The images of the eye are taken not by emitting the radiation but by the temperature changes in the human body. When the person is suffering from the diabetic retinopathy the blood pressure of the retinal area increases some retinal cells may get burst causing the increase in temperature. So based on the temperature the image is generated without making use of the radiation. Then the thermal image preprocessed and by using the SVM classifier is classified.

It is found that modern technology also fails in a lot of cases to diagnose the disease correctly. The attempt is being made to explore the area of diagnosis from different perspectives. [3]The approach used is a combination of ancestor's technology Iridodiagnosis with modern technology. Iridodiagnosis is an alternative branch of medical science, which can be used for diagnostic purposes. In this system, the dataset consists of eye images and clinical history of the subject's emphasis on the diabetic disease. The various algorithms are developed for image segmentation of iris, iris normalization and feature classification for clinical diagnosis. The artificial neural network is used for training and classification. For feature analysis, enhancement is essential for the extraction of deep layer features. For feature extraction various image enhancement methods like arithmetic operation, histogram equalization, and adaptive histogram equalization have been applied. This approach will be useful in the diagnosis field which is faster, user-friendly and less time-consuming.

Many tests like pupil dilation, optical coherence tomography can be used to detect diabetic retinopathy but they are time-consuming and affects patients as well. So some machine learning [4] classification algorithms are developed that are applied to features obtained from the output of different retinal image processing algorithms. Diabetic retinopathy is performed using alternating algorithms. The characteristic features extracted by anatomical part recognition algorithms and lesion detection are used to classify images. The most important features are the exudates which provide information about diabetic retinopathy in the early stages. The major cause of exudates is the leakage of protein and lipids into the retina through damaged blood vessels. So, ensemble-based machine learning techniques are used to detect the presence of diabetic retinopathy in an image. This paper also highlights various technologies used for the diagnosis and detection of diabetic eye disease.

Another perspective of dealing with the detection of DR in human eyes is by using different types of preprocessing & segmentation techniques [5]. There are several methods of segmenting the blood vessels that are present in the retina & once the retinal nerve fibers are segmented, one can detect whether the eyes are affected with diabetic retinopathy or not. The methodology gives a brief insight into the research work on the detection of the second-largest disease in the world, i.e., the diabetic retinopathy disease in the human eyes which could be detected using novel pre-processing & segmentation techniques.

Iris recognition system comprises of process of locating the iris and generating the data set of iris images and recognizing its pattern. A faster algorithm is applied for the localization of the inner and outer boundaries of the iris region [6]. Located iris is then extracted from the image of an eye, and, after normalization, it is represented by a data set. With the help of this data set, a Neural Network (NN) is used for the classification of iris patterns and a training set is

applied using CNN. Here, the segmentation of iris performed in a short period. The average time for iris segmentation is obtained using Matlab and its accuracy rate is 98.62%. The located iris after preprocessing is represented by a vector. Using this vector as an input signal, the neural network is used to recognize the iris and its patterns.

Diabetic retinopathy (DR), is one of the serious complications, and also the most common cause of vision loss among diabetic patients. Automatic Detection of diabetic retinopathy at an early stage from the retinal images helps the ophthalmologist to treat the affected patient and avoid vision loss. [7]The system is on detecting and extracting the features of the affected retinal images. Image preprocessing methodologies like feature extraction are done to get the features from the images and classification is done using classifier's Adaboost, Gradientboost, Random Forest, Voting classifier as an ensemble model. An automated detection framework presented is for diabetic retinopathy. The ensemble model presented in this paper is helpful for doctors for treating DR to recommend the treatment of the affected patient and avoid vision loss.

Diabetes occurs when the pancreas fails to secrete enough insulin, slowly affecting the retina of the human eye. As it progresses, the vision of a patient starts deteriorating, leading to diabetic retinopathy. In this regard, retinal images acquired through fundus camera aid in analyzing the consequences, nature, and status of the effect of diabetes on the eye [8]. The basis of the classification of different stages of diabetic retinopathy is the detection and quantification of blood vessels and hemorrhages present in the retinal image. Classification of the different stages of eye disease was done using the Random Forests technique based on the area and perimeter of the blood vessels. The scope and direction for further work are to include more instances of retinal images to construct a robust classifier for detecting different stages of diabetic retinopathy (i.e. for training and testing) to achieve higher accuracy.

