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Computer Aided Diagnosis of Macular Edema Using Color Fundus Images: A Review

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ABSTRACT
Diabetic retinopathy is the leading cause of blindness in the western working age population and micro aneurysms are one of the first pathologies associated with diabetic retinopathy. Diabetic retinopathy (DR) is caused by damage to the blood vessels of the retina which affects the vision. But when DR becomes severe it results into macular edema. Macula is the region near the centre of the eye that provides the vision. Blood vessels leak fluid onto the macula leading to the swelling which blurs the vision eventually leading to complete loss of vision. This paper is based on the detection of the edema affected image from the normal image. If the image is edema affected it also states its severity of the disease using a rotational asymmetry metric by examining the symmetry of the macular region. Diabetic macular edema (DME) is an advanced symptom of diabetic retinopathy and can lead to irreversible vision loss. A feature extraction technique is introduced to capture the global characteristics of the fundus images and discriminate the normal from DME images.
KEYWORDS: Abnormality detection, diabetic macular edema, hard exudates, learning normal.

I. INTRODUCTION

Diabetes mellitus, or simply diabetes is a disease in which a person has high blood sugar, Complication of diabetes leads to diabetic retinopathy. Diabetic retinopathy is the leading cause of blindness in the Western working age population. Screening for retinopathy in known diabetics can save eyesight but involves manual procedures which involve expense and time. Diabetes causes an extensive amount of glucose to remain in the blood stream which may cause damage to the blood vessels. Diabetic retinopathy is caused by damage to the blood vessels of the retina. During the initial stage, called Non-Proliferative Diabetic Retinopathy (NDPR). Some people develop a condition called Macular edema. Hard Exudates are formed due to the secretion of plasma from the capillaries. As the disease progresses, severe NDPR enters advanced stage. The blood vessels now bleed, cloud vision and destroy the retina leading to complete loss of vision. The severity of the risk of edema is evaluated based on the proximity of the hard exudates to the macula, which is defined to be a circular region centred at the fovea and with one optic disc diameter. The risk of Diabetic Macular Edema rises when the Hard Exudates locations approach the macula. The past research work includes the location of macular region in the fundus image. Macula is the region near the centre of the eye. The fovea is localized and the regions of macula are marked based on the Early Treatment Diabetic Retinopathy Studies (ETDRS) grading scale. The detection of the fovea is an important step in the assessment of retinal images for pathologies relating to these visual conditions. The method makes use of optic disc detection as a starting point. Since in the case of normal retina image fovea is the darkest spot inside macular region and morphological operations make it more visible than its macula background. Once the macular region is detected the abnormalities in the region i.e. the presence of hard exudates are observed. Automated solutions following this approach can be categorized as Localization of Hard Exudates or Hard Exudates Clusters and schemes for detecting the presence/absence of Hard Exudates in images. Fundus Fluorescein Angiography (FA) is a powerful tool for imaging and evaluating Diabetic Macular Edema (DME) Among recent approaches, multiple uncaliberated fundus images have been used to estimate a height map of macula in. The bright yellow color of hard exudates has been very useful for using colour features.

II. OBJECTIVE OF THE PRESENT WORK

The severity of the risk of edema is evaluated based on the proximity of the hard exudates to the macula, which is defined to be a circular region centred at the fovea and with one optic disc diameter. The risk of Diabetic Macular Edema rises when the HE locations approach the macula.It is important to detect the presence Hard Exudates on the fundus image. If the HE are present then there is a risk of Diabetic Macular Edema. If the hard exudates are present then the severity of the disease can also be detected. So proper and accurate

diagnosis of the patient can be done and accordingly proper treatment can be given. The processes of diagnosing diseases are primarily used in two different modes of healthcare.

First is the traditional healthcare performed through primary, secondary and tertiary care. The patients initially arrive at the primary care centers with health problems. If required they are referred for advanced care to secondary and tertiary care providers. We will collectively refer to this mode of healthcare as primary care. The second approach to healthcare is through public health initiatives where the goal is to prevent diseases and prolong life in population through disease screening. For example, screening for cataract and diabetic retinopathy is being adopted in developing countries as it impacts several people with vision impairment. In both the healthcare scenarios, aid of computers in the process of diagnosis, popularly known as Computer Aided Diagnosis (CAD) can reduce the time and effort spent on diagnosis when compared to manual assessment.

