Diagnosis of Diabetic Retinopathy Using Soft Computing Methods: A Review

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Abstract: In diabetic retinopathy (DR), the early signs that may lead the eyesight towards complete vision loss are considered as microaneurysms (MAs). The shape of these MAs is almost circular, and they have a darkish color and are tiny in size, which means they may be missed by manual analysis of ophthalmologists. In this case, accurate early detection of microaneurysms is helpful to cure DR before non-reversible blindness. Early detection is required to reduce the visual impairment causing damage to eye. Microaneurysms are the first clinical sign of diabetic retinopathy. Robust detection of microaneurysms in retinal fundus images is critical in developing automated system. This paper performs a literature review for diabetes diagnosis approaches using SVM, CNN, Naïve Bayes, DT, KNN, etc. In this paper, several techniques for detecting microaneurysms, hemorrhages, and exudates are discussed for ultimate detection of nonproliferative diabetic retinopathy. Blood vessels detection techniques are also discussed for the diagnosis of proliferative diabetic retinopathy. Deep Learning (DL), a new domain of ML, is introduced. DL models can handle a smaller dataset with help of efficient data processing techniques. However, they generally incorporate larger datasets for their deep architectures to enhance performance in feature extraction and image classification.

Keywords: *Diabetic Retinopathy, Microaneurysms, Retina Fundus Images, Diabetes Diagnosis Approaches.*

I. INTRODUCTION

Between medical detection, a diabetic analysis is the major issues. WHO (world health organization) report defines which the no. of diabetes patients has grown from 108 to 422 million in 2014. An approximation defines which by 2045; this no. may reach 629 million. In 2016, the approximately 1.6 million deaths were described may reach to diabetes. Early diagnosis of diabetes is important in minimizing the probability of dissimilar diseases like stroke blindness, kidney failure, heart attacks, etc.

Eyes are facing side effects due to diabetes diseases among people. The side effect mainly took place due to DR (Diabetic Retinopathy). The retina is the interior layer of the eye. It is accountable for the vision of output situations. It is the thinner layer of the tissue in the back of the eye that sensed the light and forwards the pictures to the brain. An optic disk is present in the middle that is circular and oval in shape [1]. The intermediate optic nerve radiated the main blood vessel of the retina[2].

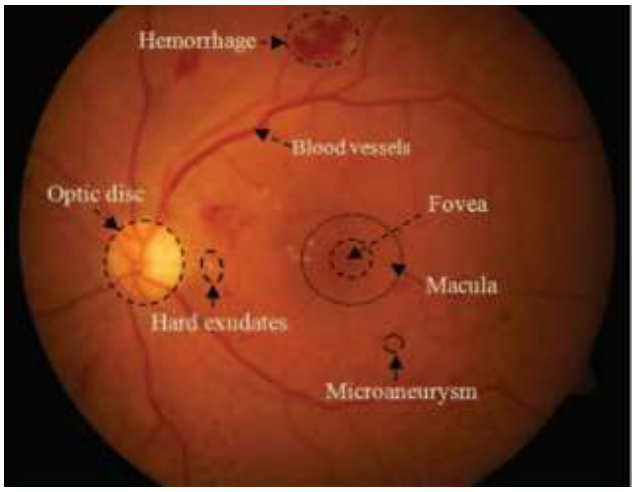

Fig 1. Different types of lesions and main anatomical features [3]

The blood vessels (BV) system is a significantly automated infrastructure in the human retina that is utilized to distinguish the different kinds of disease. Hence, the discovery of the blood vessels manually is not suitable due to the image complexity and low contrast of the retina vessel images. In addition, the retina structure ophthalmologist used the ophthalmoscope [2]. Retina fundus picture is normally utilized in the diagnosis and cure of different kinds of diseases like as diabetic retinopathy and glaucoma.