The main cause of Diabetic Retinopathy is high blood sugar levels over a long period in the retina known as Diabetes Mellitus. A Deep Learning Approach is applied in which the processed image is fed into a Convolutional Neural Network to predict whether the patient is diabetic or not. This methodology is applied to a dataset of Fundus Images of the retina [9]. Such an Automated System can easily classify images of the retina among Diabetic and Healthy patients, reducing the number of reviews of doctors. The research done in this paper is intended to help diabetic patients to remain cautious about their medical condition.

4. METHODOLOGY

The thermal image based diabetic eye disease detection system is proposed in such a way that it will classify the eye of a patient as diabetic affected or not using the painless and time-saving technique.

4.1 Thermal Images

All objects having temperature zero Kelvin above emits infrared radiations. Stefan-Boltzmann law is used for the conversion of the infrared radiation into temperature.

Thermal imaging uses in the infrared spectrum which is imitated by heated objects. Thermal imaging technique was recently used in the detection of breast cancer, diabetic foot and various eye diseases such as dry eye, glaucoma, Meibomian gland dysfunction, and thyroid eye diseases. Thermal imaging cannot see people through walls, it can only detect things in its line of sight that gives off heat. Generally, In Thermal imaging objects that appear either be purple or blue usually are cooler and red objects are warmer. Infrared thermal imaging not only captures the temperature of the corneal surface but also detects and visualizes any changes on the Ocular surface.

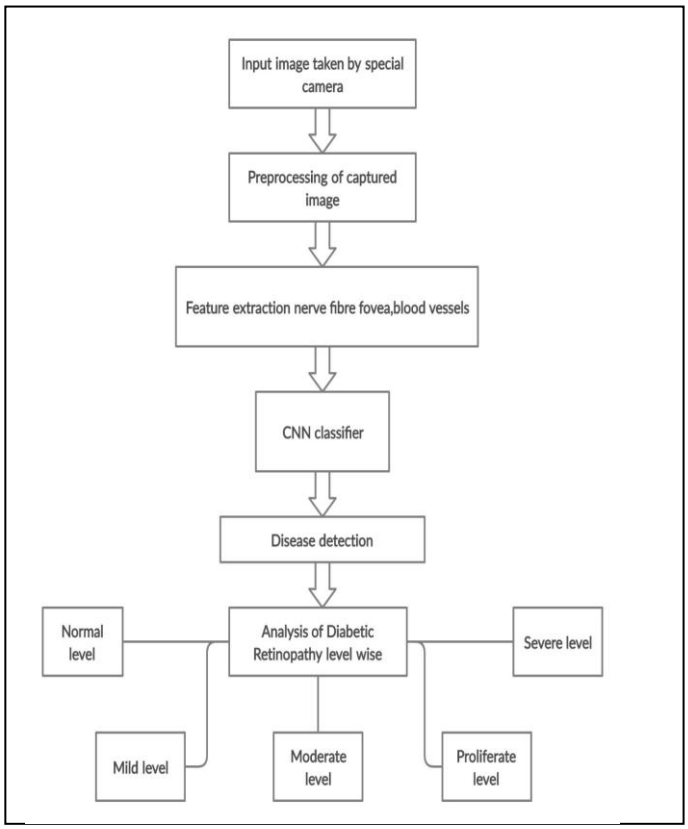
A pattern of invisible radiation of a targeted object is converted into a visible image using thermal imaging.

Thereafter, features needed for study are extracted from the targeted image and analysis of these features is done. For medical disease diagnosis, this technique is been in recent times. It is applied in the areas where the difference in temperature is to be needed for evaluation and support of the diagnosis.