2.1 COMPUTER-AIDED DIAGNOSIS SYSTEM FOR DIABETIC RETINOPATHY SCREENING

The proposed system consists of various modules responsible for the following tasks:

2.1.1 Pre-processing

Before finding anatomic landmarks and lesions within the image, its field of view (FOV) is detected by finding the optimal FOV template among a predefined group of templates that match the image. The image is then resized to have an FOV with a standardized diameter of 650 pixels independent of the image resolution.

2.1.2 Quality Verification

This module determines the quality level of the image. The technique relies on the assumption that an image of sufficient quality should contain particular image structures—namely, the vasculature, the optic disc (OD), and the background, according to a certain predefined distribution. A compact representation of the image structures is obtained applying a Gaussian filter bank (GFB) to the image and clustering the outputs. One cluster represents one structure. The distribution of the image structures within the image is then represented by means of a histogram with one bin per cluster. Using this histogram together with histograms of the R, G, and B color planes as features, a support vector machine is trained to assess the image quality. The output of this module is a probability per image indicating the likelihood the quality of the image is normal. It should be noted that the output of this module is not used to discard images of low quality, only to analyze the quality level.

2.1.3 Vessel Segmentation

The vasculature is one of the most important anatomic structures in retinal images. Vessel segmentation is necessary to distinguish small vessels from red lesions and as an aid for the identification of other anatomic landmarks, such as the OD. A pixel probability map indicating the likelihood that the pixel belongs to a vessel is obtained as output by means of pixel classification using GFB features and a supervised classifier.

2.1.4 OD Detection

The OD is another important anatomic structure. The identification of this element is necessary to prevent erroneously detected bright lesions within the OD. The OD is identified calculating a regression rule between its center location and a group of features based on intensity, vessel orientation, and density. The output of the module is a location within the image with the highest probability that it is the OD center.

2.1.5 Red Lesion Detection

Red lesions, comprising micro aneurysms and vascular abnormalities, are important signs of DR and their detection is therefore of paramount importance for a DR screening system. Potential red lesion locations are identified by using a hybrid approach based on mathematical morphology, specifically designed for smaller candidates, and a supervised pixel classification using GFB features, for the detection of larger red lesions. The detected candidates are then assigned a probability of being a true red lesion, using a supervised classifier and a group of features describing the candidate shape, structure, color, and contrast.

2.1.6 Bright Lesion Detection

Bright lesions, such as exudates, cotton wool spots, or drusen, are frequently encountered in a DR population screening. Only the first two are associated with DR. Similar to red lesion detection, a supervised pixel classification is first performed to obtain candidates that may be bright lesions. A probability that each candidate is a true bright lesion is then obtained by means of supervised classification using a group of candidate features, such as shape, contrast, color , and distance to the nearest red lesion.

The outputs of the different modules must be combined to obtain a final decision about the patient's examination. To accomplish that, a group of features based on the diverse outputs of the aforementioned modules are calculated, such as the quality likelihood or the highest likelihood of red or

bright lesions in the examination. These features are given as input to a k nearest-neighbor (kNN) classifier. This classifier was trained on an independent training set not used for any other purpose in this research. The output of this classifier is a per-examination probability indicating the likelihood that the examination would be referred to an ophthalmologist.

2.2 ROTATIONAL SYMMETRY

The color fundus image under observation will be compared with the reference image. This reference image is the ideal image of a clear eye. Here the image under observation will be taken from the database. Database will have actual defective eye images taken by color fundus camera. By using the process/method of rotational symmetry the image under observation will be compared with the reference image. Both the images will be compared i.e. the image under observation and the reference image. If both the images compared are the same then the eye is not defective. If there are spots seen in the macular region then the eye is defective and is suffering from Macular edema. Also if the person is suffering from macular edema, the intensity of the disease will be also detected as severe or not.