Several ML (machine learning) have been utilized in the MDS (medical diagnosis system). They have been verified to be précised in diagnosis, cost-effective, and successful in treatments. Diabetes Mellitus is related to diabetes which is an increasing disease all over the world. In accordance with the WHO statistical data, it is estimated that the number of persons having this disease reached up to 439 million by 2030. The main dangerous disease is blindness among the large number of people that is caused due to the limitations of the DR. However, the accuracy and timely diagnosis of the disease may avoid the growth of blindness [4]. The identification of the DR is examined on the pictures of the fundus and (OCT) optical coherence

tomography. DR is a diabetes infection that may cause blindness among adult persons. It is the major cause of serious vision loss and blindness among persons of age less than 50 yrs. age. DR is the diabetic restriction that influenced the small BV in the retina. The timely diagnosis and cure of DR is essential to avoid vision loss and blindness may be worse. Generally, the microaneurysms in the retina are called as blood dots inside the walls of the capillary vessels of the retina and it is mainly appeared closer to the macula. The major sign of the DR is the lesion of MA before the complications. The kinds of DR may be mainly categorized as non-proliferative DR and proliferative DR. It is based on the availability of the features of DR and various stages may be detected [5,6] and namely as;

- Minor Non-Proliferative Retinopathy
- Modest Non-Proliferative Retinopathy
- Serious Non-Proliferative Retinopathy
- Proliferative Retinopathy

DL (deep learning) is a part of ML in AI (artificial intelligence) which can self-learn from the information. It is reliable for USL (unsupervised learning). It may study a huge amount of unstructured and un-labeled information which even a human brain can take yrs to appreciate. DL utilizes several layers to extract properties from raw information. DL models are depending on ANN (artificial neural networks), and CNN (convolutional neural network). The simple architecture of NN is defined in figure 2.

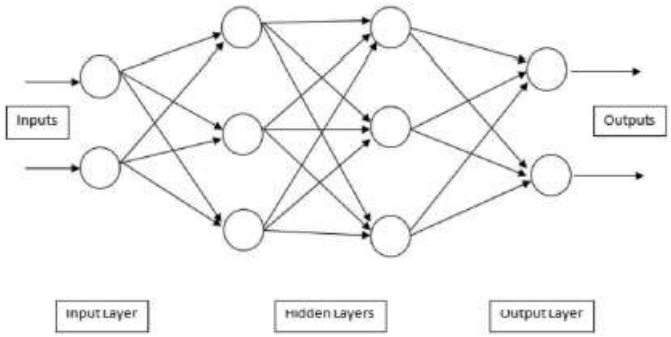

Fig 2. Simple Architecture of NN

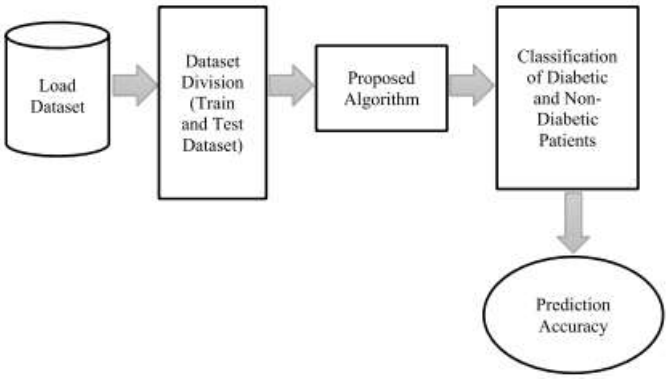

Fig 3. Flowchart of diabetes diagnosis

Fig 2 represents the flowchart of a diabetes diagnosis. This article discussed several diabetes classification techniques using ML and defined a comparative analysis of techniques [7] in our review article. The main motives of analysis work are as follows:

- Studies several diabetes prediction methods.
- Calculate and describe the existing models depending on the classification accuracy rate.
- Verify the existing issues and research gaps in the existing survey.
- It defines a comparative analysis of several diabetic prediction methods and gathers the dataset from hospitalized data or public datasets.

To review the several diabetic classification methods is to identify the diabetic prediction[8] issue by verifying, high-quality individual analyses. The review analysis has satisfied the following principles:

- This paper must have described several classification or predictive approaches and ML methods of diabetes data.
- Discussed several pre-processing methods to smooth the distorted data.