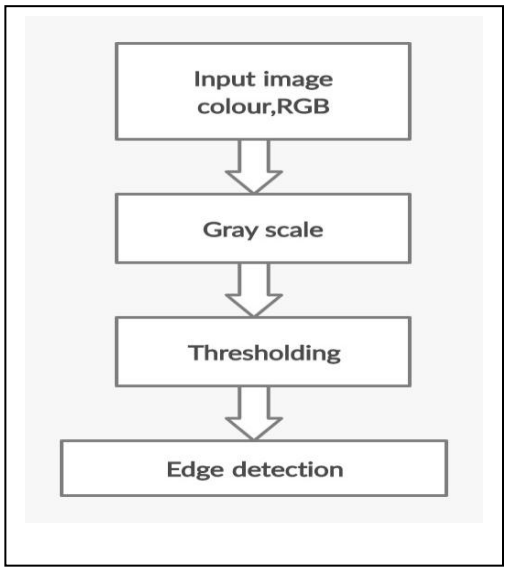
In medical diagnosis, thermal imaging starts with capturing of thermal radiations above absolute zero emitted by body organs. A captured IR image depicts the thermal distribution of body surface that delineates the heat exchange which happens between different skin tissues, inner tissue, local vasculature and metabolic processes of the body.

X- rays, computed tomography (CT) scans, and magnetic resonance imaging (MRI) these techniques are commonly used in disease diagnosis but they do not have the capability of measuring changes of metabolic processes in the body which can be easily done by thermal imaging. Thermal imaging provides safe imaging using digital thermal cameras.

The ***architecture*** is as shown below:



The input image will be pre-processed to remove the noise present as well as some irregularity in the images.

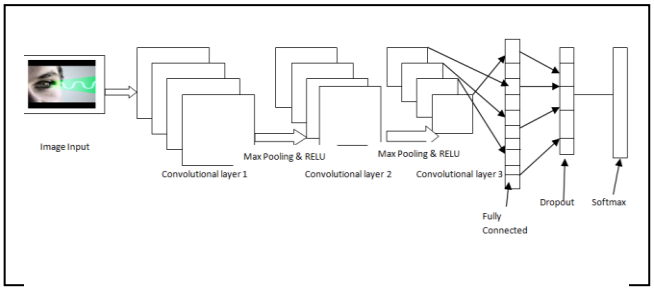


Then the features will be extracted, like only retinal features from the whole image of the eye are considered for the classification. CNN algorithm will classify the images. For making use of the CNN algorithm the dataset will be divided into two parts one will be used for training the model and another for testing after this the system is ready to test.

4.2 Convolutional Neural Networks Algorithm:

Convolutional Neural Networks (CNN or ConvNet) are unpredictable feed-forward neural systems in AI. CNN's are better utilized for picture arrangement as well as its acknowledgment in light of its high exactness. It was proposed by PC researcher YannLeCun in the late 90s when he was roused from the human visual impression of perceiving things. The CNN pursues a various leveled model, lastly giving out a completely associated layer where each of the neurons is associated with one another and their yield is handled.

With the CNN algorithm, we can implement the random forest or any other algorithm as well to check the accuracy of the result.



How the algorithm is going to be implemented for the diabetic eye images dataset is shown in the figure.

The dataset is pre-processed and then the CNN algorithm is applied to train the dataset.

The layer by layer working of the CNN is as follows:

1. Convolution layer is the first layer in CNN to which we can give a pre-processed image as input to get the different features of the input image by applying multiple image filters.

2. Images are nonlinear in the form so the thermal images are also nonlinear in the form. So to maintain the nonlinearity we need to apply RELU on it.

3. The image of the eye then will be pooled and downsampled to get the feature matrix.

4. The pooled image matrix will be flattened into the image vector so as to give it as input to a fully connected layer.

5. The dropout layer applied on a fully connected layer to regularize the neural networks.

6. The multidimensional image will be flattened and will be converted into vector format and then the classification of the eye disease into a particular category.

7. The softmax function is used for multiclass classification. (It will be good to classify an input image into the 5 levels of diabetic retinopathy accurately.)

5. CONCLUSION

In this paper, the procedure for evaluation of the presence of diabetic eye disease has been presented. The categorization of whether the patient's eye is diseased or not is done using the CNN algorithm. The procedure works using thermal images of iris which gives more accuracy. This type of approach is helpful for the screening of diabetic eye diseased patients in a large amount. Using this approach the patient also understands the stage of diabetic eye disease. Early detection of diseased eye and stage is helpful for patients to take needy medication.

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