Computer Aided Diagnostic System for Diabetic Retinopathy Detection using Image Processing and Artificial Intelligence

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***Abstract*—The number of individuals who develop Diabetic Retinopathy (DR) has increased significantly in recent years. Early detection and diagnosis is essential to prevent the vision loss. Ophthalmologist need to analyze mass retinal images to discover the anomalies, for example, spilling veins, retinal swelling(macular edema), greasy stores on the retina (exudates), and changes in the veins. Early detection of DR from retinal images is a challenging task. Medical image examination is the most effective method for diagnosis of DR. Computer Aided Diagnosis (CAD) systems, which can be used in clinical environments assists an ophthalmologist in diagnosing and detecting DR. This paper aims to investigate, the state of art regarding CAD for DR. The review focus on major techniques in image processing and data mining that are employed for developing a CAD system for DR. This survey also comes up with a common analysis of the current CAD system according to the employed modalities for DR diagnosis or detection. Future research works are discussed to develop efficient CAD systems for DR diagnosis or detection.**

Index Terms*— *Computer Aided Detection, Classification, Diabetic Retinopathy, Feature Extraction, Image Processing, Preprocessing.

I. INTRODUCTION

Diabetic Mellitus is a chronic disease caused due to excessive level of sugar content in the blood. It mainly affects kidneys, nerves, heart and minute blood vessels in the eyes[1]. DR is an eye disease, which can cause damage to the retina. A vascular eye disease will eventually cause blindness in people and can be of two types, Non-Proliferative DR (Early DR)[2] and Proliferative DR (Advanced DR). These days DR is a significant reason for visual impairment in individuals with diabetic. Therefore, constant eye check-up and timely treatment is required. However, the dearth of experts along with related higher medical prices makes regular check up pricey. To fill this opening, development of low cost CAD systems, which can be employed in clinical environments, have gained far more attentiveness in recent years.

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In this period, individuals with diabetic is more and ophthalmologist need to look at mass retinal pictures to discover the irregularities, for example, leakage of blood vessels, deformation of retina(macular edema) and small deposits known as exudates.Early detection of DR is a challenging task in ophthalmology. Most of the CAD systems use some computerized feature extraction and classification algorithms to detect DR. These can be a better tool or an intelligent diagnostic system for an ophthalmologist in detecting or diagnosing the DR[3]. Many efforts has been made to develop CAD systems, which are based on the breakthrough or advances in digital image processing, data mining techniques and pattern recognition. Development of a DR-CAD system[4, 5] is a tough task in the field of ophthalmology. Automatic detection systems were utilized different advances beginning with image processing technologies of retinal data[6] and upgraded to AI approaches such as machine learning and deep learning[7]. Optical coherence tomography and fundus image analysis[8] are mainly used as imaging techniques to draw out the characteristics associated with the retina in the diagnosis of various retinal diseases. Several methods were employed to develop CAD system that uses various datasets, feature vectors and different methodologies for classification[9-11]. Due to the technological development, numerous applications were suggested for the development of DR-CAD system. Earlier days CAD framework were employed with the support of image processing techniques for the mass screening of retinal images[1, 12]. Retinal images were segmented using segmentation algorithms, which will identify optic disc, blood vessels and fovea localization[13, 14] etc. Geometric relationship of different features and lesions can be used along with some morphological operations[15] to obtain a better framework for analyzing the retinal images. Image processing techniques can be effectively applied on retinal images for the effective segmentation[16]. Soft computing techniques[17] employ as a proficient method for the recognition of blood vessels in digital retinal images.

With the introduction of AI based approaches CAD system acquired more accuracy than the previous methods. Automatic detection systems for DR using machine-learning approaches given a new look to the CAD system[18]. Era of deep learning approaches[19, 20] provides desirable and improved results for the detection of DR. In the field of ophthalmology, application of deep learning algorithms in retinal imaging is an upcoming research area[21, 22]. Hybrid solution including image processing and AI approaches[23] is another versatile method for developing CAD system with good accuracy. Voets et. al.[24] overcomes the issues of deep neural network by incorporating new methodologies. .In this paper, we present some of the important methods, which have been employed in developing the CAD system for DR.