The association of the remaining article is as follows: sect 2 describes the related work. Sect 3 explains several predictive or classification methods by several authors. Sect 4 explains the previous limitations and problems in several diabetic classification methods, and then the conclusion is defined in Sect 5.

II. RELATED WORKS

Sabri, N. R. B., et al., 2018[9] developed the different pre-processing stages that are associated and considered. The two databases used messier and E-option which were utilized as the input picture. In addition, the picture inside the database was segmented into a binary set where shady pictures and bright pictures were measured. The desired energy law values were 0.7 for the color picture and 0.9 for the light picture determined as log conversion as the latest technique as the pre-processing phase. In the planned research, the various stages of the pre-processing were improving the retinal fundus picture. The datasets included were E-option and Messider. The two datasets were segmented where dark and bright pictures detected the lesion, respectively. The energy law value was utilized to improve the contrast of the picture. The functional rate was utilized to eliminate the noise and unnecessary illumination. During the pre-processing phase, the log conversion was converted and MA lesion features were experienced. **Eftekhari, N. et al., 2019 [10]** proposed research on diabetic retinopathy that results in loss of sight all over the world and simply the detection of reduced eye infections. Hence, the inspection of the fundus picture was done that considered the fundus pictures. In this research, an automated recognition of the retina pictures utilizing CNN was considered. The planned model combines the new model where two method procedure along with the online database leads to correct recognition whereas resolving the unbalanced data issue and reducing the training time interval comparable to existing models. They developed a CNN approach through the Keras library function. Results were evaluated on the normal stand for computing the database named as Retinopathy Online Challenge (ROC) dataset and E-Ophtha-MA dataset. The outcomes represented a favorable sensitivity rate of up to 0.8 for an average value of up false positive per picture that was compared to the state of the methods. The planned technique identified that desired enhancement in MA recognition utilizing retina fundus pictures for observing diabetic retinopathy. **Sedai, S. et al.,2017 [11]** implemented the two-phase DL model for the correct segmentation of the fovea in the retinal color fundus picture (FP). In the initial stage, the rough segmentation was analyzed to locate the fovea in FP. The located data from the initial phase was used to perform the well-refined-grained segmentation of the fovea area in the next phase. This research provided the multiple-stage DL system for the fovea segmentation dependent on the complete CNN. In the initial phase, the coarse system positions the fovea area. In the other stage, the fine system creates the grained segmentation of the fovea edge by middle feature mapping from the system. They demonstrated the efficiency of the planned approach for grained position segmentation by utilizing the database of high-resolution fundus pictures. **Swathi, C. et al., 2017 [12]** demonstrated the comparative study among the techniques utilized for the pre-processing model in retina fundus picture. In this research, they measured pre-processing of the retina fundus pictures. This stage improved the retina fundus picture dependent on the elimination of noise such as Gaussian and salt and pepper. This reviewed the pre-processing techniques and described merits and demerits. However, an adaptive median filter (ADM) has a better performance compared to other pre-processing techniques due to the high PSNR rate and low MSE. **Atlas, L. G. et al., [13]** studied the retinal retina eliminating fundus pictures by technique for the pre-processing, extracting features, classifying, and segmenting by disseminating methods and mode. By using ANFIS the influenced and non-influenced pictures were precisely partitioned and the influenced pictures were fragmented by FCM-CS enhancement strategies. The precision, particularity, affectability, FAR and FRR broke down the fragmented pictures. The results showed that the proposed framework accomplishes the best precision and performs ideal worth stood out from existing methodologies. In this research, they executed the ANFIS-based grouping strategy, which was a stunning system, and portion the pictures by utilizing FCM-CS enhancement way to deal with recognizing the nearness of Discharge. Our proposed drain grouping strategy does not need any customer intercession and has reliable execution in both influenced and non-influenced pictures. The creative procedure accomplishes 97.32% for precision and perfect regard in affectability and explicitness in FCM with CS streamlining. The results showed that the proposed system was especially suitable, since an ideal recognition rate and it requires less computing time was practiced. Right now, the displayed structure was capable of scientific application. More investigate job, the implementation of the recognizing pictures can be extended by using additional arrangement procedures, for instance, SVM and dividing methodologies like k implies grouping with novel upgraded and innovative streamlining calculations. **Win, K. Y.,et al., 2016 [14]** developed an automated approach to position the optic disc (OD) and recognize fundus retinal pictures. This approach used the histogram data. OD originates as the bright yellow area in the retina pictures. Hence, it was essential to locate the middle of the OD before the extraction. Using the OD, they computed that the execution can be recognized in a simple way through the threshold histogram model. Moreover, the database namely DRIVE, DIARETDB1, STARE and 325 retina fundus pictures from the localized database were analyzed. The planned approach acquired accuracy up to 100% and up to tp 97,3% for OD recognition. Generally, the exudates recognition was done to achieve accuracy up 99.4 and 93.2%. This research proposed an excellent and effective technique to recognize the exudates that determine the presentation of the histogram model. Simulation outcomes recognize the performance of the better position and recognized OD and exudates.