2.3 COLOR FUNDUS IMAGE MECHANISM

The robust detection of red lesions in digital color fundus photographs is a critical step in the development of automated screening systems for diabetic retinopathy. An enlargement of foveal avascular zone (FAZ) is usually found in eyes with diabetic retinopathy (DR) resulting from a loss of capillaries in the perifoveal capillary network. Currently it is difficult to discern the FAZ area and to measure FAZ enlargement in an objective manner based on raw color fundus images. Instead, ophthalmologists observe and record the occurrences of DR pathologies for the grading of DR severity. Fundus image analysis presents several challenges such as high image variability, improper illumination and artifacts due to   presence of pathologies for different patients and differing imaging conditions for the same patient.

2.4 COMPUTER-AIDED DIAGNOSIS

Computer-aided diagnosis (CAD) has become one of the major research subjects in medical imaging and diagnostic radiology. In this paper, the motivation and philosophy for early development of CAD schemes are presented together with the current status and future potential of CAD in a PACS environment. With CAD, radiologists use the computer output as a "second opinion" and make the final decisions. CAD is a concept established by taking into account equally the roles of physicians

and computers, whereas automated computer diagnosis is a concept based on computer algorithms only. With CAD, the performance by computers does not have to be comparable to or better than that by physicians, but needs to be complementary to that by physicians. In fact, a large number of CAD systems have been employed for assisting physicians in the early detection of breast cancers on mammograms. A CAD scheme that makes use of lateral chest images has the potential to improve the overall performance in the detection of lung nodules when combined with another CAD scheme for PA chest images. Because vertebral fractures can be detected reliably by computer on lateral chest radiographs, radiologists' accuracy in the detection of vertebral fractures would be improved by the use of CAD, and thus early diagnosis of osteoporosis would become possible. In MRA, a CAD system has been developed for assisting radiologists in the detection of intracranial aneurysms. On successive bone scan images, a CAD scheme for detection of interval changes has been developed by use of temporal subtraction images.

III. WORK PLAN AND METHODOLOGY

The main aim of the project is to find hard exudates in the image. For this purpose the edema affected fundus image compared with the normal fundus image. This is done using the motion pattern recognition. In the absence of any HE, there is a rough rotational symmetry about the macula. If the images do not match then the severity of the edema affected image is also determined.
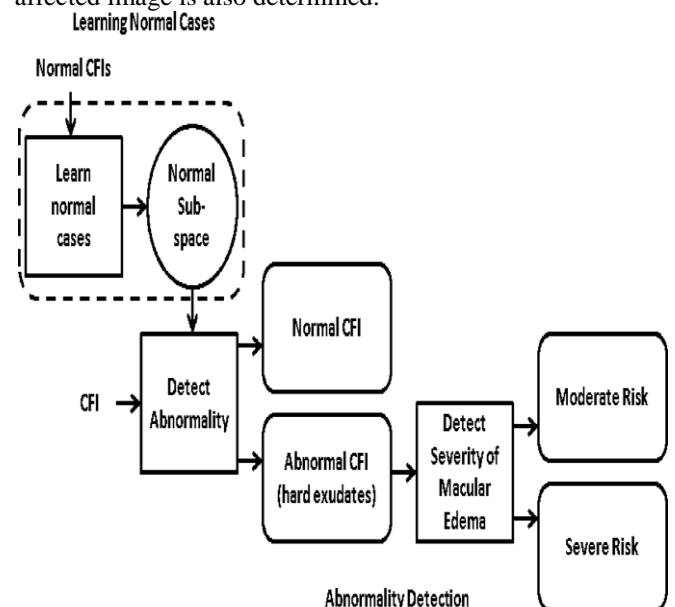

Fig. Processing pipeline for detection and assessment of DME (CFI—color fundus image).

IV. CONCLUSION

In this paper , Screening of population for disease using images is a challenging problem. Several barriers in the form of social, educational and operational issues are integral to the disease screening problem. These affect the nature of computer aided diagnosis required to address disease screening, which is significantly different from conventional primary care. We have identified and listed the challenges in image based disease screening. These challenges are pertaining to two popular disease screening problems, retinal diseases from color fundus images and breast cancer from digital mammograms. There is scope of future work in different avenues. Evaluation of the proposed hierarchical approach has been performed on several image datasets and improvement in the disease detection performance is observed against the traditional detection methods. Further analysis of the new approach is required in a screening setup to identify the operational challenges in its implementation.

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