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A.List Of Abbreviations

AHE	Adaptive Histogram Equalization
AI	Artificial Intelligence
BDT	Binary Decision Tree
BPNN	Back Propagation Neural Network
CAD	Computer Aided Diagnosis/Detection
CLAHE	Contrast Limited Adaptive Histogram Equalization
CNN	Convolutional Neural Network
CUHK	Chinese University of Hong Kong
DNN	Deep Neural Network
DR	Diabetic Retinopathy
DWT	Discrete Wavelet Transform
FFT	Fast Fourier Transform
FIRE	Fundus Image Registration
GLCM	Gray Level Co-occurrence Matrix
HE	Histogram Equalization
LESH	Local Energy-based Shape Histogram
LPBPC	Local Property-Based Pixel Correction
LFSA	Local Feature Spectrum Analysis
LTP	Local Ternary Pattern
MA	Micro Aneurysm
NPDR	Non-proliferative DR
PDR	Proliferative DR
PNN	Probabilistic Neural Network
SERI	Singapore Eye Research Institute
SIFT	Scale Invariant Feature Transform
SVM	Support Vector Machine
STARE	Structured Analysis of Retina
QDA	Quadratic Discriminant Analysis

II. RELATED WORKS

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Many research works have been developed to improve the diagnostic accuracy of DR screening[30]. Xiao et.al.[10] presented an overview of the automatic screening systems such as Iowa DR, Tennessee Ocular Telehealth Network (OTN) etc. Our paper attempts to elaborate different life cycle stages and the various methodologies involved in each stage of the CAD system. [Fig. 1]. shows the life cycle stages of DR detection.

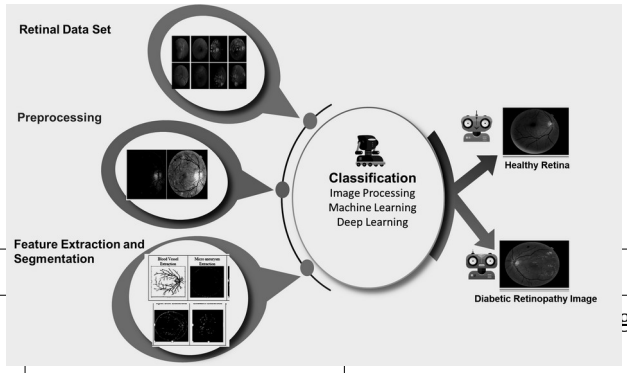

Fig. (1). Life Cycle Stages of DR Detection

A. Preprocessing of the Retinal Image

Preprocessing eliminates unwanted elements and defects from the images and resolves the problems of lighting, illumination, contrast and resolution. Preprocessing of images [31] will improve the quality of retinal images in further processing of a CAD system. Both early and modern CAD system adopted different approaches according to the requirement of the user. DR detection using image processing techniques uses different preprocessing methods to improve the quality of images. Gray scale conversion was performed in most of the images and image enhancement methods such as HE, AHE, and CLAHE were applied to it. Resizing the images to different dimensions and applying morphological operations really improved the performance of the system by reducing the processing time. Green channel extraction was performed to identify the prominent blood vessels in the retinal images. Different filtering methods including matched filter, median filter, Gaussian filter, sober filter and Gabour filter were used to reduce the noise.

Table 1. Details of available dataset.

Sl.No			Remarks
1		g various cameras.	Patients were selected from 15 National Health Service hospitals in the United Kingdom
2	DRIVE [14,21,99].	8 bits/color plane at 565 × 584 pixels.	40 fundus images with 33 typical normal images and 7 DR affected images.
3	STARE [14,21,45 ,66,79.	700 x 605 pixels.	20 retinal fundus images.
4	SERI, CUHK [22].	It was captured with a CIRRUS SD-OCT device.	128 cross-sectional scans with a resolution of 512 × 1, 024 pixels.
5	A2A SD-OCT (Duke dataset) [22].	1, 000 × 512 pixels.	384 SD-OCT volumes: 269 AMD and 115 control or normal eyes.
6	Retinopathy Online Challenge [25].	768 × 576, 1058 × 1061 and 1389 × 1383 pixels.	100 color image of the retina.
7	Messidor [26][36].	440 X960, 2240 X 1488, and 2304 X1536 pixels.	1200 images.
8	KAGGLE [27,98].	High-resolution fundus images.	It contains an aggregate of 35,126 fundus images.
9	E-Ophtha [28].	NA.	381 compressed images of which 148 have MAs presents and 233 depict healthy.
10	DIARETDB1[6][9]][28].	1500 x 1152 with 500 field of view (FOV).	28 training and 61 testing images captured at 50 ° FOV.
11	FIRE [29].	Utilizing a Nidek AFC-210 fundus camera with resolution of 2912 × 2912 pixels and 45 ° field of view (FOV).	Publicly accessible retinal image registration dataset with ground truth annotation.
12	CHASE.[14,79]	1280 X 960 pixels resolution.	28 images.

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