III. SEVERAL PREDICTION AND CLASSIFICATION METHODS

In this section describes various classification methods utilized for diabetic prediction such as decision tree, naïve bayes, KNN, CNN, SVM, MSVM, and so on.

3.1 Decision Tree (DT)

The decision tree is an attainably different well-known technique. and most general methods. The decision tree is one of the most essential classifiers which is informal and simpler to tool. The decision tree performs a DT as an analytical model recycled. It is utilized to predict infection from patients' information through the classification method. DTs [15] are rapid to hypothesize and informal to interpret. The forecast is built on the result that trees are healthy and well-ordered. It switches the massive size of data. It is additionally appropriate for data discovery. So, this method is very easier to clarify and delivered.

3.2 Naïve Bayes (NB)

This method follows the principle Bayes formula through an assumption between analysts. This method allows for rapid generation models that offer analytical skills and similarly offer a novel method of negotiating and data appreciation. This method is applied to analytical studies to build a predictive model with NB. For this, all the input features are relatively autonomous. This model is constructed simply and this method does not consist of any type of complications of iterative parameters. It is a powerful forecaster. This method is widely used for very great datasets. NBs method achieves determined attributes through the same demonstration of the construction period.

3.3 K-nearest neighbor (KNN)

This method is also a very important technique for categorizing articles constructed on neighboring training information in the feature space. It is to develop a simple path between all machine learning (MLs) laws still, the performance of the KNN method is degraded through the occurrence of yelling selections.

3.4 Convolutional Neural Network (CNN)

Recently, CNN is a state of the art method, because ofits ability to extract features in images without complex preprocessing, coupled with transfer learning and fine-tuning parameters. This study uses VggNet, Alexnet, InceptionNet, GoogleNet, DenseNet, and Resnet, which are transfer learning often used in deep learning. We use transfer learning to get the feature vector for classifying diabetic retinopathy using SVM and compare the results, which transfer learning is the best for classifying diabetic retinopathy. The classification layer is removed, and the last fully connected layer is applied to get the features for the classification process using the support vector machine (SVM) as shown in Fig. 4. A CNN architecture generally consists of convolutional layers, pooling layers or subs ampling layers, fully connected layers, and the classification layer [17] as shown in Fig . 5.

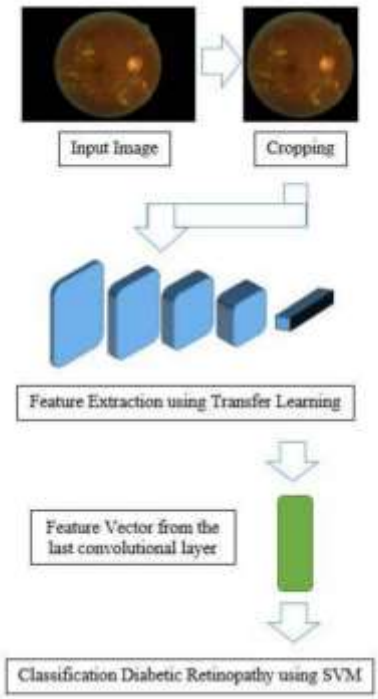

Fig 4. Classification Process Using The Support Vector Machine

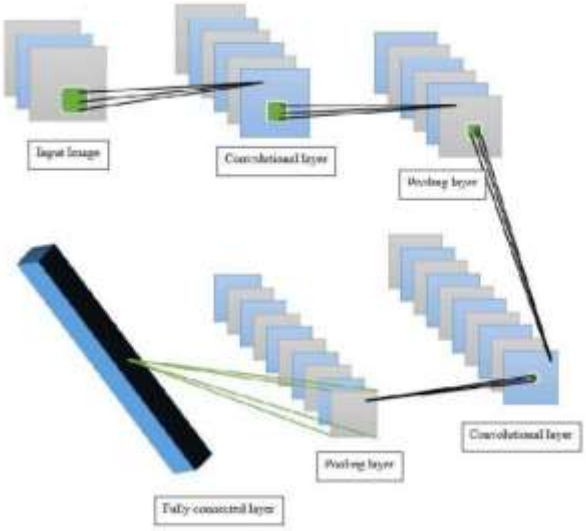

Fig 5. General CNN Framework

- **VggNet:** Developed by Oxford University, VGGnet was a transfer learning that more appropriate ConvNet architectures, which both obtain the state-of-the-art precision on ILSVRC classification and applicable to another image recognition datasets [18], and became the second winner of the 2014 ILSVRC with an error rate of 6.8%. VGGnet uses an input image of 224 x 224 with three channels (Red Green Blue). Shown in Fig. 5, VGGnet has five blocks of convolutional processes, with the first block has two convolution layers with relu activation, followed by a pooling layer, the second block has two convolution layers with relu activation followed by a pooling layer, the third block has three convolution layers followed a pooling layer, the fourth block has three convolution layers followed by a pooling layer, and the last block has three convolution layers followed a pooling layer, then followed by fully connected layers fc6, fc7, and fc8 followed by the softmax layer has 1000 neurons class scores. A convolutional layer ofVggnet architecture uses a very small kernel size, but VggNet requires a long computing time.
- **AlexNet:** Alexnet was developed by Alex Krizhevsky [19], Alexnet is a type of CNN and is deeper than Lenet. Compared to the previous CNN method, Alexnet is more optimal in the feature extraction process. Alexnet uses 227 x 227 input images with three channels (Red Green Blue), has five convolutional layers and three max-pooling layers and three fully connected layers. ILSVRC 2012 competition Alexnet is a winner with an error rate of 16.4% from an initial error of26.2%.

IV. CONCLUSION

DR is a critical medical health disorder causing blindness which is of utmost concern, and DL techniques can have an effective role in its diagnosis and early detection than traditional techniques. This paper precisely describes DR, its symptoms, features, shape, size and location of the features, and how DR causes blindness. Among different challenges in the medical diagnosis system, diabetes retina detection is one of the major technical challenges. Early diagnosis of diabetes is important as delayed detection may lead to different diseases that include kidney failure, stroke, blindness, heart attacks, and lower limb amputation. Machine learning techniques have been introduced in the medical diagnosis system as they have proven to be accurate in diagnosis, successful in treatments, and more cost-efficient. Deep learning is a subset of machine learning in AI, which has the capability of self-learning from data. It is also capable of unsupervised learning. It can learn large amounts of unstructured and unlabeled data that for the human brain may take years to understand. This research is done on existing techniques to perform a survey of the diagnosis of diabetes. This study includes papers from the last decade. The main aim of this review is to present a clear overview of automatic ML-based diabetes prediction. Various ML techniques such as SVM, CNN, NB, DT, etc., in the prediction of diabetes were analyzed in this review, which have been developed in recent days for the effective and efficient prediction of diabetes. The goal of developing a diabetes prediction model is to shift from higher precision to higher reliability for real times applications. Only a very few techniques had used different datasets for training the model and testing it. Since DM is increasing worldwide, a model that can be used to predict diabetes in the world population is needed.

In the future, if more and more retina diabetic patients use automatic glucose sensors that continuously

measure glucose levels, the amount of data related to blood sugar will greatly increase. This discussion helps to provide a clear-cut view of diabetes prediction and helps to frame better diabetes prediction techniques to overcome diabetes through timely prediction.

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